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WHEN HANNOVER MESSE went digital for the second consecutive year in 2021, it cemented a departure that seemed temporary amidst the chaos and scrambling of the COVID pandemic a year ago.

But, as we sit perched, ready to descend on the “new normal,” it’s beginning to dawn on us that many of the inconveniences we endured over the past year were really just changes in what we’d come to expect. And no one likes change, at least, not at first. Those videoconferencing calls that revealed our own technological shortcomings and distanced us from associates and co-workers ultimately shored up our bandwidths, upgraded our software and brought us closer together with family, friends and colleagues in other parts of the country and the world.

Remote connectivity has also shown that we don’t need as much real estate as we once did, and artificial intelligence (AI) and autonomous robots have quickened the journey to replace labor.

The new normal is a hybrid of new and normal. Hannover Messe is a great example.

“Hannover Messe Digital Edition demonstrated the innovative power of mechanical engineering, electrical engineering and IT companies. At the same time, it showed that the trade show of the future is hybrid,” says Dr. Jochen Köckler, CEO of Deutsche Messe AG. “Together with our exhibitors and partners, we succeeded in strengthening the core brand of the world’s most important industrial show.”

The 1,800 participating companies presented 10,500 products and innovations to 90,000 registered participants.

The conference featured 1,500 experts discussing topics such as Industry 4.0, digitalization of industrial processes, supply chain management, lightweight construction, hydrogen and electromobility.

“A digital trade show cannot replace the magic of a physical event,” says Köckler, citing trust-building face-to-face discussions, concrete leads at the booth and the hands-on product experience, as well as chance encounters that can lead to new business partnerships. “The personal contact simply is not there.”

The digital Hannover Messe confirmed that the path is taking us in the right direction, says Köckler.

“In the future we will bring together the best of the digital and analog worlds to provide our customers with a holistic hybrid trade-show experience,” explains Köckler.
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AUTOMATION IN ANY hazardous area has its challenges, regardless of the predominantly North American class and division or zone classification system of that hazardous area.

Machine builders rarely have to deal with the constraints of hazardous zones since most machine operations would be assembled in a safe environmental space. However, process control systems are more likely to have to deal with the various zones for protection.

The main issue at hand is the fact that electrical devices create sparks. That spark can and has ignited hazardous gases and dust/fibers that were in the environment of the devices.

This explosion risk is different from a high current arc flash type of explosion, which can be created by a line fault. An environmental explosion is created by three requirements: energy, fuel and oxygen.

The energy can be referred to as the spark that lights the fuse. The fuel is the hazardous gas/dust/fiber, and the air in which this spark exists supplies the oxygen. It’s akin to lighting a match or striking the flint starter on a propane grill.

There is a need to understand the environmental classifications to gain some insight into what constitutes a hazardous location.

Class I, Div. 1, defines an area of combustible gases, liquids or vapors such as ammonia or hydrogen. Zone 0 and Zone 1 classified locations further define the hazard by using phrases such as continuously present or most likely to exist.

Class I, Div. 2, suggests that the hazardous material (gas/liquid/vapor) would only be present under abnormal conditions.

Class II, Div. 1, suggests that the environment can support combustible dust under normal conditions, while Class II, Div. 2, suggests that combustible materials are unlikely to exist normally. Carbon would be considered a combustible dust. The group rating further defines the type of combustible material present.

There are many resources available to define certain areas for class/division and zone identifications.

There are four different containment technologies to learn to gain some insight into how automation can be implemented in this environment.

Potential explosion devices are spark-generating and are enclosed in explosion-proof, NEMA-rated enclosures when installed in a hazardous location. The main characteristic of the enclosure is that there is a wide flange that has multiple bolts to torque down the cover. The premise for this design is that, should an explosion occur within the enclosure, the ionized gas that would be created inside the enclosure would be cool by the time it drifted through the flange into the hazardous area, so an external explosion would not occur. Motor starters/contacts and relays would be examples of these devices.

Intrinsically safe (IS) devices limit the amount of energy that is delivered to the device in the hazardous area. This energy level is defined as the level that would be below the level required to ignite the hazardous material where the device is located.

A relatively new specification is identified as non-incendive. These devices are similar to intrinsically safe but are not suitable for Class I, Div. 1, Zone 0. These devices include many automation products from all major manufacturers including remote I/O, PLC/PACs and drives, among the most popular.

ATEX comprises two EU directives concerning explosive atmospheres. There are similar certifications in various other countries, as well. In reviewing a brochure from Rockwell Automation, I was surprised to see the number of hazardous-location devices available, including power supplies and proximity sensors.

I was also introduced to NAMUR sensors. These are devices that adjust current levels to identify the presence of the detected material instead of taking the output of the sensor from zero to some voltage. These devices can be installed directly in the field, as can intrinsically safe components.

Lastly explosion containment can be attained by having a purged enclosure. These enclosures are supplied with either clean air or an inert gas, which will not ignite based on the devices that are in the enclosure itself.

Jeremy Pollard, CET, has been writing about technology and software issues for many years. Pollard has been involved in control system programming and training for more than 25 years.
Collaboration requires presence sensing

WITH THE PROLIFERATION of collaborative robots (cobots) during this seemingly endless pandemic, the focus of automation is very squarely in the realm of the interaction between people and machines.

Cobots are designed to be deployed on a production line where humans interact with them as if they were other humans. The use of just one cobot can make it possible to provide physical separation between workers on the line by putting the cobot between the work positions.

A by-product of the coronavirus pandemic has meant that some people choose to stay home rather than expose themselves to risk of infection. The loss of workforce has made the move to automation even more important, and the relatively low cost of cobots puts them at the forefront of automation plans.

The challenge of automation has always been to keep people safe while trying to produce more product in the same footprint. The faster a machine runs, the more physical space is required to guarantee that, if something goes wrong, the machine has enough time to come to a complete and safe stop before potentially making contact with humans or other machines around it.

Traditionally, this would involve a physical cage around the piece of automation. This cage could take the form of a frame with either polycarbonate or expanded steel (fence) panels.

Made to physically defend a person from getting too close, these types of guarding systems also take up a lot of real estate. For this reason, they are not well-suited to a cobot application where we don’t want the new automated device taking up any more space than the human it is replacing.

The technology required to respond to this need for an ever tighter operating envelope has advanced dramatically, especially over the past two or three years. While we will delve into that momentarily, it is important to note that the robot manufacturers, in addition to coming up with new ways to sense the presence of people in proximity to the robot, have had to come up with ways to safely limit the range of operation to be inside the normal operating range of the robot.

As one can imagine, it’s not enough to just add software limits that are inside the physical (hard) limits of the various axes. The operating confines must absolutely prevent the robot from getting outside the working envelope and must do it in an intrinsically safe manner.

The lengths to which robot manufacturers have gone to guarantee the safety of those working in close proximity to robots is extensive. Both hardware and software has been developed to address these important criteria and the Robotic Industries Association (RIA, www.robotics.org), founded in 1974, works to ensure that all members conform to guidelines designed to keep the safety of personnel at the forefront of the manufacturing process.

Perhaps the best way to examine the need to interact with collaborative robots is to provide an example. In my own consumer-packaged-goods (CPG) manufacturing facility, we have recently started to employ cobots to automatically palletize cases of product.

For us, this is low-hanging fruit and, by the very nature of the operation, has the least risk involved as the palletizing or unitizing of product is at the very end of the production line. The heavy traffic areas in our production areas tend to be closer to the pouch-making and cartoning operations further up the line.

After the case is packed, there is a tape or glue machine and then coding equipment. This provides an automatic gap between the folks packing the cases and the folks that put the cases on a pallet.

To apply a cobot to palletizing, we added some roller conveyor to convey the finished cases to the infeed of the robot palletizer. The robot picks up one or more cases, depending on the weight of the product and the pack pattern; then it places the cases on one of two palletizing positions.

When one pallet stack is complete, the robot automatically starts placing cases on the opposition pallet position, and an operator comes by with a hand truck to remove the full pallet and replace it with an empty pallet. The time required to interact with the palletizer is minimal, allowing that operator to perform other tasks on the line or even on an adjacent line.

For the most part, the interaction between robot and human is minimal, but there are times where the human needs to be within range of the robot. The sensing of that human and how
the robot reacts to that presence is key to the use of cobots.

In general, the need to have a safe operating envelope but not use hard guarding is taken up with the implementation of area scanners. These devices utilize a laser sensor that is passed back and forth over an arc of view in a two-dimensional scan that looks for objects that pass into the area of interest.

Area scanners can be trained to ignore fixed objects in the pre-defined scan path and look only for objects, such as a person, that wander into the protected area. One or more scanners may be used in tandem to broaden the area of protection.

Area scanners, like any other safety device, provide an input to a safety relay and can trigger a variety of responses, depending on the severity of the incursion. For example, if a person enters the far reaches of the protected area, the robot will slow down it’s movements but doesn’t need to stop.

However, if the person penetrates further into the area, to the point where the person might come into contact with the robot or the product on the robot, then the robot may either further reduce speed or suspend operation altogether. The implied reason for the speed reduction is the robot will travel less distance to come to a complete stop if it isn’t travelling fast to start with.

Just imagine that same scenario if you are driving down the interstate at 70 miles per hour and have to stop versus driving 10 miles per hour in your driveway and having to stop.

For the situation where the person gets into even closer proximity to the cobot, a number of other technologies come into play. While travelling slower, the cobot still has motive force, and coming into contact with a person has to cause an immediate stop and de-energizing of the robot to prevent further motion.

One technology in use is a simple outer shield device, such as a plastic guard, that will trip a proximity switch if the shield gets displaced. The shield is often held in place by light-duty magnets that will release the shield with minimal pressure.

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Since the shield isn’t the actual robot arm or the end-of-arm tool, it doesn’t present an immediate danger to the person in the envelope and acts as a pre-warning (for lack of a better term) to cause the robot to cease operation before any contact is made with the working parts of the robot.

Another interesting technology employs the properties of conductive paint to turn the surface of the robot arm, and other components, into a sensor. Connected to appropriate electronics, the paint acts just like a pushbutton or other input device to cause the robot to respond accordingly.

What level of safety protection is needed for the production floor?

A Control Design reader writes: What role does presence sensing play in test cells and work cells? What is the approved procedure to sense and lock cell doors and still meet fire code exit requirements?

**Minimum safe distance**

Safety presence-sensing devices, such as safety scanners, safety mats or safety light curtains, can be a simple and efficient solution to keep your employees safe while allowing easy access to work or test cells. In comparison to an interlocked movable guard, such as a door or gate, a safety presence device offers operators the convenience of safely being able to reach or walk into a hazard area as is necessary. It’s also much easier to install for machine builders. To ensure those devices are effective and compliant, however, you need to consider three important factors.

First, you can only use safety presence-sensing devices as the primary means of protecting an employee from a hazard when the machine can be stopped at any point in its operational cycle. As the name implies, safety presence devices rely on detecting the presence of a person and sending a stop signal to the control system of the machine to halt the hazardous motion before the machine and the person can interact.

Critical for the effectiveness of the safety solution is to be able to predict how long it will take all hazardous motion to stop if the safety device is triggered. If there is no way for the control system to stop the machine once the cycle is started, such as with a full-revolution press, then there is no way to predict how long the hazardous motion will continue. Instead, when faced with machines that have uncontrolled stops, you will need to rely on some form of interlocked hard guarding at the point of operation to protect the employees.

Second, you need to mount the safety device at the minimum safe distance to ensure that it will adequately protect your employees. The minimum safe distance is how far away from a hazard a safety device should be installed to make certain that it would protect the employee. While there are some variations, the basic concept of the minimum safe distance (Ds) can be expressed by the equation:

$$Ds = (KT) + C$$

where:

- $K$ = approach speed constant (63 inch/s)
- $T$ = total stopping time of the machine
- $C$ = depth of penetration for the safety device

This time includes safety device response time, response of the control system and the actual time it takes for the hazardous motion to stop. While this value can be calculated, best practice calls to actually measure it using a stop time device.

To calculate $Ds$, you can use the following formula:

$$Ds = (K \cdot T) + C$$

where $K$ is the approach speed constant, $T$ is the total stopping time of the machine, and $C$ is the depth of penetration for the safety device.

Minimum safe distance

To ensure that it will adequately protect your employees, the minimum safe distance (Ds) can be expressed by the equation:

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In summary, the safe stopping distance can be calculated using the formula:

$$Ds = (K \cdot T) + C$$

where:

- $K$ is the approach speed constant (63 inch/s)
- $T$ is the total stopping time of the machine
- $C$ is the depth of penetration for the safety device

This formula takes into account the safety device response time, the control system response time, and the actual time it takes for the hazardous motion to stop.

**What is the approved procedure to sense and lock cell doors and still meet fire code exit requirements?**

Since many guard locking solutions rely on access is controlled by a guard locking gate, the best practice is to have some type of a manual release on the inside of the door. In these applications, the fenced perimeter with the interlock gate is protecting access to the hazard. The safety presence device is there to ensure that no one is trapped in the hazard zone prior to a machine restart. There are two important considerations in this type of application.

One, the safety device needs to be able to cover the entire area enclosed by the fence, without any shadows or dead zones in its sensing field. You need to avoid having gaps big enough for a person to be in, such as behind a large pole. If there is a dead zone or if the sensing distance is not long enough to cover the entire area, then it’s necessary to use multiple devices to cover the cell.

Second, with any fenced work cell where access is controlled by a guard locking gate, best practice is to have some type of a manual release on the inside of the door. Since many guard locking solutions rely on power to open,” having a manual release on the inside ensures that, if people are in the cell and need to exit in an emergency, such as for a fire, they will have a quick and easy way to leave the area.

TODD MASON-DARNELL
marketing manager, safety & service / Omron Automation Americas / automation.omron.com
The technology has been around for a while—more than five years, in fact—but this unique application to a robot truly makes it collaborative. Imagine, if you will, working alongside another person on a production line. While every human tends to have a comfort space around them, sometimes that space is diminished while working close to others. The human response to bumping into another object or person is to recoil from that interaction.

The clever engineers who have applied conductive coatings to a robot have added some of that behavior to the robot. In the most simple of cases, physically contacting the skin of the robot will cause the robot to immediately stop the robot, trip the safety circuit, thereby de-energizing the robot motion controllers, and generate an alarm that requires operator intervention to clear before resuming operation.

In more complex cases, the engineers have caused the robot to actually pull back, in a minute motion, from the source of contact. Compare that to two humans who might accidentally touch. The instinctive reaction is to pull back from that source of contact.

Presence sensing has become an ever more important tool in the automation industry. As we trend toward devices that mimic human function, it becomes increasingly important to develop technologies that resemble the human experience.

Just as powered flight mimicked the features and behaviors of birds, automation is really about duplicating the actions of humans. As cobots become more and more sophisticated, the need to create ever-decreasing work envelopes will be a natural progression, so expect to see even more innovation in the realm of presence sensing.

RICK RICE is a controls engineer at Crest Foods (www.crestfoods.com), a dry-foods manufacturing and packaging company in Ashton, Illinois.

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Bosch Rexroth wins Hermes Award 2021

THE HERMES AWARD 2021 has been awarded to Bosch Rexroth for the world’s first electrical actuator for controlling process valves under water. The award ceremony took place on April 12 at the Hannover Messe Digital Edition.

The jury, chaired by Professor Reinhard Neugebauer, president of the Fraunhofer-Gesellschaft, selected the product SVA R2 (Subsea Valve Actuator). According to Hanover Messe, the SVA R2 offers an energy-efficient and safe alternative to the actuators previously used in offshore oil and gas production.

SVA are self-sufficient assemblies with their own fluid circuit and a variable-speed pump drive. The central unit and the kilometers of lines for the fluid are no longer required. This also greatly minimizes environmental risks. The SVA only require a power supply and a data line. A displacement control regulates the flow rate from the speed with almost no loss. This simplifies the construction and increases the energy efficiency significantly.

“The winning product is another milestone and stands for high-tech in connection with environmental protection,” said Dr. Jochen Köckler, CEO of Deutsche Messe AG. “The company is thus making a major contribution to sustainability, one of the key topics at the Hannover Messe Digital Edition.”

“With the SVA R2, the developers at Bosch Rexroth combine economic and ecological aspects into a sustainably innovative product for the maritime process industry: With the Subsea Valve Actuator, existing electrical supply lines for sensors are sufficient for reliable operation of the actuators,” said jury chair and Fraunhofer president Professor Neugebauer. “The small dimensions and integrated interfaces provide industry with another advantage, because they enable the new actuator to be used and retrofitted in existing systems.”

Thanks to condition monitoring and a safety spring, the SVA R2 satisfies Safety Integrity Level (SIL) 3 in accordance with IEC 61508 and IEC 61511. The use of internationally standardized interfaces throughout means even more standardization in the subsea process industry. The actuator minimizes energy consumption and is geared toward delicate ecosystems. The functions, operating life and safety of the actuator have been successfully tested in accordance with international standards. When the SVA R2 is used in subsea factories at a depth of up to 4,000 meters, hydraulic pipes or power units are no longer required.

For the agile development of the SVA R2, Bosch Rexroth says its team worked closely with a number of suppliers and operators of offshore installations, as well as international universities. The new module comprises a pressure-compensated container that contains an electric drive, a motion control system and a safety device – and can replace the hydraulic cylinders previously used on a 1:1 basis. It requires only one cable for the power supply and communication. The SVA R2 is designed to actuate valves reliably with the power supply that is commonly used for subsea sensors. Switching to compact and safe electric actuators means that the hydraulic pipes several kilometers in length along with the associated power units and controllers are no longer required.

The Subsea Valve Actuator is designed for high volume production. The electronics for the motion control system are from the automotive division and offer proven robustness and reliability. The SVA R2 is protected by a number of patents and is designed to operate for 25 years. Bosch Rexroth relies on globally accepted interfaces throughout and supports plant engineers, operators and offshore service providers when standardizing equipment. The actuators for rotary adjustment complement the SVA L2 Subsea Valve Actuator for linear movements, which received the “Spotlight On Technology Award” from the Offshore Technology Conference (OTC) last year.

The Hermes Award is Hannover Messe’s annual international technol-
ogy prize. It recognizes outstanding products and solutions that have a particularly high level of technological innovation. All companies and institutions that exhibit at Hannover Messe are eligible to compete. Only solutions that have already been tried and tested in industry are eligible.

An independent jury also nominated Phoenix Contact and Pilz for the 2021 Hermes Award.

Phoenix Contact was nominated for NearFi technology, which enables contact-free transmission of energy and data and can replace previous plug connections. Thanks to protocol-independent and latency-free Ethernet communication, it offers flexible application options for all Ethernet protocols up to 100 Mbit/s. Transmission takes place in real time in both directions.

Pilz was nominated for its product myPNOZ, which is a new type of modular safety switching device that is manufactured in batch size 1. Using an online tool, users can put together their product without any programming knowledge, as the logic of the safety functions is defined by the module selection and the sequence in which they are connected. The product is a ready-to-install and completely individualized system.

U.S. robot density ranks 7th in car industry

THE ROBOT DENSITY in the U.S. automotive industry hit a record of 1,287 installed units per 10,000 employees, according to the latest World Robotics statistics issued by the International Federation of Robotics (IFR). The United States ranks seventh worldwide. The density is similar to that in Germany at 1,311 units and Japan at 1,248 units. China is in twelfth place with 938 units.

“Automation is the key not only to post-pandemic recovery, but to post-pandemic growth and progress,” said Milton Guerry, president of IFR. “In the upswing after the 2008 financial crisis, companies like General Motors, Ford, Fiat-Chrysler, and Tesla invested extensively in robotics and automation. As a result, thousands of new jobs were created within the automotive industry. So many years and technological advancements later, we have the opportunity to learn from this success story and emerge even stronger than before.”

Robot density in the general industry stands only at 139 units per 10,000 employees. In the U.S., yearly orders of robots from non-automotive sectors surpassed automotive robot orders for the first time. Sales of robotic units in the U.S. increased 7% in 2020 from 2019. Year-over-year orders in life sciences increased by 72%, food and consumer goods grew by 60%, and plastics and rubber saw a 62% increase.

Amazon Web Services joins the OPC Foundation

OPC FOUNDATION welcomed Amazon Web Services (AWS) as its most recent member. In the industrial sector, manufacturers adopt AWS as their industrial data platform to take advantage of AI and machine learning capabilities and to help face the challenge of extracting data from industrial assets such as PLCs, DCSs, SCADA systems and data historians at scale.

Based on OPC Unified Architecture (UA) market acceptance and functionality, AWS adopted OPC UA to support the data connectivity challenges manufacturers face implementing Industrial Internet of Things (IIoT) and Industry 4.0 initiatives.
Bell Textron celebrates manufacturing technology center opening

BELL TEXTRON CELEBRATED the start of operations at its manufacturing technology center (MTC) with a small gathering and ribbon cutting ceremony. Bell leaders and employees as well as local North Texas leaders, including Fort Worth Mayor Betsy Price, were in attendance. This event marks the next milestone in the center’s development before its grand opening, targeted for this summer.

“Through the manufacturing technology center, we can showcase how we will deliver the most affordable, capable and reliable aircraft for the warfighter,” said Mitch Snyder, president and CEO, Bell. “As we work together to define the next generation of Bell products, it’s been gratifying to watch this new facility become a reality.”

The MTC is a proving ground where Bell plans to test and refine technologies and processes and demonstrate readiness and ability to successfully build and support future vertical lift aircraft. It offers a digitally connected space for collaboration between Bell teams. New systems will be tested and vetted for production suitability before being introduced to Bell’s factories. Bell broke ground on the facility August 2020 and anticipates the facility to be fully operational later this year.

First 3D-printed RF circuit launched to space

NANO DIMENSION, AN Additively Manufactured Electronics (AME) and PE (printed electronics) provider, announced that its first ever integrated RF circuit has been flown to the International Space Station (ISS). The RF circuit was fabricated by Nano Dimension and designed and integrated by L3Harris. This project, two years in the making, was selected by the ISS U.S. National Laboratory for space effects studies.

The project will provide a systematic analysis of an additively manufactured single board for radio frequency (RF) space systems, especially for nanosatellites, and will communicate with a ground-based satellite tracking system at Embry Riddle Aeronautical University, Daytona Beach, Florida. The primary purpose of the project is to demonstrate the viability of using new technologies, such as multi-level/multi-material AMEs, which use 3D inkjet printer-based technologies to produce monolithic RF communication systems for use in space.

This project, part of the MISSE Flight Facility, is the first systematic experiment by L3Harris and Nano Dimension aiming to analyze the RF properties of additively manufactured High-Performance Electronic Devices (Hi-PEDs) in a space environment.

Nano Dimension fabricated the single RF board using its proprietary additively manufactured electronics process in the DragonFly LDM system. The board includes the antenna, the electronic traces for mounting all the functional components and the signal ground plane. The fabricated communications device was designed by L3Harris to operate at 2.4Ghz and to be integrated into the MISSE module and launch. This device will be tested at three program points: pre-flight, in-flight, and post-flight. In this first-of-its-kind space flight experiment, the hardware will fly in the low Earth orbit (LEO) environment for six months on the ISS, which will provide scientists with a better understanding of how AME technology endures in various space environments. Low Earth orbit, a region some 1,200 miles (2,000 km) above the planet, is home to the ISS, as well as a large number of communications satellites, all of which use RF communication systems.
DOE announces RFP, selects 14 clean energy projects

THE U.S. DEPARTMENT OF ENERGY (DOE) announced a new request for proposals (RFP) and $1.36 million in selections for projects that will accelerate the adoption of Smart Manufacturing practices. These initiatives support efforts to spur innovation, create a highly skilled Smart Manufacturing workforce and reduce the carbon footprint of the manufacturing sector.

DOE’s Clean Energy Smart Manufacturing Innovation Institute (CESMII), which supports advances in smart sensors and digital process controls, will manage these projects. “Smart Manufacturing will make the American manufacturing sector more productive, more energy-efficient, and more competitive on a global scale,” said assistant secretary for energy efficiency and renewable energy Kelly Speakes-Backman. “DOE’s investments in Smart Manufacturing will accelerate the adoption of these technologies and processes, helping companies to create new, integrated systems and support their competitiveness around the world.”

Through the new RFP, CESMII will expand its Smart Manufacturing Innovation Centers (SMICs), a network of individuals and organizations from industry, government, and academia. SMICs allow manufacturers of all sizes to benefit from the network’s manufacturing assets and competencies and to create testbeds. The RFP makes up to $1 million in funding available, to be matched by cost-share funding.

CESMII also selected 14 new research and development projects from a previous RFP issued last year. These projects will apply Smart Manufacturing solutions to real-world manufacturing process and operation challenges, improving energy productivity, performance, quality and efficiency.
Industrial robots to see 9% growth says Interact Analysis

**INTERACT ANALYSIS**, a market intelligence company with expertise in the industrial automation sector, has published a new report on industrial robotics showing that the industrial robots sector is on track to deliver a recovery after a two-year downturn.

According to the intelligence company, in 2019 the industrial robotics sector saw shipments fall by 5.4%. The pandemic saw a further fall of 5.9% as 80,000 fewer units were shipped than previously forecast. Interact Analysis now says that pre-COVID estimates of growth up to 2024 have dissipated. The company’s research has concluded that new industry applications for robotics and more advanced technologies coupled with reducing prices will cause an acceleration in revenues in 2021, with an increase of 9.2% in revenue terms, and 9.6% in shipment terms, which should be followed by sustained growth up to 2024.

Articulated robots are predicted to be the slowest to recover to 2019 levels, given that the automotive industry has been strongly impacted by the pandemic. Sales of SCARA robots, used in light duty pick and place and assembly operations are predicted to recover. The collaborative robot market, which saw negative growth for the first time in 2020, is forecast to bounce back with a 15-20% year-on-year growth rate up to 2028.

During the process of compiling this report, the Interact Analysis team conducted over 30 hours of interviews with 30 industry personnel at robot companies and end-users. These were conducted face-to-face or by phone. Banks of data were collected and analyzed, some direct from companies and held confidentially, some, such as company reports, from public sources.
Digital and physical worlds converge
Motion, energy, IIoT and cobots drive performance characteristics

by Mike Bacidore, editor in chief

NATIONAL APPLICATIONS ENGINEER Neil Desrosiers, Manager of National Applications Engineering Paul Robinson and President Dan Janka are integral members of the leadership team at Mazak.

The former director of the National Institute of Standards and Technology’s (NIST) Manufacturing Extension Partnership (MEP) Carroll Thomas has joined the MxD board of directors.

In her role as director of the U.S. Department of Commerce’s NIST MEP, Thomas helped U.S. manufacturers compete globally by accessing new technology and strengthening supply chains. MEP services have more than 400 manufacturing extension offices located in all 50 states and Puerto Rico.

With more than 30 years of entrepreneurial and small business development experience, Thomas’ public and private sector career demonstrates her leadership expertise. Thomas currently serves on the boards of the Information Technology Innovation Foundation and the State Department Federal Credit Union. She holds a bachelor of science degree from Drexel University in design and a master of business administration from Johns Hopkins University in international business. She is now retired.

MxD is the nation’s digital manufacturing institute, where innovative manufacturers go to forge their futures. In partnership with the Department of Defense, MxD equips U.S. factories with the digital tools, cybersecurity and workforce expertise needed to increase productivity and win more business.

Teradyne (www.teradyne.com) appointed Kim Povlsen as president of Universal Robots (www.universal-robots.com). Povlsen, a Danish native, brings global executive leadership from a high-tech and commercial perspective and will lead Universal Robots’ next stage of growth and innovation.

Universal Robots (UR) was founded in 2005 to make robot technology accessible to all by developing small, user-friendly, reasonably priced, flexible collaborative robots (cobots) that are safe to work side-by-side with people (Figure 1). The first cobot was launched in 2008.

The company, which is a part of Teradyne’s Industrial Automation Group, which was formed in 2020 and includes Universal Robots, Mobile Industrial Robots (MiR) and AutoGuide.

Danish heritage
Figure 1: Kim Povlsen grew up in Odense, Denmark, which is also the birthplace and global headquarters of Universal Robots, the company he assumed leadership of as president on March 1.

Povlsen has held various executive business and technology leadership roles at Schneider Electric. Most recently, he served as vice president, strategy & technology. Povlsen lives in Aarhus, Denmark, and holds a master’s degree in computer science & embedded engineering from the University of Southern Denmark.

Nathan Eisel is national product development manager at SMC of America (www.smcusa.com).

Sol Jacobs is vice president and general manager at Tadiran Batteries (www.tadiranbat.com).

Art Holzknecht is the engineering manager at Hiwin (www.hiwin.com), a global manufacturer of mechatronic components and systems. He has more than 25 years of experience in precision engineering and motion control system development. Over the course of his career, he has held roles in engineering design and management, program and product management and business development. Art has designed and implemented mechatronic solutions for a wide range of industries, including semiconductor and electronics manufacturing, genomics and life sciences, factory automation and robotics. He holds a BSME from the University of Michigan at Ann Arbor.
What are three key things that a machine builder, system integrator or manufacturer should know about your organization?

Kim Povlsen, president, Universal Robots (www.universal-robots.com): We are focused on taking the time, cost and risk out of automation projects. All of our development activities are organized around this theme, and we deliver results by attacking all phases in a project.

Our focus on ease of use, rapid deployment and flexibility has allowed us to bring all the benefits of automation to an historically under-served segment of the industry: small and medium enterprises (SMEs). UR’s growth in this segment, particularly in high-mix/low-volume businesses, has been phenomenal and we are just scratching the surface.

We have shipped more than 50,000 cobots into every industry and every application segment. Unlike the all-or-nothing approach of traditional automation, UR has been very successful by pursuing incremental automation—modest investments, quickly deployed, that deliver ROI in months, not years.

Carroll Thomas, board member, MxD (www.mxdusa.org): MxD is an excellent resource for manufacturers providing guidance on Industry 4.0 implementation, as well as opportunities to collaborate with other manufacturers. As a member of MxD manufacturers have access to Industry 4.0 case examples to help inform their decisions and accelerate adoption of new technology into production processes. MxD also provides access for smaller manufacturers to advanced manufacturing equipment and information on developing a workforce able to adapt to new technology through MxD Learn.

Art Holzknecht, engineering manager, Hiwin (www.hiwin.com): Hiwin is a vertically integrated engineering and manufacturing company specializing in precision automation components, mechatronic systems and robotics (Figure 2). We are one of the world’s leading manufacturers of ball screws and linear guideway bearings.

We manufacture a diverse portfolio of automation components, and we use these in our own mechatronic motion system products. This includes linear servo motors, direct-drive torque motors, linear and rotary stages, servo drives and multi-axis motion controls. We integrate these components into complete multi-axis motion systems for OEM and applications in a range of industries, including life science/drug discovery, electronics manufacturing, factory automation, precision assembly systems and packaging, to name just a few markets we serve. With millions of dollars of inventory centrally located in Chicagoland, we can ship quickly.

From components to complete mechatronic systems, we offer our customers one of the broadest ranges of solutions for their automation applications. We can provide product solutions at the level that is most economical and efficient for the customer.

Dan Janka, president, Mazak (www.mazakusa.com): First, we use Mazaks to make Mazaks. Everything about our own manufacturing process demonstrates our total commitment to the solutions we create. Our machine designs do not exist in a philosophical vacuum disconnected from the working realities of actual production. We create them to accomplish real goals for real manufacturers, and we continue to refine them so they always meet our customers’ needs for reliable,
precise productivity. To do that, we must stay ahead of what the market requires so we can anticipate new expectations and fulfill them, a kind of predictive understanding that informs the continuous improvements we make to maintain Mazak’s position as a leader in machine tool technology.

Second, because we are in the business of manufacturing tools for manufacturers, we fully understand the constant need for refinement and competitive flexibility that drives our customers’ expectations. Just as our own industry is dynamic and ever-changing, so are the diverse industries in which our customers compete. We constantly expand what we make, how quickly we make it and how much it can do, along with how and how well we can support our customers to achieve the fullest profitability for their businesses.

Third, we are a global company that thinks locally. We constantly strive to meet customers more than halfway, partnering with them to achieve more together. When we first established a North American headquarters and began importing Mazak equipment from Japan, we needed to ensure that our machine tool designs reflected the expectations and requirements of customers on this side of the planet. Accordingly, we began creating new designs, first as region-specific versions of Japanese models and eventually as original products entirely developed and manufactured in Florence, Kentucky.

Nathan Eisel, national product development manager, SMC of America (www.smcusa.com):

Energy efficiency and total ownership cost are what drive SMC product designs. These lead to unconventional, nonstandard products. We are not constrained by old footprint standards or known designs. This approach enables us to be more efficient and use new materials and manufacturing methods to solve these challenges while adhering to global safety and
other business requirements. Our products take into consideration that the machines need to occupy a smaller footprint yet do more; use less compressed and electricity; and last longer. These products are smarter and able to convey data from which decisions can be made so a machine or device can answer questions such as:

- where am I?
- what am I?
- am I well?

All of this is backed by a true global presence with manufacturing throughout the Americas, Europe and Asia, making SMC the obvious choice for today's new machine designers.

We have series of more than 12,000 products to choose from so that design engineers from all industries can find products to suit their specific requirements.

Sol Jacobs, VP and general manager, Tadiran Batteries (www.tadiranbat.com): Nearly 40 years ago, Tadiran pioneered ultra-long-life lithium thionyl chloride (LiSOCl₂) batteries that are now commonly utilized in low-power wireless devices found in remote sites and harsh environments. Bobbin-type LiSOCl₂ batteries were first popularized for use in AMR/AMI utility smart metering applications. In addition, their unique performance characteristics have made them extremely popular throughout the Industrial Internet of Things (IIoT). These valuable performance characteristics are numerous, including higher energy density; higher capacity; a wider temperature range; and the lowest annual self-discharge of any commercially available battery chemistry.

Through innovative R&D and many decades of manufacturing expertise, Tadiran has established and refined proprietary processes and protocols that enable bobbin-type LiSOCl₂ cells to achieve an incredibly low self-discharge rate of just 0.7% per year to enable up to 40-year battery life. By contrast, lower quality bobbin-type LiSOCl₂ batteries experience a high self-discharge rate of up to 3% per year, which makes 40-year battery life impossible. In addition, Tadiran manufactures a family of industrial-grade Lithium-ion (Li-ion) batteries that can operate for up to 20 years and 5,000 recharge cycles whereas consumer grade Li-ion batteries can only operate for roughly five years and 500 recharge cycles.

Tadiran primary LiSOCl₂ batteries and rechargeable Li-ion cells are capable of delivering the high pulses required for two-way wireless communications, ensuring reliable connectivity to the IIoT.

What new technologies are driving product development and why?

Art Holzknecht, engineering manager, Hiwin (www.hiwin.com):

Direct-drive linear motors and torque motors are at the forefront of new applications in high-performance motion control. They provide the capability to achieve higher levels of accuracy and throughput. They are non-contact drives, so they are maintenance-free and have very long life. The total cost of ownership is often lower than competing approaches, such as belt drives or rack and pinion, while providing higher performance. Advanced servo algorithms and faster processors have made it easier than ever to develop robust control systems using direct drives, making them appropriate for more applications and enabling wider adoption.

Paul Robinson, manager of national applications engineering, Mazak North America (www.mazakusa.com): Not only do we use Mazaks to build Mazaks, we also build our machines to perform our customers’ work with the precision and flexibility necessary for success in competitive industries. Among the technologies that drive our product development, artificial intelligence and the Industrial Internet of Things have enabled us to increase the sophistication, power and precision of our equipment designs. At the same time that we have incorporated important technological trends into our products, we have shaped those products to reflect trends in our customers’ industries that affect their production needs.

The increasing focus on small-batch, high-mix/low-volume part production leads to a parallel focus on equipment and processes that can stay ahead of constant changes in outcomes and throughput. As industries such as aerospace grow increasingly dependent on new and challenging workpiece materials to make parts that may take weeks of machining to produce, our Multi-Tasking technologies enable customers to set up a workpiece once, in a single machine, and take out a finished product. Our Hybrid Multi-Tasking machines combine conventional machining capabilities with advanced manufacturing technologies such as laser metal deposition, friction stir welding, hot wire deposition and software-driven multi-spindle synchronization for gear production.

Kim Povlsen, president, Universal Robots (www.universal-robots.com): We are focused on building unique partnerships in the industry. In particular, our UR+ program enables third-party developers and programmers to create and

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market accessories, peripherals, modules and extensions to the core UR robot family. From seemingly simple components, such as a gripper, to integrated application kits that deliver near complete solutions, each UR+ partner brings specific expertise to the industry. Our job is to build the hardware and software architecture that enables those developments, while protecting the performance and reliability of the UR robot family.

Carroll Thomas, board member, MxD (www.mxdusa.org): The whole convergence of the digital and physical worlds in advanced production processes, using technology such as 3D printing in addition to composite materials embedded with smart technology, is overwhelmingly driving product development. Ideas for product development are endless with the added capability of connecting one product with another using the Internet of Things (IoT) and applying artificial intelligence into production machines for even fairly simple products such as hearing aids.

Nathan Eisel, national product development manager, SMC of America (www.smcusa.com): SMC takes on social responsibility through offering products and technologies that support carbon reduction, as well as seriously promoting and supporting sustainability in order to minimize negative impacts to the environment. One of the key components of our comprehensive approach is our products’ compact and lightweight designs. Smaller and lighter products require fewer raw materials to make and less time to process. In addition, the products themselves use less energy.

How does the Industrial Internet of Things figure into business strategy?

Kim Povlsen, president, Universal Robots (www.universal-robots.com): The Industrial Internet of Things (IIoT) is all about establishing connections between devices, but it is also about creating connections between machines and humans. Done right, IIoT has the potential to transform and increase the efficiency of these interactions and bring humans and technology closer together. A connected product will enable Universal Robots to offer a much broader line of services that optimizes product uptime and rapid response and enables our partners to collaborate on the deployment, service and maintenance of cobots much more efficiently than today. We’re seeing a number of new UR+ certified software solutions launching now that allow
manufacturers to cloud-connect their UR cobots to monitor performance, receive alerts and support in real time and much more.

Neil Desrosiers, IIOT applications engineer, developer and MTConnect specialist, Mazak North America (www.mazakusa.com): We make extensive use of the Industrial Internet of Things in the award-winning Mazak iSmart Factory at our national headquarters in Florence, Kentucky (Figure 3). This facility first began manufacturing our products in 1974, and, after more than 15 expansions of our North American headquarters campus, we have achieved digital integration of all our factory technology through the power of the MTConnect open communications protocol and innovative edge-computing processes.

For advanced cybersecurity that protects our machines and the data on our factory network, we use the Mazak SmartBox, a revolutionary launch platform and highly secure open standard. This solution, which includes a Layer 3 managed switch, can connect multiple machine tools and other pieces of equipment with an industrialized version of the security protocol found in server rooms and other IT facilities. We use this scalable, end-to-end solution to connect all our manufacturing equipment, including machines, software and other devices, to our network and enable production data to flow freely to management systems via MTConnect.

The Mazak SmartBox also enables us to harvest and analyze production data from individual machines and manufacturing cells, including equipment from any manufacturer and of any age or type. This sophisticated digitalization gives our factory operations a fluent exchange of data under secured conditions that protect both our production information and our intellectual property. Although our customers may not operate facilities with as many pieces of equipment as our more-than-800,000-sq-ft manufacturing campus contains, they can implement the same technologies and achieve the same securely sourced data gathering and analytics.

Nathan Eisel, national product development manager, SMC of America (www.smcusa.com): We recognize customer interest in the Industrial Internet of Things and look for opportunities to support and develop product when needed. Some products already have the information-sharing capability, too. For example, the information that the SMC flow sensor is producing on the shop floor could be integrated into a system to be used as a trigger to send through email or be displayed on a screen on the top floor. SMC has recognized the opportunities to make our products smarter and is shifting development to accommodate that.

Carroll Thomas, board member, MxD (www.mxdusa.org): There are several areas in which the Industrial IoT (IIoT) could figure into a company’s business strategy, such as using it for just-in-time ordering of production supplies to keep low inventory on hand. Two other major areas IoT should be considered in business strategy are in helping to create a more diversified and adaptable list of suppliers to build in control of your supply chain and to keep customers, as well as increase revenue by creating digitally connected products and providing data to ensure proper product maintenance schedules.

Sol Jacobs, VP and general manager, Tadiran Batteries (www.tadiranbat.com): Remote wireless applications are undergoing explosive growth in response to the burgeoning IIoT. Industrial-grade lithium batteries improve product performance and long-term reliability for most low-power battery-powered wireless devices utilized in hard-to-access locations and extreme environments (Figure 4).
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**Art Holzknecht**, engineering manager, **Hiwin** (www.hiwin.com): In today’s highly competitive markets, increasing machine throughput and reducing downtime is critical to profitability. Being able to log into a machine remotely to check status and perform troubleshooting is essential. At Hiwin, our mechatronic engineers can connect to our customer’s equipment to support our products in the field without needing to travel on-site. This saves crucial time and keeps cost under control. We can read fault codes and error logs to diagnose problems before the system fails and stops production. Our customers can also do this with their customer’s machines in the field.

**Nathan Eisel**, national product development manager, **SMC of America** (www.smcusa.com): As we all know, production is king, and unscheduled downtime is one of the costliest expenditures manufacturing facilities need to endure as an unforeseen expenditure. We must have experienced staff ready at a moment’s notice when unscheduled downtime occurs. SMC is focused on how we can provide a proactive approach such as condition-based maintenance with regard to the compressed air system—pneumatic system. This means that you can identify potential unscheduled downtime on the horizon and take planned corrective action before the potential outcome becomes real. This means the facilities can keep the existing experienced staff but utilize their time in a much more efficient way, all the while mitigating the risk of unscheduled downtime. This will increase the customer’s overall efficiency and reduce costs related to downtime, thus increasing their profits.

**Kim Povlsen**, president, **Universal Robots** (www.universal-robots.com): Automation in general, and collaborative robots specifically, are solving the biggest long-term challenge in factories today: the manufacturing labor crisis. The demographic shift as the Baby Boomer generation retires and the lack of interest from younger generations to work in dull, dirty and dangerous (DDD) jobs is taking a toll in all industries. Savvy companies are investing in cobots to take over DDD applications, which is freeing up the skilled workforce to move to higher value-added tasks and assignments. A skills gap remains, which will favor candidates with better technical knowledge and problem-solving skills. UR is working on these challenges with unique online training programs through the UR Academy, and our EDU initiative to bring collaborative technology to all levels of education.

**Dan Janka**, president, **Mazak** (www.mazakusa.com): In a landmark 2018 study of the skills gap in manufacturing, Deloitte quantified and qualified the industry’s large and growing shortage of skilled workers. Although many commentators suggested that artificial intelligence, robotics and IIoT technology would eliminate jobs, reality has not borne out these assumptions. In fact, these technologies have had the

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**Hard-to-access, extreme environment**

Figure 4: Oceantronic’s GPS/Ice buoy is being used in the Arctic for use in experiments measuring wind, temperature sunlight and ice thickness near the North Pole. (SOURCE: SIGRID SALO NOAA/PMEL)
opposite effect, creating new jobs that require skilled manufacturing professionals to monitor and manage new technologies on the factory floor.

But experienced professionals with these skills are becoming hard to find. Through the attrition of Baby Boomer retirements and the industry’s struggles to attract younger generations into its ranks—often because of false perceptions of working conditions and earning potential—Deloitte estimated that 2.4 million manufacturing jobs would remain open between 2018 and 2028, creating a potential economic impact of $2.5 trillion.

These facts and predictions have become a preoccupying problem for the industry. As employers grapple with these conditions and their ramifications, they have begun to understand the need for a three-pronged approach to counter it. First, they must train their current workforce to undertake greater responsibilities with cross-trained abilities that eliminate siloed approaches to production-line tasks. Second, they must make the work they offer more approachable for people with lesser skill levels, especially new hires with minimal experience. Third, they must find ways to accomplish more work with fewer people.

Training current workers to manage automated systems responds to the first part of this paradigm. Automation itself holds a critical key to the second and third parts. Unattended operations enable manufacturers to make parts around the clock and without human personnel present on-site. Tool hives, pallet changers and other sophisticated options enable a single operator to manage multiple machines, all tied together with exceptional control technology. We build Mazatrol conversationally programming directly into our CNCs, enabling operators to serve as programmers by answering straightforward questions about each part directly on the control to optimize cutting.

How is the development of software solutions impacting requirements for hardware?

**Nathan Eisel**, national product development manager, **SMC of America** ([www.smcusa.com](http://www.smcusa.com)): This is a very tricky question that many manufacturers have had long discussions about. In the name of simple integration and ease of use, the question of how to unify both hardware component interfaces with different software platforms is a high priority. If not, you are not listening to the customer. For example, the information that the SMC flow sensor is producing on the shop floor is being used as a trigger to send an email or being displayed on a screen on the top floor. SMC has recognized this key fact and is shifting development to accommodate. Some technologies that bridge the gap are OPC-UA and MQTT. By embracing these types of interfaces, SMC can remain focused on producing hardware to improve overall OEE and maintain confidence that the sensor will be able to communicate upstream with ease.

**Art Holzknecht**, engineering manager, **Hiwin** ([www.hiwin.com]): Improvements in control software functionality and usability are making sophisticated, high-performance motion systems easier to integrate and support. This is leading to increasing applications for direct-drive motion control, which enable higher accuracy and throughput. Linear motors were once an expensive technology that required substantial expertise to deploy successfully. That has changed with better software tools, enabling them to become a mainstream choice for automation engineers looking to increase performance.

**Kim Povlsen**, president, **Universal Robots** ([www.universal-robots.com]): Advanced software for complex applications is always hungry for more computing power, and our cobots are no exception. While we continuously improve the performance of our robot family, we also make sure our hardware and software architecture support the seamless integration of additional computing power that our UR+ partners bring as part of their solutions.

**Carroll Thomas**, board member, **MxD** ([www.mxdusa.org]): One of my favorite examples is Makuta Micro Molding in Indiana, which specializes in micro injection molding. They are nearly 100% automated utilizing sensors, operating 24/7, producing 40 million zero-defect micro parts every month. The plant is jaw-droppingly spotless, and the average age of the 15 or so people who work in the plant is around 30 years old. The owner has connections with the local high school to bring in tech-savvy students to apprentice. If they do well, he makes them permanent, gives them raises as they learn new equipment and pays for them to go to college. Way back when I was in high school, employers would bring in young people for their brawn. Now they bring them in for their brains.
this is impacting requirements for hardware, but I can see how this is an issue with hardware manufacturers.

Paul Robinson, manager of national applications engineering, Mazak North America (www.mazakusa.com):

In our industry, hardware determines what machines must do while software commands them to do it and enhances hardware performance. Our CNC controls have become sophisticated processing units that can speed through the programming for complex multi-axis cutting tasks, run simulations of part operations to determine optimal tool paths, or use artificial intelligence to predict, monitor and manage production processes and the machines that perform them. The hardware informs the software, and vice versa—their success requires parallel development.

For example, we developed our Mazatrol SmoothAi CNC and its software from the ground up to support Multi-Tasking and enhance the machining process with artificial intelligence, machine learning and advanced data management. Its various software modules address specific conditions and functions with built-in and ever-growing expertise that otherwise would require additional monitoring capabilities or off-line programming additions.

Our AI technology detects any sign of spindle vibration and optimizes cutting conditions to offset its effects on workpiece quality, tool life and machine operating condition. Machine-learning displacement compensation through our Ai Thermal Shield stabilizes operating temperatures to prolong equipment life and enhance output results. Our Smooth CAM Ai software modules address the need to simulate machining operations and verify how actual production will proceed before committing to begin it.

At the same time that these and other software functions enable shops to extract every ounce of performance from our advanced machine tools, the hardware of our Mazatrol SmoothAi CNC incorporates ergonomic adjustments to make the large screen viewable for operators of all heights and present a multi-phasic view of critical machine data on one at-a-glance view. The CNC accepts an additional screen to show information from AI modules. At every turn, our hardware informs what our software must control and monitor, and our software enables shops to see and alter what their equipment does.

As engineering and IT continue their convergence, which one is and/or will be leading the direction of future automation and technology?

Nathan Eisel, national product development manager, SMC of America (www.smcusa.com): This question is misleading and compromised. I do not say this to be derogative. I say this as it is a very misinformed question. The convergence of the IT world and the operations technology (OT)/engineering world has been happening slowly for the past 20 years in production manufacturing. One does not lead the other. They are both integral in the ability to share data from the shop floor to the top floor. They must work together very closely to accomplish this. For example, flow data at the sensor level needs to be provided to a web page that is based in the cloud and is formulating a calculation on current energy consumption/machine efficiency. Both teams need to work closely together to make this data function and available (Figure 5).

Art Holzknecht, engineering manager, Hiwin (www.hiwin.com): Both disciplines have a role to play, and they are complementary. Advances in IT are enabling Hiwin to bring more software tools to engineers via web-based applications. They can calculate system performance and configure products online with intelligent tools that are developed by our engineers. Our engineers are available for support, and they can work with customers on the more challenging applications. But now custom-
Machine input

Manufacturers can also easily configure products themselves and download CAD models, enabling rapid decisions and deployment.

IoT and Industry 4.0 are still in their early stages of adoption. As the benefits of these technologies are realized, engineers will develop more products to take advantage of the benefits for their customers. This will lead to more demand for IT solutions to support them, leading to more product development in a virtuous cycle.

IT's role in manufacturing is vast and growing, as the Mazak iSmart Factory demonstrates, both as an everyday production platform and as a proven model of how our factory networking technologies can enhance manufacturing operations for our customers. The newest frontiers in enhanced machine-tool technologies can enhance manufacturing operations for our platform and as a proven model of how our factory networking.

Looking into the future, how will technology change your organization or other organizations over the next five years?

Carroll Thomas, board member, MxD (www.mxdusa.org): Because of the pandemic, we will lose a chunk of manufacturers that were not able to successfully hold on or pivot. A lot of the manufacturers we lose will be those that hadn't employed digital systems and/or practiced cyber-hygiene. Over the next five years, we will see an explosion of new or reconfigured manufacturers, with small and medium-sized manufacturers—nearly 99% of all manufacturers—going from around 50% to over 75% employing fully digitalized production systems. This will have a dramatic increase on productivity, enabling manufacturing to accelerate the economic potential for exploring the next edge of engaging the unique properties of the quantum world.

Sol Jacobs, VP and general manager, Tadiran Batteries (www.tadiranbat.com): We live in an increasingly wireless world, where AI, machine learning, M2M, automation control, smart infrastructure and similar technologies are converging and expanding into remote locations and extreme environments. As the lightest of all non-gaseous metals, lithium will remain a popular alternative wherever access to the electrical grid is impossible or impractical. Of all competing lithium-based battery chemistries, bobbin-type LiSOCL2, will continue to stand apart, especially for low-power applications that require extended battery life to reduce the total cost of ownership. Lithium-battery performance has continually improved with enhanced materials and evolving manufacturing techniques that lead to incremental improvements in battery performance.

Dan Janka, president, Mazak (www.mazakusa.com): We see technology’s continued and rising influence in everything we make and everything we do to make it. Its role is obvious, both in the digital connectivity that enhances manufacturing productivity and the new enhancements to how we make our products, train and support our customers and our own personnel. Technology also dominates manufacturing because automation and digital connectivity go hand in hand, especially during unattended operations, and the technological sophistication of these processes continues to increase.

At the same time that manufacturers collect, analyze and act upon increasing data streams, we are increasing our use of
simulation technologies and augmented reality to anticipate production needs and offer newly effective training modalities. Our customers now can use our products to create digital twins of their actual machines so they can see and fine tune how their intended production processes will play out in terms of finished results. This means that when a job consists of a single part that requires weeks to create out of high-value materials—when failure truly is not an option—our technological capabilities enable our machines to help customers plan ahead to create parts correctly the first time and every time.

Along with machine technologies that enhance predictive analytics, we also use extended reality to make training and support easier and more effective. Virtual-reality technology enables us to train customers and service technicians on digitalized recreations of expensive equipment that suffer no real-world damage if a trainee makes a wrong choice. Through augmented reality, we can annotate a shared view of a customer’s machine to provide procedural explanations, assist in troubleshooting or identify replacement parts, saving time for customers and for service technicians and delivering better results.

At the same time that predictive technologies and extended reality enhance our products and our service capabilities, we see increasing sophistication in the capabilities of our hardware. Today’s Mazaks not only perform subtractive machining at the highest levels of precision and productivity, but they can combine those processes with alternative manufacturing technologies in ways that advance Multi-Tasking beyond our original vision of Done In One.

Our Hybrid Multi-Tasking solutions add such capabilities as laser metal deposition, friction stir welding, Hot Wire Deposition and gear production to multi-axis machining. This technology applies to machines already installed in the field, not just new machines. Mazak MegaStir recently introduced an upgrade kit that customers can use to add friction stir welding to subtractive machines, broadening the reach of this groundbreaking technology.

Overall, the future of manufacturing both drives technology further and is itself driven by the technologies it serves. We see abundant opportunities for productive refinement and advancement of the tools we make and the industries they serve.

**Art Holzknecht**, engineering manager, Hiwin (www.hiwin.com): We are leveraging technology to automate many of our processes that are currently done manually. Workflows are changing to adapt to the benefits of automation. This is yielding benefits in terms of increased productivity and higher quality, while also reducing product lead times and controlling costs (Figure 6). This trend is accelerating both in manufacturing and in engineering. In engineering, we are developing software to enable our customers to do more online, including specifying and configuring products, creating standard or customized drawings, receiving a quotation and making a purchase. Automating these tasks and bringing them closer to the customer is more efficient. Over the next several years, as artificial intelligence, expert systems and augmented reality move from cutting-edge to mainstream applications, we will add this functionality to our automated tools, to make them even better.

In manufacturing, advances in robotics and automation will continue to increase their deployment. Demand for more sophisticated motion control to automate complex processes will grow. High automation content in manufacturing reduces the need for unskilled labor, which helps to control costs, improve quality and enable advanced economies to compete with developing countries with a large pool of low-cost labor. Advances in automation technologies are a key enabling element for this.

**Kim Povlsen**, president, Universal Robots (www.universal-robots.com): In the past 12 months we have seen seismic shifts in how capital equipment is sold, and, while the world is ready to move back to normal, some of these changes will not revert. Look for further developments in how equipment is supported and serviced and for continued reductions in the development cycle for new products.
WHAT’S OLD IS NEW AGAIN

One of the best times to modernize a control system is when the old one reaches the end of its useful life.

WHEN A CONTROL system reaches the end of its useful life, it’s time to make a decision on replacement. Do you look for a similar system with familiar features to maintain the status quo? Or do you take advantage of the opportunity to upgrade your controls automation and improve productivity? These two companies, American Castings and American Metal Processing turned a control obsolescence into a modernization project that paid off in the long term.
American Castings supplies large metal components to some of the world’s heavy equipment makers. The Pryor, Oklahoma-based company makes axles, frames, suspensions and other components that weigh up to 3,500 lb and are used in mining, farming and oilfield job sites (Figure 1).

The foundry where American Castings makes its heavy-duty metal components has been in operation for more than 35 years. Recently, the control system on one of the foundry’s main molding lines was showing its age, and the company decided it was time for an upgrade. This presented a major challenge. Migrating the line’s control system and extensive I/O to new technologies would require weeks of downtime, something the company’s production schedule couldn’t afford.

Then, one day, a routine sales visit led to a solution that would allow American Castings to upgrade the line’s controller while avoiding extensive downtime.

Obsolete and disruptive technology
The control system at issue was on the automated no-bake molding line, one of two production lines in the foundry. The no-bake line consists of a series of conveyors where sand molds are created, and molten metal is poured into them (Figure 2). Once metal solidifies, castings are shaken to remove the sand (mold). Throughout the line, transfer cars are used to move the molds from one conveyor to another.

The decades-old controller on the line was obsolete and causing production disruptions. In particular, the controller was experiencing slow scan times, which is how long it takes the controller to take in, read and react to information. If a conveyor was moving and a limit switch told it to stop, it could take an extra half second to one second to stop. When this happened, the metal part could move out into the way of the transfer car, and then we have a crash.

The crashes were not catastrophic, but they occurred multiple times a day and took a toll on productivity.

We’re dealing with parts that are several feet long and weigh hundreds of pounds. You don’t just pick it up and put it back in place.

Iron giant
Figure 1: American Castings supplies axles, frames, suspensions and other components that weigh up to 3,500 lb.
Not only was the controller obsolete, but so was the 1980s-era computer technology used to support it. If something happened on the line, we had to use a computer to troubleshoot the PLC's ladder logic. But the control technology was so old that we had trouble finding a computer that was slow and dumb enough to talk the same language.

It was clear the no-bake line needed to be modernized with the latest control technologies. The question was how to do it. The system had 10 remote I/O racks and about 1,100 I/O points. Replacing the controller and all the I/O would bring down production for four to six weeks. The company couldn’t afford a stoppage that long, given its high production levels.

A home-run solution
We chose to migrate the no-bake line’s legacy control system to an Allen-Bradley ControlLogix controller from Rockwell Automation. The modern controller offered significantly greater performance and capacity than the legacy PLC to resolve the slow scan times on the line. It also offered greater data availability. And it would eliminate the need for ancient computer technology to troubleshoot issues.

As far as how this new controller could be implemented with a minimal impact on downtime, a serendipitous encounter helped American Castings find an ideal approach.

A representative from Rexel, an automation distributor, just happened to be at the foundry when the topic of the control system upgrade came up. The representative mentioned the EtherNet/IP to Square D Remote I/O Gateway from ProSoft, an Encompass Product Partner in the Rockwell Automation Partner Network program. The gateway would allow the new ControlLogix controller to talk to the legacy I/O.

The gateway would only be a fraction of the cost of replacing the line’s I/O racks and rewiring all the I/O points. More importantly, the time savings from avoiding all that work would allow the control-system upgrade to occur with minimal downtime.

Before implementing the gateway on the no-bake line, our department, which also includes Jerrod Estes and Chandler Beck, decided to first try the solution in a similar upgrade for the foundry’s environmental system. The system, which runs all the roof ventilation for the 433,000-sq-ft facility, used the same proprietary control system and I/O as the no-bake line.

In that pilot project, not only did the gateway allow American Castings to retain the environmental system’s legacy I/O, it also improved connectivity to the different environmental units across the...
facility. Instead of walking across the massive facility just to confirm that fans are running, or to turn air units on and off, workers could now do those activities from a central operator station.

The new system ran about one year without a single iota of a problem. We found we had a home run. We were ready to bring this to the no-bake line.

No growing pains
With the new control system now in use, the no-bake line is achieving scan times that are up to five times faster than the legacy controller (Figure 3). This has improved machine reaction times on the line and tightened conveyor movements, putting an end to crashes resulting from slow scan times.

The new control system and its connectivity to devices on the line has also made operational data more accessible. Now, production managers can follow each component’s journey through production, as well as track overall line performance and downtime.

We expect the new control system will eventually help us increase production from about 30 or 40 molds per day to 60 molds per day.

The ProSoft gateway allowed the upgrade to occur at a much lower cost and with minimal downtime compared to replacing the legacy I/O.

American Castings saved more than $100,000 in wiring and installation costs, alone, by retaining the existing I/O on the no-bake line. And not having to shut down the line for up to six weeks saved the company hundreds of thousands of dollars more.

Certainly, not having to rewire more than 1,000 I/O points helped reduce downtime for the project. But our team was also able to run the new control system in supervisory mode to commission, test and tweak it while production continued running using the legacy system. We worked with ProSoft technical support to workout a few minor bugs related to fault handling of scans that caused a few minor headaches but were quickly taken care of.

All told, instead of being down for four to six weeks, the upgrade only brought down the line for a matter of hours.

Typically, once you start a control system conversion, you’re committed until it’s complete. This approach allowed us to have the two systems running essentially in parallel. We could go in, test the new system and review the results without taking production down for an extended period.

Currently, two of the no-bake line legacy I/O remote racks have been replaced with Rockwell Automation remote I/O with no additional loss of production. The ProSoft gateway continues to allow communication to the remaining legacy I/O racks. There are plans to replace the remaining legacy I/O on the no-bake line as the production schedule allows. With the ProSoft gateway in place, American Castings will be able to migrate one module or rack at a time based on what works best for the company and its production schedule with little or no downtime to the line.
Steel components used in products such as cars, trucks, farm machinery, construction vehicles and military equipment have to tolerate high friction, force and temperature over a long lifetime. Design engineers specify various treatment processes for these components to improve properties such as wear resistance, extending their lives and reducing cracking and fatigue.

Heat treatment is one of the most commonly requested processes for this purpose, and American Metal Processing (AMP, www.ampht.com) in Warren, Michigan, is one of the nation’s foremost providers.

Established in 1945, AMP specializes in rotary heat treatment for carburizing, carbonitriding and neutral hardening (“quench and temper”) processes. With 18 employees and seven furnace lines operating 24 hours a day, AMP is able to process millions of parts, typically no larger than 5 inches, subject to some of the most extreme operating requirements.

Compared to competing methods, rotary heat treating yields tighter physical tolerances and greater uniformity through precise process control.

So, when AMP saw that its automation systems were reaching the ends of their lives, it undertook the difficult task of modernization.

Problems and opportunities
The first rotary furnaces introduced to AMP in the 1970s were controlled through precisely calibrated weights and scales. Computerized control was introduced in 1993 with a DOS-based control system and upgraded to PLC control in 2000, but these systems were aging poorly and had limited capabilities (Figure 1):

- Programmable logic controllers (PLCs) were experiencing regular failures and were limited to controlling only the feed system.
- The operating system (OS) of the feeder system’s human-machine interface (HMI) was approaching its end of life, and AMP had no access to the HMI program source.
- The majority of system components were not integrated or automated beyond direct motor control.

The company was on borrowed time, but we saw the opportunity to use this modernization project to make the system better than before. The system was primitive by today’s standards. It needed to be more than a control system. It needed to be intelligent.

Modernization would address the need for automated interlocking and alarm notification, as well as reduce operator error through a rich HMI.

In addition to these improvements, AMP also wanted to address pressing needs around data integrity and connectivity. We wanted a back end that would be on our network and which could be fully connected to our SQL database.

AMP’s customers are typically Tier 1 and 2 suppliers to original equipment manufacturers (OEMs), and a majority of those are in the automotive industry. These customers require multi-year part traceability in case they need to investigate a particular lot.

Twenty years ago, AMP invested in a work order tracking database for this purpose, which now contained billions of records and had become important to process metrics and quality control. Intelligently and seamlessly integrating operational data into this database became an important goal of modernization as well.

While purpose-built data logging systems are available for the heat treatment industry, they are usually sold as stand-alone systems, and AMP was uncertain of their ability to communicate with the work order tracking database. AMP decided to focus on upgrade designs that included integrated data logging as a feature of the system.

Pre-upgrade system description
AMP’s hardener furnace lines consist of five primary components: feeder,
presharw, retort furnace, quench tank and conveyor.

Feeder: The heating process begins with a two-stage vibratory metering system with the feed rate controlled via an RS-232 connection from an Allen-Bradley programmable logic controller (PLC). Parts to be treated are fed through the prewash system and then the furnace at the rate specified by the operator via a Windows PC-based HMI. The HMI provides visualization of the current feed rate and the weight of parts loaded on the scale.

Prewash: Next, parts pass through a fixed-speed rotating barrel driven by an ac motor and speed reducer. Parts are cleaned in a high-temperature water spray on their way into the furnace.

Retort furnace: A rotating cylindrical retort conveys parts from one end to the other by slowly conveying parts forward across a series of internal vanes. Internal temperature is maintained by PID temperature controllers, and a two-position selector allows the operator to drive the furnace continuously in one direction or to select alternating forward-and-reverse motion when longer dwell times are needed.

The period of the alternating cycle is controlled by a dual-setpoint timer, and the rate of rotation is controlled by a variable frequency drive (VFD) and a 1-hp motor through a gear reducer. Operators manually set the output frequency of the drive via its integrated control panel.

Quench tank: Parts fall from the end of the furnace through a chute into a
7,000-gallon tank where they are rapidly cooled in either water or oil. The quenchant is circulated constantly by a fixed-speed pump driven by a large ac motor.

Conveyor: Treated parts are removed from the quench tank by a conveyor belt driven by an ac motor.

**Control platform evaluation**
Given the scope of its controls upgrade—including computerized weighing, burner control, and drive control—AMP knew it would require a custom solution. After receiving quotes from several industry system integrators, it became clear that we had two options: either pay someone more than $60,000 and give them the keys to the car or consider a homegrown solution.

Most of the companies we contacted wanted to completely rebuild the feeder system’s electrical panels, including custom programming for new PLCs and accompanying HMIs, leaving AMP with no access to the source code unless we also paid for the required design software licenses. AMP wondered whether it could take on the job itself, potentially reducing costs and giving it the option of retaining full ownership of its control logic.

For a business like AMP with fewer than 20 employees, developing a solution in-house is inherently more attractive than paying an outside company, since it allows complete control over the product and the company can modify, adapt or expand it as needs or equipment change. AMP’s general process is something that can be sketched out on a whiteboard, and we believed the solution should be simple to implement and understand.

AMP began researching what a homegrown solution would require. Opto 22 was identified as a potential solution vendor while exploring a feeder system I/O panel dating back to 1993.
panel dating back to 1993 (Figure 2). Opto 22 I/O modules were some of the few parts still working. We got a quote for a groov EPIC system and were very impressed with the value and versatility offered.

With EPIC as a potential foundation for its new control system, the company began mapping out a path to the goals it had identified using the content available through Opto 22’s developer forum, training videos and support channels. As a chemical engineer with no programming experience, I began learning Opto 22’s free PAC Control programming software with guidance from sales and support staff. The experience gave AMP the direction it needed. Opto 22 does an amazing job of teaching people who have no background in programming. When I realized we could do data logging with the groov EPIC, that checked another box for me.

Once we found a way for our lot tracking database to use REST (representational state transfer) calls to extract data from the groov EPIC, then we had a complete solution. EPIC made it possible to create a homegrown system.

**System upgrade**
AMP began developing its first groov EPIC system with a phased plan for upgrading each of its seven furnace lines. A month later, however, AMP suffered a critical PLC failure on one of its lines and decided to put an early version of the new system into service.

Built on the groov EPIC processor (GRV-EPIC-PR1), the first system incorporated the following I/O modules, each with channel-to-channel isolation, which allowed AMP to establish a basic control system (Figure 3):
- GRV-CSERI-4: four-channel serial communication module
- GRV-OVMAILP-8: eight-channel V/mA analog output module with chassis-supplied loop power
- GRV-ODCIS-12: 12-channel simple discrete dc output module
- GRV-ITMI-8: eight-channel thermocouple/mV analog input module.

The feeder system scale was monitored through one of the system’s serial inputs, with both vibratory stages controlled through 0–10 Vdc outputs.

The retort furnace controls were integrated into the control program using one input channel to measure the rotational speed of the furnace; one analog output for setpoint control to the VFD; one discrete dc output to the VFD to control the direction of rotation; and four temperature readings of the furnace’s internal atmosphere and the quench tank.

**Interface integration**
Figure 4: Along with duplicating the functions of the previous PC-based feeder HMI, AMP took the opportunity to integrate other control elements and create a unified operator interface.
The conveyor was integrated into the control program using an additional input to monitor the belt speed. Finally, AMP’s groov EPIC was connected to the company network, completing a basic design that laid the foundation for continuing enhancements. Because groov EPIC uses a quad-core ARM processor capable of running multiple applications in parallel and includes additional software applications, control logic was just the beginning of AMP’s modernization program.

Operator interface
One of the software applications included with groov EPIC is groov View, an embedded visualization server for creating onboard, external, mobile and desktop HMI displays. Along with duplicating the functions of the previous PC-based feeder HMI in groov View, AMP took the opportunity to integrate other control elements and create a unified operator interface (Figure 4).

Furnace temperature, retort speed, which corresponds to dwell time, and quench tank temperature were added to the existing feed system readings, while the manual furnace timer and rotational direction selector components were replaced with HMI control gadgets. The result was a logically arranged operator interface that anyone could understand.

To enhance the interface even further, AMP utilized previously installed IP cameras directly above the feeder hoppers so operators could continuously observe the level of parts in each. AMP used the groov View camera gadget to add these camera feeds directly to the main HMI display, allowing operators to verify the hopper level at a glance and manage equipment from one location.

All HMI screens and camera feeds are available to operators from an external display connected to the groov EPIC’s HDMI port (Figure 5). And since groov View also supports mobile displays, our managers are able to supervise operations from their smartphones.

The new system is easy to understand and even easier to visualize, which builds confidence with existing customers and helps attract new ones.

Alarming
A controlled, multi-stage, high-temperature process like AMP’s involves various safety and productivity risks, so AMP also used groov EPIC’s toolset to add layers of protection.

In PAC Control, AMP implemented overfeed and underfeed monitoring along with process logic to interlock the upstream feeder and prewash systems should any of the downstream systems stop. It also designed an emergency oscillation routine for the furnace in the case that either the quench pump or conveyor motor stopped unexpectedly.

For operator safety and responsiveness, AMP added lights and sound beacons around the furnace perimeter. They added a discrete ac output module to the groov EPIC controller and wrote additional logic to drive the alert system whenever an alarm occurs. AMP configured event monitoring in groov View so any of these alarm occurrences would also be recorded in the HMI’s operator log.

As a final measure, AMP used another of groov EPIC’s embedded applications to interact with the company PA system. Node-RED is a visual event-driven programming language from IBM for connecting data from across the Internet. It includes a library of functions for designing transactions with databases, web services, and networked devices.

AMP used Node-RED to query the company’s operations database for alarm occurrences, generate a string representation of each (for example,
“Temper furnace 204 overtemp alarm”), and send the string to a text-to-speech (TTS) function. Each EPIC stored a copy of this program, which executes in a browser on the company’s PA-management computer, creating unique audio announcements any time an alarm is triggered. Instead of an operator having to follow his ears to identify the location of an alarm, announcements direct him to the specific piece of equipment, so he can deal with the situation promptly.

Lot tracking and data logging
In addition to providing traceability of all the parts that AMP processes, the company’s SQL database stores heat-treating recipes and essentially serves as an ERP system. Previously, operators had to look up the appropriate recipe parameters in the database, input those into the feeder system HMI, as well as other furnace controls, and record work order information in the database prior to each run.

To reduce the possibility of human error, AMP integrated all of those tasks into a common interface. Now, the controller queries the company database via Node-RED and transmits recipe parameters—feed rate, retort speed, temperature, oscillation period and more—to variables in the PAC Control strategy. Work order information is recorded and sent to the database from the Work Order Data section at the top of the main HMI display. Operators can also use that interface to query the database for information on previous runs.

AMP then enhanced its basic workorder tracking by configuring periodic data logging of multiple process variables and setpoints for each run, including feed rate, VFD output and current draw, rotational direction, conveyor status and various temperature readings. These were stored in a one-week buffer on each EPIC with key data displayed in a 24-hour trend on the main HMI display. For long term storage, a time-series database (TSDB) was created and hosted on a secure cloud-based platform.

Now, each groov EPIC sends continuous process data through Node-RED directly to the TSDB. The level of redundancy offered by cloud-hosting is better than what AMP could have built on-premises, and the TSDB’s automatic compaction, compression, and downsampling algorithms intelligently balance data precision across time with ongoing storage costs.

The TSDB also made it easy to connect our process data to a visualization platform, so we created live dashboards of our process data that are displayed throughout the plant. In addition to combining work order and process data to calculate operational equipment effectiveness (OEE) and other key performance indicators (KPIs), AMP now has large screens displaying a beautiful bingo-board-style Andon system fed by live production floor data (Figure 6).

The components of the groov EPIC, Node-RED and TSDB technology stack all play nicely with each other. Having a data logger is essential, but usually it’s a separate system with its own set of logic and alarms built on technology that is far behind what we have now.

If you would have asked me two years ago if we could do this, I would have told you you were crazy, but now the pace of advancement is quite good. Operators and supervisors get instant feedback from the process. We monitor throughput and quality in real-time and can continuously improve our process based on what we learn. Our OEE will likely continue to improve over time (Figure 7).

What’s next?
AMP’s control system modernization project with groov EPIC has yielded...
tighter process control, multiple levels of error-proofing, better traceability, and historical data retention and auditing. But that was just the beginning.

AMP is now using an additional groov EPIC to monitor plant-wide systems. It started with cooling water temperature and ammonia supply level monitoring but was recently expanded to include dewpoint monitoring for endothermic gas production. AMP has five of these gas generators, which are critical auxiliary systems and require frequent sampling. We are now designing an automated valve manifold and PAC Control strategy to control the sampling process across all generators.

Beyond this, there are still many opportunities for improving and expanding basic control system functions. For instance, quench tank level management, like the feeder hopper, relies on operator observation. AMP would like to automate this and many other functions around the plant. Fans, motors, and temperature systems being controlled via manual controls are all candidates for modernization. If we can just whittle away 2%, which should be achievable, the investment would pay for itself. It’s like LED lighting. Why wouldn’t you do it?

AMP is also in the early phases of planning furnace control and automation for a recently acquired sibling company, Detroit Steel Treating, which offers heat treating using batch furnaces. It intends to base these upgrades on groov EPIC, as well Opto 22’s groov RIO edge I/O module.

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Leveraging a Smart VFD for Cost Savings and Flexibility

An injection molding customer recently experienced various issues with their cooling bed conveyor. The issues were common to using an across-the-line motor starter with an electro-mechanical brake, including excessive wear on the power transmission components as well as frequent brake replacements. During normal production, lighter parts were also shifting out of position due to the abrupt stop at the end of a conveyor index. The electrical controls were undocumented and utilized multiple outdated contactors and timing relays. While the shifting parts caused issues daily with downstream processes, the failing control relays and frequent mechanical adjustments added hours of downtime when troubleshooting.

The customer’s initial idea was to replace their motor starter with a soft starter or variable frequency drive (VFD). While replacing the across-the-line motor starter with a micro VFD seemed straightforward, it did not solve all issues. A request was made for a Motion Automation Specialist to review the existing controls and offer an updated solution.

After reviewing the existing controls and discussing the customer’s issues, Motion decided the Danfoss VLT® Midi Drive FC 280 would be a perfect fit for this application. (Figure 1.) The VFD included an integrated DC choke, making an external line reactor unnecessary. In addition, the Dual STO (Safe Torque Off) inputs eliminated the addition of external contactors to remove power to the drive – in the event of an emergency.

The included SLC (Smart Logic Control), a feature built into the VFD, replaced the existing relay controls. This eliminated the added cost and complexity of replacing the existing obsolete parts with newer components. Programming was easy after obtaining the customer’s input on their application and using the free MCT 10 software provided by the VFD manufacturer. VFD connectivity was a breeze using the industry standard USB port on the front of the unit. The team was able to program all the logic and timers using the SLC controller and MCT 10 software. Sourcing the VLT FC 280 was especially smooth with stock at Motion’s U.S. distribution centers.

The final solution exceeded the customer’s expectations. New benefits include:
• Controlled ramps for conveyor indexes reducing mechanical wear.
• Electro-mechanical brake removal, reducing their number of failure points.
• Torque limiting function on the VFD to reduce conveyor damage in case of a jam.
• Reliable safety functions using the Safe Torque Off inputs built into the VFD.
• Reduced panel space requirements by using the integrated Smart Logic Controller.
• Efficient troubleshooting from reduced control wiring and external timers/relays.
• Online editing in the VFD software allowing logic changes instead of costly rewiring.
• Complete backup of all VFD and SLC parameters using the free MCT 10 software.
• Reduced components resulting in fewer spare parts to stock locally.
• Danfoss VLT FC 280 availability from the customer’s area Motion distribution center.

The result for this customer was a significant and continuous increase in uptime. By eliminating the lighter-part shifting on the cooling bed, the downstream processes now run smoother and require less operator intervention and maintenance. (Figure 2.) The customer has requested the team to repeat this upgrade on their other two cooling conveyors; this will reduce the employee number monitoring this area from three to one.

Figure 1. Integrated Smart Logic Control (SLC) reduces the enclosure size while easing troubleshooting.

Figure 2. With the new and streamlined enclosure controls, this injection molding cooling bed and product transfer now run smoothly regardless of product weight.
Control that speaks to you
From PLCs and PACs to PCs and CPUs

PLC with analog and specialty I/O modules
The Productivity2000 PLC is a modular, rack-based system with discrete, analog and specialty I/O modules providing more than 400 local I/O points. With remote expansion, more than 4,000 total I/O points are available. Two four-channel analog input modules provide 0-20 mA or 0-10 Vdc inputs, and two four-channel analog output modules supply 4-20 mA or ±10 Vdc outputs. The P2-02HSC high-speed counter module provides two independent single-ended 5-24 Vdc inputs that accept up to 100 kHz of pulse/direction and quadrature signals. The P2-04PWM pulse width modulation module supplies four channels of 5-24 Vdc, sinking or sourcing, 0-20 kHz, 0-100% duty cycle outputs.

Embedded PCs with AMD processors
Two embedded PC variants in the CX20x3 range include AMD Ryzen processors. This hardware is well-suited for 32- and 64-bit systems, namely TwinCAT 2 and TwinCAT 3 automation software. Users can select from Microsoft Windows 10 IoT Enterprise 2019 LTSC or the TwinCAT/BSD operating system. The CX2033 is a fanless device without rotating parts equipped with an AMD Ryzen V1202B CPU (2.3 GHz clock frequency, two cores). The CX2043 is a high-performance device with ball bearing-mounted and speed-controlled fan equipped with an AMD Ryzen V1807B CPU (3.35 GHz clock frequency, four cores). The AMD processors are based on the Zen architecture.

Compact IPC for edge computing
The BL2 BPC 1500 is a compact industrial PC (IPC) for rugged environments with limited space. This box IPC is designed for entry-level automation, small machine control and IIoT applications such as edge/fog computing or decentralized data collection and processing. With its fanless design, solid-state mass storage and heavy-duty metal housing, the IPC can operate in demanding industrial applications. The standard version measures 97 mm wide x 92 mm high x 46 mm deep. An extended version is 63 mm deep, with the same width and height. Additional features include 32 GB eMMC internal mass storage and DIN rail mounting.

HMI platform in panel-mount or full workstation
The modular VisuNet FLX HMI platform is available as either a panel-mount or a full workstation suitable for pedestal, wall or arm mounting. It has a 21.5-in optically bonded, projected capacitive touchscreen with low-profile stainless steel bezel. The processor unit can be ordered as a high-powered Intel i5 in a full PC configuration, an Intel Celeron in PC or thin client configuration or as a direct monitor unit.

Light panel PC
The Advantech PPC-3241SW-Mart is an all-in-one light panel PC with a wide-format 23.8-in FHD industrial-grade LCD. It has 10-point multi-touch projected capacitive touch control, Intel Core i5-7300U, 8 GB DDR4, 128 GB SSD, 90-W power adapter and Win 10 LTSC to provide high-performance computing in a compact and fanless system. The front panel is IP65-rated. The device supports dual displays, VESA 100 with a range of dc input (12 V-24 Vdc) and configurable RS-232/422/485 and two USB I/O.
Secure PLC and PAC for remote operations
The OSA Remote control node delivers secure, high-performance PLC and PAC functionality for remote operations. The standalone module embeds cybersecurity and supports as many as 20 fully programmable I/O with an IEC 61131-3-compliant IDE. Enabling real-time cloud-based data analytics are up to 64 GB secure flash memory, 512 MB of program memory, a multicore ARM Cortex processor and support for OPC UA and MQTT. A hardened, antitamper metal enclosure, -40 to 80 °C temperature range and EMP/EMI immunity help to optimize reliability in challenging environments.

Integrated IoT edge for Industry 4.0 applications
The UNO-137 integrated IoT edge is powered by a 9th-generation Intel Atom E3940 quad-core processor and is aimed at factory automation. To support diverse applications, it features a modular, optimized base unit that can be integrated with an optional extension kit and configured flexibly according to specific usage requirements. It also supports various edge software, including CoDeSys and the company’s Wise-DeviceOn and DAQNavi software. Designed to function as an edge controller for industrial automation applications, it has been optimized for DIN rail mounting with the provision of a sliding hook that snaps into place as well as a user-friendly release latch that allows quick disassembly.

Arduino-based PLC
The Arduino-based GPRS/SIM PLC Plus from Industrial Shields is a programmable logic controller designed for professional use. Offering 17 I/Os and DIN rail mounting, the controller can be programmed using the Arduino IDE platform and expanded up to 127 modules through I2C communication, providing users as many as 7,100 inputs and outputs in controller and peripheral connections. It can be programmed through USB ports or through the Ethernet port remotely, enabling immediate access to program, maintain, control and monitor.

PLC migration solution
These PLC migration interfaces enable the control level to be exchanged safely. Adjustments or changes to the infrastructure also can be made quickly and easily without having to intervene in the field wiring. The design permits the existing field wiring to remain in place and undisturbed on the front panel adapter and eliminates the need to wire-trace or ring-out. The assembly is a universal conversion/migration system for main legacy PLC systems, enabling users to migrate to any new control system. The solution includes several versions of card adaptors and cable types to accommodate flying leads or prewired field connections.

Evaluation kit with machine learning capabilities
The i.MX 8M Plus evaluation kit from NXP Semiconductors provides a complete evaluation platform for the i.MX 8M Plus embedded multicore heterogeneous applications processors, the first in the i.MX family to integrate a dedicated neural processing unit for advanced machine learning inference at the edge in industrial and IoT applications. The evaluation kit includes a compact compute module with an onboard i.MX 8M Plus Quad processor and a larger baseboard that brings out the broad connectivity needed for product evaluation. The processor integrates four Arm Cortex-A53 cores running at up to 1.8 GHz, plus an 800 MHz Arm Cortex-M7 core for low-power real-time processing.

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Mouser Electronics / www.mouser.com
**Ilot-enabled PLCs**
The 750 series includes three Ilot-enabled Generation 2 PFC200 controllers. They include a standard version for factory applications and two XTR versions for work in harsh environments. Each PLC comes with two RJ45 Ethernet ports and two 100 Mbit/s SFP slots for fiber-optic modules. These configurable ports can be used as a switch or with individual IP addresses and support Modbus TCP/UDP, EtherNet/IP and OPC UA protocols. The fiber-optic ports are beneficial where high electromagnetic interference is a concern or long-distance networking is needed.

**Wago** / www.wago.us

**Ultra-compact control system**
The ctrlX Core is the heart of the ctrlX automation platform. The high-performance and communication-ready control platform provides the basis for software development. The Linux-based multicore technology breaks down the boundaries between the IPC and embedded system platforms and drive-based technology. With its open and flexible architecture, the compact control system is designed to meet current and Factory of the Future requirements. In addition to EtherCAT, the control hardware supports other common automation protocols.

**Bosch Rexroth** / www.boschrexroth.com

**SIL 3 controller**
The Allen-Bradley Compact GuardLogix 5380 SIL 3 controller enables engineers to scale applications up to and including SIL 3/PLe performance with 1oo2 architecture. This option to right-size a safety control system to an application based on its safety assessment helps to reduce design and acquisition costs. The controller’s increased processing power can achieve faster reaction times and shorter safe distances, helping to create smaller machines and save floor space. Having one high-performance controller for both standard and safety control also helps to reduce system complexity and cabinet size and allows engineers to mix and match standard and safety I/O in the same chassis.

**Rockwell Automation** / www.rockwellautomation.com

**Stainless steel P69K HMI**
The C6 is a moisture- and water-resistant stainless steel HMI. The IP69K-certified panel uses 316L stainless steel and is offered as a standalone HMI or as a HMI + PLC combo. It offers protection in environments in which high-pressure water or steam is used to sanitize or clean the equipment. Its rugged design makes it well-suited for industrial applications. The HMI supports more than 40 communication drivers, including EtherNet/IP, Profinet and Modbus, so it can be paired with most PLCs. The panel also includes a micro UPS to protect nonvolatile data and a software tool that permits backup, restoration and transfer of systems.

**KEB America** / www.kebamerica.com

**Processor and I/O module with preinstalled Ilot/SCADA platform**
The groov Epic processor, GRV-EPIC-PR2 (PR2), and Rio edge I/O module, GRV-R7-MM2001-10 (MM2), both ship with Inductive Automation’s Ilot/SCADA platform Ignition Edge 8.1 preinstalled. These releases are well-suited for edge-oriented applications such as predictive maintenance (PdM), remote condition-based monitoring (CbM) and digital transformation/IloT. The Epic edge controller uses Ignition to provide embedded OPC UA and MQTT/Sparkplug B communication, as well as other optional features. The PR2 processor is compatible with existing Epic I/O, power supply and chassis options. With Ignition onboard, MM2 can function as a gateway to PLCs and other third-party devices.

**Opto 22** / 951-695-3000 / www.opto22.com
Connectivity for data-rich applications

**AS INDUSTRY 4.0** and connected machines continue to touch more industrial automation applications, machine components are changing to match data and connection needs, including the cables and connectors that are bringing machines together. Connectors and cables must be able to handle more data, at faster speed and often in rough conditions. Five manufacturers—Binder USA (www.binder-usa.com), Turck (www.turck.us), Lutze (www.lutze.com), Wago (www.wago.com) and Dinkle (www.dinkle.com)—share their cable and connector solutions for smart machines and networked components, legacy updates and rugged applications.

**High-speed transfer**

As more applications shift toward connected machines, using the Industrial Internet of Things (IIoT) to move data and perform operations, those smarter and faster applications need comparable connectivity. “As industrial-automation applications become smarter, the demand for these industrial-grade high-speed connectivity requirements continues to grow,” says Maciek Czerwinski, director of sales and business development at Binder USA.

With that in mind, Binder launched its newest connector product, M16 X-code. The connector keeps the legacy of the M16 but helps to integrate users for the transition into connected technology, Czerwinski says. “We wanted to continue to evolve the offering within the same footprint. The driving force of the release of the M16 X-code was specifically for the Industry 4.0 integration,” he says.

The M16 connector uses the same footprint but is better optimized for high-speed data transfer with a density pin count up to 24 contacts (Figure 1). This allows for more connections and allows engineers to create hybrid solutions mixing power and signal. Binder sells largely to OEM customers, for use in any applications that require high-speed data computing.

The connection is suitable for outdoor and rugged environments, with an IP67 rating. The installation displacement termination (IDT) style makes it ideal for robust and harsh environment applications with high transmission rate data requirements. IDT involves splicing into the wire vs. soldering, crimping or screw terminating. “It offers an ideal solution for field assembly with this type of connectivity,” Czerwinski says.

Czerwinski says the Binder M16 chassis has been proven in many rugged applications. The design originated with the M12 X-code, which Czerwinski says is an industry standard for use with 10 Gb industrial Ethernet. Binder used the same internal components with the M16 chassis.

“With industrial Ethernet and high-speed Cat. 6 to Cat. 7 applications, the cabling is critical when the pairs are obviously twisted, and now they are individually shielded twisted pairs, and this is critical when protecting against potential insertion loss or any impedance concerns,” he says. “The X-code has basically an x-shaped shield, which splits up the individual pairs, so the shield protection continues throughout the inside of the chassis all the way to the connection point on the application. Your insertion loss and your impedance are virtually seeing zero loss and your connectivity speeds are continuing without any interference.”

A bad cable can make the best connector fail and vice versa, Czerwinski says. “The application is only as strong as the cable and connector being used,” he says, adding the most common reason for insertion loss is using the wrong cable for the length of the run. A bad termination to the connector can be another reason for impedance loss. Czerwinski says impedance is protected by making sure the connector and cable are properly terminated.

**Patented torque sleeve**

Turck’s next-generation M12 cordsets and receptacles are based on the company’s legacy connectors developed decades ago and redesigned with features to make installation easier, quicker and more reliable. The sensor actuator cables are used on a wide variety of automation applications, any kind of machine that would have a sensor or an actuator on it,
building blocks

says Lewis Fiecke, product manager at Turck. For these types of applications, "M12s are by far the most common," Fiecke says. "This is a connector that will connect your sensor or actuator to your fieldbus or your distributed I/O station or directly to a controller."

The M12 upgrade was intended to expand the company’s market share by improving on some mismatching and duplication on the old product and making it more modular overall. For its internal processes, Turck consolidated raw materials as much as possible and simplified the manufacturing to be more consistent and automatable, Fiecke says. "To help us get lead time and costs down, and on the commodity side of things, this is really important," he adds.

The M12 connectors have a keyway indicator to help installation. "You need to align that keyway on the cordsets, either to the sensor or the junction box or receptacle or whatever it’s mating to," Fiecke says. In certain situations, it can be difficult or time-consuming to locate the keyway prior to mating, or it could be entirely obstructed by other components. To make it easier, the keyway indicator is a little piece of plastic in the mold body. "Installers can both see and feel where the keyway is located," Fiecke says.

Once the pins are properly aligned, the connector needs to be tightened to a certain torque in order to properly mate. In some applications, Fiecke says, "finger-tight" is good enough. However, finger-tight is also relative to the installer, and over-tightening or under-tightening the locknut can cause ingress paths.

When finger-tight isn’t good enough and torque wrenches are not available, Turck designed this M12 connector with a patented torque sleeve. "The torque sleeve will actually cam out once the connector is tight enough and that will ensure the IP rating or ingress protection rating," Fiecke says. The torque sleeve, which sits on the coupling nuts, provides a tactile click at the right torque (Figure 2). The new cordsets are IP67-, IP68- and IP69-rated and work for applications that need vibration-proof connections.

The torque sleeves also come in nine different colors, which can help end users distinguish one connection from another. Instead of changing an overmold color, end users can pick torque sleeve colors to coordinate with their receptacles, panels or junction boxes. "If you have to tear it down and demate, it’s just quicker and easier," Fiecke says. The torque sleeves are also very inexpensive and don’t add anything to the cost of the cordsets, and Turck stocks them in large quantities.

Multi-cable solution

Lutze is also focused on the impacts of IIoT and increased electronic connectivity on machines. "In automation generally, I would say the past 15 to 20 years has seen a shift away from hydraulic and pneumatic systems and a move toward electric automation," says Matt Tarney, product manager for cable and connectivity products at Lutze. "That involves a lot more sensors. It involves networking the components on a machine, and all of those interconnections require some kind of physical cabling in most cases, so the density of cabling on a piece of equipment has gotten higher." All this had led to a growing market for cable entry systems, Tarney says.

The end goal of Industry 4.0 and Ethernet networked components on industrial equipment “is really to gather as much data as we possibly can from our manufacturing processes,” Tarney says. Data-rich machines can use software with machine learning or artificial intelligence to improve processes. “But the collection and transmission of that data all requires a reliable interconnection of equipment, and that’s hard to achieve with wireless solutions, so that’s typically done with a hardwired Ethernet cable. And, the more connected devices on a piece of machinery, the more cabling needed to facilitate those connections,” Tarney says. “That’s increasing the density of physical cabling, which requires new solutions for managing that”.

Figure 2: Turck’s M12 cordsets and receptacles use a torque sleeve to facilitate hand tightening to the proper torque.
Lutze’s Cablefix X entry system fills a growing need for multicable solutions and provides quicker installation and setup over individual cable glands. The main markets for Lutze’s cable entry system are OEMs producing equipment for installation in a factory environment, as well as UL 508A cabinet shops, which build and repair control panels.

Traditionally, cable glands are used to individually seal cables that pass from the inside to the outside of an enclosure. “If you can imagine you have 18 cables,” Tarney says, “if you’re using cable glands, you’re punching a hole for each one of those glands.” Individually installing and fitting each cable gland is time-consuming. “The space that it takes up on the side of your enclosure is also quite large,” Tarney says.

The Cablefix X cable entry system helps many of those issues, making the installation of multiple cables into an enclosure faster and covering a smaller footprint. In 2019, Lutze did an in-house study, looking at the time it took one installer to install cables using cable glands and the same thing using the Lutze system.

“Weing the Cablefix X system can reduce your cable installation time by 80% or more and reduces the footprint of those cables on your enclosure by 50% or more,” Tarney says.

The frame is rated to UL Type 4X, 12, 13 and IP65, making it suited for harsh environments. A self-healing membrane also makes the system more flexible (Figure 3). “We designed our system with a layered seal. We have some polymer seals on the front and back of that seal. We have a layer for physical strength and strain relief, and then we have this gel membrane that’s inside the sealing membrane,” Tarney says. The proprietary gel is water-blocking, so if water hits the gel, it swells up to prevent water ingress. “That’s one of the ways we achieve that 4X rating: that is actively defending against water ingress,” Tarney says. The gel is also self-healing. If cable needs to be removed, the membrane will close back up over the hole and a blanking plug isn’t needed. The system uses a standard 112-by-36 mm cutout compatible with many third-party punches.

**Dynamic connection**

Wago has seen an exploding market and demand for connectors in recent years. “I think that’s driven primarily by the trend toward smarter and smarter machines that are more connected,” says Cory Thiel, product manager for PCB interconnect products for Wago North America. “It’s driving a lot of demand for connectors and a lot of variety of different types of connectors.” He says the expanding market is also driving the need for smaller and smaller components. “People are always wanting to do more functionality in the same or less space.” With the 832 series Maxi connector, Wago packs a powerful connection into a compact solution (Figure 4). This product is geared toward power termination applications, particularly field-wired connections, Thiel says.

The product was launched in early 2019 and puts Wago’s spring pressure connection technology into a powerful, small package for field-wired applications. Instead of a screw terminal, which requires a torque screwdriver for installation, or a crimp terminal, which also requires a special tool to appropriately crimp the wire, the lever operation of the spring pressure connection technology requires no tools.

Field connections can be made by lifting the lever, inserting a stripped conductor and lowering the lever. Wago’s spring pressure connection is also dynamic, Thiel says. “Once you make the connection, that connection is, because of the spring, dynamic in nature, and it’s free to adjust for environmental impacts that could affect other static termination solutions,” he says. This can compensate for vibration, thermal cycling or corrosion that can degrade connections.

The connector system includes various configurations for wire-to-wire, wire-to-board and through-panel, as well as panel or DIN-rail mounted solutions. They can be used throughout the electrical cabinet or as a power device connection in many high-power, high-current applications, such as EV chargers, PV inverters, energy storage systems, UPS systems, power supplies and 5G antenna systems.
“We’re able to combine with the 832, relative to its current capacity, a relatively small connector, and with that easy termination without any tools and with high performance from a current and voltage perspective,” Thiel says.

The 832 series connector eases the mating and unmating of a female/male connector. “This is a higher-power device. It’s a little bit larger device. Usually, the larger you get in devices, you’re dealing with more and more friction because you need more and more metal to make those connections and carry those higher currents,” Thiel says. “Lots of friction usually means it’s difficult to connect and disconnect the male and female portions of the connections.”

The 832 series connector eases this process by plating the mating surfaces with a hard silver coating. Thiel says that silver coating is a lot harder and less porous than most contact surfaces, which makes for very smooth mating and unmating of the male/female contact.

The connector is touch-proof, as the operator cannot make contact with internal live parts. This is important for many industries and particularly for field-wired applications, Thiel says.

Updated screw connection

Like many in the industry, Dinkle is trying to push the market in new directions with push-in type connections, but much of the labor force is still used to traditional screw-in type methods. Dinkle provides many connectors with newer technology, but it has also given its traditional screw connection terminal block an upgrade.

“We’re trying to provide some type of upgrade from the traditional or conventional wiring methods,” says Matt Hou, sales engineer at Dinkle.

DKU, Dinkle’s latest version of the screw connection terminal block, is designed with spring guided screws for automatic screw alignment (Figure 5). This barrier type terminal block is used mainly for high-power applications, and it works well in harsher environments with high vibration, Hou says. The screws are integrated with washers for vibration-proof and secure connections, and the washers are made with steel, plated with zinc, to prevent them from rusting.

DKU works with ring- and U-shaped cable lugs, which are used to provide a more secure connection and prevent the screw from falling out. Traditionally, users have to back the entire washer and screw out of its fitting and then insert the U-shaped cable and reinsert the screws and washer. “We think that this will provide some potential problems. What if they lose the screw? Or what if it falls out and they can’t find it?” Hou says. With the spring-guided system, the screw is held on top in its top position at all times, unless it’s pushed down and screwed in. “Once a ring-shaped cable is inserted, they are able to align it accordingly because it doesn’t have a wire cage, as conventional terminal blocks do, and push it down, so that the ring lug and the screw are aligned properly before screwing it down,” Hou says.

Dinkle designed the product for power transmission in control panels and power-distribution cabinets, and those that have high vibration, such as transportation or railway. The product has two series, for DIN-rail or panel mounts.

In addition to preventing the screws from falling out, the terminal block encloses the screws and conductors. Typical barrier-type terminal blocks lack a cover over the screw, and DKU provides an extra level of protection for the user.

“There is a cover to protect the operators from touching the screws or any parts within,” Hou says. “This also provides extra safety for the installation and the maintenance.”
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