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HANNOVER MESSE 2023:

The Promise (and Pitfalls) of Industrial-Grade AI

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From the Editor

By **Rehana Begg**, Editor-in-Chief

A Successful Digital Transformation Hinges on Values

How best to cope with the pace of innovation and advanced technologies?

TRADE SHOWS AND CONFERENCES have been ramping up and are nearly back in full swing. That's a good sign for the industry and great news for people who have an insatiable curiosity about what's out there.

Naturally, I perked up when a moderator at a recent show asked panelists to comment on digitalization and automation in manufacturing and how they were managing it.

A statement from one panelist in the precision motion and automation space (David Holm, vice president of manufacturing at Aerotech, Inc.) sums up an echo that's currently reverberating across industries: "Aerotech, traditionally, would operate on mechanical and air bearing systems. We had our niche and we would focus on the manufacturing process or the inspection process at hand. What our customers have been demanding much more from us—not just in terms of our traditional motion capabilities—is that they're starting to push the boundaries of how we do things."

Holm continues: "For example, we used to move a part underneath a fixed laser. And now, using light manipulation technology, we actually move the laser instead of the part that's being manufactured. It's fair to say that 80% of the people in this room are impacted by that technology.

"They just don't know. And, and not only that, but our customers are expecting us to understand the upstream and downstream parts of the manufacturing process as well. So, we're being asked to understand how to handoff from a system that we did not manufacture and be able to understand that. The employment of automation engineers, and investments in those areas, are something we're definitely focused on."

Holm made his point at the Epicor Insights 2023 event in Las Vegas. All the same, his finger-on-the-pulse statement centered on industry data and how best to sense issues along the supply chain could have been stated at Automate 2023 in Detroit, or Hannover Messe in Germany.

One takeaway from Holm's experience is that adoption of new industrial technologies—automation, robotics, software and AI—lead to their intersection and, by extension, new profit pools. Another alludes to the impact: What we are doing to keep up with the rate of change?

A best practice was offered by another panelist: "You have to marry the technology and the technological tools with the process improvements, as well as the organizational cultural change. Just putting the tool in place by itself is not going to drive innovation. Technology can provide a framework or a foundation to potentially drive transformation. But adding process improvements and making organizational change through the human component and the cultural shift—that's really the secret sauce."

What's the real takeaway? Really, it depends on what any business hopes to gain from digital transformation. But for those who are recalibrating processes and refocusing the entire business around digital technologies and advanced automation, long-term success means remaking the meaning of value.

Your feedback ensures our relevance. Reach me at rbegg@endeavorb2b.com. ■

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R&D SPOTLIGHT:
Inventors Celebrate Ingenuity at Patent Medallion Luncheon

Honorees at the University of Arizona received medallions to commemorate their patented inventions.

TWENTY INVENTORS FROM the College of Engineering at the University of Arizona were recognized for their part in bringing the university to its second year as No. 28 in the world among universities granted U.S. utility patents.

Among the honorees at a Patent Medallion Luncheon in March was Hao Xin, a professor of electrical and computer engineering and physics. Xin, along with fellow electrical and computer engineering instructors Siyang Cao and Min Liang, are using radar to make breakthroughs in driverless technology.

Also present was Judith Su, an assistant professor of optical sciences and biomedical engineering, who has developed a technique known as FLOWER, or Frequency Locked Optical Whispering Evanescent Resonator, which allows for the diagnosis of a variety of diseases at their earliest stages.

"The diversity of these inventions demonstrates the many ways our Arizona engineers are serving humanity and advancing knowledge," said David W. Hahn, the Craig M. Berge Dean of the College of Engineering. "I'm honored to recognize this group of innovators for their commitment to excellence, in collaboration with our partners at Tech Launch Arizona."

Technology Transfer

Ordinarily, scientists would turn to peer-reviewed publications for idea validation. In this case, the engineering recipients of medallions can thank technology transfer, a process for patenting discoveries and licensing them to businesses that can turn them into life-saving commercial products.

Researchers who choose the patenting route can credit a pair of senators, Birch Bayh (Indiana) and Bob Dole (Kansas), for the control they have over their inventions' IP in order to market or commercialize their inventions. In 1980, the namesakes behind the Bayh-Dole Act, or Patent and Trademark Law Amendment Act, revolutionized technology transfer by allowing universities, non-profits and small businesses to turn their discoveries into viable products.

Before the law was enacted, billions of dollars' worth of federally funded research went unused, as the universities and others funded by agency support were stripped of their patent rights.

The Bayh-Dole Coalition's website notes a long list of innovations made possible by the Act, including the Ebola vaccine (Ervebo or rVSV-ZEBOV), quantum computing, magnetic resonance spectroscopy, neoprene and advanced ultrasound imaging.

Across the U.S., economic development initiatives and start-up accelerators (such as Y Combinator, TechStars and DreamItVentures) harness technology transfer to license research innovations. Others explore technical potential through Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs to help convert research from lab to market.

The 2023 University of Arizona College of Engineering Patent Medallion recipients. *Tech Launch Arizona*

Patent Inventors

Early-stage inventions, such as those from the University of Arizona, stand to benefit from the protection of a successful patent system, since no competitors can use their discoveries for a certain period of time.

The University of Arizona noted that, of all the university patents in the most recent fiscal year, 20% were issued to engineering faculty and their collaborators.

The following University of Arizona faculty members, graduate students and alumni received medallions.

Aerospace and Mechanical Engineering

Linan Jiang – *Micro-Scale Concentrated Photovoltaic Module and Polymer Waveguide Interconnect Between Chips*

Peiwen Li – *High Temperature Fuel Cell System*

Jekan Thanga – *Laser Position Control and Space Traffic Management*

Biomedical Engineering

Carissa Grijalva (graduate student) – *Active Assist Orthotic*

Minkyu Kim – *Antimicrobial Biopolymers for Microbial Infections*

Marek Romanowski – *Ocular Cranial Nerve Monitoring System*

Marvin Slepian – *Determining Overall Motion and Flexibility Envelope; Systems and Methods for Characterizing Sepsis; and System for Monitoring Therapeutic Procedures*

Tsu-Te Judith Su – *Photonic Apparatus, Methods, and Applications*

Chemical and Environmental Engineering

Gregory Ogden and Kimberly Ogden – *Optical Device for Monitoring of Microorganisms*

Electrical and Computer Engineering

Siyang Cao, Min Liang (alum) and Hao Xin – *Automotive Radar Using 3D Printed Luneburg Lens*

Wolfgang Fink – *Vehicular Tip or Rollover Protection Mechanisms and Traverse Optimization and Multi-Purpose Tracking*

Min Liang (alum) and Hao Xin – *Hollow Light Weight Lens Structure*

Mining and Geological Engineering

Jinhong Zhang – *Material with Improved Strength/Water Resistance*

Materials Science and Engineering

Pierre Deymier – *Tunable of Quantum-like Mechanical Elastic Systems*

Douglas Loy – *Dihydropyridazine Antioxidant Sunscreens and Forming a Network Foam Using Diels-Alder Reactions*

Optical Sciences and Engineering

Chaohan Cui (graduate student) – *Quantum Receiver Method Decoding an Optical Signal* ■

Manufacturers Automate Through Robotics

THIS YEAR, THE International Symposium of Robotics (ISR) has been organized in conjunction with Automate (May 22-25, 2023). Underway at press time,. the annual gathering in Detroit is organized by A3 (Association for Advancing Automation), with a focus on how operational robots are impacting the manufacturing world.

Globally, the stock of operational robots now tallies 3.5 million and holds an estimated installation value of $15.7 billion, according to the International Federation of Robotics. Behind these figures are advances in robotics that propel the connected digital ecosystem.

Foremost are the rise of solutions that pair user-friendly software with intuitive user experience, according to IFR reports. This means OEMs can work in tandem with lowcode (and no-code) partners in setting up easy-to-use programming interfaces. The pairing will effectively make it easier, for example, to equip traditional heavyweight industrial robots with sensors and software to facilitate collaborative setup operation.

The news and technology updates that follow below can offer a sampling of robotic automation and R&D that are opening up a host of opportunities in the here-and-now.

Highly Automated Facility Manufacturing Next-Gen Robots

Electrification and automation leader ABB reported that close to 90% of its robots geared for the U.S., Canada, Mexico and South America, will soon be made in Auburn Hills, Mich.

An expansion of ABB's existing North American robotics headquarters and manufacturing facility in Auburn Hills will supplement the $14 billion sum already invested in the U.S. since 2010. The project is expected to benefit growth sectors, such as electric vehicles, healthcare, packaging and logistics, and "responds to the increased demand for automation from 70% of U.S. businesses looking to bring production closer to home," noted an ABB Robotics survey.

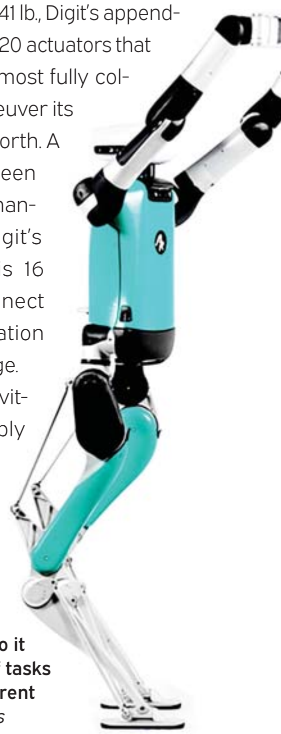
ABB stated in a press release that the plant will employ flexible, modular production cells that are digitally connected and networked, and served by intelligent autonomous mobile robots. AI-powered robotic systems will take on tasks such as screw driving, assembling and material handling. The project, representing an investment of $20 million, is expected to be completed in November 2023.

Intralogistics Robot with a Human Form Factor

Agility Robots unveiled the next generation of Digit, a bi-pedal, multi-purpose robot made for picking and placing, at ProMat 2023 in Chicago (March 20-23, 2023). A key feature related to a robot with human form factors is its ability to fit into and navigate spaces designed for people. In existing warehouse operations and as-built infrastructure, this could mean deployment without costly retrofitting. A fleet of Digits could foreseeably switch between applications and take on dirty and dangerous tasks, depending on warehouse needs and seasonal shifts.

The latest generation of Digit includes newly designed end effectors optimized for grabbing and moving plastic totes commonly found in warehousing. Standing tall at 5-9 and weighing in at 141 lb., Digit's appendages are designed with 20 actuators that enable the robot to almost fully collapse its legs and maneuver its bodyweight back and forth. A head and eyes have been added to improve human-robot interaction. Digit's optimized runtime is 16 hours, and it can connect itself to a docking station when it needs to charge.

Agility Robotics is inviting companies to apply to deploy Digit in their warehouses by applying to Agility Partner Program before it is commer-



Digit is multi-purpose, so it can execute a variety of tasks and adapt to many different workflows. *Agility Robotics* cially available. The working relationship will help train and improve the robots in workflows and operations..

Autonomous Mobile Robot Handles Heavy Loads

OTTO Motors, a provider of autonomous mobile robots, is building on its material handling portfolio with the release of the mid-range AMR, OTTO 600. Complete with an all-metal, rugged construction and IP54 rating, this AMR can move pallets, carts and other payloads up to 1,322 lb and can move at a maximum speed of 4.5 mph.

The AMR also benefits from OTTO's latest software release, 2.28. According to the company, the software not only has a new facility configuration interface for quicker workflow setup, but also upgrades the traffic management functionality, so that users may create different rules of the road for groups of different OTTO AMRs in a facility. OTTO also supports the AGV standard, VDA5050, which allows customers to manage dissimilar types of material handling solutions from a third-party master controller interface.

Cobot and AMR Collaboration

Picking, packing and screwdriving are among the laborious tasks that plants can now delegate. OMRON's collaborative robot performs a palletizing operation together with the LD-250 250kg payload autonomous mobile robot (AMR). The TM series of cobots are equipped with various vision functionalities that enable safe, flexible engagement between human and machine.

OMRON also released a "mobile-compatible" model, which seamlessly integrates into OMRON's LD series autonomous mobile robot. This raises the level of complexity to where the robot can pick and place onto a tray or container, as well as to connect processes with autonomous mobile robots.

Harmonized Automation

Omron's showstopper at Hannover Messe 2023 was an application based on the evolution of the industry-renowned FORPHEUS AI-based table tennis robot.

The demonstration both elevated the concept of "harmonized automation" and pointed the way to a future where robots can help humans improve their skill sets, as well as their manufacturing and production processes.

OMRON paired a flexible assembly machine with AI-powered learning, by combining automation technologies such as robotics, control, sensing and vision with emerging technologies such as AI, AR and 5G.

Using OMRON's core "Sensing & Control + Think" technology, the robot learns how to execute the assembly task by following the hand movements and learning from the human operator's mistakes. The machine develops the optimal strategy for assembling the product. A digital twin of the robot is then created to train other operators in a virtual environment. The process enables continual performance improvement. ■

HANNOVER MESSE 2023 BOOTH TOUR:

How Enterprises Embed and Unleash AI

Damien Geso | iStock / Getty Images Plus

Machine Design's pit stop booth tour at Hannover Messe confirmed AI is being woven into as many portfolios as there were minds of decision-makers.

by **Rehana Begg**, Editor-in-Chief

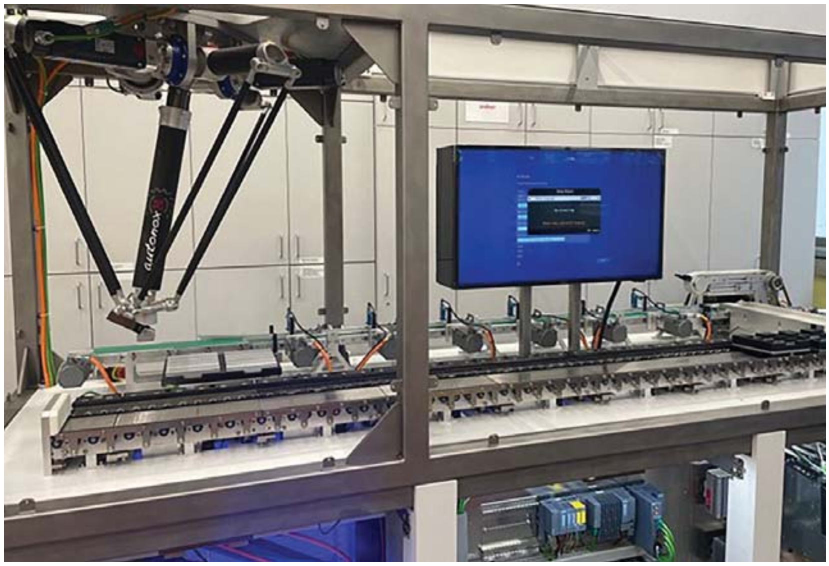
AT THE SAME TIME as our fascination and fear of trending generative AI systems heat up, researchers focused on the industrial manufacturing realm are bolstering their AI toolkits—all the better to be part of the next wave of innovation.

Recognizing the practical potential and revealing the breadth of problems that the machine learning techniques behind generative AI can solve was ample reason to make it a core topic at Hannover Messe 2023, the international tradeshow for industrial transformation, which took place in Germany (April 17-21, 2023).

Generative AI, a subset of machine learning, is crucial to the future of industrial business, from manufacturing and automotive to aerospace and defense. With help from generative AI, the industry can, for example, explore different designs and speed up simulation to a degree that engineers can iterate 100 different designs in a given timeframe, while finding the optimum design for a particular component or application. "AI really helps to make those design cycles faster, and the output—fingers crossed—better," said Boris Scharinger, senior innovation manager, Siemens, during a presentation.

The objective for Siemens, according to Scharinger, has been to reach "industrial grade," a term he coined to refer to the output quality of AI solutions. "We could all be driving autonomous cars, but if I look at you, no one here today arrived in an autonomous car," he said. "Why is that? Because we don't trust that bloody thing yet. If we don't trust it yet, we all need to work as much as the automotive industry does on the autonomous car to make AI industrial. So that's partly our mission."

For Scharinger, the problem of developing industrial-grade AI is not unique to Siemens. Rather, scaling qualitative AI solutions that meet manufacturing demands is a universal challenge. In the interim, he said, solutions remain stuck in test lab environments. The near-term goal, said Scharinger, should be to see industrial-grade AI emerge from that space.



AI motion is used in Siemens' Intelligent Infeed solution. The technology is aimed at the packaging industry. *Siemens*

On the tradeshow floor, where Scharinger's high-level observations were in play, vendors demonstrated the multitude of ways they apply AI in broad industrial applications, while striving to make their solutions economical through automation.

Two notable takeaways emerged from this year's show: The first is that, in tandem with connectivity, the talent of training robots is an important lever in driving big business and shifting the labor pool. The second is that finding a way to bring it to the shop floor remains a stumbling block for the masses.

In this analysis of emergent technologies below, we trace the promise and pitfalls of AI and machine learning at this year's fair.

Pick-and-Place AI in the Chocolate Factory

Rather than teach the robot to grasp, Siemens fed their robots millions of examples of how to grasp an object. Using neural networks, the robot learns to grasp a given object based on an image database.

A neural network is a complex algorithm that can learn tasks by analyzing vast amounts of data. The algorithm learns to recognize an object (for instance: a human, a dog, a chocolate bar, a microchip) by looking at thousands of labelled photos. The dataset of input-output relationships is programmed to predict the specific output for a given task (or output). Deep learning stems from the fact that the examples were first created in simulation in the virtual world. When the neural network is plugged into the robot, it is able to master the task of grasping physical objects in the real world.

The deep learning approach isn't new. Siemens showcased the algorithm's capabilities through its SIMATIC S7-1500 TM NPU object-recognition product at Hannover Fair 2019. Back then it was a first step in the direction of adaptive automation.

This year, reinforcement learning played a more prominent role. Siemens characterized it as a framework that enables robots to learn behaviors through interactions with its surroundings. The key focus in reinforcement learning is to provide robot controllers with "high-level specifications of what to do instead of how to do it," noted Siemens. As the robot learns independently, the payoff is higher yields.

During Scharinger's presentation, he demonstrated Siemens' efforts to meet "industrial grade" by pointing to a use case of a pick-and-place conveyor belt system used for recognizing and sorting chocolate bars. In his example, the optimized control algorithm was not connected to a tool system, but to a digital twin of a conveyor belt that was exactly matched to the actual conveyor's light barriers, IOs and electrical drives.

After 72 hours of training on the digital twin, the AI had learned key sequences that allowed it to control the real machine. Not only could it perform such functions as aligning the chocolate bars in the same direction and positioning them at equal distances, but it could also run in the cycle time of the actual PLC. This solution is integrated with Siemens' SIMATIC portfolio.

A shortcoming of reinforcement learning has been limited adoption, mainly due to the large amounts of data needed to get robots to execute tasks properly and to successfully learn control policies. Siemens researchers have also set their sights on a combined method, known as residual learning, which requires only a fraction of the samples needed in reinforcement learning. In this approach the robot's task is approached with conventional feedback control (that is, position control) and is augmented by residual learning.

Digital Twin Barista

Christoph Donker, director, EMEA Marketing, Altair, explained how his employer gave Gruppo Cimbali a taste of digital twin capabilities that would take crafting drinks beyond mechanical, thermodynamics and aesthetics. *Altair*

A coffee break at the Altair booth would likely be accompanied by a gratis lesson on how to enhance the performance and energy efficiency of a coffee machine. Known for its simulation, high-performance computing (HPC) and artificial intelligence (AI) solutions, Altair has been working with Gruppo Cimbali, an Italian industrial coffee machine manufacturer, to develop a digital twin-driven process for the lifecycle management of the coffee machine.

"The goal of this project was to reduce the energy consumption of the machine and optimize thermal management," said Christoph Donker, director, EMEA Marketing, Altair. "Several parts of the machine were losing temperature. With the help of the digital twin, we identified those parts of the machine and optimized it."

Information about each drink crafted is logged into a database, along with insights about the drink's quality to ultimately improve daily management, explained Donker.

Engineers were not only able to simulate the entire system with the help of Altair's open integration and simulation platform, Altair Activate, but also reduced the number of physical prototypes. Time to market for the coffee machine is 30% faster than it was before and energy consumption was reduced by 25%.

Simulations like the coffee machine project are entirely transferable. By creating fully automatic professional espresso coffee based on IoT functionalities, Gruppo Cimbali now also has a way to expand into telemetry markets and expand its offerings to innovative management, display and data representation systems for Wi-Fi-connected machines.

Technologies that build digital twins can be applied to almost any machine and are effective for extending the remaining useful life of a product without the use of a physical prototype, Donker explained. Altair also works with automotive, aerospace and defense and machine building industries.

"The next project involving the coffee machine might be to capture data—such as the grading of the coffee beans or the temperature during the coffee-making process—and then optimize the whole process again," Donker said.

With the new No Cable Technology (NCT), XTS movers can become mobile handling or processing stations, thus expanding XTS into a highly flexible multi-robot system. *Beckhoff*

R&D Meets the Marketplace

The increasing complexity of products spurs the need to use AI solutions to stay competitive and set the pace for the working world of the future. At the it's OWL stand, 33 companies and 19 research institutions and networks converged to demonstrate how to tap into AI-based solutions to design and operate production in a sustainable manner. KI MarktPlatz, or AI Marketplace—a platform covering the whole value chain from engineering through production and logistics—ensures secure data exchange and data sovereignty, in addition to the intelligent matching of AI service providers and companies.

In the past, the goal was to digitalize companies. That perspective has changed

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Festo's GripperAI is an autonomous solution that uses AI. The tool provides an efficient and economical way for gripping parts. *Festo*

When AI is used in engineering, it can improve sustainability, Lessman explained further. In generative design, this process saves materials through light-weighting or the simulation of energy efficiency. Then, through testbed performance, the researchers can draw conclusions on resource efficiency. User companies harness the platform's expertise gleaned from 11 years of experience and 300 projects worth €200 million to date, as well as the partner network it provides to implement the efficiency gains.

Lessman said collaborations with the technology network means customers can pool resources and leverage the three prerequisites for using AI: AI expertise, data and the culture of innovation. In one exhibit, where AI and machine learning were used to reduce production times at an early stage in the engineering, researchers performed a systems analysis of requirements and developed proposals for particular parts of the client's production system.

Another partner, Beckhoff Automation, demonstrated its modular XTS (extended transport system), a mechatronic linear transport solution, which consists of magnetically driven movers that pass along a path at up to 4 m/s. The hardware required for the transmission technology is integrated into the motor module and implemented in TwinCAT. The flexible configuration means the mover can transport, move, handle and measure individually. The system was expanded with NCT (no cable technology) to include a special motor module as well as electronics that can be mounted on the movers.

Depending on the requirements, the number of movers on the system can be changed, so the system can be optimized for sustainability. An increase current consumption by the mover, for example, can mean increased friction, noted Beckhoff's subject matter experts. Designers looking for resource efficiency and energy savings would take advantage of the compact design, as well as tap into the data from the controller and additional sensors as the basis for diagnostics and the detection of system changes at an early stage. This, in turn, will decrease downtime.

Unresolved Issues Resolved

Last year, Festo invested about 7% in R&D. Part of that spend was allocated for what to do to get AI directly in the production process. At an area designated for Industrial Transformation at the Festo booth, subject matter experts explained how digitalization and AI can optimize machine and system control. Consider as an example the software GripperAI from Festo.

The autonomous solution enables "blind bin picking" or self-directed picking with robots, cobots or Cartesian gantry. GripperAI follows an autonomous learning scheme to recognize and grip unfamiliar objects, a functionality Festo touts as unprecedented. With conventional solutions, vision systems or robots learn either based on images or CAD, or manually teaching the robot's movements through image recognition and gripping point calculation.

Depending on the level of flexibility required, a tool change can be triggered by the end-effector. New functions such as positioning and feeding can be realized by the module, too. Implementation is flexible and can be done on the gripper itself via RaspberryPI, on a PC on the robot or in the camera, or a cloud connection can be established. According to Festo's press notes, a partnership with ibk Ingenieur Consult GmbH will allow the robot supplier to bring an online configurable robot cell to market as an entry-level model. ■

Toward Carbon Neutrality

igus plugs heat recovery invention at Hannover Messe.

by Rehana Begg, Editor-in-Chief

DURING A ONE-ON-ONE interview at the igus booth at Hannover Messe, Frank Blase expressed contentment with a debriefing he held the night before with various product units.

"Whether it was [a customer query about] a plastic gear with a super tight precision or a customer interested in joining us in the iguverse [virtual reality platform] to rent real estate, everything was on topic," said Blase, CEO, igus GmbH. "I'm very happy with the depth and width, and that our innovations have found conversation."

As participation at international trade fairs go, feedback from prospects is invaluable. Members of the igus events team had arrived a month in advance to set up. With more than 190 products and designed around the theme, "Enjoyneering," the booth was outfitted to represent a colorful playground featuring 10 internal digital products that highlight engineering power.

"Before coming here, most companies would put forward topics of decarbonization and reduction of CO2," said Blase. "We also cover the topic here in Hannover. We also chose to focus on additional innovation projects."

For the motion plastics company, a big part of decarbonization would have to be connected to recycling, and Blase said it is the work of igus R&D teams to consider ways to "reuse and reuse and reuse" products.

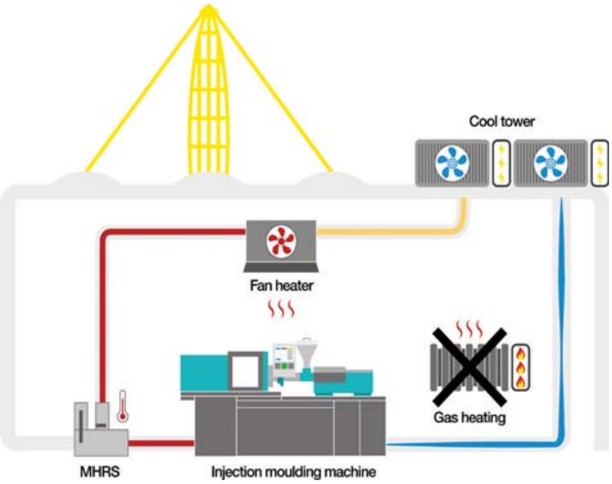
He also acknowledged there are problems to solve around the use of plastics, particularly the effects of micro-abrasion or plastic particles. "It is on the R&D drawing board; we are working on this," Blase said.

About four years ago, igus solidified its commitment to a circular economy with an option to customers to return plastic energy chains for recycling when they had reached the end of their service life. The program was expanded in 2022 with the "Chainge" program, allowing the return of six engineering plastics and creating a digital marketplace that enabled access to selected recyclates.

A surge in interest has been the motivation behind increasing the recycling platform and for considering new ways to reduce energy, Blase said.

A New Heat Recovery Model

igus can thank three of its engineers for their ingenuity in coming up with the company's latest sustainability initiative.



The new Machine Heat Recovery System from igus heats industrial spaces with machine heat, without the need for heat exchangers. The concept is freely available to all companies. *igus GmbH*

"We are very happy this year that we have found ways to use the machine heat from our injection molding machines in a simple way and in a way that we haven't found anywhere on the web or with experts," Blase said.

In a solution called a "Machine Heat Recovery System" (MHRS), the engineers successfully harvested waste heat from injection molding machines to heat a large factory hall at the igus head office in Cologne-Lind. The engineers, led by Dennis Berninger, factory manager at igus, tinkered for six months before arriving at a successful method for rendering the use of fossil fuels redundant during the production period.

A brief description of the MHRS is this: Hydraulic motors from injection molding machines heat up during operation. Already in use in the vicinity, cooling towers provide cold water and conduct it to the machines along a pipe system. When the heated water returns to the cooling tower, it is re-cooled and heat escapes into the atmosphere. But with the MHRS, lost energy from the cooling circuit can be captured and redirected to the heaters. The new system eliminates the need for heat pumps, the added expense from energy loss when using a heat exchanger, as well as the need for an additional feed of waste heat from air compressors.

According to igus' calculations, more than 1 million tons of CO2 and more than 548 million cubic meters of gas could be saved if all injection molders worldwide were to use this technology. (That's the equivalent of the annual gas consumption of 238.434 four-person households.)

The invention is a departure from the company's usual motion plastics horizon, but has garnered a high level of confidence from its leadership and igus will apply for a patent. Rather than licensing the technology, the company has decided to make the concept available free of charge.

"That would be a sizable impact, and I'm proud of our engineers to devise this and open it up to the public," said Blase. ■

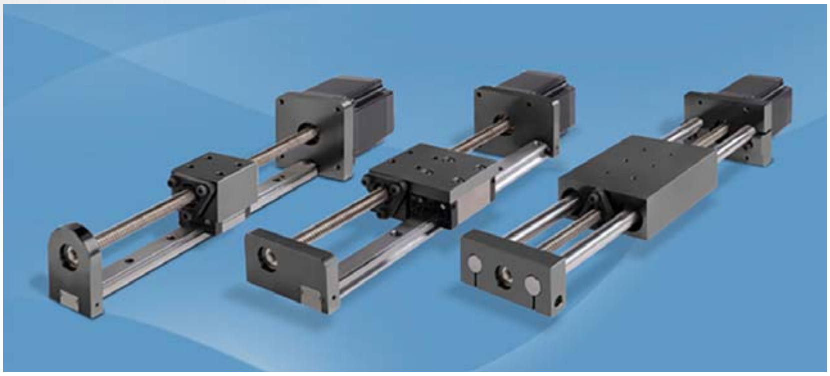
image_jungle | iStock / Getty Images Plus

CUT TIME AND COSTS

by Customizing Motion Control Systems with Standard Components

As manufacturers broaden but standardize offerings, designers will be able to create a solution using off-the-shelf modules that require minor adaptations. Plus, tips for linear system design.

by Matt Palmer, Thomson and **Chris Diak,** Motion Industries



1. Standard compact linear system configurations may include the lead screw mounted vertically above profile rail (left), alongside profile rail (middle) or flanked horizontally by round rails (right). *Photos courtesy Thomson Industries, Inc.*

As miniaturization trends drive the demand for more complex compact linear motion systems, the need for customization continues to grow. However, machine designers may not have to build an entirely new system from the ground up. Working closely with motion technology vendors, they can get an optimal solution from standard configurations with targeted customization. This avoids the higher cost and drawn-out development times of fully customized solutions without sacrificing performance.

Starting with Standards

Generally, starting with a standard compact linear system assembly is best. These systems typically incorporate the following motion control modules:

- A stepper motor with an integrated lead screw
- A load-bearing nut that rides across the lead screw threads
- Carriage blocks and linear bearings that travel with the nut to support the load
- Round or profile rails that provide additional guidance and support, anchored by end blocks and motor support blocks

Small systems like these are often available in one of three standard configurations. When the application needs a smaller footprint but has vertical space available, the designer might choose an assembly that stacks the lead screw vertically above a profile rail, as shown in *Fig. 1* (left side). This slim configuration has a smaller footprint than comparable configurations but is taller, and thus requires more overhead space.

Where overhead space is limited, designers might arrange the screw and profile bearing horizontally, as shown in *Fig. 1* (middle). This configuration flattens the configuration but demands a larger footprint.

A third standard popular configuration involves mounting round rails on each side of the lead screw, as shown in *Fig. 1* (right). This version can span across gaps without requiring full support along its length. Dual rail configurations can also handle roll moment loads because two evenly spaced rails share the load.

One final example of a flexible design enables its use in dirty environments

2. Positioning slides utilizing screw support technology and a plastic cover strip system allow operation in dirty environments, fully protecting the internal system components while reducing friction to a minimum.

while providing positioning and movement using ball screws and linear bearings. The enclosed design provides greater application opportunities while keeping the design in a standard product family, as seen in *Fig. 2*.

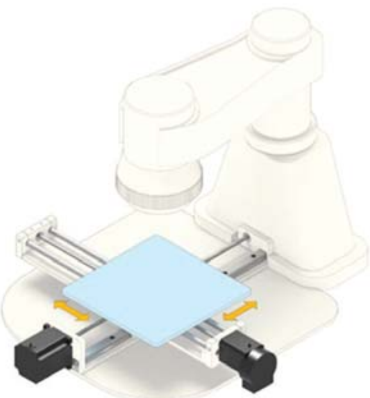
Fine-tuning

These configuration examples represent a range of available possibilities using just standard components. They are typically offered in a wide set of standard sizes and have served most purposes. However, the demand for more complex configurations grows as modern industrial processes evolve.

Despite the complexity of future manufacturing, most emerging applications will not require total customization. As manufacturers continue to broaden but standardize their product offerings, designers will be able to create a solution using off-the-shelf modules that require minor adaptations. Systems might need shorter or wider support blocks, relocated mounting holes, different bolt patterns, reorientation of the guide rails to the lead screw, modified stroke lengths or resizing of the motor to accommodate load changes.

These minor modifications fall within the existing manufacturing process limitations for the product. Manufacturers are beginning to incorporate these minor modifications into their process to expedite delivery times while providing flexibility in their offerings.

Suppose the designer concerned with moment load handling chose the configuration with two round rails flanking the lead screw *(Fig. 1)*. The application requirements changed during the design process, needing a higher moment load capacity. The engineer can adapt and accommodate the change starting with off-the-shelf round rails, lead screws and nuts. This may be achieved by widening the mount of the existing product or upsizing the bearings to maintain a specific envelope. Because mounting blocks are machined individually, changing support block designs can be done with little added expense and results from using standard product.



3. XY stages can usually be built with standard compact linear components, but gantries and other peripheral components may require customization.

XY assemblies are yet another application that often benefits from adapting standard modules *(Fig. 3)*. Like the previous examples, these units might require redrilling mounting holes or modifying mounting surfaces for customized gantries to accommodate cable management, limit switches or pneumatic hoses/accessories. These considerations are usually very specific to the application. But even then, much of the adaptation is made with standard mounting blocks.

Critical Success Factors

Targeting customization to only specific components can have tremendous value in cost-optimizing your motion control system for confined space operation. However, this approach's success depends on three things: the breadth of the vendor's product line; the expertise of the design team comprising the end-user, distributor and vendor; and the extent to which modern engineering collaboration tools can be leveraged. These could be as simple as drawings, sizing tools or even simulation software.

The product line breadth is essential because it compresses the supply chain, eliminating the cost and time needed to locate and bring in outsourced components. It also means that the vendor will have more capability to mass-produce the product efficiently.

The design team's expertise is important for their experience with similar adaptations or additional insight into a manufacturer's abilities within a product line. The combined knowledge of the end-user, distributor and manufacturer will always offer more information and views on tackling a difficult application.

The design team's expertise is important for their experience with similar adaptations or additional insight into a manufacturer's abilities within a product line. The combined knowledge of the end-user, distributor and manufacturer will always offer more information and views on tackling a difficult application.

Lastly, modern engineering collaboration tools are valuable for enabling real-time collaboration around the customer's specific problem, shortening the time between customization and production *(Fig. 4)*.

4. Collaboration tools such as virtual design consultations allow customers to work side by side with an application engineer to optimize their solution and review CAD models during or after their session.

Moving Into the Future

If the automation industry trend-spotters are right, we are on the verge of Industry 5.0, where humans and machines interact more effectively to leverage the unique benefits of each. As part of expanded cyber-physical interaction or the Extended Internet of Things (XIoT), more axes of motion will benefit from automation. Standard linear motion technology will continue to drive the bulk of applications in this space. Targeted customization with a foundation of standard products will make the transition smooth and cost-effective. ■

MATT PALMER is the product line manager of systems for Thomson and manages the linear motion systems business, supporting product line growth initiatives and product development efforts.

CHRIS DIAK is the Southeast automation manager at Motion.com and has worked in the electrical/automation field for 28 years.

LINEAR SYSTEM DESIGN TIPS

1. **Consider the environmental conditions** under which the system will operate, including temperatures, dust and dirt levels, chemical exposure, washdown processes, vibration and shock load, and radiation. Fully enclosed units that use a cover strip may be required for dirty or wet environments. In clean factory environments, open designs may provide cost savings and enhanced design flexibility. In extremely dusty environments, fully enclosed units can be equipped with a positive air pressure system to purge any particles that may get through the cover strip.
2. When defining the direction and magnitude of your load, **the system orientation can be important**. With a horizontal orientation, the drive load is equal to the payload weight times the frictional coefficient, while with a vertical orientation, the drive load is equal to the weight. For vertical applications, know that the mechanics alone may not be enough to hold the load when stationary and an external brake may be needed. This could extend the overall length of a unit.
3. For applications that require **accurate positioning**, preloaded ball screws or high-precision lead screws can be used, and the mounting surfaces of the rails can be machined.
4. **Lead screw drives,** used in low- to medium-duty cycle positioning applications, operate at low noise levels and provide excellent repeatability of 0.005 mm.
5. **Purchasing a configured linear motion system** can reduce engineering time and assembly cost by 90% or more while providing 20-30% cost savings in material.

REPLACEMENT PARTS are a 3D Print Away

Reverse engineering has applications across industries, especially where parts cannot be sourced. Selecting the right production method gives way for design and manufacturing improvements.

by Eric Utley, Technical Sales Engineer, Protolabs

People often contact me because they want to 3D print a replacement part. The requests have been as mundane as a stove knob or as novel as a replacement crystal for a chandelier. Typically, they are trying to source rare automotive parts. Others request parts for antiques or niche industrial equipment. Regardless of the application, the approach to a replacement printed part is largely the same.

Before pursuing 3D printing a replacement part, I always recommend first exhausting all of your sourcing options. If a part can still be ordered from a vendor, it is very rare for it to make economic sense to 3D print it. Depending on the part, there may be a forum online or a junkyard to source a replacement.

However, some parts are truly "unobtanium," a fun term restorers use for parts that truly cannot be sourced. There is some investment involved in getting a replacement 3D-printed part, so these parts are of high value. These will usually be parts that, if broken or missing, will render an expensive piece of equipment or vehicle non-functioning and useless.

◀ **The direct metal laser sintering (DMLS) process builds parts from sintered powder. The resulting parts naturally have a textured finish that is similar to cast metal parts.** *Images courtesy Protolabs*

Creating a CAD Model: the Key to Replacing Rare Parts

The first and largest hurdle to 3D printing a replacement part is getting a 3D CAD of the part to accurately describe the part's geometry. In rare circumstances, you may get lucky and find such a file on the internet or find a technical drawing identifying the dimensions. For a simple part you could recreate the design by taking careful measurements with calipers, but often for more complex or organic parts, the part will need to be 3D scanned. This process can cost a few hundred dollars with a company that offers a professional service. Increasingly, there are solutions to 3D scan using smartphones, but the results are quite inaccurate.

The 3D scan data may require some additional work to get it a clean, 3D-printable file. An STL file can be used for 3D printing, but STP files are better because they can be used for a myriad of other manufacturing processes outside of 3D printing. Even with a professional scan, it is important to understand what the critical dimensions of the part are to ensure functionality and a proper fit—and then double-check them with calipers to determine if the 3D CAD accurately captured the part details. The last thing you want is to spend money on a part with critical dimensions that simply don't work in the assembly.

The Difficulties of Recreating Parts

If the part being replaced is damaged or nonexistent you have a real challenge. On many vehicle components there is a left-side and right-side variant of the part. If one side is damaged and the other is not, it may make sense to reverse engineer the non-damaged side and the design can simply be mirrored once translated to 3D CAD. Be aware, though, that reverse engineering damaged parts comes with some risks, and you may have to go through a few iterations to get a proper fit.

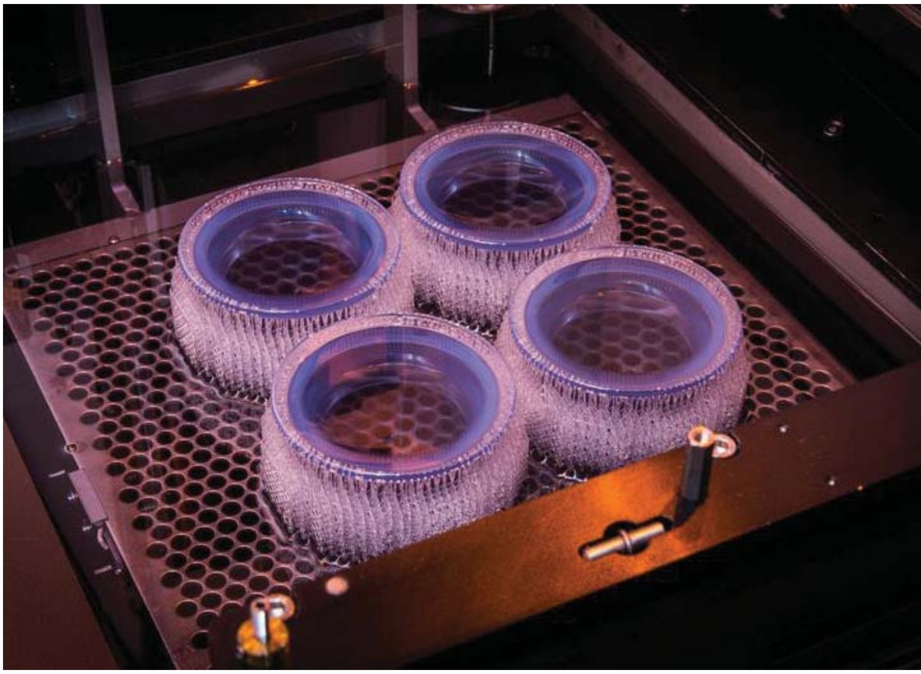
Once the 3D CAD is created, you can 3D print the replacement part. If the component is plastic, there are many available plastic printing processes, each with their own pros and cons. It is important to consider the type of plastic in which the original part was made and what sort of environmental forces are put on the part during its lifetime. Does the part see high heat? Is it exposed to chemicals such as gasoline or brake fluid? Is it commonly exposed to sunlight? Parts with specific material requirements will often drive the decision about which 3D printing process to use to replicate the part.

Available Production Methods

FDM (Fused Deposition Modeling) is the most common technology for desktop 3D printers and will nearly always be the cheapest option. The tradeoff is the part will have distinct layer lines and the parts may be weak along the print layers. This can cause them to delaminate and break along the layer lines when pushed beyond their limits. The printing process also requires a scaffold-like support structure, which can limit printable geometries.

FDM has a very wide range of available materials. If a part needs to be made in a specific plastic, FDM may be the way to go. For parts with low cosmetic and low strength requirements (such as the aforementioned stove knob), this will be the best process.

SLS (Selective Laser Sintering) and MJF (Multi Jet Fusion) are similar processes that both create parts by sintering plastic powder. These are the most common 3D printing processes for creating end-use plastic parts. Parts made in this



When selecting a material, consider the material properties, manufacturability and cosmetic appearance. Stereolithography (SLA) and other light curing processes are not always suited to replacement parts, as long-term exposure to UV light and moisture will affect the stability of the materials.

process are typically stronger than those made via FDM and the finish is textured but also more consistent than FDM. Aesthetically, they do not have that coarse 3D-printed look that you often see on FDM parts. These processes do not use support structures, and each offers more design freedom than FDM.

The material options are more limited than FDM, but SLS/MJF have several common production plastics such as polyamides (aka nylon), polypropylene and TPU (thermoplastic urethane). You can choose to use vapor smoothing to improve the surface finish and make it glossier and smoother, helping the part mimic the finish of injection molding, which is by far the most common manufacturing method for production plastic parts. These technologies also scale well at higher volumes. If multiple copies are needed these options are worth considering.

SLA (Stereolithography) and other light curing processes are rarely used for replacement parts but are worth mentioning for more niche applications. Most materials made with these processes are light sensitive and will discolor and become more brittle with exposure to sources of UV light (like the sun). Light sensitivity is the main reason this process is not commonly used for replacements. However, this limitation can be overcome by coating the part in paint, clear coat or plating.

SLA processes can offer clear material options, making them worth considering when a clear part is needed. Capable of very high resolution, SLA is also the best choice for parts with small features.

Urethane casting is often used in conjunction with 3D printing to produce replacement parts. A copy of the part is 3D printed and used to produce the mold for urethane casting. Alternatively, 3D printing can be used to create the mold itself into which urethane can be poured. This is a labor-intensive process, but it can create a very high-quality replacement. Also, urethane casting offers a wide range of robust plastic-like and elastomeric material options.

> ***Capturing the design in a 3D CAD before printing gives you a window of opportunity to improve, modernize, or customize the design. If faithful reproduction is not the goal, then why not improve?***

DMLS (Direct Metal Laser Sintering) is a 3D printing process that uses a laser to selectively melt metal powder to 3D-print parts out of metal. Although DMLS printing creates metal replacement parts, it's expensive, so the viable use cases are more niche. For example, you could use DMLS to manufacture parts for exceptionally rare and expensive vehicles, such as a World War II-era fighter plane or an early 20th Century steam-powered car.

Because the printing process builds parts up from sintered powder, the printed parts naturally have a textured finish. Interestingly, the finish is quite similar to cast metal parts. Casting metal was (and still is) a very common manufacturing method for creating many metal parts. The finish and appearance of the printed metal replacements often naturally resembles the finish of the original part. Like casting, the printing process has a tolerance of a few thousandths of an inch, meaning for precision fits the parts may need secondary machining. It is not uncommon to have to do secondary machining such as tapping threads or machining a mating face flat.

Improving Old Parts with 3D Printing

Beyond straightforward replacement parts, 3D printing can be used to create novel improvements and adaptations of existing or past designs. Capturing the design in a 3D CAD before printing gives you a window of opportunity to improve, modernize, or customize the design. If faithful reproduction is not the goal, then why not improve?

3D printing can be used to satisfy demand for low volumes of custom parts that may be lighter or personalized. For many industries, there is a small segment of the market willing to pay more for a custom version of the product, and 3D printing gives an avenue to explore and satisfy that market demand. For example, 3D printing is used in racing applications for virtually every vehicle imaginable, from boats to bicycles, where a select few are looking for the lightest parts possible. For aircraft and nautical vehicles, reducing weight can result in significant weight savings that increase range. ■

A 3D-printed titanium bracket has the benefit of low thermal expansion. It maintains its form well when exposed to heat.

Smart Manufacturing and the Convergence of OT and IT

The foundation for achieving higher operation efficiencies is the convergence of OT and IT to uncover actionable insights.

Greater operational productivity blurs the boundaries between traditional information management and operations management on the factory floor, providing data to improve overall operations. *Siemens*

by Rahul Garg, Vice President, Industrial Machinery & SMB Programs, Siemens Digital Industries Software

Smart manufacturing approaches are enabling industrial companies to address the challenges of global competition, sustainability, supply chain snarls and labor shortages.

The goal is to become more efficient and drive the maximum utilization of factories. Manufacturers are discovering that digitalization is the new equalizer to achieve an innovative level of smart manufacturing. In the past, automation focused on reducing costs. But today, digitalization can take manufacturing processes to a whole new level if done right.

The foundation for achieving higher operation efficiencies is the convergence of OT and IT to uncover actionable insights. Using the wealth of data generated by factory operations technology (OT) from edge sensors and smart equipment, information technology (IT) can then store, retrieve, process, analyze and recommend action based on that digital data.

The actionable data leads to closed-loop manufacturing processes that are continually optimized and closed-loop product quality. Ultimately, it supports the creation of a comprehensive digital twin of the manufacturing environment to maximize throughput.

IT/OT Fusion Delivers Actionable Insights

This article focuses on IT/OT convergence, which is the initial crucial step to achieving smart manufacturing. It helps to start with definitions for OT and IT:

- Operation technology (OT) – Provides the capabilities that run a factory. It includes all the software that goes into the operation of the physical equipment, the controls and the technology driving the machines, and the programmable logic controllers (PLCs). In other words, it helps the factory to function.
- Information technology (IT) – The organization's computer information technology stores, which processes, analyzes and acts on data gathered from operations. Supervisors and management use IT to make decisions, while operation technology drives actions.

So where is the source of this data? Most factories today are a mix of older and newer equipment. Newer smart machines are designed to share data with a network, whereas older machines are data islands. A network of sensors is added to the factory to connect those islands to ensure robust data across all manufacturing operations, bringing operational data together for IT to analyze. These edge sensors can stream data to an entire range of measurements to provide a solid sense of the equipment's performance. As a result, in almost every factory today, data is collected by various physical sensing technologies, including PLCs, sensors and gauges, IoT devices, etc.

Today, OT and IT are interacting more to achieve superior operational efficiencies. Traditionally, these were two distinct areas. But the search for greater operational productivity blurs the boundaries between traditional information management in server rooms and office buildings and operations management on the factory floor, providing essential data to improve overall operations.

OT and IT converge when information technology is captured as the factory floor is running, fed into IT systems that digitally optimize business decisions, looking at this data from edge sensors in smart machines. They can now better understand how the equipment runs to initiate real-time decisions. These decisions help to optimize and further maximize throughput from factories. Together, they assist in making critical decisions, uncovering a specific part of a machine that may be failing, running out of stock or having issues that impede factory production.

A simple example of one of the benefits of OT/IT convergence is monitoring air compressor operational trends. Experts estimate 30% of compressed air energy is wasted in leakage, with additional capital required to address capacity loss. By analyzing OT data regarding air compression, IT can quickly pinpoint inefficiencies in energy usage due to worn or leaking components, efficiently directing maintenance efforts to address them before they become significant energy losses. Maintaining near-zero leakage is an effective cost-saving benefit for manufacturers using substantial amounts of compressed air.

Closed-Loop Manufacturing and Quality are now Attainable

Once all the key data is available on an ongoing basis from OT/IT convergence, it creates a connected feedback loop that strengthens the correlation between the as-planned product with the as-built and as-used product in a continuous, iterative process. Now, manufacturing engineering can receive timely feedback to make better choices for other critical manufacturing activities such as:

- Rescheduling the shop floor.
- Bringing in new support capabilities.
- Delivering proactive service before equipment fails.

It all leads to the goal of zero downtime.

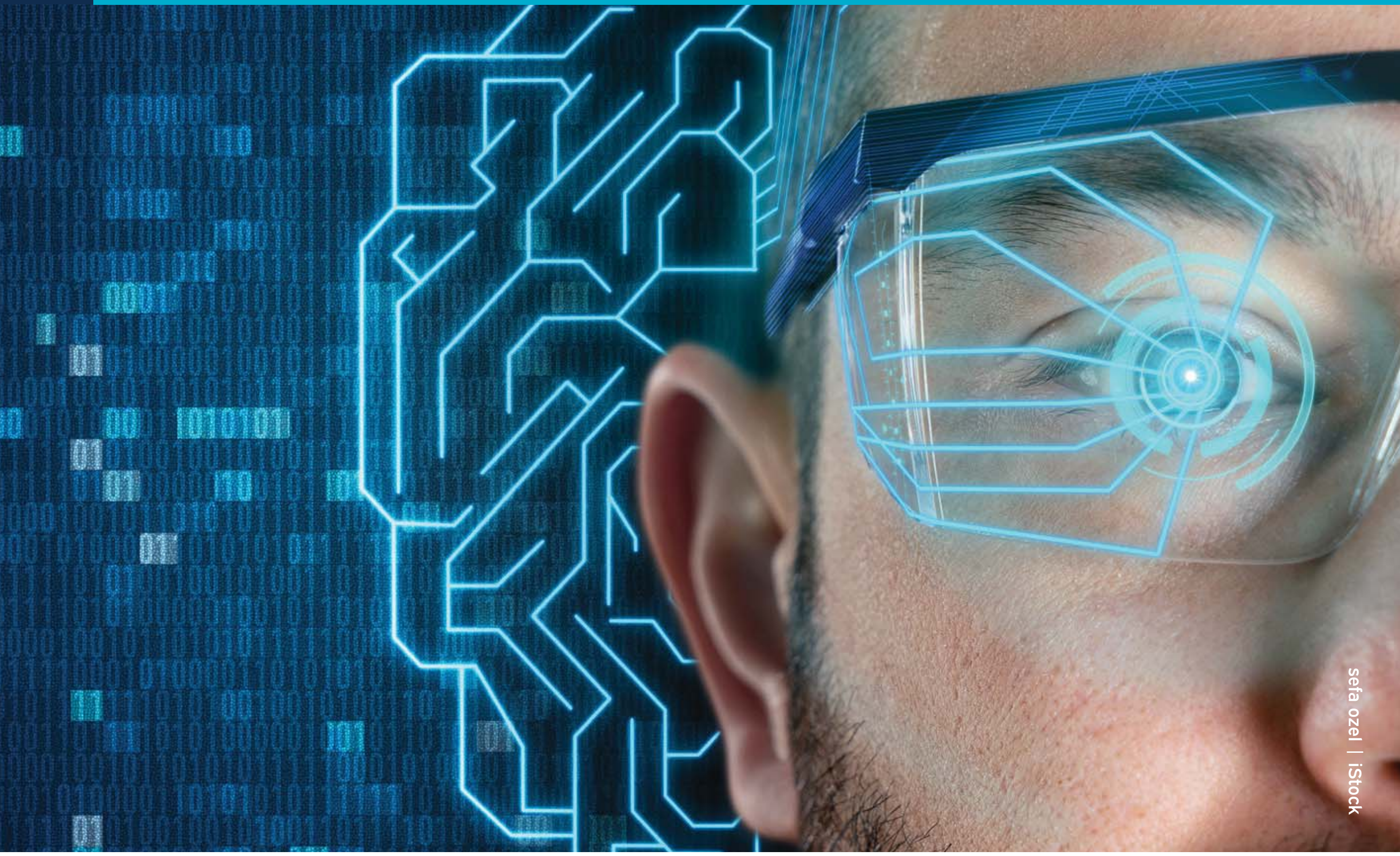
With OT/IT convergence continuously enhancing manufacturing, it is now possible to pursue optimal product quality that includes long-term sustainability goals—such as zero waste. As a result, closed-loop quality ensures complete visibility of quality-related metrics from planning through delivering on the quality of the completed product. Closed-loop quality processes achieve a median product compliance rate of 99%, with a majority performance ranging from 97 to 100%. That means near zero waste without compromising on product performance or sustainability.

The Digital Twin of Production

Ultimately, OT/IT convergence lays the foundation for implementing a robust digital twin of the manufacturing environment. The digital twin is a virtual, digital replica of the physical objects of an entire machine, manufacturing system or shop floor in a digital environment. While the factory operates, the digital twin provides a physically accurate simulation of operations by combining the virtual and physical worlds to provide new insights and efficiencies for product manufacturing through data analytics and AI.

More data equates to a higher-fidelity digital twin. And OT and IT convergence delivers the requisite real-time data and information to create a complete digital version of the factory. As a result, while the factory is running, the entire factory's digital twin with each machine mirrors that activity in a replica, digital format. All that operational data ensures much higher fidelity of the digital twin and provides insight into real-world operations.

The comprehensive digital twin is the basis for improving the real-world version via simulation of the digital model, thus closing the loop for manufacturing operations and quality. In addition, it provides manufacturers with a mechanism to understand what will or could happen in the future. As a result, they can confidently use the digital twin for optimizing operations and predicting maintenance, plus enabling more efficient commissioning, better changeovers and faster production line changes. All are critical capabilities for business operations to conduct their business more efficiently. And a change in a digital environment does not cost anything; it's a zero cost. That encourages managers to examine a broader range of feasible approaches before committing to physical implementation on the production floor. ■



Computer Vision Transforms Production and Quality Control

AT A GLANCE:

- While computer vision is implemented in the manufacturing and automation industry for navigation and inspection, the technology has a long way to go before being deployed to its full potential use.
- Benefits computer vision can introduce to traditional automation and the manufacturing industry include current uses in inspection and navigation.
- Barriers to implementing computer vision on a wide scale include cost, complexity and environmental sensitivity.

Computer vision has the ability to transform production and quality control and allow for greater efficiency and flexibility.

by **Barry Clark**, Director of Robotic Software, Bright Machines

Modern technology is ushering the manufacturing industry into a new period of innovation, and at the center is the rapidly growing field of artificial intelligence (AI). More manufacturers are turning to technological advancements, advanced analytics and data-driven solutions to improve efficiency, streamline production and make operations more cost-effective.

In particular, computer vision—which has been studied for more than a half century—is experiencing a new spike in advancements. Like other branches of AI, computer vision began as a field of research that sought to mimic human behavior—in this case, perception—in software and robotics. Over time, it has evolved into an interdisciplinary field dedicated to algorithms and software that allow computers to automatically extract and analyze useful information from digital images and video.

The Basics of Computer Vision

Unlike the related topics of machine vision and digital image processing, the goal of computer vision is broader, enabling a "full-scene understanding" of imagery or a 360-deg. view. If we imagine the field of AI as the entirety of the brain, then computer vision would be the visual cortex (where visual information is processed). While this comparison is accurate enough, it fails to capture the full complexity and potential of this rapidly growing field.

Digital image processing refers to a broad branch of signal processing applied to images. It includes the general application of pattern recognition, feature extraction and classification and represents a set of tools used in computer vision. Machine vision is a subset of computer vision concerned with the engineering or industrial use of vision for automatic inspection, process control and robot guidance. Computer vision is a larger field than machine vision and comprises more fields than just signal processing, including machine learning.

Driving Efficiency and Flexibility

Machine learning and, in particular, deep learning, are large driving forces for technological improvements in computer vision. And as machine learning becomes more prevalent across industries with each passing year, so do unique applications of computer vision.

The applications are growing, with uses ranging from consumer electronics, autonomous driving and robotics to retail and smart agriculture. In agriculture, for instance, computer vision running on images taken from overhead drones can help farmers and farm equipment identify weeds and disease, and even estimate soil makeup and moisture content. AI-enabled farm equipment can accurately pick ripe crops without harming them while moving past crops that need more time to mature.

For the manufacturing and automation industry, computer vision has the potential to transform production and quality control and allow for greater efficiency and flexibility.

Transforming the Factory Floor

We are starting to see computer vision implemented more broadly in two categories: inspection and navigation. While many companies strive for solutions, the inspection process typically ends with a human operator verifying the final result. The next wave of computer vision promises to automate this process, allowing it to happen at various points along the production line.

By catching errors earlier and more consistently, computer vision will help reduce costs and improve assembly efficiency. It also has the potential to increase uptime, reduce manufacturing flaws and decrease the amount of custom hardware required.

Similarly, computer vision for navigation has largely been avoided unless absolutely necessary in the past. As the new wave of computer vision reaches the factory floor, many of the problems experienced with navigation in the past (i.e., drift over time, sensitivity to environmental conditions, etc.) will disappear, making its use in assembly automation more ubiquitous.

Another benefit is the way computer vision can help bring manufacturing closer to the consumer, also known as reshoring (or nearshoring). According to the 2021 Thomas Industrial Survey, the pandemic and its impact on supply chains have increased interest in reshoring. Of the manufacturers surveyed, 83% indicated that they were likely to reshore, an increase from 54% in March 2020.

In addition to supply chain management, automation and machine learning applications, including computer vision, can significantly offset labor costs. In this vein, computer vision technology can enable "micro-factories" or smaller operations that produce quality products closer to the consumer base.

Barriers to Implementation

Naturally, the most prevalent barriers to implementing computer vision are similar to other emerging technologies: cost, complexity and environmental sensitivity.

It remains expensive to upgrade factory operations with computer vision, from the cameras to the computer systems it requires. Moreover, incorporating the technology into the assembly line requires the services and oversight of skilled experts. While there are many computer vision experts in the field today, they are far from prevalent, and most industry technicians don't have the necessary training. However, this challenge may also represent an opportunity for reskilling and upskilling in the workforce.

But with current advancements, these issues will become problems of the past. And once these and other barriers are overcome, widespread implementation on the factory floor will follow.

Driving Resilience with Computer Vision

As computer vision continues to grow and improvements are made, the associated costs of implementing it will come down significantly. Similarly, as the technology becomes more mainstream, training and expertise in the field will expand as well. In the meantime, organizations that take the initiative to train employees to service computer vision software and hardware will be ahead of the curve as the technology becomes more widespread.

Ongoing research and development will also address technical issues, allowing for systems that are easier to use, more capable, less sensitive and more adaptive. This work is well underway and is being driven both by new technology and consumer demand.

Above all, the growing reliance of industry on machine learning will fuel the demand for more sophisticated visual systems. As computer vision becomes more common, cost-effective and easier to use, it will become a regular part of automation. For manufacturers, systems that can not only see but also recognize and understand will become an indispensable part of assembly solutions. ■

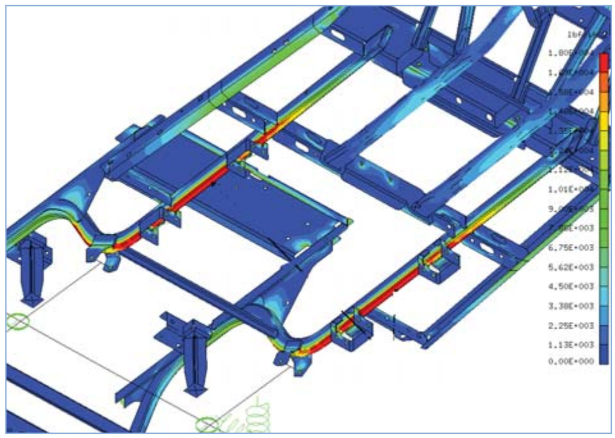
Physical Testing is Alive and Well Throughout the Engineering World

The real-world data provided by physical testing remains critical to the design, manufacture, quality and performance of products.

by Robert Farrell, President of Farrell MarCom, LLC, and Co-Founder of Revolution in Simulation.Org

In this digital world, it may be hard for some to believe that there's still a place for anything manual or physical—especially in the engineering realm. And, while it's true that today's technologies have cut into the dependence on physical testing, real-world data remains the lifeblood of the product lifecycle.

From product design to troubleshooting in-service equipment, next generation product planning and all phases in between, testing remains critical to the design, manufacture, quality, performance and evolution of virtually all products.



Test data collected in the field is applied to CAD model designs to verify structural integrity and identify areas of high stress and potential failure. *Six DoF Testing & Analysis*

New Product Development

For centuries the process to create or enhance a product consisted of building and testing a long series of prototypes. This build it/test it/break it approach was generally repeated until a satisfactory design was identified. While effective, the process was both costly and time-consuming—with these factors often limiting innovation.

Since the late 1960s technologies such as computer-aided design (CAD), computer-aided engineering (CAE) and simulation, have continually evolved to lessen the dependence on physical prototype testing and thus shorten development cycles. These tools allow 3D representative digital models to be created and analyzed for manufacturability, performance, durability and reliability at component, sub-assembly, assembly and product levels.

With up to 80% of a product's total cost committed in the early upstream stage, design is the optimum place to locate and correct potential geometry, performance and manufacturing flaws. Simulation not only removes much of the cost and time associated with the building and testing of multiple prototypes, but product innovation is enhanced as designers now have the time to explore design iterations.

Principals from Six DoF Testing & Analysis pioneered many of the testing tools, processes and methodologies that are now standard. The company's senior engineer, Garth Wiley, explains that while the impact of these digital tools cannot be overstated, this does not diminish the value of testing. In fact, over the past several decades, testing is largely responsible for the evolution and advancement of such tools.

"Data collected from products operating in their natural environment provides the baseline for these digital tools. Equipment operating in mining or construction environments, for example, is instrumented with sensors to capture exact loads, stresses and conditions to which these products are routinely subjected. This data is used to drive simulation models and analysis tools to predict if a new or modified design, material choice or application will meet performance targets," said Wiley. "With even a relatively small sample set, engineers can project the performance of that equipment, structure, machinery, etc. over its projected life. This provides designers and manufacturers with a quantifiable understanding of the viability of that product design."

It's safe to say that in the foreseeable future testing and data collection will continue to develop an even greater interdependence.

Non-Destructive Testing

One can verify that a part, product, or structure meets certain standards in many ways. For example, a car crash test is an example of a testing method where that being tested is destroyed. While this is acceptable for prototype testing, it is not acceptable for in-service equipment or parts coming off the manufacturing line.

Non-destructive testing (NDT), also known as non-destructive evaluation (NDE), includes a variety of analysis techniques used to evaluate the properties of materials, parts or systems without causing damage. NDT is widely used in maintenance, certification, safety or verification scenarios or in a manufacturing environment to verify that a part meets quality standards before being shipped to the OEM or customer.

There are several forms of NDT including Eddy-Current, Liquid Penetrant, Magnetic-Particle, Radiographic, Ultrasonic and Vibrational testing. Visual inspection is another form of non-destructive testing. There are also several variations/special techniques for some of these methods that can apply to certain applications.

These methods are routinely applied in industries where failure would result in significant hazard or economic loss. Examples include product quality inspection and weld integrity verification.

Capturing real-world operating data in the product's physical environment ensures that new products will meet performance and durability targets. *Six DoF Testing & Analysis*

Weld Verification

NDT is a common practice used to verify weld integrity for vessels and other structures and in-service equipment found throughout the aerospace, automotive, industrial manufacturing, petrochemical and power generation industries. This form of testing helps to ensure that the weld has the strength to do the job for which it is intended. For example, lawn mower decks contain structural welds that are designed to withstand vibration up to a specific level. But welds on a bridge structure are more critical. Manufacturers must be sure that the weld can handle tremendous loads and move without cracking.

Professional NDE Services Group offers third-party assistance for all NDT methods. The company's emphasis is on responsive, reliable and professional customer service and its services include Level 3 services, training, audits and Best-Practice implementation. The company's business development manager, Mark Koehler, says that weld failure can be traced to any number of areas.

"Weld failure is often traced to over-cycling, over-stressing... it might also be simply under-designed. Or in other words, the engineering wasn't correct on the front end. Improper weld technique can also cause failure—such as if the weld hasn't properly fused to the base material. Obviously, any inherent defects that are present in the weld can propagate and cause the weld to crack or otherwise fail."

Koehler sums it up by explaining, "Weld failure can be traced to any number of areas from engineering, design and materials, to processes, conditions or workmanship. Non-destructive testing allows welds to be evaluated before failure can occur."

Product Quality Testing

When defective products are allowed to leave the manufacturing facility, the results can be catastrophic. At a minimum, customer complaints and scrap rates are increased; but poor quality can also lead to excessive warranty claims, lost contracts or even litigation. Quality inspection testing is used at the manufacturing stage to detect structural flaws or to validate conformance to customer specifications before that product leaves the manufacturing floor.

This form of testing provides consistent and objective testing that is rooted in science and replaces manual processes that are open to subjective interpretation. Relying on the judgement of even the most experienced quality inspectors to determine what is acceptable (or not) as products roll off the production line creates opportunity for errors. When human judgment or emotion is at the center results can vary from one inspector to the next or from one day to another.

However, removing subjective interpretation from the equation is not always easy. For example, supplier requirements might call for the product to satisfy any number of specific design and performance specifications and be free of other objectionable noises. But how does one quantify what is objectionable?

Fortunately, technology has emerged that allows suppliers to inspect every part that they manufacture to identify flaws and ensure conformance to rigid specifications.

Quality inspection must be repeatable, consistent, metrics-based and above all "objective." Because of this, many suppliers rely on automated end-of-production quality inspection technology from Signalysis to verify that parts are defect-free. As a provider of testing systems, the company has built a reputation on detecting product flaws and protecting the reputation of its manufacturing customers.

This thorough, highly technical and systematic approach begins by gathering customer specifications. This could be anything from specific failure modes—such as ticking in a motor, excessive noise or rattling, modal parameters for rotors or an OEM's general specification to the non-descript "other objectionable noises" catch-all. The next step is to acquire baseline data on a sample of parts to help quantify and differentiate acceptable from non-acceptable. Ideally these test parts represent the full range for each failure mode, including those that do not meet quality standards, borderline parts and acceptable parts.

Equipment Troubleshooting

Field troubleshooting or problem-solving is another form of testing. When a key piece of equipment, such as an industrial motor, fan or generator is down, fast and decisive corrective action is critical. Testing is used to not only identify the cause of the problem, but to evaluate and determine the best corrective steps.

For example, rotating equipment, with its multiple components and sub-assemblies, is subjected to varying vibrational forces. While certain levels of vibration are inherent to the normal operation of pumps, fans, gen-sets and similar equipment, sometimes vibration levels become excessive. As vibration increases, equipment and supporting structures are susceptible to cracks, fatigue and catastrophic failure.

When troubleshooting rotating equipment, it's important to quickly determine the root cause of the problem(s). A cracked fan blade, bent shaft or crumbling foundation may or may not be the result of poor design, manufacturing or installation. The culprit could be vibration originating from the unfavorable dynamic interaction of otherwise good systems or components.

When troubleshooting rotating equipment, it's best to adopt a system-level approach. Because each subassembly is generally designed and manufactured independently, little consideration may have been given to its interaction with other units when installed as part of a larger system. Premature wear, excessive or abnormal maintenance, high vibration and/or structural cracking are indicators of a serious, potentially catastrophic issue that should be addressed immediately.

The Future of Testing

There's no question that engineering analysis, simulation and similar technologies have had an impact on testing. Product development cycles and associated costs have been reduced as the number of physical prototypes needed to validate next generation products has been reduced significantly.

However, as today's digital infrastructure and collaboration tools evolve, testing will continue to adapt to fully leverage these (and similar) technologies. Expanded internet bandwidth and greater cloud data storage, along with advancing sensor, Bluetooth and imaging technology, will ensure more economical uses of the test engineer's time.

"In a growing number of cases we're able to leverage a customer's in-house resources without the time and expense to send test engineers onsite," said Wiley. "Through today's hi-def imaging and collaboration applications we're able to guide test setup, collect data and monitor tests remotely."

It's safe to say that in our physical, mechanical, physics-based world, there will remain a need to identify flaws, ensure structural integrity, troubleshoot problems and provide the real-world data needed to confidently design tomorrow's products. ■

Converters Turn Analog Sensors into I/O-Link Outputs

WAGO's new IP67 rated I/O-Link analog converters offer a solid and cost-effective solution for incorporating conventional analog sensors and actuators with I/O-Link communications. The 765-2702/200-000 has two 0-10 VDC inputs that are converted to I/O-Link for monitoring field level sensors. The 765-2703/200-000 has two 4-20ma analog outputs while the 765-2704/200-000 has two 0-10 VDC analog outputs. Both devices will convert I/O-Link signals to analog outputs and all of these devices can be set up using I/O-Link configuration tools such as WAGO's I/O-Link configurator software. These devices are ideal for new systems as they take advantage of the benefits offered by I/O-Link. Users who wish to update older systems to digital communications can also leverage these compact IP67 devices.

WAGO

www.machinedesign.com/21266445

Mounting System Offers Flexible Use of Vision, Scanners

AutomationDirect has added Swivellink Standard series device mounting systems to its Barcode/RFID/Vision product category. Device mounting systems are assembled using several components and can be configured to mount vision cameras, lights, sensors and scanners. They allow for precise adjustment and ease of equipment installation. These mounting systems are modular, and components are selected individually to suit the needs of the application. The systems are custom-configured and start with a base, which is fastened to the mounting surface. Then a link or tee is connected using knuckles which provide full rotational adjustment. Mounting plates finish the mounting system, predrilled for specific manufacturer equipment or blank for custom drilling. Components are available in metric or imperial units and include bases, knuckles, links, tees, mounting plates, sensor mounts and optional clamp handles.

AutomationDirect

www.machinedesign.com/21266444

Flushing Rings Offer Accurate Measurement, Fast Assembly

The Rosemount 319 Flushing Ring with valve-integrated design from Emerson accurate differential pressure measurement and lower maintenance suitable for a wide range of differential pressure applications. Available in traditional and compact options, the Rosemount 319 Flushing Rings provide a process-to-seal connection and allow for faster diaphragm seal maintenance without disconnecting them from process flanges.

EMERSON

www.machinedesign.com/21266450

Panel Mounted Fuse Holder Offers Small, Light and Robust Protection

SCHURTER's FRM-A panel mount fuse holder with DRM-A SMT fuse is a small, light and robust circuit protection solution designed for avionics applications. The extreme-performance circuit protection system is the most compact in its class, measuring <15 mm deep behind the panel. The FRM-A fuse holder was originally designed to withstand harsh environmental conditions in the avionics industry, qualified for use up to 50,000 feet. However, its modest dimensions and high ingress protection rating of IP67 make it ideal for use in any challenging environment. The FRM-A has successfully passed vibration, shock and salt mist tests according to NF C 20-7XX and IEC 60068-2-XX, confirming its exceptionally robust design. It is built according to UL 4248-1 and CSA C22.2 no. 4248-1 and developed exclusively for use with SCHURTER's SMT ceramic fuse DRM-A. Used together or the fuse separately, the FRM-A and DRM-A have a broad range of application use in industrial markets, AV/IT applications according to IEC/UL 62368-1, as well as household appliances according to IEC 60335-1. The fuse holder and fuse combination also comply with end-user safety and sustainable product standards, and correspondingly carry the marks for CE, UKCA, RoHS, China RoHS, UL, Halogen Free and Reach.

SCHURTER

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Ad Index

DEI ROUNDTABLE: Key Associations Highlight Progress and Next Steps

by Rehana Begg, Editor-in-Chief

Machine Design, in collaboration with the Endeavor Business Media Design & Engineering Group's WISE (Workers in Science and Engineering) initiative, recently assembled a panel of association leaders to reflect on progress made in Diversity, Equity and Inclusion efforts. Though their value propositions differ, our experts were able to show how their investments point the way to the future.

Our roundtable consisted of Monica Moman-Saunders, professional engineer and fellow, ASME (American Society of Mechanical Engineers); Dr. Roberta Rincon, associate director of research, Society of Women Engineers (SWE); and Jackie Mattox, founder, president and CEO, Women in Electronics.

Below, an abridged version of their conversation captures an essence of their work.

Rehana Begg: How does DEI show up in your association's value proposition?

Monica Moman-Saunders: ASME's approach is to change the culture of engineering. We are advancing DEI internally through volunteer engagement and by providing accommodations for people with disabilities, by fostering inclusivity in event participation, enhancing inclusivity for working parents, and supporting women and career empowerment.

DEI is showing up in our organization's strategic plan through our outreach…We're opening roads to technical careers through an initiative with community colleges and partnerships with historically black colleges and universities (HBUs) to help align engineering curriculum more closely with market needs.

Roberta Rincon: The Society of Women Engineers is a diversity serving professional association. Our 40,000-plus membership is predominantly women. We empower women to achieve their full potential as engineers and leaders, and we strive to demonstrate the value of diversity and inclusion…It's only recently that we have considered ways in which we, as an organization, can serve as a DEI model for others.

Our strategic plan includes four broad goals, one of which focuses specifically on DEI and belonging (DEI&B). The goal states, "We will champion intersectional diversity within engineering and technology and model an inclusive and equitable environment." Under this goal we have strategic objectives that we aim to achieve over the next three years.

Jackie Mattox: At Women in Electronics, we focus on gender parity, opening the opportunities for women in the electronic component industry and related end-user markets…We enlist our male counterparts to be allies and sponsors in this effort… Our goals are to empower, advocate, develop and celebrate. Mentorship is huge part of what we're doing. We're connecting Europe and the United States right now with industry veterans and mentors that could mentor our members.

RB: Has investment increased/decreased/stayed the same? Has sponsorship grown?

MM-S: "As of late, we've even seen some donors inquire about our DEI initiatives...I'd say our investment has increased, and so has the sponsorship.

RR: We need organizations to be comfortable to put up a mirror and say, "Okay, if we're serious about this, then we've got to see where we are right now and really make those changes that are needed."

RB: "Diversity fatigue" is not a new phenomenon, but it basically refers to the stress associated with laborious attempts and fears associated with trying to diversify the workforce. When people are overwhelmed, disheartened, how do we continue to demonstrate that DEI initiatives are institutionally beneficial?

JM: It's an evolving conversation. It's about how well can you pivot, and how well can you take in new information and communicate it back to stakeholders and members in a way that's digestible and useful?…We try to simplify a very complicated subject. So, practice agility; we adapt, we change, we take in new information, we adjust to that.

MM-S: We have to meet people where they are, and recognize that everybody is at a different point on the spectrum…The strategic measure we can take to stem fatigue, is to be intentional, to stay engaged and to keep focusing on the task.

RR: Globally, we're paying attention to DEI, tying funding to some of this work and bringing greater recognition to the contributions of those who have been overlooked historically. We've got to push initiatives we believe are going to create the systemic change needed to create the inclusive climate and culture within these STEM spaces that is just missing. ■