



A Pandemic Did Not Stop Engineering Innovation:

BY ALAN S. BROWN

DESPITE WORK-AT-HOME ORDERS, SOFTWARE SNAFUS, NEW WAYS OF COMMUNICATING AND COLLABORATING, AND PROBLEMS DOING HANDS-ON DESIGN, ENGINEERS FOUND WAYS TO THRIVE DURING THE PANDEMIC.

COVID-19 first showed up on **Bob Roth's** radar at a company board meeting in late February. Two board members said it would be worse than anyone imagined, and that he should prepare for disruptions in customer programs and supply chains.

Roth, a second-generation owner and president/CEO of RoMan Manufacturing, a Grand Rapids, Michigan, industrial transformer and power supply maker, took note. Still, he was optimistic. Two years ago, his \$35 million company had re-engineered some transformers to lower customer costs and sales were booming.

Then the pandemic hit, and Roth's world changed. On March 23, Michigan issued a stay-at-home order. That day, he told his 150 workers they should not come to work the next day. His management team spent 24 hours online and found that industrial transformers and

power supplies were critical infrastructure. After one day at home, he recalled his factory workforce back.

This proved easy since technicians already worked apart from one another at their own workstations. RoMan installed sanitizer stations and gave everyone gloves. "Some workers complained about wearing masks, but they were the same ones who complained about wearing safety glasses," Roth said. They fell in line. Eventually, RoMan relaxed its mask policy, letting socially distanced technicians work alone without them as long as they put them on when they came by.



BOB ROTH

In the office, where employees worked near one another, most employees worked remotely, though at least two senior managers came in every day. "If we're asking most of our techs to come in daily, then top management ought to show we're willing to do it, too," Roth said.

Meanwhile, the engineers took their powerful desktops home. Once there, they linked to RoMan's virtual private network (VPN), which let them access applications and share data securely. RoMan was fortunate to have an up-to-date VPN, and after the initial confusion and testing, everything worked seamlessly.

That was not the case for RoMan's enterprise resource planning (ERP) software, which manages inventory, production, and scheduling. Modern ERP systems automatically input data from engineering and sales software. RoMan's old ERP system did not. The company had developed workarounds in the office, but they proved torturous when done remotely. New ERP software is now a RoMan priority.

Roth has been forced to adapt to communicating and managing via email, Zoom, and Microsoft Teams. He is still getting used to it, but he has noticed that video conferences move faster. "We might talk in a conference room for

30 minutes about something we could have handled in 10 or 15 minutes,” he said. “Now we’re finished in 10 or 15 minutes.”

Despite the churn, RoMan kept production up. When demand crashed in June, Roth put his factory techs on half-schedules.

Under Michigan’s Workshare program, RoMan paid for healthcare and half salaries and Michigan provided half unemployment benefits. With the \$600 federal supplementary unemployment benefit, most workers received the equivalent of full pay and RoMan kept its workforce intact.

Roth says he is ready when demand bounces back. “We have learned we can navigate through our weaknesses in systems and communications,” he said.

He is not alone. Engineers are problem solvers, and during the pandemic, most have found ways to work and collaborate remotely, build prototypes, and keep production up. What they have learned may change the profession for years to come.

REMOTE

Remote work is nothing new. In the tech industry, many software teams have been virtual or partially virtual for years. Firms like Google, Apple, Microsoft, and Facebook have all made

a smooth transition to working at home, and some, like Google and Facebook, say that will continue until mid-2021. Engineers are more tied to the physical products they produce, especially when they combine hardware, electrical circuitry, and software and require lots of interdisciplinary collaboration.

Typically, engineers work in teams in offices where they can bounce ideas off one another, test and modify prototypes, or step onto the factory floor to resolve a problem. Engineering managers rarely let anyone work from home on a regular basis.

Still, studies show that working from home can boost job satisfaction and productivity. In an eye-opening experiment in 2014, Stanford University economist Nicholas Bloom had 500 volunteers at a Chinese travel booking company work remotely. Their productivity rose 13 percent and their retention rate doubled, though they were promoted less often.

Today, we are seeing a similar experiment replicated in real time, though no one got to volunteer. The pandemic has made remote work the rule rather than the exception, said **Alison Olechowski**, a professor of mechanical engineering at University of Toronto who was studying remote collaboration before the

pandemic hit.

“If you had asked engineering managers in February if they thought it was possible for their team to work remotely, most would have answered, ‘No,’” she said. “Now, they are open to it, at least part time.”



**ALISON
OLECHOWSKI**

Olechowski has been on the phone (or on Zoom) talking with remote engineers and managers since the pandemic began. She found larger companies and teams working on complex projects transitioned easily to remote work because they were already sharing models and using software that provided version management and security.

Engineers on smaller teams without such integrated software figured things out, she said. Their jobs have grown increasingly collaborative and most had software and processes that let them share files, models, and drawings between groups. When the pandemic hit, many upgraded their VPNs so they could remotely access applications and

Angela Heinze, P.E., NYX '04, (left), and Jake Andrew, P.E., (right) are both structural engineers at architectural engineering giant Thornton Tomasetti. The company squeezed months of IT work into weeks to roll out improved remote capabilities. Still, many miss the random interactions that spark creativity and team cohesion when people work together.



share files and data on computers left running in their offices.

That was the case at Pittsburgh-based HEBI Robotics, said chief operating officer **Bob Raida**. The 13-person company makes control systems for robots. To demonstrate the system, HEBI decided to build a robot to inspect infrastructure around it. In March, Raida was getting ready to fly to Chevron and demonstrate it when the refinery called to say it could not accept visitors.

When the shutdown hit, HEBI moved quickly. The engineers packed up their workstations and took them home. The company was already using Google for data storage, email, documents, and spreadsheets. Once HEBI upgraded its VPN to handle the additional traffic, the engineers were able to share information as needed.

The company had enough new products in the pipeline to keep its engineers busy building models and they continued to look for ways to slash bill-of-materials costs. When work slowed, some HEBI engineers pitched in on marketing.

A faster VPN is not always the answer. Two RoMan employees lived in rural areas with poor Internet and had to work in the office. Meanwhile, Steve Chillszycn, CEO of Evolve Additive Solutions, Minnetonka, Minn., which is building a 3D printer to compete with injection molding on speed and quality, got bogged down by other family members.

“My daughters were online for classes and my wife normally works at home, so there were bandwidth issues,” he said. “My voice would cut out of a Zoom meeting, so I’d have to shut off my video during the discussion. I don’t think I was the only one having these



**BOB
RAIDA**

types of problems.”

It took a big IT push to get everyone online at Thornton Tomasetti, a major architectural and infrastructure engineering firm with 1500 employees in more than 50 offices worldwide. “The way the firm is organized, our people move and work from around the world,” said **Scott Schneider**, co-leader of the firm’s structural engineering practice.

His group’s 30 global offices often collaborate on projects. “We have a tool set that facilitates this, but we needed to fine-tune the technology and make it more available.”

As the pandemic struck, Thornton Tomasetti deployed more laptops and accelerated its online communications platforms, including Ring Central (based on Zoom) and Microsoft Teams.

During the first six weeks of the pandemic, the firm’s IT group did six to nine months of accelerated work, Schneider said. “We’re using an increased level of communications technology and we’re constantly thinking about best practices,” he said. He talks with close aides daily, sees everyone in his 90-person New York staff weekly through online group project reviews and social events, such as happy hours.

Thornton Tomasetti engineers also connect through existing special interest groups, such as a group that discusses drones for inspection. The company has embraced biweekly town halls to update everyone on where things stand—the type of information they might have picked up through the office grapevine six months ago.

When it comes to communications,



**JIM
DOWNS**

however, Thornton Tomasetti continues to adjust on the fly, Schneider said. His firm is not the only one. Communication makes collaboration and innovation possible and everyone is grappling with how to get it right online.

COLLABORATION

Today’s open offices encourage collaboration and innovation because everyone can see what everyone else is doing. “If you’re a mechanical engineer and you have a question about the best route for electrical wiring, you can peak over your cubicle and see if Cathy the electrical engineer is busy,”

Olechowski said. “If not, you can go over and ask a question. You can’t just do that on Zoom.”

HEBI’s Raida agrees. In his small office, everyone is within earshot. Raida could look up and see how someone’s day was going. Now he must schedule calls to find out.

The same is true for **Jim Downs**, who leads a team of 18 engineers as executive director of innovation at American Axle & Manufacturing in Detroit. “I had to make a point to reach out to people in place of walking around,” he said. “It took me a few days to get into the role.”

Now that he does it regularly, he has discovered that Skype, a digital phone system, uses a red-yellow-green light to show when people are busy, away, or free. He monitors the lights and then calls “somewhat randomly” to check in on people.

Managing online meetings, on the other hand, takes a whole new skill set, said **Vivian Chu**, chief technology officer of Austin-based Diligent Robots, a startup developing hospital service robots.

“We are used to being in a room and brainstorming and whiteboarding,” she said. “We started a project the second week we were remote and the online

“FOR PEOPLE TO LISTEN,” OLECHOWSKI SAID, “YOU FIRST MUST BUILD UP GOOD WILL AND BE RECOGNIZED AS A PROBLEM-SOLVER. MANY MANAGERS ARE SUCCEEDING BECAUSE THEY ARE BANKING ON THE REPUTATION THEY BUILT BEFORE COVID-19.”



Vivian Chu, chief technology officer of Diligent Robotics, with Moxie, a robot designed to help hospital workers. Linking Moxie to Diligent's VPN enabled her team to reprogram and test the robot remotely.

meetings caused more friction than I could have ever imagined. People kept interrupting and others got frustrated because they couldn't say what they wanted to say."

At the time, Diligent was using Google Meet, which did not have a grid view to show all meeting participants. Once Diligent resolved that problem, Chu and the company's other managers had to learn new ways to run a meeting.

When someone on the grid would push "unmute," Chu knew he or she wanted to say something. She would then prompt them to speak. Eventually, everyone began to pick up on the visual cues from the meeting display. One of the reasons that worked so well is that Chu and her managers had already built rapport by helping their teams solve problems and meet deadlines. This is true for many successful managers.

"For people to listen," Olechowski said, "you first must build up good will and be recognized as a problem-solver. Many managers are succeeding because they are banking on the reputation they built before COVID-19."

For online meetings to work well, team members must also have a sense of "psychological safety," the willingness to take interpersonal risks—admit a problem, ask for help, contradict a senior

team member—that is necessary for teams to brainstorm productively, she continued. Teams build it when people get to know each other through those water cooler conversations, side discussions during meetings, or lunch with colleagues. None of that is possible on Zoom or other meeting apps, Olechowski said.

Another thing communications apps cannot replace is the random interactions that spark innovation. That is the reason business incubators and labs have cool open spaces, Olechowski said. It encourages engineers to talk to each other and apply the tools of one discipline to the problems of another. Studies have proven that this leads to greater innovation. "The struggle with remote work is that there is no water cooler, no overheard conversation, no display showing something you recognize," she said.

Peter Adamczyk, a mechanical engineering professor at University of Wisconsin, misses that collegiality. Online, he communicates directly with students and faculty collaborators regularly. "It's not great, but it's direct communications and we have a chance to talk about stuff," he said. "Everyone else that I would see at department

meetings, in the hallway, on the parking deck—none of that happens anymore. This is especially hard on people who are completing their first year here and never fully integrated. I don't exactly know how to fix that."

REOPENING

Eventually, though, these remote engineers needed to get their hands on the things they are building. This has happened, but not without growing pains.

To start off, engineers needed to make their labs, test spaces, and factories safe. OSHA has published advisory safety standards and most employers are checking employee temperatures, installing sanitizer stations, social distancing, having employees wear masks, and going to two half-shifts to reduce the number of workers in the plant. Some added automated light switches, faucets, and flushers, and switched to push-pull bathroom doors.

At Diligent Robotics' Austin office, Chu originally let two engineers at a time sign up for two-hour time slots to go in



PETER ADAMCZYK

and work on hardware and prototypes. Unfortunately, the engineers' can-do attitude led to chaos. Engineers would sign up, but unexpected complications would drag their project out for many more hours or even days. That backed up everyone else waiting to get in.

Chu's team solved the problem in two ways. First, they only allowed engineers to sign up for a full day. Second, they put their robots on the company VPN. This let them install software remotely and monitor the results via video cameras.

Big Metal, a Denver-based startup, remained open because it was working on an unpowered cargo ship for the U.S. Marines. The company has developed a 3D printer that combines metal wire arc deposition with five-axis CNC machining. It can print and machine complex structures directly on metal slabs.

They were using it to build a prototype 50-foot-long aluminum craft—large enough to hold two ISO shipping containers—that the Marines could tow ashore.

Big Metal was halfway through the project when COVID-19 struck. "The world went into chaos and we were on

Slade Gardner, CEO of Big Metal Additive, was halfway through a project to build a 50-foot-long lander for the Marines when the virus struck. He used his hybrid metal 3D printer to make and mill parts when his supply chain broke down.

a tight schedule," CEO Slade Gardner said. "Our suppliers were telling us that things were going to be late. Our electrical vendor couldn't install hardware and machinery in the shop on schedule. We tried to coordinate shipments and it was chaos."

So, Gardner's team decided to control the only thing they could control. Their six techs began running two shifts per day to get ahead on parts they could print in-house. They also printed parts they could not source. When nearby job shops closed, Big Metal used its printer's CNC machine to cut flat stock, mill chamfers and slots, and make mating holes and join plates. "It worked just fine in a crisis and we finished the boat," Gardner said.

Meanwhile, at Evolve, Chills-cyzn was running into problems with his highspeed 3D printer, which is based on a commercial Kodak color laser printer. After 10 years of development, Evolve promised to deliver its first Scaled Volume Production (SVP) printers to customers at the end of 2020. In mid-March, his shop closed.

"If you're building an electromechanical machine, you have to be in front of the machine," he said. "How do you take that work and try to do it at home?" Yet, that is exactly what Evolve did. The company's materials lab in Rochester,

NY, tests and formulates plastic "toner" used to deposit a full layer of material at a time. A few of those engineers took some equipment home with them so they could continue to run tests in their basements.

Evolve subcontracted the machine's modules to local firms and most of them remained on schedule. Since this was the company's sixth SVP generation, it already had a model that could simulate minor changes accurately. One new part, however, involved a major change. The engineers bought a sensor and tested it at home to simulate some of its behavior, but had to wait until they returned to their offices in June to validate the part's model.



TUCKER MARION

CHANGES

Somehow, the engineers made it work. They brought their work home, found ways to access the design and simulation tools they needed, developed new ways to communicate, and returned to their workshops if not always their offices.

"Our online tools have saved us," **Tucker Marion**, associate professor of entrepreneurship at Northeastern University, said. Marion pioneered the use of many of these tools and procedures as an entrepreneur 15 years ago, when he put together virtual teams of engineers from around the world. Since then, he



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has been preaching for companies to embrace greater digital collaboration.

“The past few months have been a very fast learning curve,” he said. “Now, almost everyone is on the same playing field. If this had happened 10 years ago, we would have been in a worse position. Most early adaptors were not comfortable with collaboration tools. Fortunately, we’ve had 13 years of the Apple iPhone, FaceTime, and Skype, so we’ve all been exposed to these sorts of things.”

Many engineers are still discovering the power of their digital tools. Chu, for example, knew she could link her robots to a VPN, but never saw the value in it. AAM’s Downs learned to create Skype subgroups to get an entire team on a call with one click. He and Thornton Tomasetti’s Schneider now use Teams to share and co-edit files. Wisconsin’s Adamczyk will continue to use digital tools rather than whiteboards so he can document design and software changes more easily.

Forced to embrace digital life, managers have grown more comfortable with remote work. RoMan’s Roth is one of them. “Engineers used to ask if they could work at home, and I’d always say, ‘No, we’re a manufacturing company, we do our work on site,’” he said. “Now I’m kind of a convert. Our people have demonstrated they can do it, that they’re accountable and productive.” AAM’s Downs agrees. In fact, he was surprised to see productivity rise 25 percent once his engineers got on a task.

AAM’s leadership had worried that employees would abuse time at home.

Instead, many of Downs’ engineers are so grateful to eliminate their two-hour commute, they are instead using some of that time to work on projects.

“It’s a step forward for industry, people, the environment, everything,” Downs said. “It’s a wake-up call for industry. Imagine you’re GM and you only need half as much office space as you used to

have. You could save millions.”

Of course, remote work also has its negatives.

“Women, for example, often found working at home a good option,” Olechowski said. Now that the pandemic closed schools and daycare, remote work puts additional burdens on many women, who are often the ones who also care for children and elderly adults.

Not everyone has made an easy adjustment to remote work. Some members of Diligent’s engineering team, especially younger engineers and new hires with less social connections to the team, appear more disconnected. “It can be demotivating,” Chu said.

Schneider, meanwhile, is looking to balance office and remote when people return to work. His team has proven it can execute projects remotely, but online meetings cannot replicate the creative sparks that happen when everyone is together.

Prior to the pandemic, he noted, engineers who called into conferences often seemed “a step behind,” perhaps because they could not read the expressions of the people in the room.

Schneider personally hopes Zoom and other new tools will change that. He has two young children, but his job keeps him away until late. Working a day or two at home would allow him—and many others—to be present for his family.

Communications remain problematic as well. Most engineering teams have mastered the technical aspects of using such tools as Meet, Skype, Slack, Teams, and Zoom. Managers have generally learned to use them for small and large meetings and to communicate transparently so their dispersed workforce knows where things stand.

Still, Marion worries about Zoom fatigue. Managers often schedule too many online meetings and they go on

for too long. He thinks shorter meetings, 15 to 30 minutes with a focused agenda, are more effective.

He also worries about what he calls “fidelity of communications.” In an office, he explained, if someone wants to add a feature to a design, he or she could point to where it goes. That’s not possible in text. Instead, engineers should augment their instructions and suggestions with models or screen shots to ensure others will understand exactly what they are talking about. His research shows that the more specific the comments are up front, the less ambiguity and confusion down the line.

Online tools also make it easy for engineers to not give issues their full attention. “You may think your comment resolves that issue,” Marion said. “But maybe it didn’t. We all get lazy and maybe we reply with a thumbs up. But did you really pay enough attention to the problem when you replied? What sounds good may not be the appropriate response.”

Communications and collaboration are, as every engineer we spoke with said, works in progress. In a few short months, COVID-19 has gone from a potential supply chain issue in China into a pandemic that has changed the engineering world. It will probably take years before everyone has truly mastered the best practices these changes have created.

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