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Editorial

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It's Always the Right Time for Improvement

The arbitrary passage of time has less importance than what we actually do with the time we have.

It's traditional to get both sentimental and optimistic as a new year arrives. Both are valuable emotions, particularly in these days, but neither have much to do with the changing of the calendar. Optimism isn't seasonal; neither is sentiment. It should be among our daily tasks to embrace both whenever practical.

Practicality is the key to it all. It is the clear-eyed assessment of our problems and the available solutions that drive process improvements. Where solutions aren't available, innovation is the typical outcome. It is the completion of the problem solving that drives our optimism. It almost never works the other way around.

There are several theories around the concept of time. Most people see it as linear, and while there are theories from Einstein to Newton that perceive it in other ways, the simplest way to account for time is that it continuously moves from one moment to the next. The inventions of calendars and watches are human constructs that measure time, but they are not time itself.

So the arbitrary passage of time—in minutes, days, months and years—has less importance than how we spend the time we have.

That is the idea around continuous improvement, one of the areas we explore in this first issue of the new year. Improvement is another concept not bound by the calendar. We always have the opportunity to improve. We can analyze the world as we find it and see ways where we can be more efficient. For some of us, the new year is a time for resolutions, but for the person focused on continuous improvement, those resolutions are less about timelines and more about goals and objectives.

Etiamos/Dreamstime

We *should*, of course, resolve to get better at everything we do. The program we put in place to achieve improvement can be time-based and goal-based, but when we achieve the goal, is that the end of time? Continuous improvement advocates say it is not, and I'd tend to agree. We have to keep reaching for what is next, and we have to keep searching for better.

I've spent my entire career on deadline, and I can tell you those occasions where I've bumped up against a deadline are almost always a function of poor planning or poor execution. There always are exceptions; a few late nights in the newspaper industry were driven by external events instead of internal deadlines. The solution was to move the deadlines, but that required a process in place to adjust operations. It also had the effect of creating a plan for the next such event. We practiced continuous improvement without even knowing it.

Time is not the enemy of improvement; it also shouldn't be the motivation for it. If your continuous improvement plan begins in January 2022, great. If you're in the midst of such improvement, time-based benchmarks are one way to evaluate those projects. The focus should be on the improvements, however.

When it comes to getting better at what we do, there's no time like the present. ■

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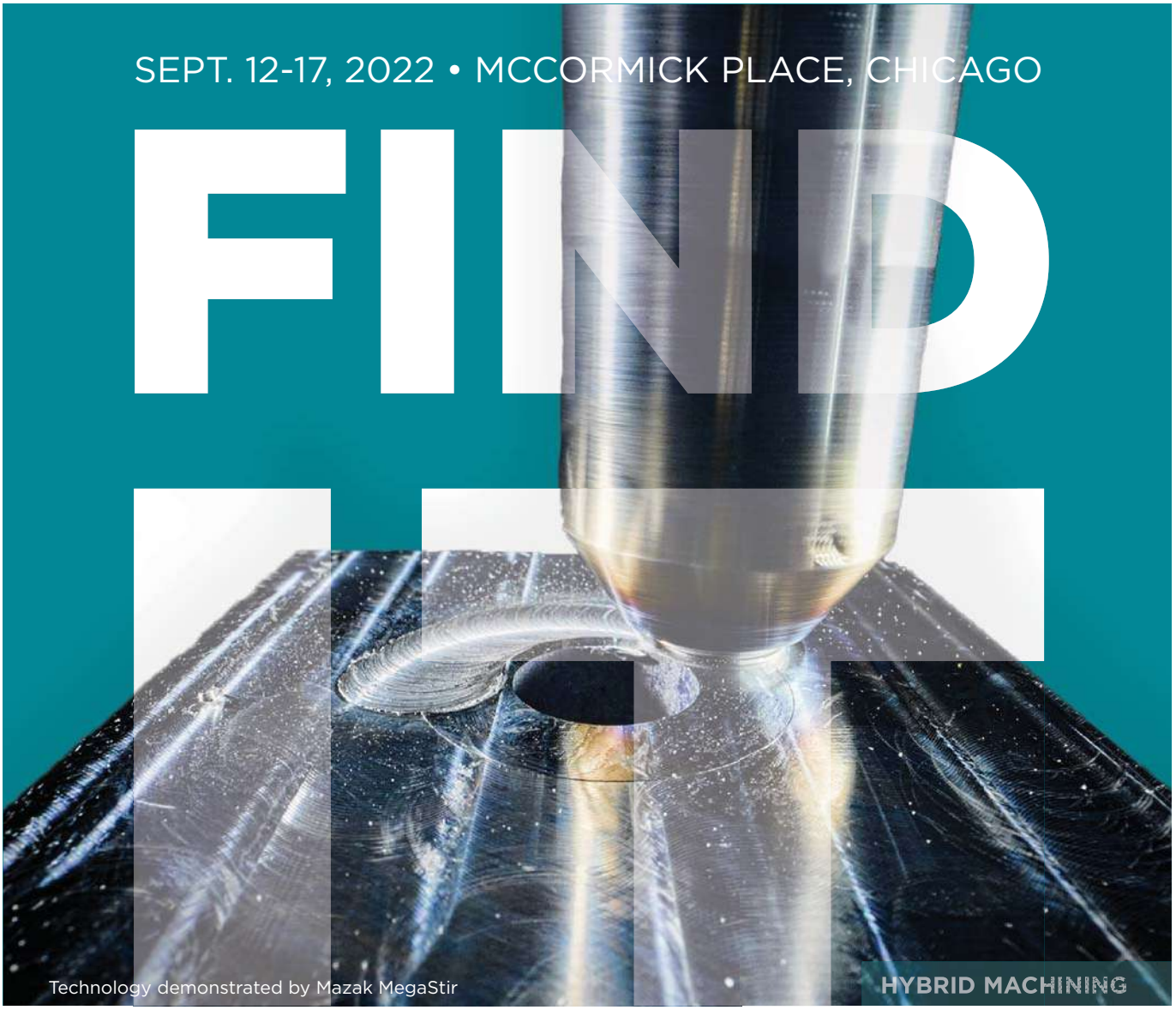

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News

What's Next for Productivity?

Mobilizing the Workforce

How productivity software can enable companies to temporarily suspend mobile apps based on the work being performed, the work location or even the user.

Tap. Scroll. Drag. Click.

After years of being piloted with varying degrees of success, the use of mobile technology in industrial settings is running at full tilt.

Much more than tools for providing remote access, the latest offerings in enterprise mobility tools signify not only a change in the way organizations manage production floors, but also the way they engage their employees.

When employers adopt mobile tech into their workflows, employees tend to perform better in their roles, improving productivity and efficiency, said Joe Boyle, CEO of Truce Software, a provider of contextually-aware mobile device management solutions.

Joseph Boyle, CEO, Truce Software

The pandemic, Boyle said, proved to be a stress test for enterprises trying out new mobility processes and propelled decision-makers toward viewing digitalization as crucial to shaping business opportunity.

According to a recent report, *IDC FutureScape: Worldwide Digital Transformation 2021 Predictions*, "digital first" dominates in every experience, with 60% of enterprises noting they will invest heavily in digitalizing employee experience in 2021. The effect will transform the relationship between employers and employees.

Planning ahead, companies will routinely need to consider the tools that support their workforce. With people returning to offices, said Boyle, enterprises have shifted to a new mentality that takes into consideration how to leverage technology to accomplish more and work faster with virtual teams.

AT A GLANCE:

- As more and more industrial enterprises design mobile-first strategies, the use of handheld devices, such as smartphones and tablets, are taking centerstage.
- Configured to fit the requirements of the job and the device policy of the organization, mobile applications can respect privacy while improving safety and productivity.
- Joe Boyle, CEO, Truce Software, helps companies become more flexible and resilient in the face of disruption and more mature in the post-pandemic era.

"It opened up a world of possibility for people around the world to contribute to the working environment from wherever they are," said Boyle.

Digital-first Mentality

Historically, mobile technology was designed to first serve the laptop or desktop computer user. But the current generation of mobile computing starts with the smartphone as the central form factor, noted Boyle, who has 20 years of experience building software-as-a-service (SaaS) and software business models.

The Lisle, Ill.-based Truce, which offers a contextually-aware mobile device management solution, essentially focuses on how workers and companies get the best out of mobile technology without succumbing to some of the downside risks. If used inappropriately, mobile devices can present liability issues associated with personal safety and data privacy and security, Boyle explained.

Truce focuses on harnessing the user's context into the task of managing the acceptable and productive use of mobile technology in the workplace. "What's going on around the device is as important as what's happening on the device itself," Boyle said.

"It takes a different set of technologies and processes to facilitate one's work when one is away from the corporate facility and working remotely," he explained. "COVID-19 and work-from-home realities have really opened everyone's eyes to the unique challenges of doing work away from a corporate office.

"It's taken all of the executive teams and the traditional office-based staff and put them out into a proxy for what field-based workers live every day…and that's leading to some really smart and effective investments in how companies support their mobile-first policies."

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Trust and Privacy

Whether enterprises provide company-issued devices or enforce BYOD (bring your own device) policies, secure access can be achieved when only applications relevant to the job function are installed and managed so that data remains protected for the organization and the employee.

The ability to control the permissions of a mobile device based on the context of the employee is a gamechanger, as it minimizes non-work-related distractions, improves productivity and provides a measure of protection, said Boyle.

Cybersecurity remains a primary concern in information systems infrastructure, and enterprises need to consider security measures (such as firewalls) along with managing the rights of active users.

At the same time, organizations need to be transparent about how they use information, Boyle noted. "At Truce, we're a mobile-first environment, but privacy is an essential component of mobile first," he said. As a solution provider, the firm subscribes to the ideal of being transparent.

Establishing trust is essential, emphasized Boyle, who said his company will neither gather, store or monetize data, nor will it provide insights into what enterprises are doing with their mobile devices.

"I do the majority of my work on [my iPhone] throughout the course of the day," said Boyle. "This device also has all of my credit card information, and every photo that I've ever taken of my kids is on the device. While this is a work device, it is deeply personal to me. And that's one of those shifts that has taken place.

"I have never felt personally connected to my computer or my laptop at work, but that's not true for our mobile devices. So, that element of trust and privacy is absolutely essential for anything we do to deploy mobile devices in the workplace today."

How Context Mobility Works

Contextual mobility management (CMM) software, which resides on an employee's smartphone, identifies or senses pre-set zones—such as when the employee is driving, operating machinery on the plant floor or moving through a highly secure environment, as well as when the employee is outside of the work context. CMM recognizes the different aspects of each work environment, but also changes the user experience so they can operate their devices in a relevant, appropriate or safe context at any given time.


Truce Software

Truce Software works by identifying situational triggers and adapting what users can do on their device in the moment, explained Bruce. The company uses the mobile device's network connections, which could include the IPS (indoor positioning system) and GPS (global positioning system) navigation, as well as geotagging, Wi-Fi access point triangulation, sensors, proprietary beacon technology and other emerging technologies to understand the context in relation to the user's profile, the location and proximity of the mobile device.

A mobility server and its contextual logic engine is the foundational infrastructure in CMM deployment. It follows the user's movements, determines the appropriate actions and populates a smart device with control information relative to the employee's responsibilities at that location.A field operator who needs access to SCADA data, for example, may log into a plant and download maintenance histories and procedures, but may also have access to function controls that suppress alarms related to equipment repair. Only the functionality needed for the user's role is presented on the screen. "It's an intelligent, dynamic adaptation of the user experience," said Boyle.

Emphasis on Employee Experience

Companies aiming for digital transformation (DX) examine every opportunity to modernize and improve current operations. But wholesale digital transformation requires a fundamental shift in thinking, and Boyle argued that embracing digital technology such as contextual mobile device management for all interactions and all processes is an essential component.

The use of mobile devices in workplaces is an underserved area in business operations, said Boyle, and its use will expand to more functions, particularly in the areas of wearables and to ensure worker safety in high-risk environments.

These mobility trends, combined with other IIoT trends (such as AI adoption, wireless connectivity options and automation), will continue to accelerate to create mobile working environments that are more productive and safer for those working on the shop floor or on remote sites. "I think that the pandemic has really opened people's eyes to how we can better enable our workers with mobile technology," said Boyle.

Digital design and innovation are undergoing a shift towards strongly considering the user experience, said Boyle. "At the end of the day, it's always been about the people and how to give people what they need to get their job done." ■

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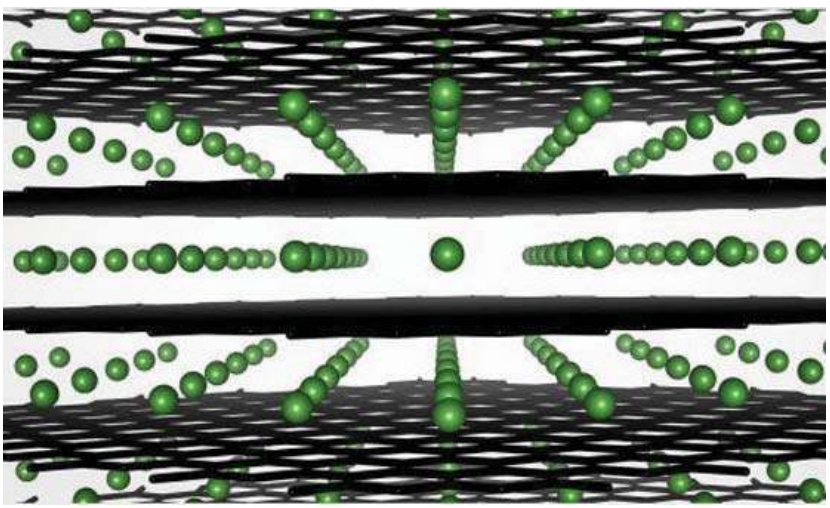


This illustration shows intercalation of lithium ions (green) in a graphite anode. *Argonne National Laboratory*

RESEARCHERS AT THE Argonne National Laboratory have uncovered some interesting chemical behavior in Li batteries that partially explain why they can't yet be recharged quickly.

Lithium-ion batteries, like most other batteries, have a positively charged cathode and a negatively charged anode, and they are separated by an electrolyte that moves lithium ions between them. But the anodes in Li batteries are typically made of graphite assembled out of small particles.

Lithium ions can insert themselves inside graphene anodes in a process called intercalation. If intercalation takes place normally, Li batteries successfully charge and discharge. If an Li battery is charged too quickly, however, the ions aggregate on the anode's surface, creating a "plating" that damages the anode.

"Plating is a main cause of impaired battery performance during fast charging," says Argonne battery scientist and researcher Daniel Abraham. "As we charged Li batteries quickly, the team found it plated the anode but also caused a buildup of reaction products inside the electrode's pores." As a result, the anode undergoes irreversible expansion, which degrades the battery's performance.

Using scanning electron nanodiffraction, the team also discovered another change in the anode's graphite particles. At the atomic level, fast charging distorts the lattice of graphite atoms at the particle edges, and this upset the intercalation process. "Basically, the atomic network in the graphite becomes warped, preventing lithium ions from finding their place inside the particles," Abraham said. "Instead, they plate on the particles...The faster the Li battery is charged, the more atomically disordered the anode becomes, which ultimately prevents lithium ions from moving back and forth between the anode and cathode."

He adds that there are two ways to solve this problem: Either find ways to prevent the disorder, or somehow modify the graphite particles so that the lithium ions intercalate more efficiently. ■

Framestock Footages/Dreamstime

MAKING ROBOTS Easier to Use

MEMBERS OF ADVANCED ROBOTICS FOR MANUFACTURING (ARM), a group of more than 300 organizations in industry, government and academia fostering a strong national robot-based manufacturing environment, are working to make robotics more accessible to manufacturers of all sizes and in all industries. One of the group's goals is to break down proprietary barriers that make it difficult to combine and interconnect different robot

platforms, thereby eliminating barriers to technology adoption and providing vendor-agnostic plug-and-play platforms for smart manufacturing.

Currently, robots and robotic components from different manufacturers are rarely able to "talk" with each other, which greatly reduces flexibility and increases complexity—especially in small- and medium-sized companies that lack the staff or skills to manage all of these different components.

Here are three ARM-funded initiatives that are trying remedy that situation.

The teaching pendant is the most common method used to operate, control and program industrial robots. Unfortunately, these pendants are vendor-specific and usually cannot accept additional inputs from such useful tools such as machine vision and torque sensors. ARM's "Teach Pendant" project aims to bridge this gap with an open-source approach.

Robotic QA of complicated metal parts that can be conducted 24/7 and without human intervention would reduce the number of defective parts and lower manufacturing costs. Developing the necessary technology for such a goal is another ARM project (Automated Defect Inspection for Complex Metallic Parts).

An ARM team is working on a method to collect imaging data that is robotically collected to quickly analyze surfaces and profiles using AI. In tests, the approach has yielded good results, including detection rates above 95% and an expected 345% return on investment if deployed at one site. GKN Aerospace is already adopting the technology by building such an inspection cell in a factory.

ARM is also looking to expand robotics to industries that currently do not or cannot use robots. The apparel industry, for example, must rely on a lot of manual labor due to the difficulties in handling limp textiles. ARM's project, the Robotic Assembly of Garments, is trying to overcome this limitation by developing a robotic assembly process that temporarily stiffens garment pieces by laminating them with water-soluble thermoplastic polymer, thus simplifying automation.

The polymer is easily removed by washing and can be recycled for use in several cycles. The technology was successfully demonstrated at a Bluewater Defense production facility and is being further developed to handle more complex sewing operations such as medical gowns and face masks. ■

TRICIA HATLEY | Immediate Past President, National Society of Professional Engineers

Pavel Shlykov 195353446/Dreamstime

Engineering Your Career, Part 2: Licensing

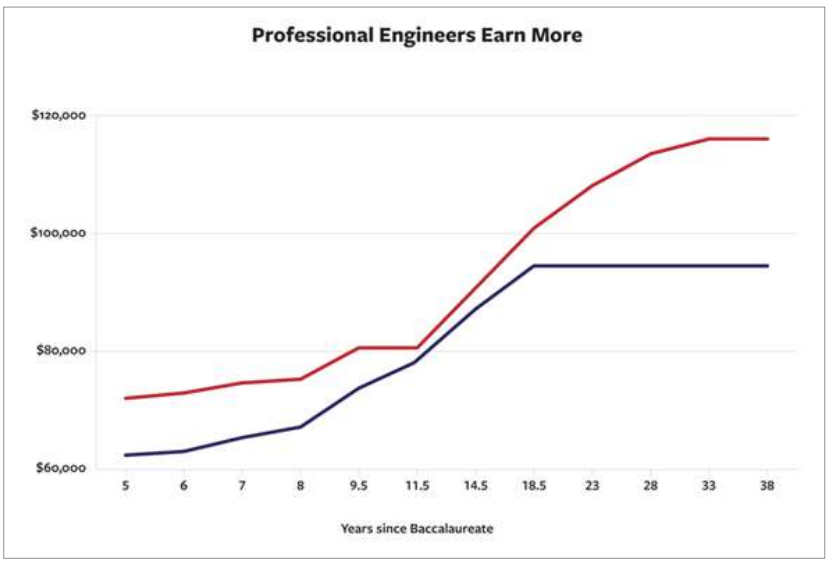
The PE license and engineering excellence.

An important step in an engineer's career is obtaining a professional engineering license. The license, and the PE after your name, sets you apart from others and tells the public you have the education, experience and qualifications to solve their engineering problems. To understand the value of a PE license in relation to an individual career, here's a look at the history of licensure in the U.S., the value of the PE and challenges to the current licensing system.

History

It is common to see professions and occupations regulated through a licensure system, but it wasn't always so. As late as the early 1900s, anyone could practice engineering, and this put public safety at risk. Engineer David Steinman recognized the risk to the public and was concerned about the situation, so he began advocating for a licensing system for the competent and ethical practice of engineering.

In 1935, Steinman said: "The technical problems of civil, mechanical, electrical, mining and chemical engineers are divergent; but the professional problems are alike. The technical societies, for the best fulfillment of their essential purpose,



This graph shows the average salary of engineers based on if they have a PE license or not and how long it has been since they earned a B.S. in engineering. (Red: engineers with PE licenses; blue: engineers without PE licenses.) *American Association of Engineering Societies*

are divided on lines of differentiation of technical branches or specialties. This division into separate organizations, with diverse traditions and viewpoints, prevents effective united effort for the interests of the profession. A single national professional society with solidarity of purpose and concentration of strength is needed to effectively provide for the professional interests of the engineering profession."

Professional licensure is a responsibility delegated to each state by the U.S. Constitution, but Steinman saw the need for an organized effort to establish professional engineering licensure across all the states. To reach this monumental goal, Steinman crafted a framework for creating the National Society of Professional Engineers (NSPE). It was then founded in 1934 with the mission of advocating for establishing PE licensing in all the states to protect engineers (and the public) from unqualified practitioners, build recognition for the profession, and stand against unethical practices and inadequate compensation.

In 1907, Wyoming become the first state to adopt a licensing system. By 1959, when Alaska and Hawaii were granted statehood, all 50 states had licensing systems.

In 1920, as state licensing boards recognized the need for a national council to make rules and laws more uniform and promote mobility of engineering licenses, the National Council of Examiners for Engineering and Surveying (NCEES) was created. Today, the council's members are comprised of the 69 engineering and surveying boards from all U.S. states and territories. Through NCEES, states and territories have worked to provide uniform model laws and rules, promote professional ethics among engineers and shape the future of professional licensing. For more than 100 years, public health, safety and welfare have been improved by the protections provided through engineering licensure laws.

The Value of the PE

Through rigorous standards for education, experience and examination, the PE license protects the public health and safety from unqualified practitioners. But what does it mean to individual engineers? Simply put, it means options and money.

Although a PE license is not required for all engineering jobs due to industry and government exemptions, it is required for many. In many states a person must hold a PE license to own an engineering firm, provide consulting services and to call themselves an engineer. If someone chooses not to obtain a PE license by earning a degree from an approved college or university, passing the necessary exams upon graduation and working under a licensed professional engineer for the prescribed time, they limit their options for employment and most likely reduce their earning potential.

In the rapidly changing world, young professionals and students should keep all options open and available. Obtaining a PE license does just that. Data clearly shows that engineers with PE licenses earn more money than those who don't.

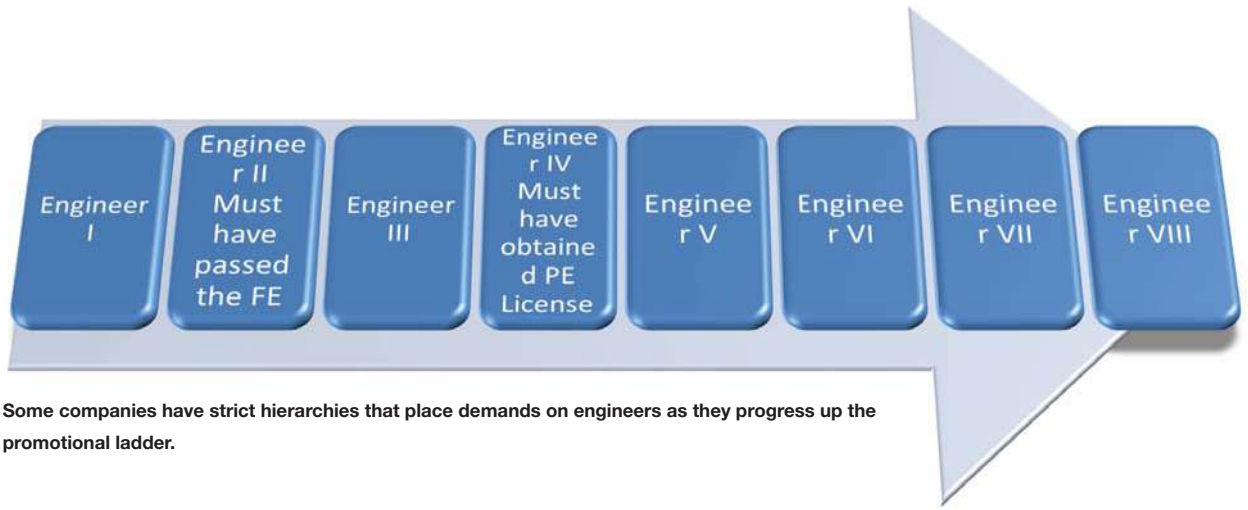
For example, at my firm, the career ladder for engineers starts at an Engineer 1 (a new graduate) and progresses up to an Engineer 8, with pay increasing as a person moves up the ladder. To move to an Engineer 2 position, a person must pass a Fundamentals of Engineering (FE) exam, which is also a requirement in earning a PE license. To advance to Engineer 4, they must get a PE license.

An Engineer 4 makes significantly more money than an Engineer 1 or 2. More money and more responsibility equate to challenging and rewarding opportunities and job satisfaction.

Pressures for Change

If a PE license is so valuable and necessary, why are there so many exemptions? Why are state license boards under continual fire to abolish licensure? Perhaps a change is needed so that the license's value, and the protection it affords to the public, remains constant in our ever-changing world.

The debate over the government's role in regulating occupations and professions has recently come to the forefront. According to the Bureau of Labor Statistics, occupational licensing directly affects nearly 30% of U.S. work-



Some companies have strict hierarchies that place demands on engineers as they progress up the promotional ladder.

ers, including barbers, cosmetologists, florists, interior designers and many others. Although the work of professional engineers—like that of doctors, registered architects and attorneys—clearly affects public health, safety and welfare, it is not uncommon for state legislatures to categorize highly educated and trained PEs with barbers and cosmetologists in the debate over eliminating occupational licenses.

For example, 2015 model legislation championed by the American Legislative Exchange Council (ALEC), an association of state lawmakers that supports private-sector interests, led to a recommendation that would have eliminated PE licenses in Indiana.

As the result of extensive advocacy efforts by the Indiana Society of Professional Engineers and NSPE, the Indiana Job Creation Commission, inspired by ALEC's model law, rescinded its troubling recommendation to eliminate licensure of professional engineers. However, nearly identical versions of this legislation were quickly introduced in several other states, and variations of that legislation persist today across the country.

Although ALEC's legislation does not specifically target PEs, it opposes occupational licensure in general. This broad attack undermines PE's value and unintentionally affects engineering licensure. Clearly this is an attempt to muddy the difference between occupations and professions. Much work remains to be done in educating the public and especially legislators on what licensed professional engineers do and why they are critical to the continued health, safety and welfare of the public.

There is no doubt that new and better technologies will continue to be developed and implemented, often at breakneck speeds. And while new technologies aren't inherently bad, they should be developed so that the public health, safety and welfare are protected.

In dissecting this issue, it is important to first understand the form these challenges take when introduced to state legislators. The repeated legislative threats to our licensure system come in various forms but can be grouped into four categories:

- Consumer choice
- Least restrictive
- Right to earn a living
- Universal licensing

Consumer-choice legislation is the most dangerous of the licensing threats because it seeks to let anyone practice any profession, regardless of whether they are licensed. NSPE refers to this as "buyer beware" because it places the onus entirely on consumers to determine if someone is qualified to practice engineering. This is problematic as the public generally doesn't understand engineering and how to select qualified professionals. Additionally, the work of engineers affects not just the individual buyer; in many cases it also affects the public at large. For instance, do consumers have a say in selecting the engineers who will design the bridge they will drive over or the trains and planes they will ride in?

Legislation commonly referred to as "least restrictive" is also a significant threat because it assumes market competition will protect the public. This assumption removes preventative measures in licensing regulations intended to protect the public. The only recourse for consumers comes after something has gone wrong. Even then, consumers are limited to legal actions.

Right to earn a living legislation comes primarily from the American Legislative Exchange Council. ALEC has developed model legislation that requires a state's licensing boards to review all licensing regulations. Typically, this type of legislation uses the "least restrictive" approach described above.

The fourth type of legislative threat comes in the form of universal licensing. These bills are not a threat in and of themselves, but they occasionally include language that lowers the standards required for licensing. For example, they may let applicants substitute work experience for education or may not require that the applicant's original licensing state have the same education and experience requirements. Sometimes this legislation seeks to prevent a state from requiring a state-specific exam, which is problematic for states such as Alaska, Florida and California that require additional technical knowledge to address local issues, such as seismic activity.

Emerging Fields

There is no doubt that new and better technologies will continue to be developed and implemented, often at breakneck speeds. And while new technologies aren't inherently bad, they should be developed so that the public health, safety and welfare are protected. Ensuring the ethical development and testing of new technologies, such as autonomous vehicles, and including a professional engineer in developing and deploying those technologies can help. To date, much of the discussion on emerging technologies has been about their capabilities and perceived public benefits, but many questions remain unanswered, especially around ethics:

- How will these technologies affect our behavior and interactions?
- How can we guard against mistakes?
- How do we eliminate bias in these technologies?
- How do we keep technology safe from safe from terrorists or countries with ill intent?
- How do we protect against unintended consequences?

Answers to these questions and many others must be found so the considerable risks can be mitigated, and society can reap the full benefits of emerging technologies. The public's interests are best served when licensed professional engineers oversee the design, development and deployment of emerging technologies to address uncertainties. Engineers as a profession and individual professionals should contribute to these emerging fields and use their knowledge and experience for the greater good.

Professional engineers should use their influence and prestige to mentor others and help develop future engineering leaders. Engineers who have not obtained their PE licenses should learn more about the process and the opportunities a license provides. And engineers should help elected officials and decision-makers understand the value of engineering and its impact on people's daily lives. ■

THIS IS THE SECOND PART of a four-part series on how engineers must adapt in these changing times. Part I covers the challenges of engineering, Part III covers personal and professional development, and Part IV looks at risk-taking.

MARIO DeVINCENTIS | Engineering Manager, Schneeberger Inc.

From design to prototype to installation, specifying linear motion in the medical device field is as exacting as its role in helping find cures and save lives.
Schneeberger, Inc.

Linear Motion a Lifeline in Medicine

Medical and clean-room applications carry specific design and operational challenges.

Life science, medical and biomedical equipment manufacturers must constantly pursue improvements in advanced technology, workflows and processes to pursue competitive pressures and market growth. But progress cannot only focus on expanding success; it must also ensure precision, reliability, functionality during operation—the prevention of in-use failures.

Neglecting improvements and safeguards in one seemingly minor component of in-process linear motion systems can generate consequences ranging from inconvenient to catastrophic. Manufacturers, as well as users, must remain vigilant.

With the proper focus, next-generation linear motion systems can be specified, designed, installed and maintained to advance and ensure the benefits of life science, medical and biomedical equipment in vital and even lifesaving applications.

Consequences

Because reliable linear motion is an operational necessity, equipment manufacturers and equipment users must monitor even relatively rare failure risks in linear motion components or systems throughout the process. This concern includes equipment ranging from DNA sequencing to bioprinting to atomic force microscopes (AFMs).

The stakes are enormous.

Failure of a single part or system can cost equipment users hundreds of thousands of dollars for even a relatively short-duration downtime event. Depending on location, severity and response time for repair or replacement, costs could mount to a great deal more.

The personnel safety risk is another paramount concern. While rare, design flaws or failure to follow operational safeguards can lead to anything from pinch points to runaway stages and cause damages from crushing injuries to electrical shock.

Specification and Design

Linear motion manufacturing facility be fully ISO-certified to ensure consistency in all its key processes. In addition, meticulous prototype builds help uncover steps that are key to maintaining the performance and the reliability of the finished motion component or system. Missing or not correctly performing any of many small, crucial steps in assembly or testing could ultimately lead to a failed system in the field.

Many manufacturers also establish targets that translate into many years of reliable service before an equipment upgrade. It is therefore important to properly calculate component service life. Because duty cycles may vary from application to application, service life is stated in kilometers traveled for many linear motion components. The linear motion maker must then translate that calculation into various decisions about the product.

For example, one widely-used cable specifies more than 10 million flex cycles if a 50-mm or greater bend radius is maintained. But, if the bend radius is not correctly sized, particulates falling from the cable or stress on the cable tracks or connectors could conceivably cause early failure in the process (especially where maintenance schedules are not strictly observed).

Consider Customization

Off-the-shelf parts play a critical role in many equipment assemblies. One concern, for example, is that a stock linear motion stage element may not have been designed and constructed to work with the precise combination of other components and structures that the supplier is assembling. Unexpected incompatibilities may arise.

The question is: Will a manufacturer catch issues during its routine design, quality control and inspection protocols? Probably. But not certainly.

Often, only customized offerings can meet the objectives of specific performance and design requirements. They allow the manufacturer to focus on the design aspects of the stage that the application requires, specifically tailoring factors from speed to acceleration to stability. They can even reduce cost by eliminating unneeded features that come standard with an off-the-shelf stage. And they ensure an integrated solution without hidden incompatibilities.

Suppliers should look for true "spec-sheet-to-prototype-build" control of their order from the linear motion manufacturer. Such intelligent customization is vital to anticipating and eliminating product shortcomings, avoiding roadblocks in integration and preventing failures throughout.

Specify products with the precise size, shape, coating or material the job demands. And insist on solutions that meet the unique targets for accuracy, speed, flatness, preloading (to increase stiffness by eliminating internal clearances), service life, maintenance levels and price.

Sometimes, more innovative materials may also help reduce risks in specific custom designs. For example, carbon fiber construction can optimize structural strength, stiffness and stability (despite its reduced weight and thickness). At the same time, ceramic bearings may be a viable solution for specific lubrication issues.

Handle With Care

Once a linear motion component destined for a specific application arrives on the equipment maker's floor, other risks can arise.

Linear motion manufacturers may be called in to solve a host of problems arising at this intermediate stage. For example, a linear motor may suffer a binding problem, where the coil traveling inside the motor track is rubbing against the track in its travel. This might be caused by a handling issue due to jarring that slightly shifts the coil or the track out of alignment. It is possible the saddle—the moving stage segment—may get bumped and suffer distortion. In building the larger tool, screws that are too long may be added, pushing through one linear motion plate into another, causing scratches and the risk of unpredictable forces during operation. It also is possible a coil may be unscrewed from its mounting to allow access to run an additional cable, then re-screwed incorrectly.

Such mishaps run risks ranging from a slight degradation of performance in the process to burnt-out motors and major downtime events. Surface preparation also merits close attention. Tolerances must match in all particulars.

In some cases, a manufacturer building tools for these processes may source a linear motion component constructed for flatness of travel, say 0.0005 in. (12.7 µm). But the toolmaker then bolts that component down to a larger assembly with a flatness of only 0.005 in. (127 µm). The consequent twisting of the stage may be almost imperceptible. For example, this may cause binding of the bearings resulting in premature wearing of the bearings, additional forces on the ball screw or higher power requirements from linear motors resulting in excessive overheating and potential failure.

Get Grounded

Ensuring that all components in the linear motion system have proper electrical grounding is another precaution that manufacturers can undertake to prevent a future problem. Such an oversight might result in electrical shock risks for operators. But it can also have an impact on system performance.

A ground loop in the system that feeds back through the ground path could induce false readings in the encoder so that a component only travels 1 mm, but the controller registers travel of 100 mm. If the oversight is missed, for example, positional accuracy may result in errors

in the readings of the instruments leading to inaccurate analysis.

Transport and Installation

The relatively low resistance of linear motion systems to impact loading was discussed earlier. The points of most significant risk naturally occur in three periods:

- During transport from linear motion supplier to equipment tool maker;
- During arrival and incorporation of the system into the equipment tool; and
- During transport of the finished equipment assembly to the process floor and installation.

A reliable, experienced linear motion supplier can significantly decrease the chance of shock damage during the first phase. Supplier experts can ascertain manufacturing space constraints early, so they do not design a stage that is too large or too heavy to be easily assembled in a cleanroom or manufacturing floor. They can also plan transport equipment usage (cranes, dollies, etc.) so that the stage can be safely transported from crate to tool, minimizing the risk of injury to onsite personnel, as well as the chance of damaging impacts.

Finally, during installation, the linear motion system or the relevant portion of the tool can be equipped with the necessary passive isolation measures (such as elastomer feet or pads) or active isolation dampers (sensor-adjusted airbag systems) to reduce the chance of excessive shock or vibration during subsequent operations.

In the Clean Room

For both the first and second phases, the linear motion supplier should follow best practices in constructing transport crates and bagging systems. For example, one leading supplier envelops the system in two bags, one applied within the nitrogen atmosphere and the second in a cleanroom, for transport. They then provide special rigging and carts for delicate transport transfers.

In the third phase, if the system will be placed on the tool assembly from above, the tool makers' crane may suffice. However, if a more challenging sideload maneuver is necessary, the supplier provides a specialized chamber crate, which can be bolted to the side of the tool until mounting is accomplished.

Lubrication

Although linear motion systems usually run cycle after cycle without trouble or extra attention, a small amount of regular maintenance is always critical. Here there are three keys to effective maintenance: lubrication, lubrication and lubrication.

Every linear motion system supplier ships their product with a specified relubrication service cycle. Yet, human nature being what it is, many problems can be traced to simple failures to follow that recommended cycle. Without necessary lubrication, friction stresses mount and eventually cause extremely undesirable events—such as shutdowns or motor burnouts.

Other lubrication issues include premature failure of the bearings resulting in reductions in performance such as straightness, flatness, pitch, roll and yaw.

Moreover, not all vacuum greases are created equal. Different systems may require different formulations, such as those marketed by Klüber, Barrierta and Krytox.

It is important to use only the correct grease on each machine. Take great care never to mix incompatible oils or greases. This includes using different greases when servicing a machine from one cycle to the next. This will change the required viscosity, often resulting in the buildup of a gummy, cement-like material that is the last thing to desire in delicate equipment. If the material also includes particulates from an over-flexed cable, a cable carrier or even elsewhere, usually rail failure will soon result.

Performance Roadmap

In response to demands from equipment manufacturers, linear motion equipment makers are continually working to push the envelope in performance. But first, they must ensure that any improvements do not inadvertently increase the risk of linear motion failures.

A good linear motion supplier will supply a "performance roadmap" highlighting elements of the system that can be designed not just for current requirements but with the performance capacity for next-generation use. This commitment is especially critical in the manufacture of advanced life science, medical and biomedical technology.

Linear motion process systems may not be the most prominent elements in most advanced technology equipment, and nor are they typically a top-of-mind concern for most users. But their failure can have severe consequences for all involved. Fortunately, proper attention to design, installation, operation and maintenance can ensure linear motion systems play a vital role in the continuing critical—and perhaps even lifesaving—successful operation of the most advanced life science, medical and biomedical equipment. ■

MARIO DEVINCENTIS is engineering manager at Schneeberger Inc. He is well-known in the area of linear technology, with 30 years of experience in system development, system manufacturing and applications engineering works to identify opportunities and optimize processes.

lbreakstock/Dreamstime

Design with the End in Mind

Early troubleshooting of small details can avoid problems down the line.

DESIGN AND CONSTRUCTION of control equipment for a linear motion system holds the greatest potential for causing mishaps down the line. While issues such as improper wiring can crop up, the myriad steps of programming the control and integrating the hardware and software demand the most care.

Among the questions to ask:

- Are all limit switches—with sensors that protectively trigger on or off states when the stage hits a point, such as a hard stop for limit of travel—ordered as an option if a stage is a stock purchase?
- Were all properly set, correctly oriented (with plus or negative limits sent to left or right pins, as applicable), suitably connected to the controller and appropriately used?
- Are limits for the electrical current set to the proper levels? Is the stage correctly tuned?
- Is the velocity limited so that it never exceeds the specified limits of any component in the system?

A mistake here might even lead to a runaway stage in the application. If the moving part loses communication with the controller and starts moving on its own volition, it can reach the point where it goes beyond the desired end of travel and impacts another part of the machine.

Troubleshooting Issues

In a more likely scenario, a control design oversight could lead to an overcurrent situation and cause motor burnout. For example, suppose the limits are not correctly specified, and during travel, a motor-driven component (such as a stage or table) is physically impeded by an unexpected object on the rail (a fallen screw, an operator's hand, its end of travel, etc.).

In this case, the motor may draw more and more amperage until it burns out. The result is equipment shutdown, disassembly, and service or replacement. All of these outcomes include significant downtime and costs for that part of the application.

An even subtler problem may arise if the control designers neglect to consider every possible condition that could occur during linear motion equipment operation. For instance, a three-axis linear motion component might perform perfectly during routine operations through thousands of iterations.

But in what might be an exceptionally uncommon configuration with no limit switches set (such as when the X, Y and Z axes all happen to be at their very lowest points of travel simultaneously), the moving component may run into a structure in its surrounding environment. Not accounted for in planning, this could include hitting a nearby post or holder or dispenser.

Linear bearings are excellent at accommodating continuous dynamic and static loading, but not impact loading. If a linear motion component hits something at high velocity, it generates what could well be an out-of-spec impact load. Potentially a single such hit could destroy every bearing in the system.

Do not think in terms of buying even the best single component. Instead, focus on creating a complete metrology solution from the floor up to the point of measurement. Besides highest-performance cross roller bearings to provide extreme smoothness and speed, seek a solution that takes ownership of the entire assembly.

This includes not just the stage but the properly isolated frame to which it is mounted. This also includes state-of-the-art active dampening measures. This kind of integrated technology helps ensure solid control of both component movement and any ancillary vibration. ■

BOB VAVRA | Senior Content Director

Additive Manufacturing Accelerates Racing Solution

3D Systems teams up with Formula 1 car designers for a printed accumulator.

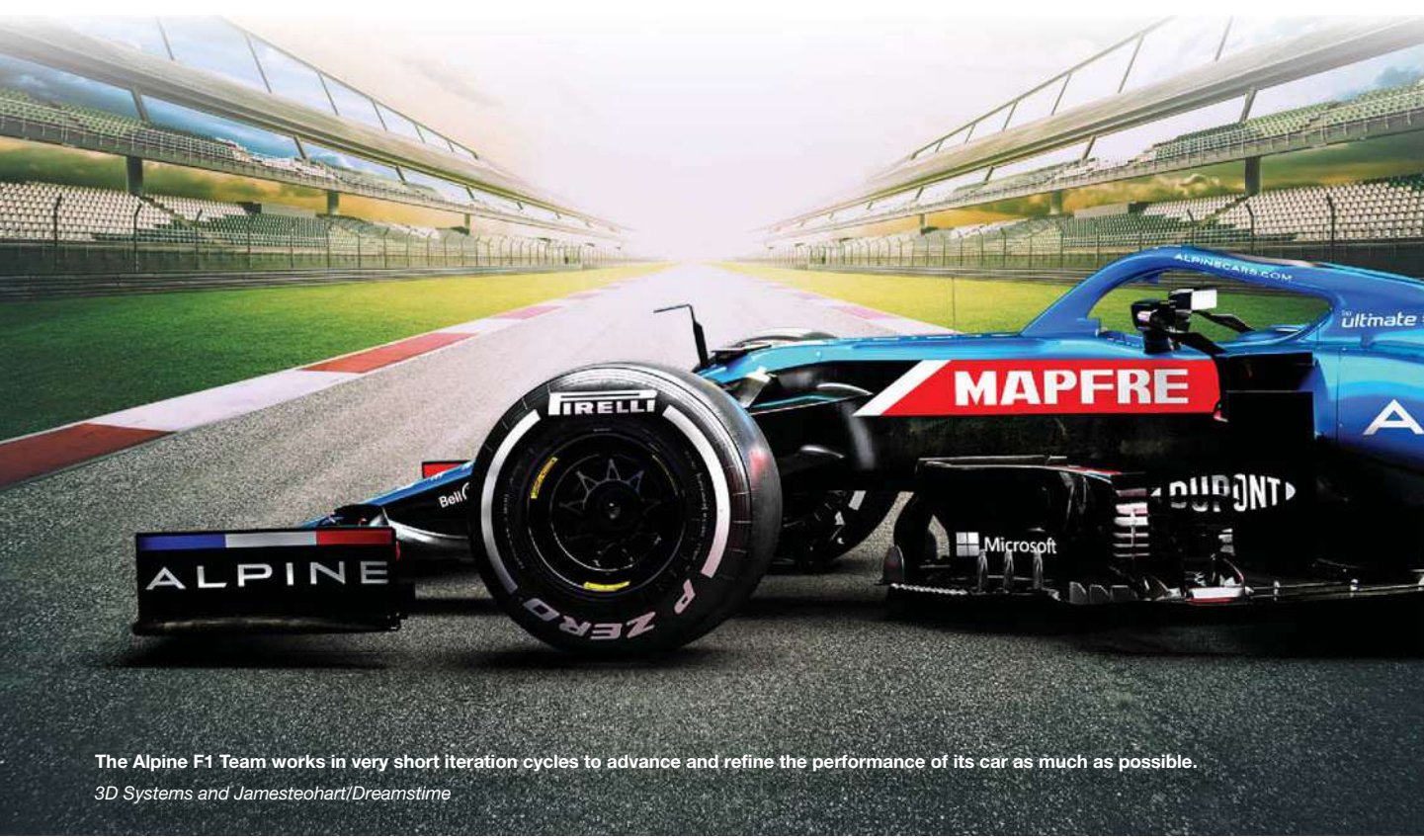
Formula 1 racing cars can reach speeds of more than 220 mph, so parts reliability is a critical consideration. The weight of the car also is important, which leads car designers to develop innovative solutions to meet both requirements.

The Alpine 1 racing team designed a hard-line damper, which is part of a rear heave damper in the rear suspension system inside the car's gearbox main case. A long, rigid piece of tubing, the accumulator stores and releases energy in order to average out pressure fluctuations. The performance of the line damper is related to its internal volume, and as such the length of the component.

The Application Innovation Group (AIG) at 3D Systems developed a design and manufacturing process for the component using titanium for both strength and weight. It uses additive manufacturing (AM) to save space and weight while achieving the required tolerances. "We designed this part to be as volumetrically efficient as possible, and to share wall thickness between adjacent tubes," said Pat Warner, advanced digital manufacturing manager at Alpine F1 Team in a press release. "Achieving this volume is only possible with AM."

The final titanium dampening coil used 3D Systems' DMP machines create a strong, precise part that is both clean and repeatable for future needs.

The lessons learned from this high-speed challenge have implications for other AM projects in automotive and elsewhere. *Machine Design* discussed some of those applications with Kevin Baughey, segment leader for transportation & motorsports at 3D Systems.



The Alpine F1 Team works in very short iteration cycles to advance and refine the performance of its car as much as possible.

3D Systems and Jamesteohart/Dreamstime

Machine Design: First, talk about some of the complexities faced by Formula 1 racing teams as they pursue both speed and reliability. How has additive manufacturing in general helped meet these goals?

Kevin Baughey: In terms of helping with speed and reliability, AM allows Formula 1 teams to iterate designs in a matter of hours, which allows them more testing cycles to ensure the parts are working properly. AM also optimizes the constrained time teams have for wind tunnel testing by rapidly printing and integrating parts into the model. Turnaround time between races is extremely tight, and AM is significantly quicker than traditional manufacturing to help facilitate having parts ready for the next race and those that follow.

Kevin Baughey
3D Systems

MD: **Let's now talk about the specific titanium hydraulic part you've developed for the Alpine F1 team. What does it do for the car? What was needed in terms of design improvements to help improve its performance?**

KB: For the hydraulic accumulator, specifically a rear heave fluid inerter coil, the Alpine F1 Team designed a hard-line damper, which is part of a rear heave damper in the rear suspension system inside the gearbox main case. A long, rigid piece of tubing, the accumulator stores and releases energy in order to average out pressure fluctuations. As such, the performance of the line damper is correlated to its internal volume, and thus the length of the component.

Additive manufacturing enabled the Alpine F1 Team to maximize the length of the dampening coil while packaging complete functionality within a restricted space. The final design would be impossible to produce using any other method due to tight tolerances and shared wall thickness between adjacent tubes. Being able to handle the volume while fitting it in the tight packaging space was only possible utilizing AM.

MD: **One of the inherent advantages of additive manufacturing is its rapid prototyping capabilities. How did you work with Alpine's engineers to evaluate and test various design iterations? And how long did that process take?**

KB: That process is continual. Design iteration timelines differ depending on the application, with some parts only being used for a single race and others that are used throughout the season. 3D Systems works closely with the Alpine F1 Team's designers and engineers on the schedule they need to meet, and then we maximize the time available for iteration, fit and function testing, and aerodynamic testing.

> **"A race team will utilize several different AM technologies for prototyping and end-use parts. Stereolithography, powder sintering of metals and plastics, and extrusion will all be implemented in some capacity."**

Additive manufacturing enabled the Alpine F1 Team to maximize the length of the dampening coil while packaging complete functionality within a restricted space.
3D Systems

MD: **What other technologies are involved in bringing these designs to the race car? And what other considerations are involved in both the design and production process?**

KB: A race team will utilize several different AM technologies for prototyping and end-use parts. Stereolithography, powder sintering of metals and plastics, and extrusion will all be implemented in some capacity. Some key considerations in design and production are in the areas of lightweighting, complex part design and constrained packaging space, as AM excels in producing parts with high strength-to-weight ratios, parts with sharp edges and intricate curved designs, and parts that are constrained in the space they need to fit into, like the hydraulic accumulator.

MD: **What lessons has 3D Systems taken from this experience that you can apply to other customers? And as manufacturers explore AM for their own facilities, what are some of the key questions they need to ask?**

KB: Each application that is solved with AM represents a learning experience for us. Years of optimizing part design have provided us the expertise to balance part performance with the correct weight and mass needed. Designing for additive is unique in that conditions like shrinkage and growth in the build chamber have to be accounted for in the initial phases of design. Understanding this allows us to pass along best practices to customers in other industries.

In addition, working closely with manufacturing environments allows us to answer many key questions, such as how much space will be needed for an AM department, what types of post-processing equipment will be utilized, what precautions have to be used when handling powder or resin, and how will AM equipment work into an integrated production workflow that includes traditional manufacturing, CNC machines and testing/inspection equipment. ■

THOMAS RENNER | Contributor

Plastics Help Solar Power Reach Potential

From energy chains to lubrication-free connectors, applications are emerging.

As the world pushes ahead with demand for carbon-neutral technologies, the drive for developing solar-powered products is rapidly advancing. While many solar energy applications are well-known, engineers are just beginning to scratch the surface on the number of potential solar applications. The scope of the projects ranges between wastewater plants that are the largest in the world to trash bins that are about as big as an outdoor grill. Even more have yet to be discovered.

Many of these solar applications are including plastic components. Besides their self-lubricating properties, many engineers have discovered that such products extend service life, resist ultraviolet rays and are extremely lightweight. Officials at igus, the Germany-based manufacturer of motion plastics, believe the potential for more solar applications will emerge.

"We're going to see products using solar energy continue to increase," said Richard Won, igus' Industry Manager for Renewable Energy. "The United States, especially, has huge potential. There are a lot of big companies in the U.S. doing business all over the world and they are figuring out different ways to use solar power."

Solar and Wastewater

One of the most unusual applications centers on how solar energy is being used to manage wastewater in plants ranging from Egypt to Colombia to the United States. A unique system developed by HUBER uses solar energy in a sludge dryer that dramatically reduces the costs for sewage disposal.

The Bahr El-Baqar drainage canal in Egypt is considered one of the most polluted tributaries in the world. Industrial waste and sewage from Cairo, along with agricultural runoff, pesticides and fertilizers, end up flowing into the drain. Water quality scores range from 37-48, a rating that is marginal or poor. Much of the water is used for irrigation and fishing.

This is where the HUBER system has made a huge difference, The system includes 128 sludge turners and can accept approximately 490,000 tons of sludge per year. The system, which cost approximately $700 million, is constructed on more than 39 acres.

The SOLSTICE system from HUBER works in 16 greenhouses in the Egyptian system. The turner travels on rails and repeatedly rearranges the sludge on the ground. During the movement, the sludge is dried by solar energy. At the end of the drying lane, the sludge turner picks up the dry granules in the tool that repositions the sludge during its forward movement. The dry material is relocated to a recess in the ground, then collected and transported to a container.

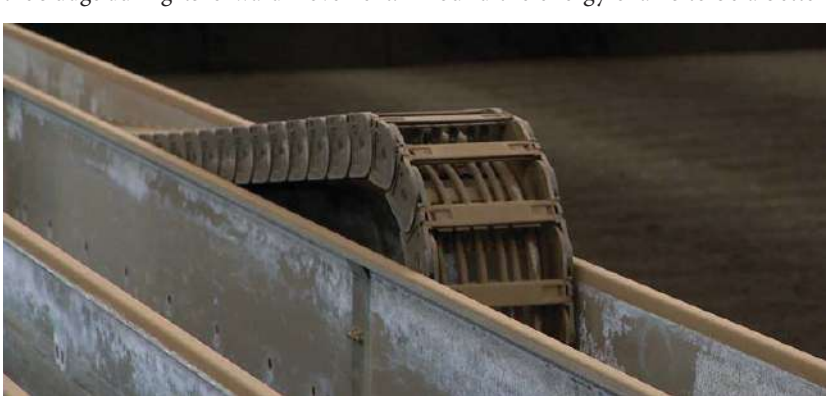
While the Bahr El-Baqar system is the world's largest, similar systems have been installed in Sanford, Fla. and Toole, Utah. In warm and cold climates, communities are turning to solar dryers to reduce sludge disposal costs and protect the environment.

Long Travel Energy Chains

The SOLSTICE units include self-lubricating and durable energy chains manufactured by igus. Besides those advantages, easy installation and maintenance of the e-chains were important factors for HUBER in the design of the system.

"Energy chains are the best solution for cable guidance on long travels," said André Großer, HUBER SE product manager. "It requires little room, protects the cable and is easy to install and maintain."

Engineers considered festoons but found the energy chains to be a better



The HUBER Sludge Turner SOLSTICE units work in greenhouses, and the turner travels on rails and repeatedly rearranges the sludge on the ground. During the movement, the sludge is dried by solar energy. The system takes a solid mixture that is 78% moisture and water and 22% dry solids and converts it to 75% dry solids. *igus*

solution. "The problem with festoons is that the cables are always moving," Großer said. "The movement puts stress on the strands and necessitates more maintenance than is the case with energy chains. The festoon also hangs in the air, causing obstruction, and its trolley takes up valuable space."

The e-chains also contain igus chainflex cables, which provide dependable data transfer and energy supply. The energy chains were delivered with the cables already installed.

Three individual cores and a CFPE cable, all with a TPE outer jacket, ensure connection to the cable. Data exchange is with an igus CFBUS cable with a PUR outer jacket, and those cables are designed specifically for use in energy chains. They also include an abrasion-resistant outer jacket and special interior stranding.

Pre-assembly allowed for faster installation. With the cabling already in place, the number of suppliers was dramatically reduced and made on-site installation faster and easier. To reduce delivery costs, the fully equipped energy chains were placed on a drum and loaded into containers.

"This allowed us to save space and reduce shipment costs, and that was significant in a project of this size," said Michael Offner of igus.

Pedestal Connects PV Platforms

An adjustable bearing consists of two half-shells made of plastic from igus—housing connected to the metal frame and an inner part mounted inside. The igus

Sidebar

Solar Transportation Challenges Get Students Moving

BY LAND AND BY WATER, solar energy is changing the way people go about their travel. Young and aspiring engineers, in particular, are helping to develop transportation equipment that runs on the sun.

Students founded the University of Minnesota Solar Vehicle Project in 1990, and three years later designed their first vehicle. Since then, the team has built 13 vehicles and raced in 30 solar challenges in three continents. The team finished second in a competition in August in a race from Independence, Mo. to Las Vegas that covered nearly 1,000 miles.

Students from Minnesota used the igus chainflex cables, while the boat includes iglide bearings in the steering assembly. The students took advantage of the lightweight and self-lubricating properties of the products.

The car designed by the students in Minnesota "is one of the most ambitious cars we've made in a while," team member Shane Spangler said. ""The igus components were used in cabling for the solar panels and high-voltage BUS cables. The chainflex is very flexible and can get into very tight spaces."

"A lot of companies in the United States are using solar power technology," said Spangler. "My goal in life is to help impact climate change. I don't see myself as a manager at a car company, but I do want to have an impact. Everything is going to need to be powered by renewable energy. We have to find ways to do that."

Students in Poland's Wroclaw University of Science and Technology developed a solar-powered boat. Wroclaw is the fourth largest city in Poland and offers some unique advantages for testing boats of any kind. Located on the Odra River, it is referred to as the "City of 100 Bridges," as the river and its tributaries meander around 12 islands in Wroclaw.

The team from Poland used double flange iglide J bearings in the steering system. The bearings are lubrication-free and seawater-resistant. The bearing offers low wear at low to medium pressures, and also wears low against different shafts.

"igus bearings ensure long life," said Dominika Dewor of the student boat team. "They reduce overall system weight, eliminate lubricants and are easy to install."

Both teams were supported by the Young Engineers Support (YES) program, which gives students access to free and discounted product samples. The program is designed to foster the mechanical design ideas of students with a passion for engineering in high school or college. Students in the program have developed a wine storage product designed by students at Gsechs University of Applied Sciences in Hamburg. ■

Students at an engineering school in Poland designed a solar-powered boat that included lubrication-free and seawater-resistant bearings from igus. *igus*

The solar tracker includes unique pedestal bearings from igus that connects the profiles of the PV system along with a metal bracket manufactured by ZIMMERMANN. *igus*

parts are made of lubricant-free and UV-resistant high-performance plastic that are extremely robust even when exposed to high temperatures or dirt. The upper part is a metal bracket manufactured by ZIMMERMANN. The division into a lower and an upper part allows for easy assembly and disassembly.

Despite its low overall weight, this solution is suitable for storing loads of up to 1.5 tons. Due to the overall structural design, the rows of solar panels in the ZIM Track System can be up to 96 meters long. The ZIMMERMANN PV trackers are located in Europe, Australia and South America.

Floating photovoltaic systems are more common overseas, where space for ground-mounted systems is in short supply. The National Renewable Energy Laboratory in the United States estimates photovoltaics could generate about 10 % of the nation's annual electricity production.

Smaller Scale Projects, Too

Smaller projects that also require solar power still have significant needs.

A company in Finland, Finbin, developed a trash compactor that significantly reduces operating costs and the ecological footprint. The technology ensures that waste is compressed in a ratio of 6:1. The bins, approximately as tall as a standard outdoor grill, can hold over 1,200 liters of litter.

Engineers designed the units with plain bearings from igus for the hatch, pedal and pedal rods. The bearings are made with igus iglide G material, which are wear-resistant as well as resistant to dirt and dust. The bearings are used in a wide range of applications from medium to high loads, such as agricultural and other machines, automotive, and sports and leisure equipment.

The device illustrates the creativity with which engineers are working to develop more products that rely on solar power. There have been prior industrial revolutions, and it now seems the world is beginning a new one that relies on renewables. There are challenges, but there are also opportunities.

"There is no limit on what can be achieved through the use of solar energy," Won said. "There are a lot of great innovations in the pipeline. Lubrication-free products that are resistant to dirt and dust, lightweight, durable and extensively tested are tremendously beneficial to any project that is looking to implement solar power." ■

THOMAS RENNER writes on engineering, building, construction, architecture and other trade industry topics for publications throughout the United States and Canada.

AD INDEX

BOB VAVRA | Senior Content Editor

Flooded with **Information**

A new sensor system has been designed to deliver sump pump failure mode warnings.

When you've been in your basement after a thunderstorm, up to your ankles in water because your sump pump failed, it's too late to think about being able to predict the health of your pump with the same accuracy as the weather.

Wayne, which manufactures water pumps for homeowners among its many other fluid management products, was looking to solve that problem for its end-users. The company already was working with Naperville, Ill.-based Grid Connect Inc. on embedded network solutions for the existing Wayne HALO line of sump pumps when the challenge came up to build an app-based monitoring system that would marry consumer needs with pump performance metrics.

Among the electrical values that can be measured, one of the most important is current leakage, a key indicator of pump health. "They're the experts in pumps, and we're experts in IoT and connectivity," said Adam Justice, chief executive officer of Grid Connect, Inc. "When we started to work with them, we began to unpack what they wanted to monitor."

The result was the Wayne Basement GuardianHALO—a smart sump pump that is compatible with Alexa voice commands and can provide consumers with an app-based monitoring of its health.

Grid Connect already had a reputation for power monitoring within Wayne, but the new challenge was to put the data in the hands of the homeowners. Consumers, of course, aren't particularly well-versed in such things as current leakage… but they do want to know if the pump might fail soon.

"The homeowner is not concerned with leakage," said Anthony Linder, vice president of operations and overseas manufacturing for Grid Connect. "We understood the challenges from an engineering perspective, but we also needed to understand from a consumer perspective. We interviewed a lot of their customers and tried to understand that story."

"Why did they want a connected product? It's a 'Jobs To Be Done' methodology," added Justice. "People don't want a quarter-inch drill; they want a quarter-inch hole. We wanted to find the quarter-inch hole for the sump pumps."

It also helped that Wayne and Grid Connect had worked together on other sump pump sensor projects. "Speed to market was why we called on Grid Connect to be our IoT development team and manufacturing partner," said Eric Tinnemeyer, president of Scott Fetzer Consumer Brands, which owns Wayne, in a press release announcing the product launch.

Linder said the process to identify how to turn data into consumable information for the average homeowner tried to allay fears, provide clear information and still use the technology effectively. "We wanted to display actionable steps a homeowner could make—including consulting someone else," he said. "There's a lot of green in the app to show the homeowner that everything is great."

Wayne officials noted in a press release that over time, a sump pump's electrical insulation and seals will break down and the pump won't work. When the sun is out, of course, it's hard to tell the difference between a broken sump pump and one that simply isn't needed. The Grid Connect's IoT controller constantly analyzes electrical signatures from the pump's components and predicts problems and alerts the consumer when there is a problem.

"The average person cares about pump health instead of current leakage," Justice said. "When they looked at the app, they saw the state of the pump or it gave them an action to perform. What people are buying is peace of mind. We wanted to give them better peace of mind—real-time peace of mind."

Engineers at Grid Connect found that by measuring current leakage in a sump pump, they could predict pump failure. They worked with pump manufacturer Wayne to develop an app-based monitor for the homeowner. *Grid Connect/Wayne*

"People were sleeping next to their pump," Linder added. "They don't have to do that anymore."

The Engineering Challenges

Before the sump pump consumer could get a good night's sleep, the teams at Wayne and Grid Connect put in a number of long days. "We were on the road map from this project rather than being an add-on," said Linder. "We operate best in a world where we can understand their customers just as well as they do. When we can do that, we can exceed their expectations."

The rise in home-based apps and the lessons learned from the work with Wayne have Grid Connect officials confident other sensor technology can be effectively embedded in a wider range of electrical products.

Because the finished project turns sensor data into action, it also can turn the aggregation of that data into product insights, and into future product improvements. "We started with a drawing," said Cris Codreau, Grid Connect's vice president of engineering and the person who originally developed the IoT-based Wayne HALO. "With an ever-increasing number of pumps in the field, our data engineers can show a correlation with circumstances. If we know what the rain situation at any moment, we can be aware and alert users." ■

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