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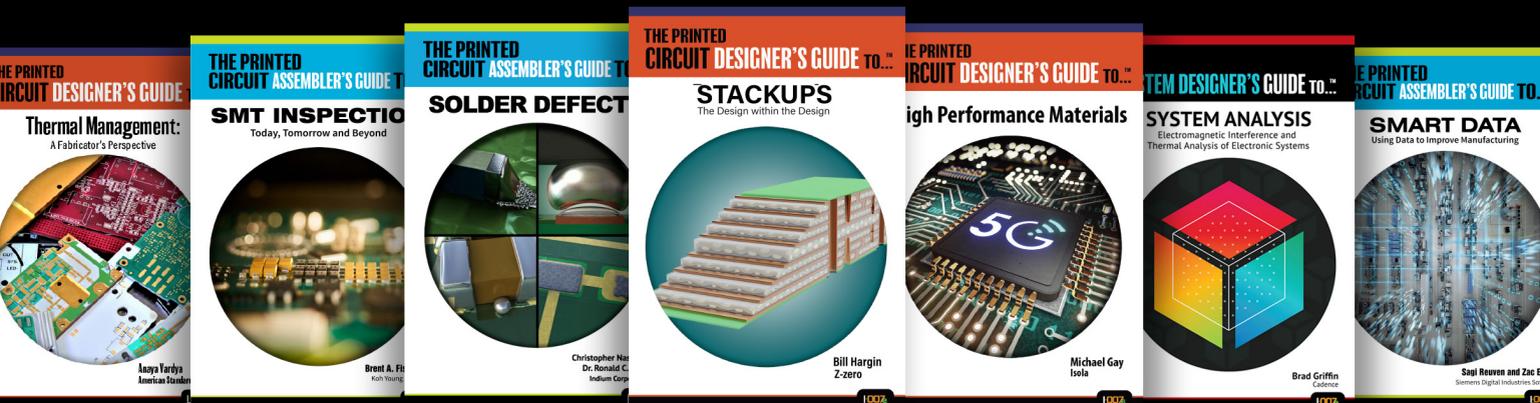
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Upskilling in Your Game of Life

Upskilling in today's market is more than a fancy-sounding idea. It's imperative. PCB fabricators must look at supporting their workforce or face dire consequences. This issue provides a framework for what fabs are up against, clear options for continuing education, and ways to fill some of the most common gaps. It's advice you'll come back to time and again.

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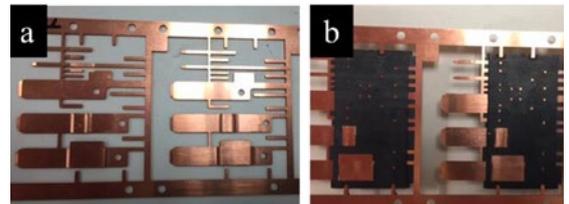
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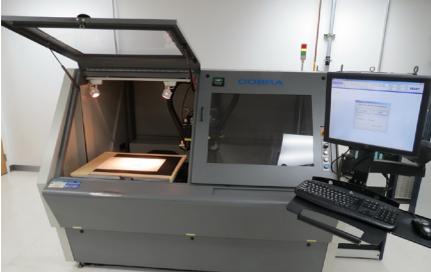
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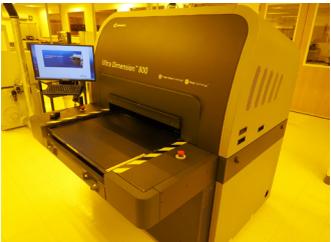
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The Shaughnessy Report

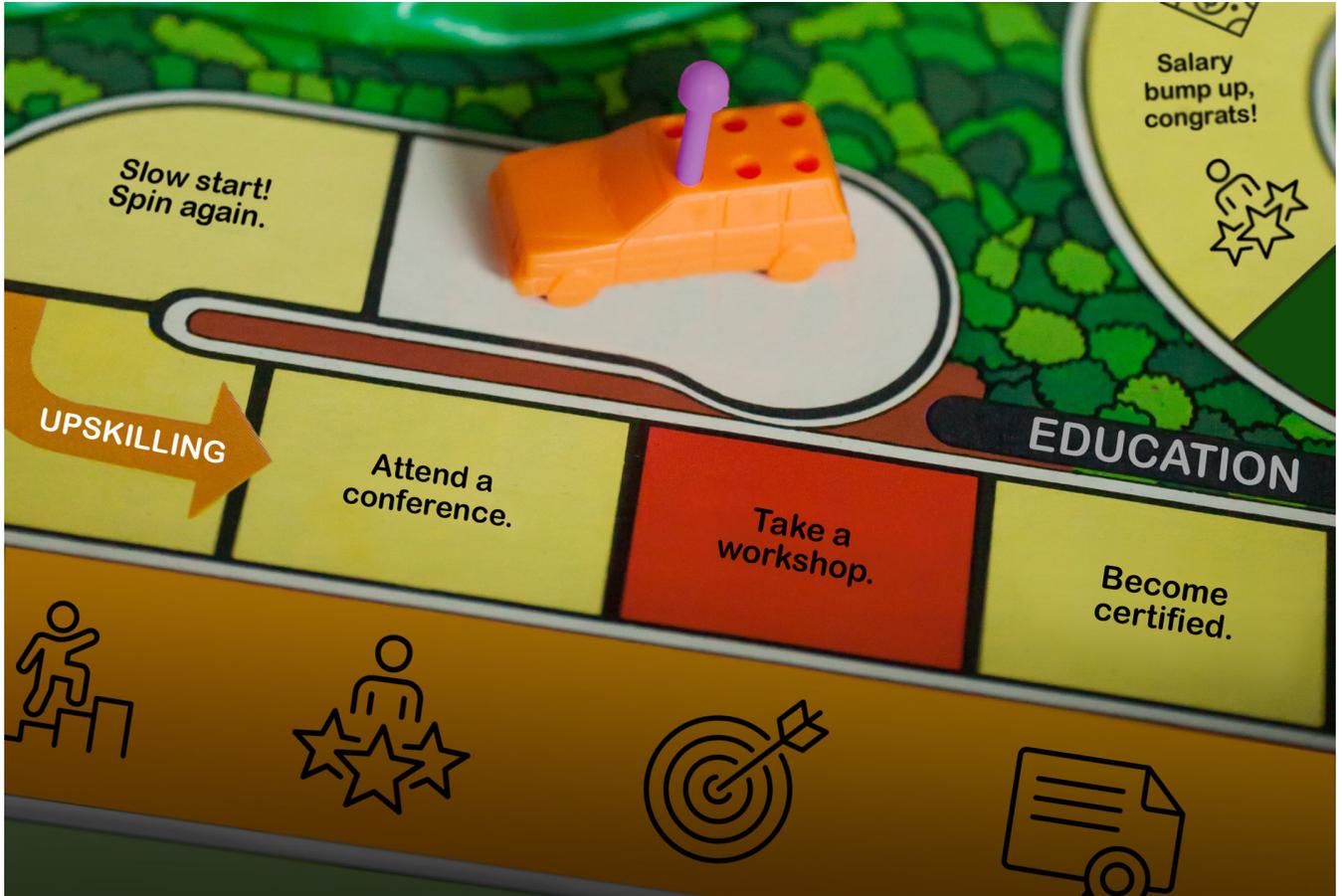
by Andy Shaughnessy, I-CONNECT007

For the past few years, industry analysts have been talking about the need for fabricators to “upskill” their employees to be ready for the technologies of tomorrow. The Smart factory and Industry 4.0—not to mention the ramping-up of AI—are just a few reasons that your staff really needs continuing education throughout their careers.

But upskilling is more than a fancy-sounding idea. In today’s labor market, fabrication

management may not have any other alternatives than to make the best of the employees they have right now. That, and pray that none of the subject matter experts retire in the meantime.

(If I owned a board shop right now, I’d set up putt-putt golf in one corner of the shop floor to satiate the 63-year-old staffers who are looking forward to spending life on the links. And make every day Hawaiian Shirt Day. But I digress.)



It's certainly a good time to be adding tools to your toolbox of skills. As the Smart factory and Industry 4.0 lead the drive to replace more humans with technology, the need for humans who are trained to manage AI-optimized systems will increase exponentially. Much of the software used to fabricate and assemble PCBs contains AI or machine learning—it just operates in the background, learning as it works.

But what's the best way to upskill your employees? Several managers we spoke with said they don't have time to take staff off the shop floor for training sessions. Your best bet is to incentivize employees to continue their education and training on their own time. But how do you make that happen?

For fab managers, upskilling is almost your only good option. We're still feeling the effects of the brain drain of the past few years; many who were close to retirement pulled the pin during the pandemic. As 10,000 Americans turn 65 each day over the next 15 years, this is becoming our reality. More shop managers are finding themselves with a lack of subject matter experts in-house, and a tight labor market isn't helping them fill the gaps.

So, some managers have adopted the mantra, "If you can't find them, grow them." They're sending their current staff to be upskilled, whether at conferences, trade shows, or industry training centers. With three or four open positions for every job-seeking engineer, training your current workforce to be the best they can be is just good business.

In this issue, our contributors discuss the skill sets they see lacking in the fab community, and some strategies for training and educating employees to fill these gaps. We cover the challenging topic of the skills gaps and upskilling. We will bring insight into some of the common gap areas and methods to fill in those gaps.

We started by talking with IPC's David Hernandez, who outlines some of the organization's educational plans, including a curricu-

lum approach that can be tailored to a company's needs. We also asked three Sunstone Circuits managers to share their thoughts on upskilling for tomorrow's fabricators. For his monthly column, IPC President and CEO John Mitchell shares valuable insight into the workforce challenges, and columnist Todd Kolmodin shares tips on how to best optimize your training time.

Our new columnist Hannah Nelson explains how students can be better prepared for an internship in this industry, and Editor Nolan Johnson discusses some of the lessons he learned from *Analyzing Performance Problems*, a book authored by Robert Mager and Peter Pipe in 1970. Barry Matties brings us interviews with two representatives from the FIRST robotics programs in Oregon and Washington, who share their enthusiasm for the program and the need to attract more students into STEM careers. We also have columns by our regular contributors Christopher Bonsell, Steve Williams, and Happy Holden.

There's never been more opportunity than there is today for your employees to become valuable than there is today. But you'll have to support them by giving them time to continue their education, and they'll have to step outside of their comfort zone to learn about new processes and technologies.

Don't forget: You're in this together with your employees, but they have more options than you do. While that may feel like a sobering reality, it's about perspective. Taking the opportunity to upskill means everybody wins. **PCB007**



Andy Shaughnessy is managing editor of *Design007 Magazine* and co-managing editor for *PCB007 Magazine*. He has been covering PCB design for 20 years. He can be reached by [clicking here](#).



A Game Plan for Upskilling Your Fab Workforce

Feature interview by the I-Connect007 Editorial Team

There's been a lot of talk among PCB manufacturers about the need to upskill their workforce. But where do you start—do you set up your own program or send staff to third-party training centers?

The I-Connect007 Editorial Team recently asked David Hernandez, IPC vice president of education, to weigh in on this topic, and the criteria that goes into creating IPC training programs. In addition to upskilling strategies, David also delves into the need for our industry to develop a labor pipeline, as well as the challenges we face in hiring, training, and retaining employees in this industry during a tight labor market.

Nolan Johnson: Dave, our conversation today is on upskilling and how the circuit board fabricators should be looking at that situation. This is a big issue for the industry as we deal with staffing issues.

David Hernandez: We are seeing challenges for companies trying to hire at the operator level, the unskilled or low-skill level, but also seeing the same challenges at the high-skill levels, like engineering, as well. Now, there are different challenges in each one, but the consistent theme across the board is that we don't have a pipeline that is feeding talent directly into the industry, and therefore industry is struggling to identify ways to bring in talent. Once they bring in the talent, they're having challenges to onboard and level-set that talent, because they're not pre-trained. They are also having challenges just keeping talent in the industry.

Finally, and it's a big part of what this conversation is about: Once they have that talent in the industry and they're able to keep them, how are they able to continually upskill them to new technologies, new processes, and best practices? When we talk about these challenges, it's not one thing; it's really a culmina-



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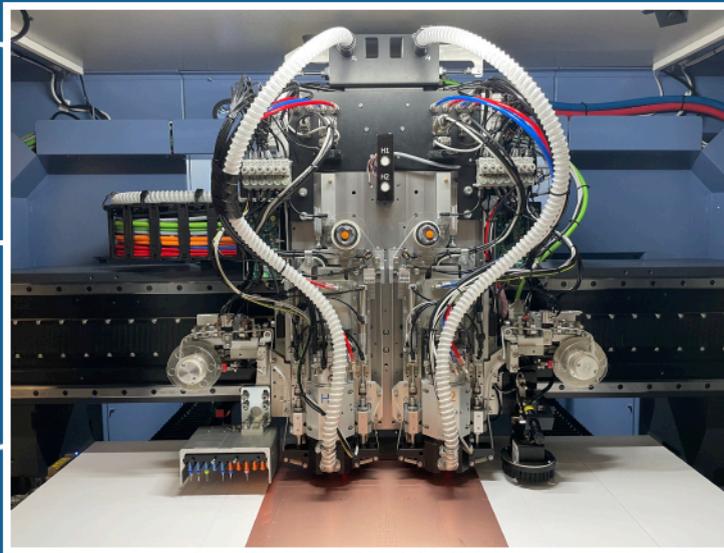
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David Hernandez

tion of these different challenges throughout the industry coming together at the same time.

Johnson: Interesting. I was about to ask you whether one tackles this by hiring people with proven skills or by hiring people who seem to have an aptitude and then training them. I think I know the answer.

Hernandez: You should hire whoever you can hire at this point. You take whatever you can get. It's kind of funny (but not really), but I have companies that have told me they will hire people out of supermarkets. They will take anyone that they can get at this point because the challenges are so great that they would rather have a body who is untrained than not have anyone.

Johnson: Well, that certainly does put a spotlight on basic training and upskilling.

Hernandez: Yes. It's a perfect storm today.

Dan Feinberg: You're talking about the entry-level people and the mid-level staff—your engineers and so forth—but what about the

junior executive level? If you can hire new people at the junior executive level, they may have a wide group of associates who, if they're going to take a new position, can probably say, "I'm going to work at this company to do this. Would you like to consider joining me?" I think that's a level that isn't talked about that much.

Hernandez: That's a great point, Dan. We talk a lot about skill and competency training for these various jobs in the industry. But that's one aspect that doesn't get talked about enough. We do have a challenge with hiring businesspeople, those on the administrative side, because they either come up in our industry and therefore have the technical knowledge and understanding of the industry, but lack the business knowledge, or it's the other way around.

Feinberg: Exactly. One of the hardest groups to clean out is your senior level. If you have somebody at that senior level—a vice president of finance or a vice president of human resources who is clearly a weak point—we tend to not want to clear that position and replace it.

Hernandez: Yes. I realize that we're here talking about upskilling, but I think it's critical that we take the opportunity to take a step back and realize the broader problem. There's an inherent issue with how we train and retain employees in this industry, unlike other manufacturing sectors in the United States. I'm now mostly talking about the U.S. because there are different challenges when you start talking about Europe and countries in Asia.

In the United States, unlike other manufacturing sectors, electronics manufacturing does not have a well-defined pipeline of talent. You can go to any number of high schools in the country that have training programs for the culinary arts, HVAC repair, electricians, carpentry, and automotive. What you find is that those programs tend to feed talent into the industry on a continual basis. But our current

pipeline is not filling this particular gap. We have a fundamental lack of a pipeline feeding talent, and this exacerbates all our other problems.

Johnson: That is an interesting point because it means that basically the training starts not at the educational level, but at the new hire.

Hernandez: Exactly. For many organizations, that's absolutely true. We recently built a program that I never thought we would have to build: an entry-level engineering training program. We created this because the industry kept telling us that they're hiring talented engineers, from the top engineering programs in the nation, who have no knowledge of PCBs. Unfortunately, that's happening more and more.

Johnson: We established that upskilling starts at the new hire. Basically, at any point when you're hiring somebody at a technical level, there is an immediate need to be upskilling that person. What are the best practices for getting started?

Hernandez: It's a great question. As a side note here, we don't even refer to that as upskilling yet. We refer to that as "onboarding" or "level-setting." Your immediate goal is not optimization, but rather to have this person you just hired reach a full level of productivity as quickly as possible.

Feinberg: Integration, yes.

Hernandez: Exactly. You are trying to get this new person in your organization to be able to contribute with the minimal amount of outlay of cost and time, because the more time that they spend training, the less time they're able to produce for you. So, because there's not a well-established pipeline feeding already pre-trained talent to you, these organizations are having to take on that training themselves.

Feinberg: Which means instead of having someone drop out of the program in the educational track, you are often hiring them, paying them a wage, and funding their training, just to find out they just don't have the aptitude.

Hernandez: You may, and that's unfortunately one of the challenges that the industry runs into. These are not training organizations that are hiring people. These are EMS companies, fabricators, and OEMs; they are here to manufacture electronics. Their core competency is not education. They may hire some trainers to be part of their organization, but that's not their core competency.

There should not be an expectation that they're going to have the knowledge, or the wherewithal, to develop well-defined training programs.

What you typically see in the industry is a hybrid approach to training: "We're going to teach you how we do things internally, and you're going to shadow some people and learn from them. You're going to pick up a little bit of skill here, and a little bit of skill there." But what ends up happening is that they're training for months on end. They're picking up this skill little by little, and it could be six months down the line before you realize that this guy's never going to get it, because you've never actually put him in a formal training program. You never put him into something that will measure his ability to comprehend, understand, internalize this information, and retain it.

For example, I'm great with my hands, but I can't do any car work. I could go on YouTube, figure out how to do some automotive work, and brute force my way through it. But if I did that every time something broke in my car, imagine how long it would take me to do it.

Feinberg: Or how long the car would last.

Hernandez: But put me in a formalized training program to learn these things in a period of weeks or days. At the end, I'm going to be

much more competent and proficient than I would be trying to pick up auto mechanics on my own, piecemeal, a little bit here and there, without any kind of formalized training.

Without that kind of formalized training program to put people through, you will have a very slow ascension to full productivity, and you also must deal with the potential side effects of training on the job like that, such as picking up bad habits and shortcuts that other people are using. You won't learn the vocabulary that everyone is using to communicate, or there may not even be a vocabulary that is shared amongst your teams, because everyone's learning on their own. Having a formalized training process really moves the needle significantly forward in getting and keeping quality people.

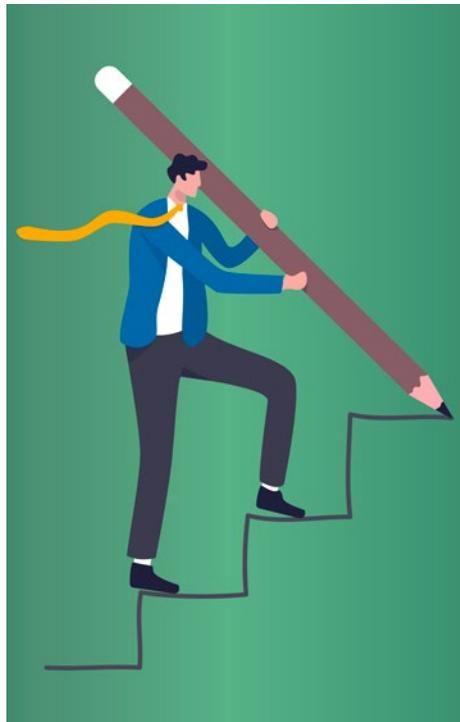
Barry Matties: What characteristics are you looking for in someone who might have a higher degree of success? For instance, Happy Holden always says that when he was hiring people, he looked for people who can solve problems.

Hernandez: It really depends on the role you're looking for, but my general rule has always been to find people who are curious, because curious people want to continuously learn. To be efficient in the long term in this industry, it's a process of continuous education. Often, we settle for people who know their jobs will be the same every single day, pushing these same buttons, and they're comfortable with that. But I want to find people who are uncomfortable with that, who have a desire to learn.

Feinberg: When you look at skill sets, it seems you're looking at ones you might need later.

Identifying some potential future-needed skills could be very helpful. Are you seeing that?

Hernandez: Yes, and part of the challenge is that we need people who think of their jobs as careers. Let's say that you start off as an operator. The most I can offer you is that you're going to be an operator making more money 10 years from now. That's not much of a career, though. That's just a job. Those are the people you lose to the company across the street or to Amazon because they're paying them a little bit more money.



Johnson: How can I grow that person? How do I develop a relationship with my employees to grow, develop, and improve? That doesn't happen in a vacuum. How does a PCB fabrication company start to set that up if they don't have one already?

Hernandez: That's where we get into something that we call career pathways: Today you're an operator, and we will train you for these skill sets. That person across from you taking those boards and inspecting them before they

get shipped off to the customer is an inspector. That job has a whole different set of skill sets. You tell your operator, "You can, over time, grow those skill sets by doing these different jobs here and by taking these training programs." You've now given that person a clear roadmap of where they can go if they put in the time and effort. You, as an organization, then provide the resources.

Feinberg: People are building new skills, but are they retaining and using them? Is the company putting those skills to use, and can you measure it?

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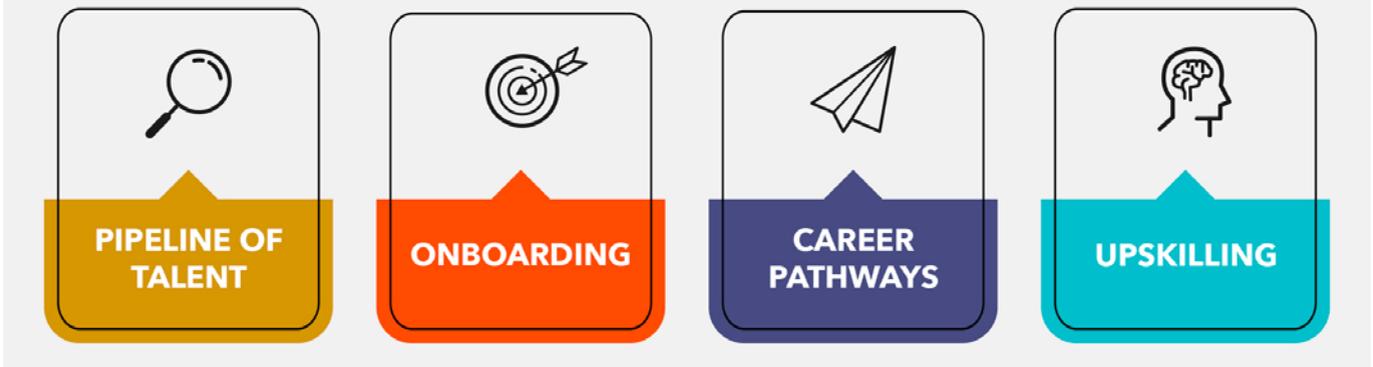
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THE FOUR PILLARS OF WORKFORCE CHALLENGES



Matties: How do we get this to be self-empowered, or self-incentivized by the company, and done at the pace of the employee on their own time?

Hernandez: You have to match the skills to the opportunities. Today we discussed the four pillars of the workforce challenges that we face today: the pipeline of talent, the onboarding, the career pathways, and the upskilling. They occur at each of the levels—engineering, operator, and executive. We have onboarding programs for operators, engineers, and designers. We have upskilling programs for engineers and designers. We have new programs coming out for inspectors later this year. It’s a growing catalog of tools that we’re providing the industry to solve whatever internal problems they have, based on what their needs are.

Johnson: How many of these are students joining the training who have referred themselves on their own initiative vs. being sent by an employer?

Hernandez: Most of it is coming from employers. I don’t have a percentage, but I would not be uncomfortable saying more than 80%.

It’s driven by the employers right now. This is an employer seeing something, or someone on another team saying, “Hey, we can use this skill set here. We can use this training to help

us solve this problem here and implementing it in turn.” They can implement that, and it gets them 90% of the way there. They then take that last 10% and say, “Take everything you learned, and we’re going to talk about how we apply it here internally.” Now I’ve cut down the time that I must invest into this person by 90% and I can focus on that last 10% that really has to do with how we do things.

Johnson: Dave, if 80% of the attendees are coming from employer assignment referral rather than volunteering, what do you think that percentage should be?

Hernandez: What should it be? I like to think it should be closer to 50/50.

Matties: But if employees are taking on this training themselves, they’re either doing it because they’re going to switch jobs or their employer says, “That skill set is of value. We’ll pay you more if you have it.” But what’s the motivation beyond that for employees to jump in on their own?

Hernandez: It goes back to the type of person you’re hiring. If you’re hiring someone who is inherently curious and wants to grow, they’ll take it upon themselves to get that training, but you’re not going to benefit from it as an organization because they will take that skill set somewhere else.

Matties: Yes, if you're not there facilitating and inspiring and motivating your people to do it, they'll do it on their own to just to get a new job.

Happy Holden: I'm thinking of three or four senior executives in this industry who worked for me. We once thought, "Where are they going to be? They've really got the capability," not of where they will go next, but where they will go after that; they're now senior executives in this industry.

Matties: Are you seeing formalized training programs on the rise, or are companies just too busy to even stop and think about it; they're just firefighting, so to speak?

Hernandez: It depends on whether you're looking at organizations that are trying to do this internally on their own or if they're working with IPC to do this. Some companies have great internal training programs. They've invested a lot of time and money to develop well-defined training programs, with great resources for their people internally, but that's not the norm. Oftentimes, these are training programs that are developed because there's an absolute need, so you develop it, but really, you're just putting on a Band-Aid.

Matties: Now, you have a training program in the box, so to speak, that they can bring into their facility, open and get started straight away?

Hernandez: That's the idea. We're still getting the word out about this. We started launching these programs about 18 months ago, and one of the reasons why we didn't make a huge, overwhelming splash is that I'm a firm believer in having proof that something works before you start promoting it at that level.

Why? Because education is filled with snake oil salesmen. It's created a terrible reputation for workforce training. You often hear, "This is

the solution for your problems; all you have to do is pay us money and all your problems go away." It's a common aspect of for-profit education and unfortunately that's become very common here in the United States.

It's often what you hear in for-profit education centers, so I'm very sensitive to that. We wanted to build an industry program, not an IPC program. For instance, when we built the entry-level assembly operator program, we worked with more than 100 different organizations from around the world. We did not build the program ourselves. It's an industry program. This is not an IPC program; we just help facilitate it.

It's very much like a standard. We don't write the standards; we just help facilitate. We didn't decide what went into the program, or the depth at which we teach this material. The industry decided that. All we did was use our educational development experts internally to decide on the most efficient and effective way to teach what the industry wants to teach. We validate that the student is walking away with the highest level of retention possible.

Matties: What is that teaching methodology? Is it online with coursework at home, or is it in the factory?

Hernandez: It depends on the program. Our design programs, for example, are project-based curriculum programs. You meet with a live instructor and have discussions a couple times a week, then you take what you learn in those discussions and apply it to a project. Every week you have a project that you need to complete with the knowledge that you're gaining, so you're applying it immediately after you learn it. Then you build on the knowledge from the previous week for more complex projects.

In the meantime, you're gaining feedback from the instructor. If you have questions or you don't know how to do something, the instructor is there to help you. Why? Because

these are really complex topics, and you want to make sure that someone can apply it in a practical manner immediately.

With something like the entry-level operator training program, we do it as an online, self-paced program. Our system is designed to identify the knowledge this candidate already has. It utilizes a variety of different methodologies, videos, interactive elements, games, and activities, along with a virtual instructor to teach them at the pace they need to learn. If they already know it, they can go through it rather quickly. If it's something they don't understand, they can spend more time to deeply understand.

Every five to seven minutes, the program asks the operator to apply what they're learning. These intervals are intentional because this is an onboarding program; to a lot of them, it's brand-new material. You want to be sure they understand this concept; that they're able to apply this concept before you teach them the next one.

Matties: As the online data is capturing their progress, you're essentially able to watch them learn, see where they grasp a concept, and really apply it, vs. struggling to sort it out.

Hernandez: Not only are we tracking all that, but we're refining the program based on that data. We can understand where people are having trouble. "Maybe this needs more explanation. Where are people spending the least amount of time? Maybe we're going too deep there." We can adjust all this on a regular basis, based upon the data and analytics that we collect from users.

We also work with a lot of organizations that run their own internal analytics, and so we're able to get feedback from them, like, "This has cut down our average training time of new operators by this much." We had a case study done recently where they let us know that they cut down new training time for operators by over 60%.

Matties: That's amazing.

Hernandez: They're able to track it internally, and share it with us, which helps to refine the product. Again, it's an industry product; they designed the product for their own use, which is why it's so efficient and why they're getting such good results. It also means that they're willing to share that information with us because ultimately, they're the ones gaining the benefit.

Matties: Now, when it comes into actual learning inside the facility, obviously the company must make an investment into that resource and have it available when it's needed.

Hernandez: As someone who has spent his entire career as an educator promoting the idea of education technology, I can tell you emphatically that there are some things you can't learn to do well online. Our philosophy with these programs is to utilize the technology to efficiently teach what we can online, and then help organizations to identify what should be taught in person to augment this learning, and at what point.

For example, these programs for the operators include instructor guides and organizational guides; it's what we call "operational hands-on." We tell them, "Once they've completed this, you should take them out onto the floor and do X, Y, and Z to reinforce what they learned in theory." They may not have a formalized in-person training program, but this is giving them the roadmap or blueprint on how to do that.

Matties: If we focus on just-in-time training, you're going to have a much higher and quicker return on your investment for that person, that's for sure.

Hernandez: Absolutely.

Matties: An important message for industry is to place a high value on that training program,

whatever it happens to be. It helps in the long run to do so many things that you may not even realize.

Hernandez: Not only your training program, but as these people progress, make them part of the training on the next level below them.

Matties: I'm sure you're familiar with Khan Academy. What I like about their approach is that they would give the lessons in two or three different ways, and you could access it in whichever way was best for your learning style, whether it be visual, experiential, or whatever. How are you approaching the learning styles?

Hernandez: I'm a big fan of Khan's and I've always thought that he's one of those people who can get results from education and really move the needle. He gets it. You want to build programs that utilize different techniques to really entice different types of learners. Make sure that you have engaging visuals that your visual learners are going to be interested in. You want to make sure you have audio, and that's why we hire professional actors to do the voiceovers for our educational programs. It's not even really done by teachers. It's done by professional actors because we want them to feel the emotion and to feel interest in what they're saying.

You continuously have these interactive elements where they're applying what they're learning. You're asking them to engage with the learning continuously for your kinesthetic learners. Some of the content is going to be written on the screen for those read/write-type learners. We make the transcripts and add subtitles for ESL students. We've made the

platform flexible enough so that you can learn in the manner your prefer.

Matties: Is it available in multiple languages, David?

Hernandez: Some of our programs are available in English and Spanish. We're still working on how to be able to efficiently bring this into other languages beyond that. Remember, this is not death by PowerPoint with some audio or something that you read. This is like learning software. You're experiencing this class. We call them "learning experiences" for a reason. You're experiencing this class throughout.

The 30 or 40 hours you're spending on this program is well-crafted and defined; it's engaging, but that makes it complex. Translating it takes a lot more than just translating a standard.

Johnson: Dave, most companies in our space don't really have a training program in place; what's your guidance for them moving forward? What's your guidance for creating a program if you don't already have one in your company?

Hernandez: Call IPC. I'm not joking. We are here to serve the industry. This is what we do. This is our core competency in the education team. If you don't know what to do, give us a call, and the reason that I'm saying this is not because I'm trying to be vague, but it's hard for me to give you advice on how to implement something when every organization's challenges are slightly different and therefore the solutions they need will be different.

Johnson: Thank you so much, Dave.

Hernandez: Thank you all. PCB007





Training the **Future** Manufacturing Labor Force

Feature Article by the I-Connect007
Editorial Team

To better understand what's needed for upskilling your labor force in today's job climate, we reached out to Sunstone Circuits, a PCB fabricator in the Pacific Northwest. We posed our set of questions to individuals in three departments to hear their perspectives depending on what area they work in. The following are the questions and answers from Michael Connella, operations manager; Matt Stevenson, vice president of sales and marketing; and Debra Coburn, human resources manager.

Q: There has been a lot of talk about the need for fabricators to “upskill” their employees to be ready for the technologies of tomorrow. What skill sets do you see lacking in the fab community?

Michael Connella: We are seeing a larger part of the workforce with experience and “tribal knowledge” of circuit board manufacturing either retiring or moving on to other career paths. I have seen this throughout our industry. Without that in-house knowledge, there are fewer opportunities to glean best practice process control to teach a new generation of line operators and engineers.

Matt Stevenson: Most of the skills needed to be successful in manufacturing can be taught on the job. Having the ability to understand logic, ordered process steps, reading and understanding documentation, cause and effect, and basic math concepts are some of the inherent skills that are needed in manufacturing—and less common in 2022 than 10 years ago.

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Matt Stevenson



Michael Connella

Q: What are the best strategies for training employees to fill these gaps? In-house in-person training, Zoom classes, conferences, classes, online videos, or a mix of these?

Connella: We have focused on cross-training individuals in several departments and it has helped immensely. Having detailed processes documented, while simultaneously getting quality one-on-one process training has proved to be valuable.

We recently promoted an employee into an engineering tech position. This individual has been part of our team for over 10 years and has experience in several areas. He has been doing research using online literature as well as online videos. With a variety of options through multi-faceted resources, the opportunities to improve on skills and knowledge base has grown and all should be utilized.

Stevenson: Most positions on the manufacturing floor do require in-person, onsite (on the job) training. It is the nature of the beast. For roles that can be done remotely, a combination of in-person and video (Zoom) training can be very effective in training primarily as a substitute for in-person.

Debra Coburn: In-house, in-person training is the best, but has been challenging during the pandemic. Our plan is for in-person trainings, which tend to be far more effective, but we may need to resort to online options if we run into further pandemic roadblocks.

Q: What new technologies do you see Sunstone moving toward in the next five years?

Connella: We are currently in the final stages of implementing some higher, more complex capabilities and in the planning stages for more similar projects. It's exciting to be looking forward and we will definitely need motivated staff as we progress.

Stevenson: Sunstone has several manufacturing upgrades planned for the next few years related to more HDI capabilities which spans nearly the entire manufacturing process. We will also add more automation into processes as it makes sense. It's making processes more capable, repeatable, and ultimately, operators more successful.

Q: In addition to a degree or work experience, what soft skills (good communication,

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Debra Coburn

troubleshooting, etc.) do you look for in new employees?

Connella: Excellent communication skills, being self-motivated, trouble shooting background, high attention to details, and having a short learning curve are some of my biggest needs.

Stevenson and Coburn: Attention to detail, good communication, positive attitude, flexibility, and work ethic are the most important soft skills for us. And of course the desire to be a part of our Sunstone family.

Q: With several open positions available for every job seeker in the U.S., how can a company make itself attractive to these potential hires?

Connella: From what I've seen, companies need to have competitive wages and employee benefits for the region where they are seeking people. Those employee benefits must be front and center in the marketing of employment needs.

Stevenson: In today's landscape, where everyone is hiring and advertising very high hourly

wages, it is difficult to really stand out to be attractive to job seekers. Wages are definitely important, but the other pieces can be very effective: benefits, culture, flexibility, and geography (people are becoming increasingly interested in working closer to home).

Coburn: Good benefits, low turnover, and work/life balance are even more important in the current competition for talent. I know there are companies utilizing 12-hour shifts and 60-hour weeks to try to extend their workforce, but this schedule has the undesirable effect of exhausting those employees to the point they burn out, and the compounding effect of making it even harder to find new workers. In order to make itself more attractive, a company need only pay a fair wage, and demonstrate respect for your employees as humans who want to have a life outside of work.

Q: Is there anything else you'd like to add?

Connella: In the current climate, where there are more openings than people willing to work, it has been extremely difficult to fill positions. We often get leads, set up interviews, and the potential candidate simply does not show up. Over the past two years, COVID-19 has affected every aspect of our lives. We have extended and increased unemployment benefits, rental assistance benefits, and rental protection polices, and included in this is the rising minimum wage across the country.

These changes may have affected how people weigh the benefits of staying home and not working vs. coming to work for 40 hours a week. It may also be a determining factor when choosing between a demanding, high stress position in manufacturing vs. a lower stress position somewhere else.

Coburn: We are very lucky to weather this storm with the amazing group of people we have on staff at Sunstone Circuits. **PCB007**

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Working Together to Address Workforce Challenges

One World, One Industry

Feature Column by Dr. John Mitchell, IPC PRESIDENT AND CEO

While the conflict in Ukraine has captured headlines for the past several weeks, the challenges facing companies on the workforce front have not abated. When I speak with executives around the world, they are singing the same song in two-part harmony: supply chain and people.

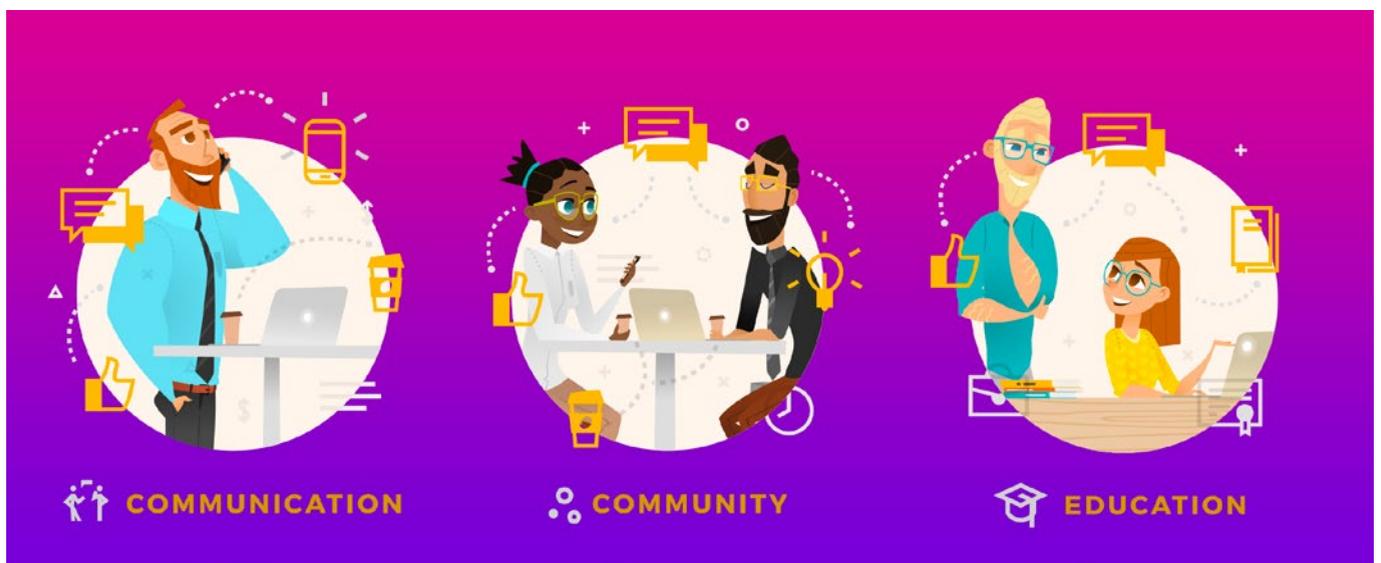
Let's talk a little about the people challenges that are keeping management up many nights. Even though we say there is a workforce problem, it is not just one problem. This obstacle is multifaceted.

Some of the Challenges

Let's first examine the factory floor. There are several facets to this challenge. First, there is the challenge of finding people, any people, who are willing to work in the industry. It is not that the electronics manufacturing industry isn't attractive; it is that, due to the down-

ward pressure on electronics, the operator roles don't tend to pay as much as the Amazon factory down the road. This kind of competition makes it very difficult to find people. Our industry is not the only industry looking for people; practically every industry is looking and trying to make deals to woo employees into their locations. Some of these enticements, such as providing tuition toward a degree if you come to work for their factory, are things that have never been considered at this level of employment.

The other challenge that has come about due to COVID-19 is that of the virtual workforce. During the pandemic, many of the operators were able to experience getting paid while not going to the factory. This presented a different way of life that had not been considered previously. At the operator and inspector levels, this really isn't an option. It is almost impossible



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to build, inspect, test, and verify the electronics coming off the line without being present in the factory. With the ever-changing technology being built and being used to build, the skill set of the workforce in the factory needs to be continually advanced to meet the needs of the business.

The workforce shortage is not limited to just the factory. The dearth of engineers has continued for over a decade, making it critical for us to get engineers aware and interested in the challenging and rewarding career path of electronics manufacturing. The IPC Education Foundation (ipcef.org) is striving diligently to do this at the college level with competitions, awareness campaigns, chapters, and interactions with local electronics shops to help engineers and technicians gain awareness of the interesting and exciting work that is happening, in many cases, right under their noses.

In addition, we are starting to see executives move around the industry as well. The challenges facing operators, technicians, and engineers have escalated in discussion over the past six months, and now seems to be affecting executive positions. As the “Great Resignation” envelops much of the world, opportunities are abounding, and with opportunities comes movement. This is a relatively new phenomenon. These movements are happening both within the industry and with people moving outside of the industry.

Okay, enough of the doom and gloom. We know we have challenges. What are we to do about it?

What Should Be Done?

Let’s talk about potential solutions to each category mentioned above: factory line, technicians, engineers, and executives.

Factory Line

First, we must do what we are good at—we need to innovate. We need to look for people in different ways and in different spaces. I have seen job fairs work to good effect. Now, I know you’re

thinking that job fairs are old school. But these latest job fairs are bringing in people, providing tours of the facility, teaching them about the company, interviewing them, and offering them jobs to start as soon as the next Monday—all in the same morning. That is a very different job fair from what we have seen in the past. Another innovation is to look in places we haven’t looked before. I have seen groups approaching families with graduating seniors—not to hire the graduate, but to make an offer to the parent who will no longer have a reason to stay at home. Other innovative sources include the military, prisons, high schools (no, I am not equating high schools to prisons), etc. Look in places where most people don’t look. If you are at a restaurant, for example, and your server is competent, invite them to come to your factory for an interview. Finally, utilize modern skills training programs like the Electronics Assembly for Operators (AEO) and Wiring Harness for Operators (WHO) to bring new talent off the bench and onto the line within hours instead of weeks.

Stay tuned for a new industry-developed program on the inspector front coming later this year from IPC to help on this increasingly needed (especially with automation increasing) area of expertise.

Engineering

I have already mentioned the efforts of the IPC Education Foundation. If you really want to leverage that, I urge you to get involved. You will find internship opportunities and first-hand interactions to give you a leg up on bringing new graduates into your organization. One other solution that IPC has developed along with the industry, to ensure that new engineers are ready to work in the factory, is the Electronics for Assembly Engineers course. This online course brings novice engineers rapidly up to speed on all the basics of electronics manufacturing. This course is ideal for new engineers who haven’t had enough exposure to the specifics of our industry. Now they can get that at their own pace and in a consistent manner.

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Executives

My best suggestion is one that has been used to great effect in some companies. Just like other industries are looking to poach from our industry, we can look at new sources to pull in from other industries. This opens a whole new pool of people to consider. There are many kinds of manufacturing experts who can translate what they know and have done into our industry, whether at the general manager level, supply chain, procurement, human resources, development, engineering management, or financial. The added benefit of bringing in

someone from outside is that you will also get new ideas and approaches. I call it diversity of thought. This is a competitive advantage and not something to be dismissed lightly.

The workforce challenges will continue. We need to continue to do what we do to solve problems: work together and innovate. **PCB007**



Dr. John Mitchell is president and CEO of IPC. To read past columns or contact him, [click here](#).

BOOK EXCERPT

The Printed Circuit Designer's Guide to... High Performance Materials

Chapter 1: The Evolution of the Resin System

Evolution of the Resin System

Most basic resin systems have been around for a long time. Here is a little timeline of developments through more recent introductions.

- In 1907, the first laminate was made with pure phenolic resin by Westinghouse in Pittsburgh, Pennsylvania. Formica became the first true sheet laminate.
- The first application—a radio by Paul Eisler in 1936—led to practical manufacturing for military radios in the U.S., and use of single-sided copper-clad phenolic laminate started in about 1943 using paper and cotton as the structural component. Epoxy resin was introduced shortly after in 1947.
- Still reigning as the lowest loss resin system, a PTFE, RT/Duroid® was introduced in 1949.
- The first polyimide was discovered in 1908 by Bogart and Renshaw. However, the high heat-resistant polyimide laminate material was brought to the market in 1951.
- Isola began production of copper-clad laminate in 1956.



- Epoxy-based laminate systems followed around 1960 and used woven E-glass fabric.
- Shortly after, G-10 epoxy laminate (non-flame retardant epoxy resin plus E-glass) and a flame-retardant epoxy version called FR-4 (flame-retardant epoxy resin plus E-glass) were introduced in 1968.

From that time forward, there have been various blends, such as PPO (polyphenylene oxide)/epoxy, CE (cyanate ester)/epoxy, and polyimide/epoxy, that were created to balance properties of pure resin systems to achieve specific enhanced properties. Each new resin system was built on learning from previous products. Resin system developments for high heat applications such as LED lighting, ultra-thin non-reinforced films for capacitance and halogen-free systems to meet RoHS and REACH environmental requirements, continue to be developed to address the performance and reliability needs. With each new need, laminate material manufacturers go into the lab and see what new raw material can be used to improve resin system performance.

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Book Review

Advocacy by John Daly

Feature Article by Cheryl Tulkoff

NATIONAL INSTRUMENTS



John Daly

I've always wondered why some great ideas succeed while others fail. Fortunately, I had the opportunity to be both a student of Dr. John Daly and to read his book on advocacy. I highly recommend checking out his YouTube videos as well.

He's an energetic and entertaining speaker.

Advocacy: Championing Ideas and Influencing Others helps you understand the whys and provides concrete techniques to elevate your ability to sell ideas. Change and change implementation require more than just a good idea; they also require advocacy—the ability to sell to the people who make decisions in organizations. The most successful people are those who have learned how to advocate their ideas to gain interest, support, and funding from decision-makers.

At some point in their career, everyone must perform the role of a “salesperson.” To sell something, people must be able to:

- Clearly communicate their ideas
- Understand how their “brands” shape opinions
- Build partnerships and alliances with subordinates, peers, and managers
- “Pre-sell” their ideas

Advocacy outlines four key steps in the persuasion process.

1. Communicate the need to change (pain).
2. Explain “why change now?” Establish urgency. Are times tough? Emphasize saving money or taking a bigger risk to bet on the future. Are times good? Emphasize making even more money

and don't propose radical changes to something that's working.

3. Communicate “what's in it for them” (WIIFT). WIIFT includes appealing to how the change can improve reputation, finances, efficiency, status, relationships, productivity, safety, security, and appearance. Take advantage of the “fear of missing out” (FOMO). Regret for a missed opportunity is a powerful driver of change.
4. Tell a good, credible story. Humans are natural storytellers.

Once you've used these steps and your persuasion is successful, follow up with:

- Tell: Explain the concept
- Show: Demonstrate it
- Do: Apply it
- Respond: Reinforce and redirect

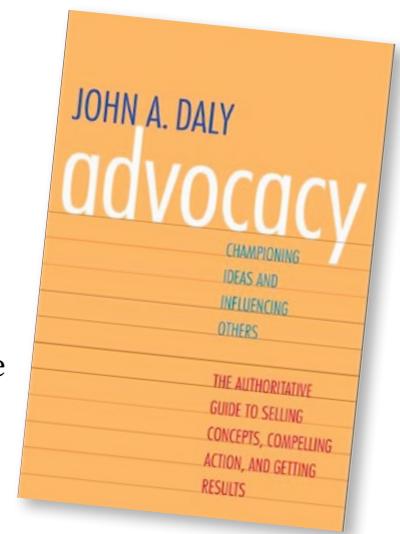
Successfully transforming ideas into practice requires a combination of good ideas, clear needs, and effective influence. Advocacy explains how to do this in a fun, informative way. The book is available on Amazon, and he uses of the ideas from the book in his address to the McCombs Alumni Business Conference¹. **PCB007**

References

1. “Advocacy: Influencing Others and Selling Ideas,” April 10, 2012, youtube.com.



Cheryl Tulkoff is senior director of corporate quality for National Instruments, and member of the SMTA Global Board of Directors.





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Optimize Your Training Time

Testing Todd

Feature Column by Todd Kolmodin, GARDIEN SERVICES USA

Today's training has become an essential part of any operation, especially because most quality management systems (QMS) require this. To be compliant with ISO 9001 you must maintain a competence and training system. However, there are a few things to keep in mind when taking on the competence and training mission.

process or work instruction is assigned to a person, usually a quality engineer or technician, or possibly the manager of the department, cell, or manufacturing unit. This is a problem, as that person may quit, move to another department, or otherwise become unavailable; the process is now orphaned. So, a process or work instruction should be assigned to a department and not a person. Therefore, it is always a task for the department.

Next, the building of the work instruction based on a documented process should not be a solo activity. Many times, the document is written by a third party or technical writer that has no real familiarity with the task being documented. This leads to process anomalies. Of course, a new machine or process may be assigned to a technical team to get

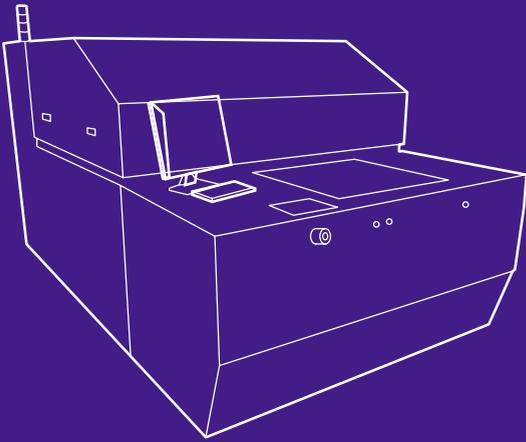
the machine online and document the operation of said machine. But it cannot stop there. Line operators should be involved in the documentation process. They are the ones who will be performing the task daily. The overall operation of the machine or process is to provide a goal, which may be a product, part, or combination thereof. Just documenting how to run the machine is not suffi-

Too many times you just hire the new employee, give them some work instructions and practical training, document their completion, and that's it. Unfortunately, this can lead to many problems, and here is why.

Assigning Employee Instruction

First, you must make sure the process or work instruction is robust. Too many times a





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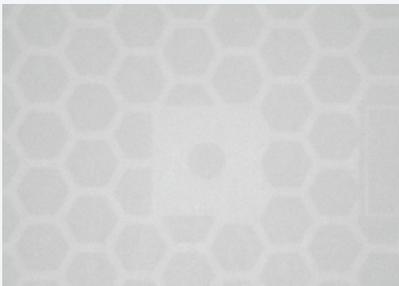
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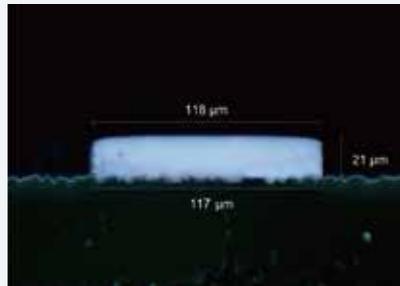
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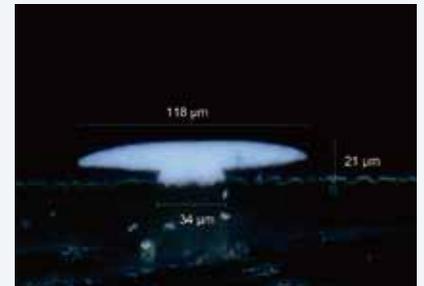
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cient. For the work instruction and process to work cohesively, we must combine the task with the surrounding environment, tools, and space. This requires looking at it from a higher level.

To begin with, we must evaluate the space. Is the machine or tool placed efficiently? Are there any hazards due to the installation? These could be:

- Tripping hazards
- Crush or pinch hazards
- Ergonomic hazards

One thing that is overlooked when installing new processes and/or equipment is the impact the work area has on the success of the process. If we don't look at these things, we are creating waste. In this context I do not mean waste or scrap of the product but the waste of time due to poor planning of the space.

We need to look at items such as:

- Tools required for the task
- Movements the operator must make
- Travel if the operator must move the product to and from the machine
- Health and safety such as lifting and twisting, if so applicable

This is where the importance of combining the process or work instruction with efficient development of the workspace or cell comes in. Another important aspect is to optimize the workspace so that it only contains the tools and supplies needed for the task. Get rid of everything else which serves no purpose and just creates clutter.

Time to Test

Here is where involving an operator-level employee benefits the overall success. Once the process or work instruction is documented, it must be tested. Go through the steps one by one to validate the necessity. You will find that some of your requirements may be dumb. During this evaluation you will be able to optimize the steps, validate the ergonomics of the area,

and streamline movements to achieve the best possible outcome.

It is only after this is complete that you can effectively train your workforce. They will learn the task based on optimal efficiency and the repeatability will be higher than that of a loose or messy process. The thing is, if you leave holes or gaps in a process, your operators will find the shortcuts or ways to deviate from the intended task. Having a robust and tested process, as well as work instruction, will keep this behavior to a minimum.

Now that we have our employees trained, we need to document this to be compliant to the QMS. Many times, we train the employees, document their file as trained, cut them loose, and they disappear into the abyss. Well, that doesn't work either. Once the employee is trained and documented, they need to be reviewed on a regular basis. Most common is an annual review. This ensures they are still performing the task correctly and/or have improved or degraded since last review. Because the QMS needs to be reviewed at least yearly, it gives the department an opportunity to review the process as well. Perhaps the machine was upgraded. Perhaps there is an obsolete step or a new one required. This is all part of the overall continuity between the process, work instruction, and employees performing the tasks.

Conclusion

The process must be designed optimally, including workspace, tools, and ergonomics. In today's times, efficiency, repeatability, and the minimization of waste is crucial. When processes and work instructions are "in tune" the ability to efficiently increase productivity and quality will quickly become apparent. **PCB007**



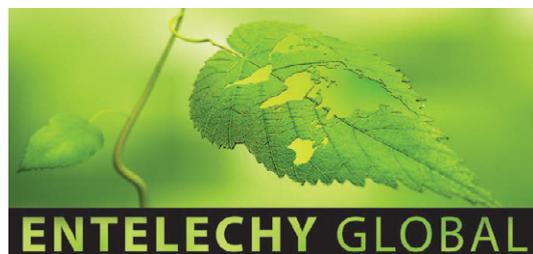
Todd Kolmodin is VP of quality for Gardien Services USA and an expert in electrical test and reliability issues. To read past issues or contact Kolmodin, [click here](#).

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ein Electronics Industry News and Market Highlights



SEMI Survey Highlights U.S. Chip Industry Competitiveness, Government Investment ▶

SEMI, the industry association representing the global electronics design and manufacturing supply chain, released the results of a survey of more than 400 U.S. member companies that highlight challenges facing the semiconductor industry.

Siemens Investing \$54M in U.S. Manufacturing Footprint to Support National Infrastructure Projects ▶

Siemens joins President Biden at the White House to announce it will invest \$54 million across key U.S. manufacturing facilities that serve critical infrastructure markets.

Lenovo Study: Three in Five CIOs Would Replace Half Their Current Technology ▶

A new global research study from Lenovo reveals how the CIO role has evolved, shedding light on growing areas of responsibility and increasing influence in the C-Suite, as well as removing barriers to business growth.

Standex Acquires Sensor Solutions ▶

Standex International Corporation announced that it has acquired privately held, Colorado-based Sensor Solutions for approximately \$9.7 million in cash.

Nokia, Palo Alto Networks Join 5G Open Innovation Lab ▶

Nokia and Palo Alto Networks have joined the 5G Open Innovation Lab as the newest corporate partners. The 5G OI Lab has uniquely pio-

neered an open innovation model that brings together influential startups, global tech platform leaders, industry partners, and investors to connect and collaborate.

Women in Semiconductors 2022 to Highlight Women in Leadership and STEM Talent Pipeline ▶

The vital importance of workplace inclusion and diversity to the growth of the global semiconductor industry will take center stage as the Women in Semiconductors (WiS) program returns in-person on May 2 in conjunction with the SEMI Advanced Semiconductor Manufacturing Conference (ASMC 2022) in Saratoga Springs, New York.

Cadence Collaborates with GlobalFoundries to Advance Silicon Photonics IC Design ▶

Cadence Design Systems, Inc., announced a collaboration with GlobalFoundries (GF) aimed at speeding silicon photonics IC development for 5G communications, hyperscale computing, healthcare, automotive, IoT and aerospace systems.

Maricopa Community Colleges, Intel to Launch Semiconductor Workforce Initiative ▶

To support the growing semiconductor industry's employment needs and welcome diverse talent into the technical workforce, Maricopa Community Colleges and Intel Corporation have announced enrollment is now open for a new semiconductor manufacturing Quick Start program at Mesa Community College (MCC).

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Prepping for an Internship?

Three Tips to Shore up Your Skills

The New Chapter

Feature Column by Hannah Nelson, VALPARAISO UNIVERSITY/IPC STUDENT DIRECTOR

When I first logged onto my computer in summer 2021, I was beyond nervous. I had just accepted the role of corporate intern at Caterpillar Inc., where I would be working on the product service development team. As I started

my online internship, I felt like I didn't know anything—and I mostly didn't. The scariest part for me was thinking I would be expected to perform a job I didn't have the knowledge or experience for. But that first day made me realize that I wasn't expected to know everything. I was there to learn.

What helped me become more comfortable in my position was being welcomed by several individuals who created an inclusive work environment. One of those individuals was my mentor, Christine. Within a week, I got involved in Caterpillar's Women's Initiative Network and was assigned a mentor to guide me through my internship. Christine not only mentored me but encouraged me to find purpose in my work. She provided me with knowledge and insight into the corporate world, and she encouraged me to learn about the different career paths at CAT. Because of her, I made a variety of connections from the marketing, engineering, and leadership rotational programs, and even learned more about travel engineering opportunities.

Once I was comfortable in my new role, my internship didn't seem as scary. If I had a question on a project, I knew someone would be there to help me find an answer. Some parts of my internship were enhanced by the skills I had gained through my schooling. My education gave me the skills I needed to build stronger relationships with my coworkers and engage quickly with difficult projects. While my education provided me a glimpse into the corporate world, there was still a disconnect





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between the tasks I had at work and the education I received.

What Did School Bring to the Table?

Here are three main ideas I gained from my education that helped me with my internship:

1. *How to communicate effectively*

It is vital that students become involved in campus activities beyond the classroom before entering the workforce. Leadership and volunteer experience are not the only things employers search for, but they give students the ability to work effectively with others. I was involved in several activities on campus before I started my internship. These activities helped me grow into a stronger leader and taught me how to communicate effectively with others. Because I had worked to enhance these skills, it was easier for me to build a stronger relationship with my mentor and manager during my internship. These stronger relationships allowed me the chance to conduct several informational interviews with employees throughout the company. While there, I was able to learn about the different careers in Caterpillar and build my network.

It is vital that students become involved in campus activities beyond the classroom before entering the workforce.

2. *How to think*

Throughout engineering school, we are required to take several difficult courses within the STEM field. These courses encouraged me to find the most efficient way to solve problems. At times I hated this and would spend countless hours pulling my hair out, but I believe

it showed me the true value of hard work. By having the ability to solve problems, I accomplished many of my given projects with ease.

3. *How to write technical documents*

Electrical engineers at Valpo University are expected to take a technical writing course. This course helps students become more aware of writing technical documents and emails. During my internship, I was tasked with revising an electrical connector publication. I had to put the document in language that our dealers would understand. My technical writing course helped me with this task as we had prepared several papers addressing a range of audience members. This was to prepare us to write in terms of individuals who may not be familiar with engineering jargon.

Where's the Disconnect?

In my first team meeting, I learned more about real world application in electronics than I learned during my three years at college. Most of the projects were unlike anything I saw at school, and within three months I felt like I had learned a whole new language. That was when I realized most of the topics I learned in my classes were too broad and theoretical to apply to my specific job role. It was discouraging to discover that I could not apply much of what I learned in school to my internship. Although this was the case, it's also important to understand that the electronics industry is so diverse. Most colleges encourage engineers to graduate within four years, which is a tight timeline to educate students on every aspect of every industry.

How Can Schools Bridge the Disconnect?

Schools can encourage students to engage in professional organizations such as IEEE, the IPC Student Chapters, and SMTA. By engaging in these organizations, students can learn more about careers within the electronics industry and the processes they work with in their future careers. They also gain hands-on

experience even before they reach the workforce. Schools should also build their students' professional skill sets. Students should be encouraged to participate in career fairs, which allow the development of their networking and communication skills. My college mandates all engineering students to participate in a career development program where we are taught how to build a resumé, interview with employers, and thrive at a career fair. This program helped me land my first internship and gave me the skills necessary to create deeper connections with my coworkers.

Final Thoughts

Overall, colleges should provide more insight into engineering careers, but students should also take the initiative to participate in career development programs within their school. Students should be networking, practicing their interview skills, and engaging in professional activities. Through leading professional organizations, participating in career fairs, and

practicing my interview skills, I was able to get the most out of my own internship experience.

What the Industry Can Do to Help

As the electronics industry grows, we need your help to inspire students. Although STEM careers are being pursued by more students every day, this isn't enough for the rapid growth we are experiencing within this industry. Some students aren't even aware of different career paths (such as PCB design) because schools have a set curriculum they can teach. By attending career fairs, promoting educational webinars, and engaging in youth mentorship, we can reach our youth and jumpstart a passion for their career. **PCB007**



Hannah Nelson is a student at Valparaiso University, part of the IPC Emerging Engineer Program, and an IPC student director. To read past columns or contact Nelson, [click here](#).

Additive Reality

Drop-forging Solder Mask Thickness With Inkjet



By Luca Gautero

Traditional coating processes for solder mask handle thickness as a single parameter for the whole board. There will be differences between the amount of material on the laminate or on the copper, and these will depend on the height of the copper and in some cases on the section of the copper feature. Overall, it is reproducible: It looks homogeneously green, and it is easy to estimate the amount of material consumption. Therefore, everybody is happy.

Still, the homogenous color stems from the presence of opaque fillers which, already in small quantities, would reduce the dependence of transparency on the coating thickness. In other words, with a top view, there is little clue left as to how thick the solder mask actually is. Cross sections are therefore

a nice ally: In one sample, the geometrical details of copper, laminate (together with its many layers), and solder mask are in clear sight.

The predictability of the material consumption does not imply that the coating thickness benefits itself from the level of certainty: a $\pm 20\%$ variation on material consumption is solved with a temporary bigger stock space and might even be insignificant compared to bill-to-book fluctuations. Instead, the same variation on the solder mask thickness could bring about troubles in the PCB assembly because of poor predictability of the board topography.

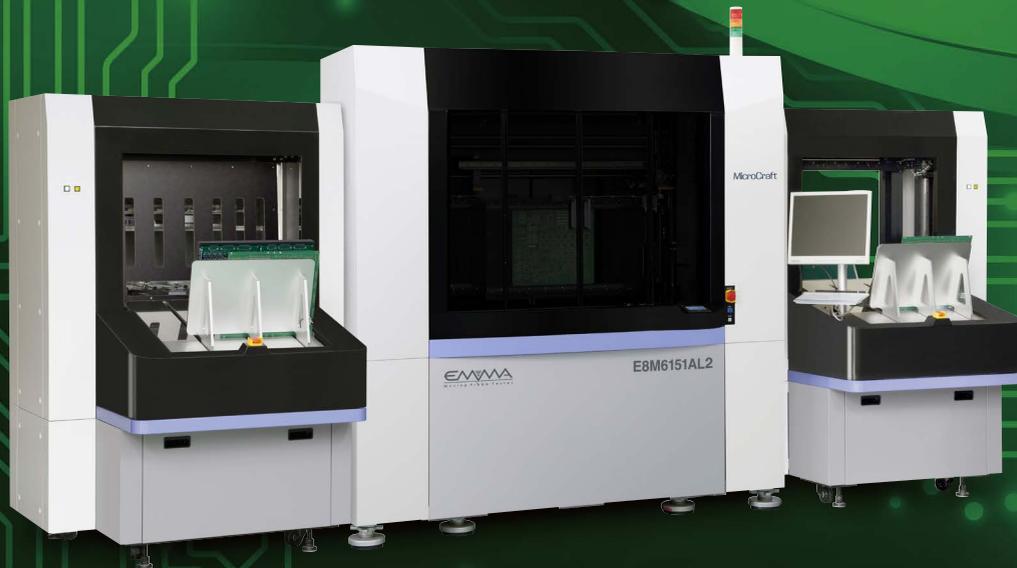
Inkjet solder mask coating, in this early adoption phase, is evaluated by mimicking traditional solder mask. Furthermore, it could not be any different since the same CAM procedures define it on the printer tool.

To read the entire column, [click here](#).

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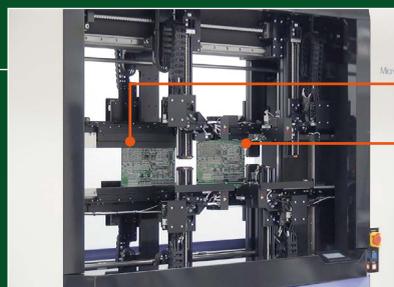
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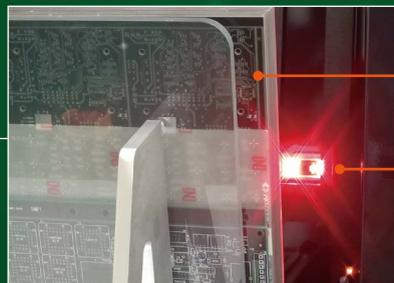


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Supplier Highlights



Arlon Takes on Role as EMC Master Distributor in North America ▶

Arlon EMD, a division of Elite Materials Company (EMC) and an American manufacturer of specialty laminates, is assuming the role of Master Distributor for EMC materials in N. America. Arlon has a 45-year history of manufacturing specialty materials for the aerospace, industrial, and military markets.

Insulectro Hires PWB Commodity Specialist Laura Martin as Director of Technology ▶

Insulectro, the largest distributor of materials for use in manufacture of printed circuit boards and printed electronics, has hired PWB engineer/specialist Laura Martin for the position of director of technology.

James Francey Joins Isola Group as RF Business Development Director, Europe ▶

Isola Group, a global leader in circuit materials and materials technologies, is pleased to announce the hiring of Jim Francey as RF Business Development Director, Europe.

MacDermid Alpha to Present on High Reliability Materials for 3D Structural Electronics at LOPEC 2022 Exhibition and Conference ▶

MacDermid Alpha Electronics Solutions presented the technical paper, “Next Generation Interconnect Materials for Smart, Functional, and 3D HMI Surfaces” at the LOPEC 2022 Exhibition and Conference in March at the Messe München, Germany.

DuPont Interconnect Solutions Announces Energy Surcharge ▶

DuPont Interconnect Solutions (ICS), a business segment under Electronics & Industrial, announced that effective April 1, 2022, an energy surcharge will be added to the invoices for products in the ICS business.

Excellon Installs COBRA-II Hybrid Laser System at TCLAD, Inc. ▶

Excellon announces the installation of a COBRA-II Hybrid Laser System by TCLAD, Inc. of Prescott, Wisconsin. The Excellon COBRA-II Hybrid Laser System offers both UV and CO₂ (IR) laser sources on a single platform.

IEC Announces Partnership with TUC ▶

IEC proudly presents another new partnership with innovative laminate and prepreg manufacturer, Taiwan Union Technology Corporation (TUC).

EMC Launches 112Gb/s Design and New IC Substrate Materials ▶

At DesignCon 2022, EMC highlighted extreme low loss materials EM-892K/EM-892K2 (“K” indicates low Dk/Df glass, while “K2” stands for next generation low Dk/Df glass).

Insulectro Hires Industry Veteran Doug Gotelli as Technical Account Manager for Silicon Valley ▶

Insulectro, the largest distributor of materials for use in manufacture of printed circuit boards and printed electronics, has hired Doug Gotelli as technical account manager in its San Jose Branch.

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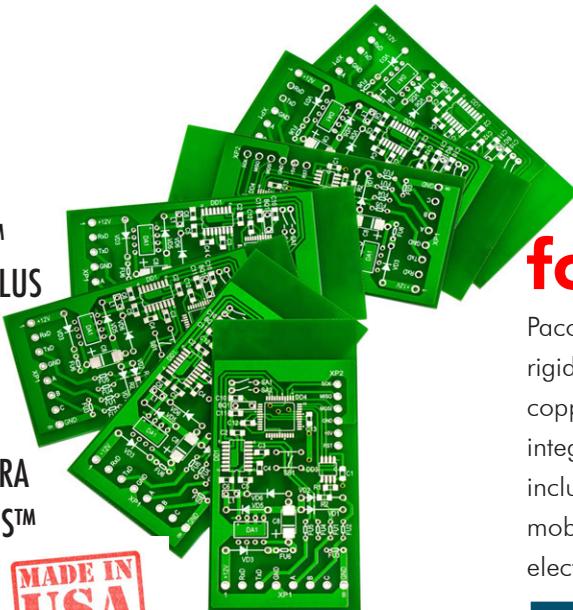
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Addressing the **Gap** in Process Performance



Feature Article by Nolan Johnson

I-CONNECT007

The first steps in process improvement are to determine what the gap is and why it happens. Having a process is not sufficient; the process needs to be effective as well. For those responsible for creating and maintaining processes, the ultimate goal is to create a procedure that becomes self-perpetuating, that seeps into the fabric of the company's culture. For better or worse, plenty of procedures do indeed become ingrained in company culture. How does one go about ensuring that company culture is loaded with effective processes that deliver a positive outcome? That is the question, to be sure.

Analyzing Performance Problems, authored by Robert Mager and Peter Pipe, was published in 1970. Even 50 years later, it is still one of the most definitive—and digestible—books on the topic of skill gap analysis.

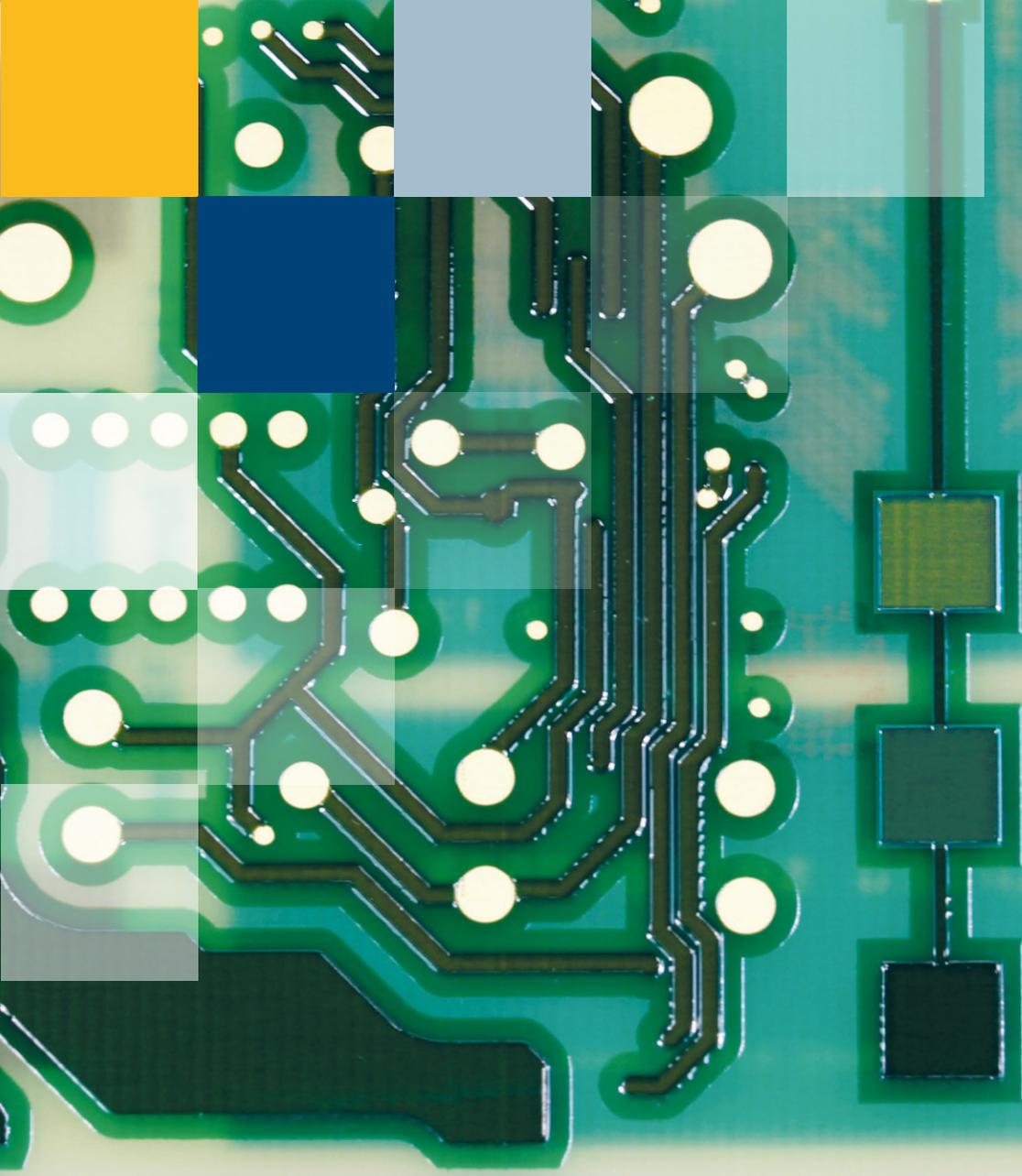
Their model presents a thorough and effective method for troubleshooting performance problems.

According to Pipe and Mager, first identify the performance problem. To do so, make the key metrics:

- Measurable
- Observable
- Performance-based

Armed with the metrics, the next questions are critical to the analysis:

- Is it worth solving?
- Can we apply fast fixes?
- Are the consequences appropriate?
- Is there skill deficiency?
- Are there other causes?
- Which solutions are the best?



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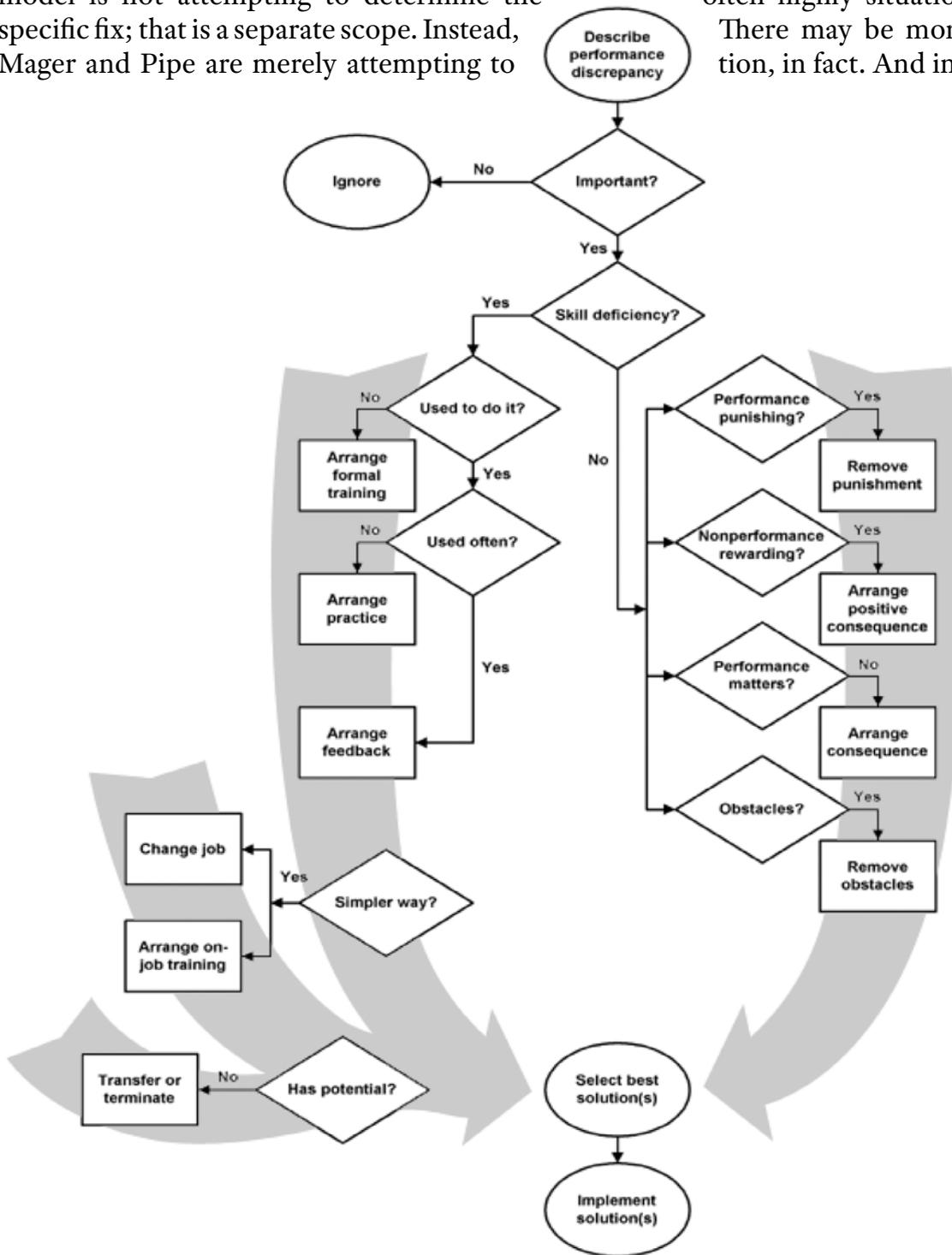
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This analysis process is captured in the flowchart for Mager and Pipe's model (Figure 1).

While this model might seem almost simplistic, my personal experience is that the power of the model comes from the simplicity. This model is not attempting to determine the specific fix; that is a separate scope. Instead, Mager and Pipe are merely attempting to

perform the triage, to identify the nature of the breakdown in performance. Once the root cause of the breakdown is understood, the type of resolution can be determined. How exactly that resolution is implemented, of course, is often highly situationally dependent. There may be more than one solution, in fact. And in terms of the cur-



Quick-Reference Chart for Analyzing Performance Problems

Figure 1: Mager and Pipe's troubleshooting model.¹

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rent challenges in upskilling, is this 50-year-old method still meaningful?

Upskilling normally refers to training current staff to be competent in more highly skilled work. A careful read of the Mager/Pipe flowchart reveals that upskilling as we know it resides along the left side of the flow—when the answer to “Is there a skill deficiency?” is a definite “yes.” The next two triage questions, “Could they do the work previously?” and “Did they do that work often?” determine the next steps to be taken. If this is a new skill for the individual, then formal training followed by practice is in order.

Upskilling normally refers to training current staff to be competent in more highly skilled work.

It is interesting that this model even has room to accommodate continuous improvement or total quality management ideas. For example, the flowchart reminds us to ask, “Is there a simpler way?” Remembering to be mindful of process improvement as well need not be a process expert’s role alone. Staff who are upskilling can often provide great insight into the efficiency and appropriateness of your current process. In a former life as a trainer, my students would sometimes make suggestions to a process and I would regularly watch how they learned the process, looking for places to shorten the procedure.

The next phase of the upskilling process, of course, takes place once the skill has been learned and demonstrated. Now the process experts are watching the right side of the flowchart. If it’s not a skill deficiency, then chances are good that the process itself is not rewarding in some way. Rarely is it that the employee

doesn’t want, or isn’t able, to do the job properly. When that is the case, then the lack of potential can be identified, and the employee removed in one way or another. Most of the time staff members want to succeed. This puts the spotlight on figuring out what’s wrong with the process to keep it from being self-enforcing and self-rewarding.

Some careful thought on the implications of this flowchart and some interesting points start to emerge:

- The solutions to most performance problems are not training
- While upskilling has a definite place in organizational improvement, it should not be considered the reflex response to a performance gap
- Even when training is necessary, proper attention to process efficiencies can amplify the training benefits for your employees

In my time as a corporate training manager at a capital equipment manufacturer, we used this flowchart to assess our field service personnel’s skill level and developed training only for the specific skills needed. The rest of the internal training program’s attention was spent on improving the processes and procedures, identifying hurdles, and inadvertently punishing outcomes to the processes. Oh, and eliminating the things that weren’t important after all.

Analyzing Performance Problems is still in print. You can find a copy at any number of booksellers. **PCB007**

References

1. Adapted from *Analyzing Performance Problems* (Second Edition, 1984), by Robert F. Mager and Peter Pipe, Lake Publishing Company, Belmont, California.



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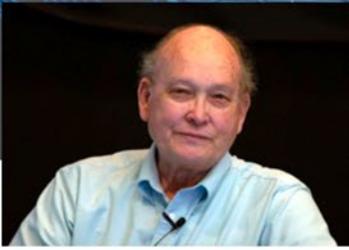
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Journey to a Smart Factory

Feature Article Excerpt by Happy Holden
I-CONNECT007

Automation and computers have been my passion for the last 55 years, both as a student and a professional. This article will introduce the methodologies that have served me over the years in automating electronics manufacturing.

The hardest step is getting started. I know this because I have designed and built portions of nine automated PCB factories in my career, and a dozen more process factories, all automated by computers and the software that drives them. This article focuses on:

- Who should design it?
- What should they learn?
- How do you analyze and plan the automation?
- How long should it take?
- When is the right time?
- How much will it cost?

Let's get into some detail on these key questions to help you to get started.

Who Should Design It?

Independent factory automation consultants are exceedingly rare and, if you find one, they will most likely charge you for learning your processes and procedures. They will be restricted to their products which then restricts their choices of solution. It usually is a better investment to select your own engineers who are familiar with your processes and procedures and let them learn how to do the automation planning. Then they can teach others, as the factory will need to pass along this skill repeatedly.

One recommended team configuration is having two engineers: a process engineer (usually a chemical engineer) and a control/data engineer (usually an electrical engineer). Having access to a statistician (either a university or a consultant) will be extremely useful. Both engineers should be capable of working independently, with the capability to quickly learn new skills, including statistical tools and data analysis. New college graduates, especially with a graduate degree, would be suitable. A bonus and compensations need to be established, as successful factory automation engineers are highly prized and heavily recruited.

What They Need to Learn

There are six major topics to be addressed with the primary one being to meet your company's business objectives. The company should already have some long-term business objectives that will shape the priorities for an automation strategy and product roadmap. Achieving these objectives depends upon the other six topics listed here:

1. Zero waste: Waste of any sort, including materials, rework, repair, paperwork, environmental, or workforce, are all suitable focus for benchmarking (or best practices) analysis to improve performance.

2. Internet-of-things sensors: New sensors to provide real-time data are the basis for most Smart factory automation. Sensors can be purchased to provide relevant information and integrated by low-cost programmable logic controllers (PLCs) for storage in the cloud. Some may have to be a DIY sensor, like the specific gravity unit or amp-hour unit from Chapter 4 of *Automation and Advanced Procedures in PCB Fabrication*.

3. Predictive analytics: Using new sensor data stored in the cloud, regression analysis, and DOE procedures can create predictive models (digital twins) to reduce or eliminate defects or enhance product specifications like impedance control and registration.

4. Zero-defect manufacturing: Unless your yields are 100%, defects are your largest waste and benchmarking will provide project focus.

5. Driving zero-downtime: Downtime for equipment or process affects the bottom line and delivery performance; new sensor data and predictive models can eliminate this.

6. Create solution templates: Documenting automation solutions with a template that others can follow to solve similar problems and waste.

To read this entire article, which appeared in the April 2022 issue of *SMT007 Magazine*, [click here](#).



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The First Step to Upskilling is FIRST-skilling

by Barry Matties



I was invited to attend the FIRST PNW district championship competition in Salem, Oregon, this past March. Friends of ours, Dylan and Cardin Nguyen, are team members on West Linn High School's FIRST robotic team named "2B Determined." As they say, "Team 7034, 2B Determined, is determined to inspire students in science, engineering, and technology while developing individual skills and character. Our team strives to be role models in the community, engaging every student and challenging ourselves and others through collaborative learning and problem-solving, mak-

ing a positive impact on each other, the city of West Linn, and beyond."

Over the past several months Dylan and Cardin have shared with me their team's progress and excitement about being a part of this team. Dylan has been thrilled to be engineering and crafting parts using 3D printing and CNC tools, as well as finishing the metal parts with a powder coat. Meanwhile, Cardin has been busy coding the software the team would use to drive the robot. It's so easy to see the positive impact FIRST has had on these two students.

As I watched the event it was clear that this was so much more than building and battling robots. FIRST is a program that is helping kids build self-confidence and so much more. In 2016, I had a chance to interview Dean Kamen, the founder of FIRST. In that interview, Dean said:

“We have a million and a quarter kids involved in FIRST (For Inspiration and Recognition of Science and Technology) with the same passion as any other sport. They go to the competitions; they bring the cheerleaders and the mascots and the school bands. They live and breathe the technology and the excitement of the competitions, except at the end of the season, these kids have learned how to build electronics, how to write code, how to fix the code they wrote, how to debug those electronics, and how to figure out why the smoke is coming out of that magic box.”

I found this and more to be true at the March event. To have such an astounding number of students involved is fantastic. The students are learning how to work together as a team and

contribute in many ways, aside from the actual build of the robot. I was told that there could be as many as 50 kids connected to one robot team. Students are fundraising, building workbenches, designing logos, producing video and photography, and so much more.

Talking to some of the mentors and volunteers at the event, many indicated that they went through the FIRST program and because it had such an impact on their lives, they want to stay a part of it, give back, and have fun doing so.

By the way, 7034 is the robot for the 2B Determined team. As it turns out, 2B Determined has done very well and heads to the world competition in Texas, April 19-23, 2022.

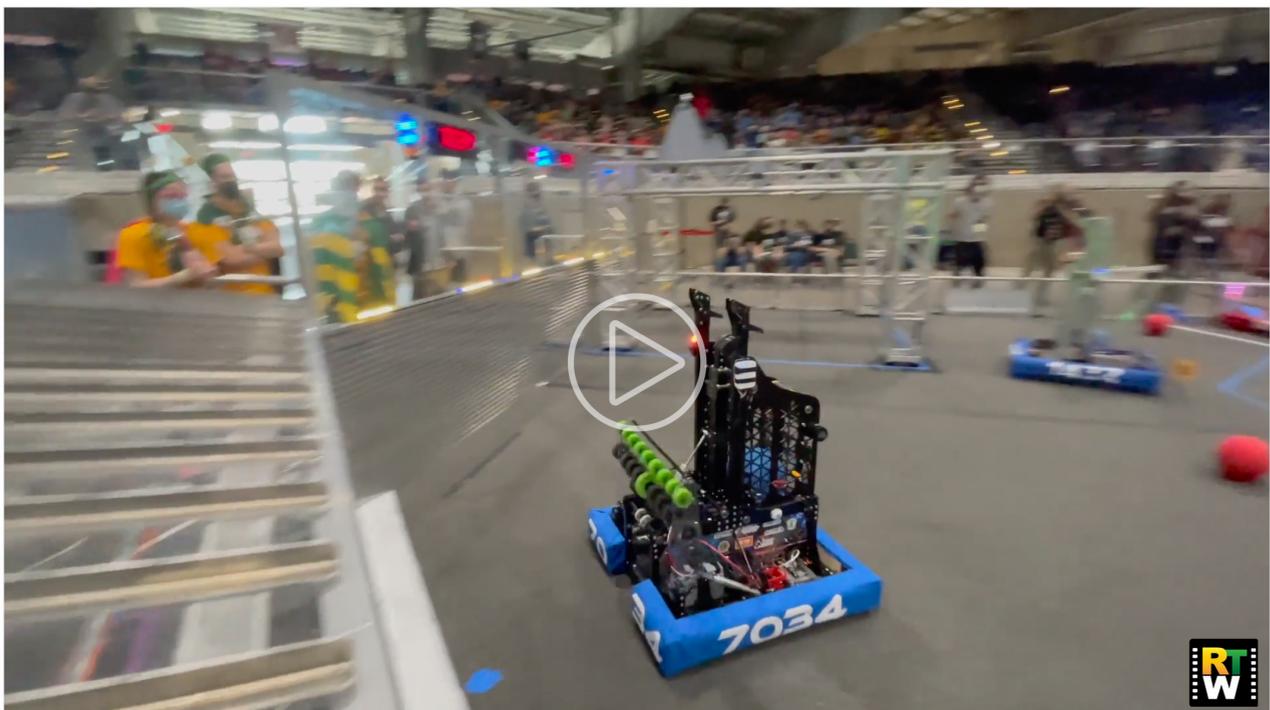
FURTHER READING:

“The Future of the World is Truly in the Hands of Our Youth,” by Barry Matties, December 2019.

“Interview with Dean Kamen, Segway Inventor and Founder of FIRST,” by Barry Matties, April 2016.

Details on the FIRST 2022 Championship: firstchampionship.org.

Curious about the FIRST robotic challenge? Here’s a snapshot video of a FIRST event from the recent 2022 Pacific Northwest FIRST District Championship in Salem, Oregon.





FIRST Program **Inspires** Next Generation of Innovators

Feature Interview and Photos by Barry Matties
I-CONNECT007

Today's students grow up immersed in a world of technology, yet how many of them actually see themselves taking on careers that advance this science? Since many of the jobs for our future workforce haven't even been created yet, what can be done to encourage students toward STEM careers? In this interview, Barry Matties speaks with Adrienne Collins, director of programs at *FIRST*[®] Washington, about the success of a student robotics program that fosters innovation, builds problem-solving skills, and cultivates a concept that most of us have never heard of—gracious professionalism. When you see the interplay of these skills in action, you are blown away. There's a bright future ahead.

Barry Matties: Adrienne, we're at a FIRST robotic event today. What is your involvement with FIRST?

Adrienne Collins: I run all the programs in Washington state, which includes FIRST LEGO League, FIRST Tech Challenge, and the FIRST Robotics Competition (FRC). I got involved when my daughter's friend started a team in 2007, and we got sucked into it. I've been doing it for 16 years because it's so fantastic. I became a full-time staff member in 2014 when we started man-



TAKING IT TO THE EXTREME

HIGH HEAT

BY TAIYO



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aging the FRC events on our own, rather than having it done in New Hampshire.

Matties: Do you have a background in education?

Collins: No. I worked in the library at my kids' school, got involved as a volunteer, and they sucked me in. I've been involved in a lot of my kids' activities, but I've never seen a program affect students as much as this one did. I continued to be involved, and when they gave me the opportunity to work for the organization, I jumped at the chance.

Matties: What is the biggest takeaway for students who participate in an event or program like this?

Collins: It's not just about STEM—engineering and science. It's also about being presented with a problem, having a limited amount of time to solve it, and figuring out what resources you need. Maybe you're doing web design and marketing to promote your brand and help with fundraising, or maybe you're designing or building the robot. But you're working side by side with professionals in the industry and giving people an opportunity to try something they never thought they even wanted to do. Some find out they love it, but others still say, "Well, yeah, I still don't want to do that." But it

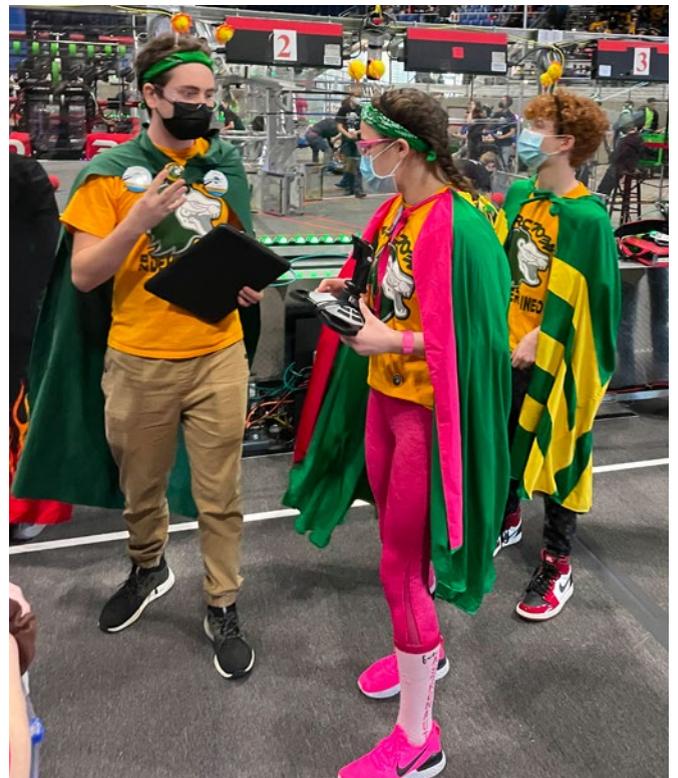
gives them an opportunity to problem solve and think outside the box either way.

Matties: I've talked to former students who are still connected to FIRST. It seems like it's lifelong once you're in it.

Collins: It really is. It's so amazing what it does for our students once they become involved; they want to stay

involved. In fact, many of our key volunteers who are running these events started with a student on the team, their student graduated from high school, and they may or may not be supporting the team, but they wanted to stay involved at a higher level. They start volunteering at the events and doing things behind the scenes, just because they've seen the change that this brings to kids.

Matties: On game day, it's all about the robots and the arena, but what's happening behind





the scenes? What other skills are being utilized there?

Collins: Our highest award, the Chairman's Award, is all about giving back to your community, spreading the word of FIRST through outreach, but also helping at soup kitchens. It's giving back to both your local community and your FIRST community, neither of which have absolutely anything to do with the robot performance.

Matties: I'm friends with Dylan and Cardin, two great kids who are both on a FIRST team. It's easy to see this program has tapped into their passions.

Collins: We draw a lot of students who might not participate in a sport; we bring them in, and they feel like they're in a sport. At the same time, I've had football players participate; my daughter's a cheerleader and she's involved. Because of that sport feel, we combine some groups that typically might not work together. When I was coaching, I always said that everybody on my team can be a varsity player because there are so many different jobs. If you want to contribute, you can be a varsity player.

Matties: Now, the other work that you're doing is talking to them

about possible career paths. They are the future workforce of America, right? How does FIRST lead them into thoughts of a career path?

Collins: Today's students really need to be innovators, because many of the jobs they'll have in the future aren't even created yet. We don't even know what those are. When we were younger, maybe you wanted to be a doctor, so you studied medicine. Because the world is changing so much, we teach our students to be innovators, to notice problems, and take action to solve them. They will be the ones changing technology because they built these skills.

Matties: One of the brightest minds in our industry, Happy Holden, was the chief technical officer for Foxconn. He also worked for HP and developed some of the first scientific calculators. In a recent conversation with him about





Collins: Yes, we teach teamwork and “gracious professionalism,” because the team that you compete against in one round, you will collaborate with in the next. Our students are extremely competitive; they want to win. But they want to win because their robot’s the best, not because their competitor’s robot is struggling and having problems. You’ll see teams working on another robot, helping a team that’s struggling, even though they’re competing against them in the next match. It’s all about being the best because you did the best job of solving the problem or meeting the challenge—because you earned it, not because somebody else failed. I think that is my favorite thing. It doesn’t matter whether you’re here or not, you can have that feeling. Even through COVID, I was worried if some of that would be lost, because most of these students have never seen a competition. Thankfully, that whole feeling of gracious professionalism survived the pandemic.

Matties: “Gracious professionalism” is a great phrase, and one I haven’t heard before. Thank you for sharing that.

Collins: It was coined by Woodie Flowers, one of our founders. It says so much, and I love it.

Matties: Now, how is FIRST funded? Is it fully sponsored?

Collins: No, the teams do quite a bit of fundraising for what they need. FIRST national gets some sponsorships; locally, ORTOP and FIRST Washington get sponsorships to support the teams. But local teams have to work with their respective schools for help. Summer camps help spread the word about FIRST, but part of their problem solving is figuring out how to raise funds. This money helps buy technology, travel to competitions, and do all the things they need to do.

Matties: That’s great.

hiring practices, he said first and foremost he looked for somebody who knew how to solve a problem. If you understand how to solve a problem, then you can really make advances in life. When I talked to students here today, one of the first things they told me is that they’re learning how to solve problems.

Collins: As we bring on more sponsors at FIRST national and *FIRST* Washington, the sponsors are recognizing the value in those problem solving skills. I’ve had a lot of people say, “If we see FIRST experience, that resume goes to the top of the pile, because we know they can solve problems and that they’re innovators.”

Matties: You’re also fostering teamwork, because nothing is done alone in this program. Tell me about that.



Collins: Fundraising will look very different depending on where the teams are, such as eastern Washington vs. eastern Oregon, and what’s available to them. It’s learning about your community, then tapping into resources where you can show how donations support students and the value it gives.

Matties: You are doing very important work and you are greatly appreciated.

Collins: Thank you very much.

Matties: Do you have anything else to share regarding FIRST?

Collins: The first thing would be to come to a competition if there’s one in your area, because that speaks volumes. I can’t tell you how many times I try to explain it and people don’t get it, but as soon as they see it in action, they’re blown away. Reach out to your school, and find out if there’s a team in your area.

Matties: If someone wants to be a sponsor, what’s the best way for them to sponsor a team?

Collins: Visit firstwa.org for information, but Lila Mowatt, director of fundraising, will be happy to help you out. She can let you know if there’s a local team in your area or pass them off to me if they need help.

Matties: Thank you so much for your time today.

Collins: Thank you. Thank you very much. PCB007





FIRST: Endorsed by Teachers and Students Alike

Feature Interview by Barry Matties

I-CONNECT007

For Inspiration and Recognition of Science and Technology (FIRST) is a robotics program at Oregon's West Linn High School led by computer science and engineering teacher Tim Manes. Barry Matties caught up with Tim and his student team, 2BDetermined, at the FIRST Pacific Northwest District robotics event in Salem, Oregon. The team has excelled at the local and regional levels and was invited to participate in the world competition in April.

Barry Matties: I'm here with Tim Manes at the FIRST district event. How is it going?

Tim Manes: It's getting close to the finals. This is the fourth week, a lot of teams have had time to refine their robot, and the competition's getting stronger.

Matties: You teach at West Linn High School and you're in charge of the school's robotics team. Tell me what that experience is like for you.

Manes: Coaching students in robotics is extremely rewarding. I started as a math teacher and slowly started to build an engineering program during the day, which grew into FIRST Robotics Competition.

Now we have a substantial number of students who are getting experience they wouldn't get in a normal classroom environment. It's very rewarding.

Matties: What is the biggest takeaway for students who are participating in this event or with their FIRST program?

Manes: Every student who walks through the classroom door for the first time has never seen a machine. They've probably never riveted, or used CAD or CAM. So, between the time they first walk through the door, and when they show up at an event, most of these students



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a lot of “off season” training that we do with students. We find opportunities to ensure that every student, even the ones up in the bleachers right now, have touched robots. For example, we started trying to create a powder coat oven about three years ago, before the pandemic, because the robots are powder-coated black. Because I have a lot of students, this was an opportunity for some of them to get their hands on a part of the robot. They took ownership by finishing the powder coat oven and learned how to powder coat.

have experienced things they’d never imagined they would have an opportunity to, especially in high school.

Matties: Now, one of the students was talking to me about how this has really helped him learn to problem solve and think logically.

Manes: I say it all the time that we’re all problem solvers. We get up in the morning, and all day long we are solving problems. Some problems we can solve one time, like how to tie our shoes. But new problems always come up, so it’s such an important skill. Students are capable of being great problem solvers, they just need the commitment and perseverance to understand the problem and find a resolution.

Matties: What is your role in terms of actually building the unit? Are you hands-on?

Manes: I teach each one of those kids and they build the robot. There’s also

Matties: I was talking to your student Dylan, and he was so excited that they were designing, CNCing machine parts, and powder coating. These are the kinds of things that you don’t think about in a program like this, but it really does create opportunity for everybody.





Manes: Absolutely. Students are scouting so that we can make the right decisions when it comes to alliance selection. Another example is when students become specialists of individual components. They design, prototype, and test it, then they install them on the robot. If something breaks on that robot, there's a certain person or group of students who know how to deal with that.

Matties: What about the age groups? It looks like you have all age groups here.

Manes: Correct.

Matties: There's a lot of tribal knowledge, if you will, being passed down from the older to younger grades. But being able to bring those age groups together as one enters high school while another is departing has got to be powerful as well.

Manes: Yes, that's true. COVID made that more difficult, but we never stopped even when classes were online. We continued to CAD and design; we built

our community. We even had students who joined during COVID because they were looking for something that interested them. We would meet up to 12 times a week using Zoom for a variety of reasons, not just building robots. We also had virtual camps where we hosted primary and middle school students, as well as an all-girls middle school camp. Some were virtual, while others were a hybrid of virtual and in-person. In fact, we have some campers here today who have joined our team.

Matties: COVID caused some problems, but it also created an opportunity for you to teach ways to navigate challenging times.





Manes: Yes. I will put a lot of it on the students. They owned a lot of that.

Matties: At the same time, you provided structure for them. It was your dedication that helped to grow the team.

Manes: FIRST is a black hole. There's something about it that would be really hard to leave, because the a-ha moments on the field,

at the pits, in the classroom—there's passion, even sometimes the tears. It's hard, but you see these kids grow so much.

Matties: Well, you're teaching a lot of life lessons, life skills. I was talking to Cardin, who's working on coding, as you know, and he's so passionate, so excited. He lives and breathes it. What you're doing here is not just teaching kids, but you're helping them feel a passion that they may not have realized or felt earlier. You help them bring focus to it.

Manes: I feel lucky. This beats grading papers, I'll tell you that.

Matties: They can learn math doing this, that's for sure. What advice do you have for young students these days?

Manes: Take a challenge, take a risk, put yourself out there. There are so many things you're capable of that you haven't even tried yet.

Matties: Good. Thank you so much.

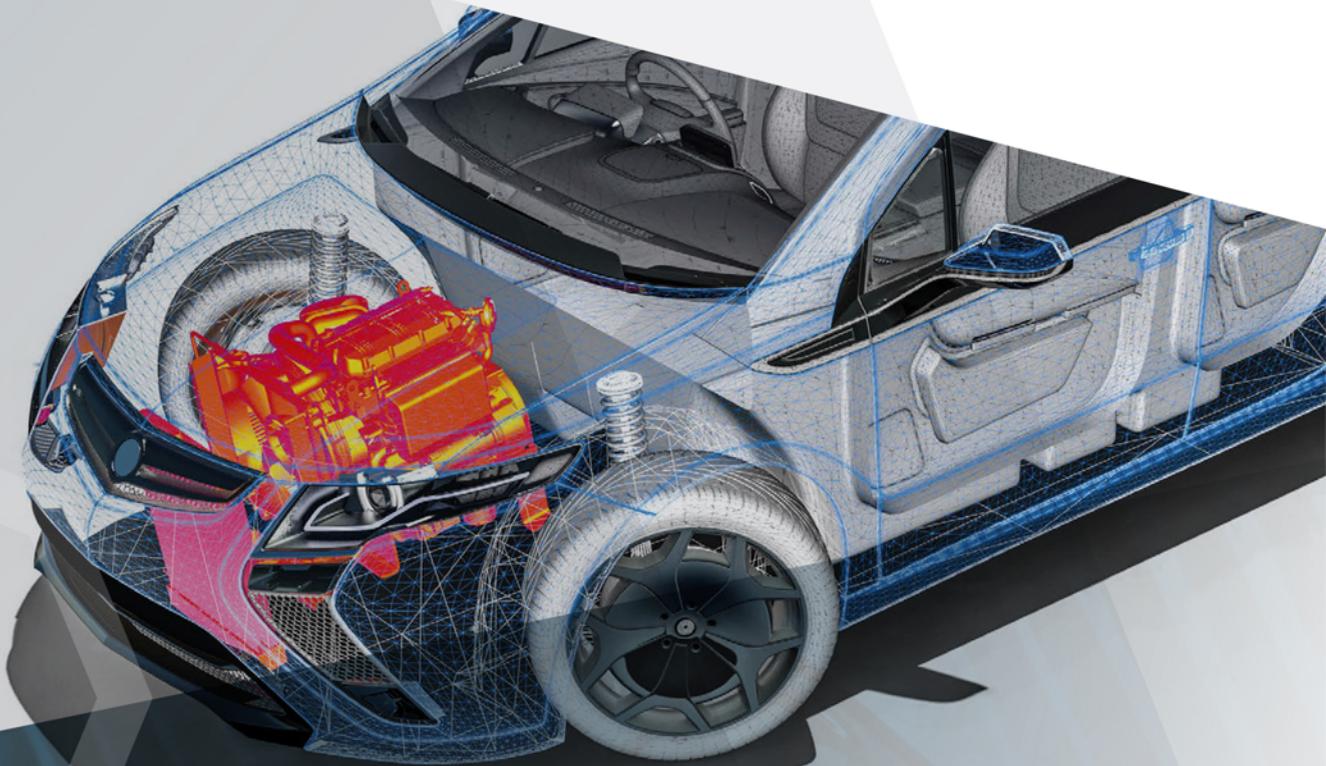
Manes: Thank you. PCB007





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The Case for Preventive Maintenance

The Chemical Connection

by Christopher Bonsell, CHEMCUT

Preventive maintenance (PM) is a routine maintenance performed to ensure equipment runs efficiently and won't experience problems any time soon. This routine maintenance can become highly important when you are running a business that relies heavily on equipment for production. Printed circuit board (PCB) shops are no exception to this because their production is dependent on many different complex machines working together.

Although PM is critical, a large portion of PCB shops don't have a PM program. Far too often, manufacturers will wait until a machine starts to experience problems before they act. This behavior is likely because PM can sound like a tedious and costly task. The truth is that the benefits of PM heavily outweigh the drawbacks. In fact, having a PM program can even give you an edge over PCB shops that don't. Here's how.

Machine Longevity

Starting a PCB shop requires a large investment in many different pieces of equipment, so why not make the most of each machine you have? With a PM program, you can drastically extend the life of your equipment. This is because often there is a domino effect

when it comes to wear and tear on machine parts. Once a part becomes damaged, it can cause severe damage to your machine if left unchecked. A PM program prevents this domino effect by finding the damaged part before it goes on to affect others.

A PM program to improve your machine's lifespan involves checking the conditions of conveyor components, heating and cooling units, and general equipment cleanliness as well as verifying all system components and controls are calibrated. Even keeping your machine clean is a form of PM that can go a long way toward ensuring your equipment stays in shape.

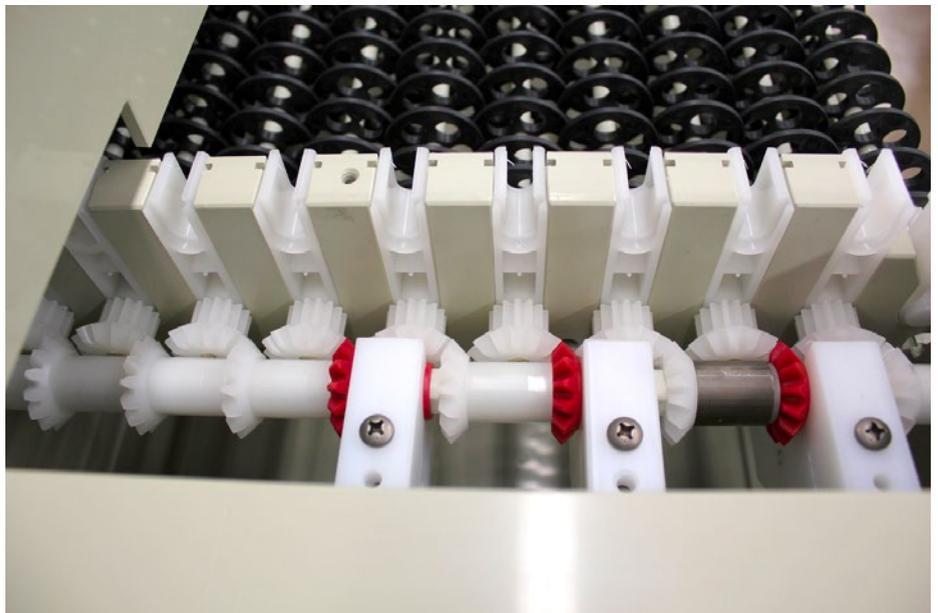
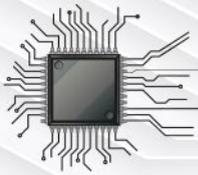


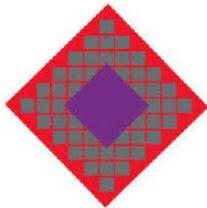
Figure 1: Conveyor shaft, side-rail, and gears for an etcher. These parts are often checked in wet processing equipment for mechanical damage or wear.



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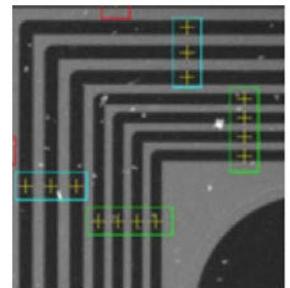
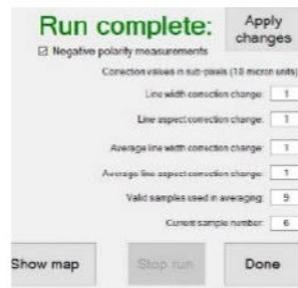
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Shop Safety

When it comes to safety in a PCB shop, containment of the corrosive and toxic chemicals from the wet processing end is key. With a PM program, you can reduce the number of unexpected leaks and spills that occur. Containment of the chemistry serves two purposes for safety. First and foremost, it prevents your employees from having direct exposure to the chemistry. Second, it prevents deterioration of equipment. Sometimes equipment can corrode to the point where dangerous components, like electrical and mechanical components, can become exposed and open the opportunity to seriously harm someone.

PM for containment would involve inspections of plumbing, seals, ventilation, and containment trays. A PM program would also involve ensuring that the materials involved in your processes are still chemically compatible. This is a good practice because nearly all materials will eventually experience some form of damage when exposed to the chemicals used for PCB processing. Performing this check will also be useful because sometimes employees will need to swap out parts. If the employee isn't aware or careful enough, an incompatible material could be introduced to the machine and cause a potential spill or leak. Etching and stripping machines, for example, can have very similar parts. Although the parts seem similar, they are often made of different materials because the chemistry that they need to withstand inside these machines are widely different. Since their parts look alike, they can be easily mixed up if one is not careful. In these kinds of scenarios, you won't see an immediate change, but after a few days or weeks you may start to notice some impact. If a leak or spill is not caught, it can worsen over time.

Equipment Efficiency

Having a PM program can also help maintain your equipment's efficiency. Depending on the equipment, whether it's a wet or dry process,

there will be different factors that will affect efficiency.

Wet processing equipment requires you to be wary of the by-products you are creating. Over time, these by-products will build up within your machine and reduce the efficiency of your solution and potentially cause problems with your filtration and nozzles. By-products or contaminants are best removed on a frequent basis. If they are allowed to significantly accumulate, you risk damaging your machine and you will have difficulty removing them. PM to maintain efficiency in wet processing equipment will generally consist of changing out the filters, cleaning spray nozzles, and performing titrations to get a sense of what state your chemistry is in.

In the dry process equipment, the concern mostly comes down to cleanliness. Since the efficiency of the dry processes, laminating, and exposing depend on how effective your cleanroom is; most of the PM is about maintaining the cleanroom's quality. This can mean cleaning it to ensure no trace particles are brought in and checking the air filtration system.

Production Reliability

If you are running a PCB fabrication facility, you want to consistently manufacture products. By maintaining a PM program, you won't have to worry about emergency maintenance and unexpected downtime. PM will keep you



Figure 2: A lower spray rack being removed from an etcher to check nozzle condition.

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on the same page with your machines and allow you to diagnose problems before they escalate into bigger problems. Having unexpected downtime can be very costly. When you need to perform emergency maintenance, you first need to take time to diagnose the problem. If you haven't been carefully keeping track of your machine's condition, it can take many hours to find the root cause of the problem. Even if you find something that is going wrong, it could be unrelated to what caused you to shut the machine down in the first place. Once you find the root cause, chances are you will need to replace a part. If you don't already have the part you need, you must order it from your equipment supplier. Depending on your equipment manufacturer and the part you need, the time it takes for you to receive it will vary. This will result in more wasted time that could have been prevented. With PM, you would at least be able to foresee problems like this and order the part earlier or maintain a better inventory of parts.

Without a doubt, a PM program can greatly benefit your PCB shop. As a PCB manufacturer, it is highly recommended that you do the best you can to maintain some form of PM—even if that means just performing routine cleanings. Any amount of PM is better than no PM. Some companies that manufacture PCB equipment do offer PM programs where they will schedule a time for a technician to visit and perform PM; some may even help you develop your own PM program. Therefore, if you are considering a PM program, it is highly recommended that you reach out to your equipment manufacturer(s) and ask about PM options. **PCB007**



Christopher Bonsell is a chemical process engineer at Chemcut. To read past columns or contact Bonsell, [click here](#).

It's Only Common Sense

A Simple Framework for Elevating Your Employees



by **Dan Beaulieu**

One of the great things about being a manager (and not just a sales manager) is the opportunity to mentor, challenge, educate, lead, and most importantly, inspire the members of your team to do things they did not think they could do. You can help them achieve a level of accomplishment they did not realize they could.

As a manager and leader, you should always be evaluating the members of your team to find their talents both internal and external. Watch and study them to see what they are good at, what inspires them, and what makes their hearts sing.

Once you discover those special passions in each person, start helping them find a way to use those passions to enhance your department and company, as well as themselves.

One member might be a great writer, another fantastic at social media. You might have team members

who are solid with numbers, are great organizers or perhaps confident speakers and communicators.

One thing I can guarantee is that every member of your team is good at something; each has a special talent. If you have done your hiring properly (as every great leader should), each one is in some way smarter than you are.

So, discover their particular gifts and talents. The best way to do this is by talking with them. Remember, your responsibility as a leader is to bring out the best in your people, to encourage them to take their skills and talents to the next level. Learn everything you can about the people in your charge. You are literally in the position of being the steward—not only of their talents but their careers as well. They will, of course, pass onto the next step in their career path, but you can be instrumental in having a significant impact on their careers and their lives while they are under your wing.

To read this entire column, [click here](#).

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¹IPC. (2017). Findings on the Skills Gap in U.S. Electronics Manufacturing.



MilAero007 Highlights



Doug Pauls, Collins Aerospace, Receives Dieter Bergman IPC Fellowship Award ▶

Recent recipient of the Dieter Bergman IPC Fellowship Award, Doug Pauls worked nine years for the Navy, eight years as technical director of Contamination Studies Labs, and 19 years at Rockwell Collins (now Collins Aerospace), in the Advanced Operations Engineering group, where he is a principal materials and process engineer. Doug was awarded the Rockwell Collins Arthur A. Collins Engineer of the Year Award in 2004.

Designers Notebook: Design for Test, Part 2 ▶

Current generations for PCB designs have increased in complexity. The product developer and assembly service provider, whether in-house or outsourced, must consider manufacturing efficiency, throughput, and process yield. Design to accommodate product testing should ensure that the end product will perform reliably without compromise.

BAE Systems Completes Acquisition of Bohemia Interactive Simulations ▶

BAE Systems announced that it has completed the acquisition of Bohemia Interactive Simulations (BISim) for \$200 million, subject to customary closing adjustments.

Winonics Receives Lockheed RMS Supplier Approval ▶

Winonics announces the recent approval by Lockheed RMS as an approved supplier for rigid printed wiring boards for IPC-6011 and 6012 specifications. The approval followed a rigorous quality and systems audit that was

conducted by the Supplier Quality Services department of Lockheed RMS based in Moorestown, NJ.

Adventures in Engineering: 5G Expansion and Radar Altimeters ▶

The expansion of cellular broadband in the 3.7–3.98 GHz spectrum band has crossed into the working frequency range of Radar/Radio Altimeters (RAs). Commercial RAs are intended to operate in the frequency band of 4.2 to 4.4 GHz. However, Radar altimeter receivers may be sensitive to frequencies outside this range, and this is the basis for the FAA's current reluctance to wireless 5G wireless station deployment near airports.

Electronics Industry Praises Congress for Providing \$7.5 Million for Lead-Free Electronics R&D ▶

The U.S. Senate last night approved an FY 2022 spending package that contains \$7.5 million for further research and development on lead-free electronics in defense and high-performance applications, sending the measure to President Biden for his expected signature.

Northrop Grumman Develops Prototype Constellation Supporting Joint All-Domain Command ▶

Northrop Grumman Corporation received an award with a potential value of \$692 million from the Space Development Agency (SDA) to produce and field an innovative, proliferated constellation of 42 low-Earth orbit (pLEO) satellites for the Tranche 1 Transport Layer (T1TL) mesh satellite communications network.

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Leadership 101— The Law of Sacrifice

The Right Approach

by Steve Williams, THE RIGHT APPROACH CONSULTING

Introduction

Good leadership always makes a difference; unfortunately, so does bad leadership. This leadership truth continues as we will be talking about law 18 of the 21 Irrefutable Laws of Leadership from John Maxwell.

“The Law of Sacrifice: The leader must give up to go up.” —John C. Maxwell

The Early Years

Early in my career I had no idea what I wanted to do; I got into this business because printed circuit board manufacturing was the family business. Back then it was just a starter job, and I had no idea that it would turn into a 46-year (and counting) career path.

After years of working, hearing both internal and customer complaints, and noticing what things worked and what did not, I began to find my groove. I decided to position myself to make a difference and change the things I could influence, starting what turned out to be a life-long journey of self improvement. I went back to school, earning both my undergrad and MBA while holding management positions in the industry. Talk about sacrifices; balancing work, home, and school takes a toll on yourself and your family. I played competitive softball for 40 years on Friday nights and my biggest sacrifice was having to switch to non-alcoholic beer after games because I had a four-hour class Saturday morning.

All this was without the knowledge of what it would all lead to, including starting my own business nine years ago to help organizations improve performance.

Four Rules

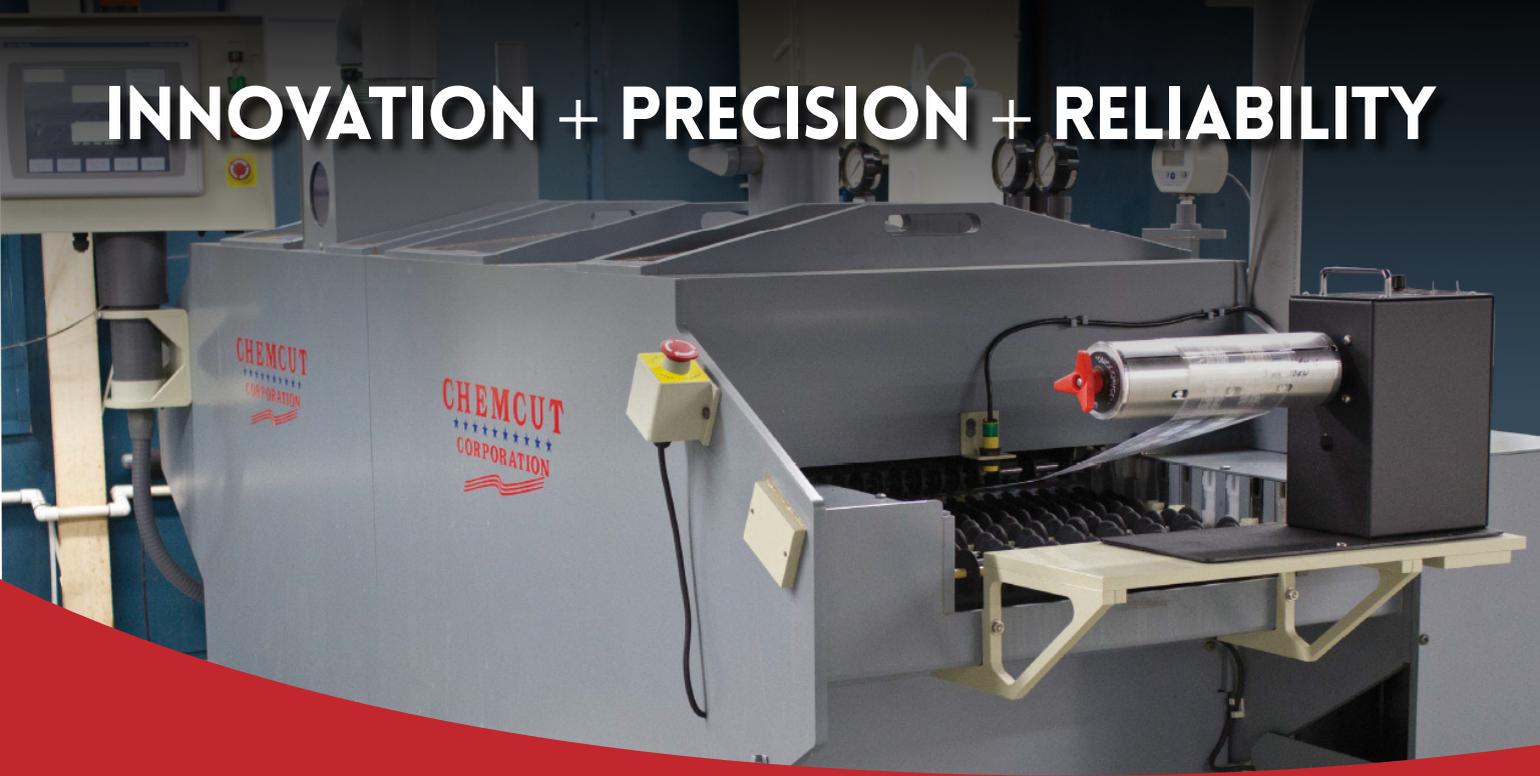
If you truly want to become a great leader you must be willing to make sacrifices. Here are four rules to keep in mind to this end:

1. There is no success without sacrifice.

Every person who has achieved any success in life has made sacrifices to do so. On a daily basis I meet people who wish they had more, but are unwilling to make the necessary sacrifices to make this happen. You can't have a successful online business if you aren't willing to build a website, connect to people on social media, build your network, or stay up to speed with the latest technology. Many leaders want to climb the corporate ladder, hoping that freedom and power wait at the top. They don't realize that leadership really requires sacrifice.



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2. Leaders are often asked to give up more than others.

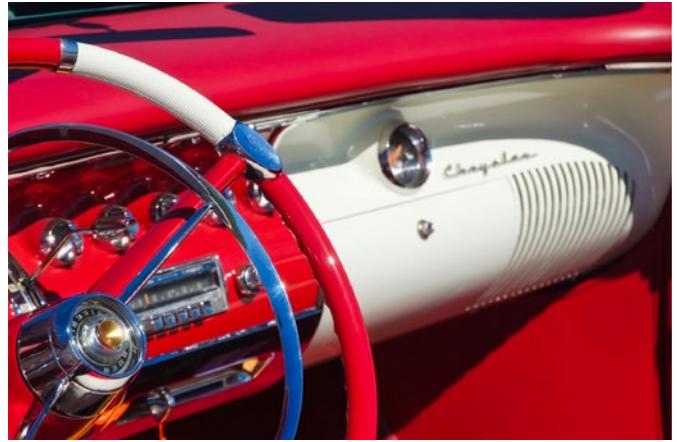
Leaders must give up their rights for the greater good. Leaders learn how to put others ahead of themselves. It's not easy, but you need to give up more than the people you lead are expected to give up. When you have no responsibilities, you can mostly do whatever you want. Remember the recurring Maxwell theme that the heart of leadership is putting others ahead of yourself.

3. You must keep giving up to stay up.

John Maxwell takes the Law of Sacrifice even further when he states, "If leaders have to give up to go up, then they have to give up even more to stay up." In business, we talk about history being the best predictor of future performance. We apply this to leadership by stating, "Today's success is the greatest threat to tomorrow's success." There's always a cost involved in moving forward, and the day you stop being willing to pay the price is the day you stop creating the results you desire.

4. The higher the level of leadership, the greater the sacrifice needed.

You've probably noticed that the higher the position, the fewer the number of people able to step in. It's not because there's a lack of capable people; it's simply because there are not enough people willing to pay the price. It seems we are constantly bombarded with the false ideal about the utopia of communism—where everyone is equal, and everybody should have the same rights and the same pay. The problem with this is the Law of Sacrifice. There will always be some individuals who are willing to sacrifice more, while others are not willing to do anything extra. No philosophy of equality will ever be able to overcome this mindset. It's the inner job. You must decide for yourself how much time, effort, or other sacrifice you're going to assign to a specific job, project, or task.



Case in Point

I still remember the signs in the early 1980s, "Iacocca for President," following his historic turnaround of Chrysler. This success did not come without monumental sacrifices by the newly-minted CEO in 1978, Lee Iacocca. He had accepted the job with Chrysler, but it required many personal sacrifices. The salary he accepted at Chrysler was a little over half what he had earned as the president of Ford. The next sacrifice came in his family life. To lead Chrysler, Iacocca had to work almost around the clock. Finally, to gather support in U.S. Congress for federally guaranteed loans, and to persuade suppliers, dealers, and union workers to make sacrifices to overcome the challenges that Chrysler was facing, Iacocca ended up cutting his salary to \$1 a year. But his sacrifices brought Chrysler back from the brink of insolvency to become a highly profitable company that remains relevant today.

Follow these guidelines and The Law of Sacrifice and you will truly be surprised at the results. Focus on enhancing your leadership skills to lead by example and the results will be epic. **PCB007**



Steve Williams is president of The Right Approach Consulting. He is also an independent certified coach, trainer, and speaker with the John Maxwell team. To read past columns or contact Williams, [click here](#).

PCBAA Member Profile

Davy Nakada, Rogers Corporation

1. Are there any specific issues you feel PCBAA will help you with this year?

Our industry has suffered from a lack of visibility with policymakers. PCBAA brings many voices together so those in Washington realize what's at stake. Semiconductors have received the most attention in recent years while the domestic production of PCBs and related PCB materials continues to decline. We are now seeing legislative language supporting domestic production because of how PCBAA has educated lawmakers and policymakers on the PCB's place in the microelectronics ecosystem.

2. Why do you feel the time is right for PCBAA to exist?

I think it is the perfect time for PCBAA to arrive on the scene. It took decades for domestic production to shrink to a single digit percentage of the world supply. We shouldn't let the number fall any further. With all the focus on supply chain resiliency and trusted sources, PCBs need to get the same level of attention that semiconductors are getting. One doesn't work without the other. How we view the microelectronics ecosystem needs to be more inclusive and not simply focused on chips.

3. What challenges does the industry face and how is PCBAA helping your company meet those challenges?

As I mentioned, the PCB industry has been in the shadow of semiconductors for some time. PCBs are not as well understood both in terms of function and complexity. Gone are the days of simple green plastic boards with a few components. PCBs are complex microelectronics that require specialized and costly equipment to both prepare materials and manufacture the final products. Many of the materials needed are almost exclusively from other countries. PCBAA is advocating for our industry to get the kind of legislation and policy support that



Davy Nakada

will bring manufacturing back to the United States. We will never get to 100%, but to have a thriving, resilient supply chain for this industry, we need to stand united. PCBAA helps us do just that.

4. What do you see as the benefits of membership in PCBAA?

We benefit from having a presence in Washington focused solely on our industry and technology. The PCBAA has an experienced team that knows the way things work in Washington, the people to contact, and how to create the awareness we need to reinvigorate and grow the domestic PCB industry. Being part of PCBAA also brings us together with like-minded companies where we can share ideas that benefit the entire industry.

Davy Nakada is senior director at Rogers Corporation. To read more about PCBAA or contact the association, [visit its column page here](#).

Next-Generation Application Specific Modules

Happy's Tech Talk #7

by Happy Holden, I-CONNECT007

Introduction

In 1965, Gordon Moore predicted that the number of transistors that could be packaged into a square inch of space would double every year for the near future.¹ Although his projection was later revised to every 18 months, “Moore’s Law” has withstood the test of time for five decades. Today, we are beginning to see obstacles to this type of exponential growth due to the inherent limits associated with silicon lithography, packaging of the devices, and component placement on PCBs.

A new electronics packaging method known as application specific electronics package (ASEP)² has been developed for applications in the growing electric vehicle (EV) market. The technology enables the integration of PCBs, connectors, and high-current conductors, as well as active and passive components, into a single device. ASEP assemblies can have multilayer circuitry and three-dimen-

sional features. They can be inherently hermetically sealed, manufactured with thermally conductive resins that are effective in dissipating heat, and designed in such a way to benefit from the high conductivity of metal to carry high currents and heat, making the process an ideal solution for assemblies that must withstand elevated temperatures, high currents, and harsh environments.

ASEP Manufacturing

New and smarter ways of manufacturing electronics, as well as better ways to dissipate the heat being generated, must be developed for the electronics industry to continue a robust growth trajectory. ASEP is an additive manufacturing process that builds up the conductive patterns on the surface of the plastic substrate, as opposed to etching away the copper on a PCB.

Thermoplastic ASEP substrates can also be remelted and reused. Figure 1 shows the basic

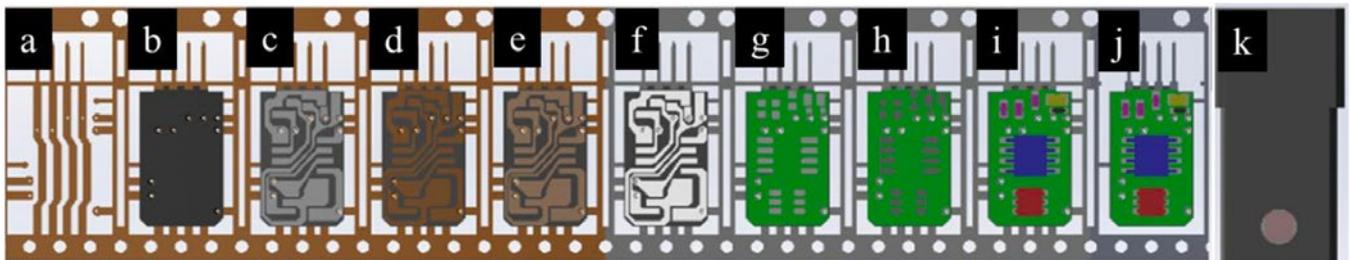


Figure 1: ASEP manufacturing process from a) stamping to k) final assembly. The process is continuous and requires roughly half as many process steps as conventional PCB manufacturing. (Source: All images courtesy of Molex/Ford)

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Today, Electronics are a fully integrated part of our daily lives and have advanced in performance, device size, and design. This trend continues at an exponential speed and keeps pushing component miniaturization along with an ever-increasing need for more product functionality. For the PCB industry, it is impacting the use of stacked microvias, especially in high-reliability applications where failure is not an option. With the release of **Printoganth[®] P2** and **Printoganth[®] PV G2**, Atotech has revolutionized the capabilities of electroless copper processes for advanced microvia applications. Controlled stress within the copper deposit enables both solutions to provide excellent coverage, with no blistering on a wide range of dielectric materials. This helps you “future proof” your process for both horizontal and vertical equipment. Thanks to throwing powers “beyond the norm”, and a formulation optimized for maximum compatibility with via-fill electrolytes, Printoganth[®] P2 and Printoganth[®] PV G2 now make electroless copper truly universal.

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process steps for ASEP manufacturing. A list of the process steps is as follows:

- a. Stamp metal carrier
- b. Insert mold plastic substrate
- c. Lasers modify the surface
- d. Inkjet print nanoparticle conductors
- e. Sinter to make the traces conductive
- f. Electroplate with Cu and additional metals
- g. Inkjet print solder mask
- h. Dispense or screen solder paste
- i. Pick and place components and reflow
- j. Singulate
- k. Place into final assembly housing

The novel ASEP is small enough to offer the modularity that EVs will need to function effectively. The example illustrated in Figure 2 has both a microprocessor and network, along

with high-voltage and high-power devices needed to control the new EV motors.

High current and high voltage, accompanied by the heat generated by the power devices, are becoming a significant challenge in the automotive, commercial vehicle, and industrial equipment industries. The ASEP module is 58% smaller and 22% lighter with 25% improvement in current capacity at 110°C than a printed circuit board. Typically, power control electronics have been made with “thick copper” PCBs, where copper traces are between 75 and 200 microns thick. Even with these copper thicknesses, they have not been very efficient in conducting high current as well as high voltages while managing the heat when compared to thicker stamped Cu alloys which may be up to several millimeters thick.

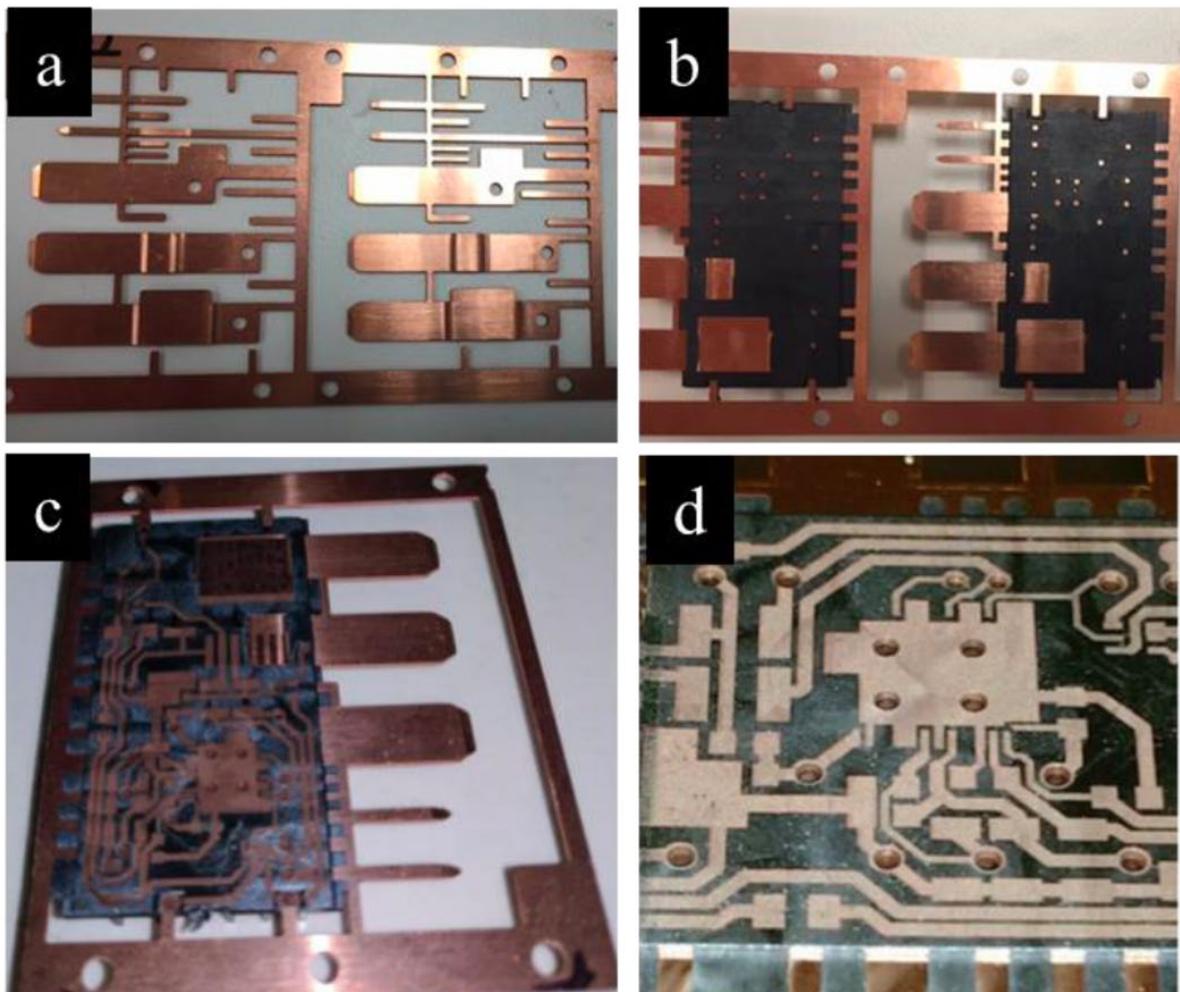


Figure 2: Four steps of ASEP manufacturing: a) metal stamping; b) overmolding with LCP; c) laser marking the surface; d) inkjet printing of nanoparticle metal and solder paste.

The ASEP process starts with a stamped metal carrier which is over-molded with a high temperature substrate. A nanoparticle ink is used to print the patterns and then the traces are electroplated with conventional metals commonly used in the PCB industry (Figure 2). A solder mask is applied and then components are reflowed onto the ASEP assembly.

The stamped metal carrier within the ASEP assembly serves multiple crucial functions in the manufacture of the product. The substrate is a way to carry the ASEP assembly through the manufacturing process steps as well as the electrical contact for the connector features of the ASEP assembly. In addition, the substrate serves as a method to transfer the heat generated by the components placed onto the ASEP assembly and provides a path to carry high current that would otherwise be impossible to carry within a conventional PCB assembly.

For higher density electronic packages, a two-sided reel-to-reel manufactured polyimide flexible circuit either replaces or is integrated with the stamped metal carrier, creating up to five layers of circuitry. This type of ASEP packaging would be used to design miniaturized consumer electronics, sensors, medical devices, and small wearable devices. For high temperature applications, a thermally conductive substrate such as a liquid crystal polymer (LCP) is used; it effectively becomes a heat sink or spreader, reducing the temperatures of the heat-generating components.

After the stamped metal carrier has been over-molded with an LCP substrate, a laser is used to define the circuit patterns on the surfaces of the substrate. Since all the 3D features such as vias, recesses, or cavities have been molded into the substrate, the laser must be able to image the pattern in three dimensions. After the patterns have been

laser marked, an inkjet printer deposits a thin conductive layer of metal onto the traces that were defined by the laser.

ASEP Attributes, Features, and Performance

By integrating the functionality of a PCB, connector, and thermal management features, ASEP combines the functions into a single device which will be smaller, lighter, and more efficient. Because the process is fully additive, new SAP processes will be able to provide fine traces and spaces. Advantages are that ASEP applications can be made to be inherently hermetically sealed. The combination of these advantages should result in very cost-effective electronic solutions.

Figure 3 shows an ASEP package without components. The package, called ASEP microPDB (micro power distribution box), adds additional power switching and circuit protection to the vehicle's wiring architecture. The two high-current electrical paths for the field effect transistor (FET) in the lower bot-

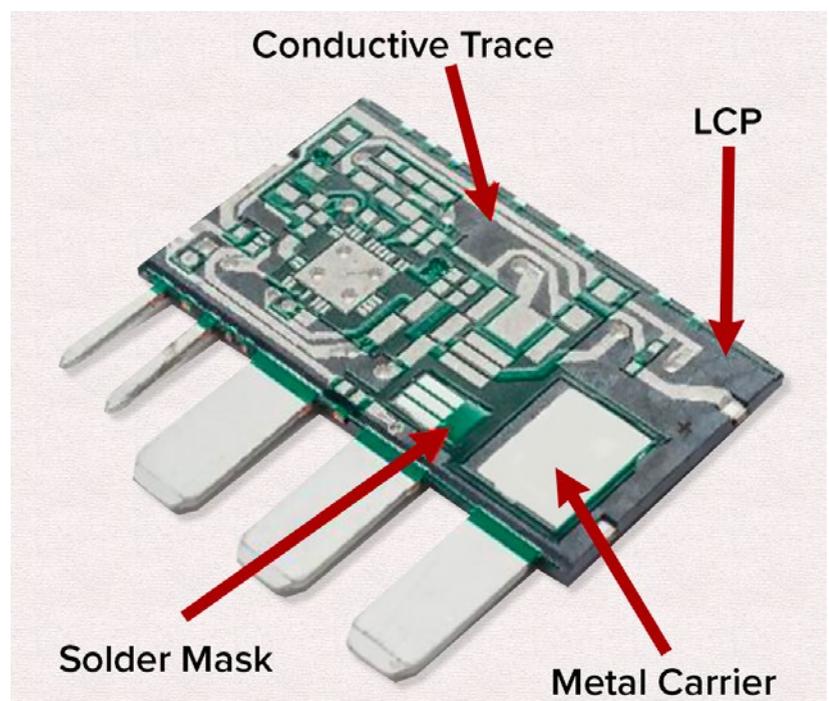


Figure 3: An ASEP microPDB substrate without components. The FET will be soldered to two of the contacts on the microPDB that are direct extensions of the 800-micron thick copper alloy contacts.

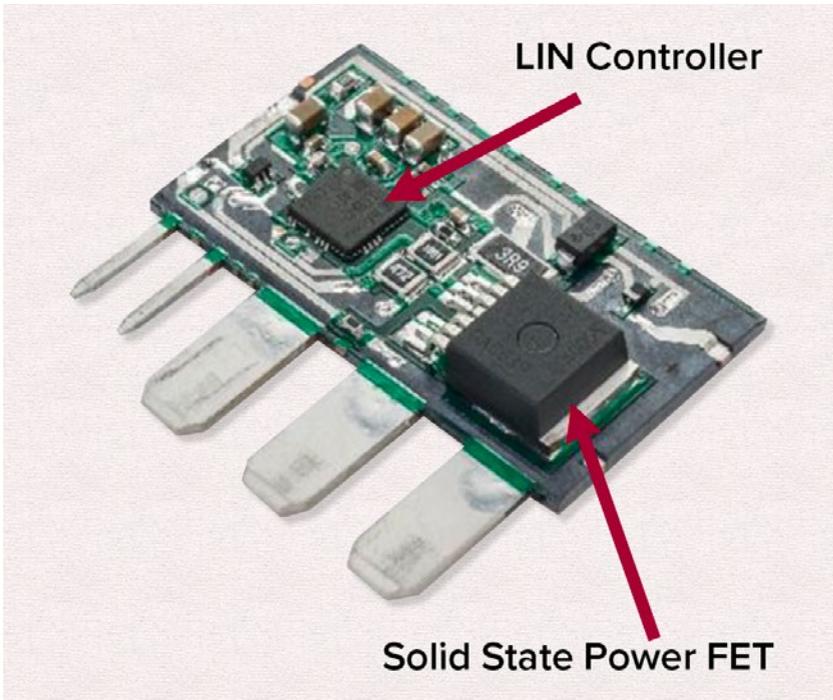


Figure 4: The FET is soldered directly to the thick copper alloy contacts. This results in low thermal and electrical resistance between the heat-generating FET and ambient.

tom corner of the device are extensions of the actual metal contacts. Therefore, the FET (in Figure 4) is soldered directly to the 800-micron thick Cu alloy; the resulting electrical and thermal path has been optimized. This reduces the resistance in the system (reduces heat generated) and reduces the resistance in the thermal path to remove the heat from the device very efficiently. Furthermore, the ASEP material used for the application can be a thermally conductive plastic (such as LCP) which spreads the heat generated by the FET. In effect, the ASEP material itself can be the heat sink or spreader, making it possible to reduce the temperature of the heat-generating devices.

The ASEP microPDB is a power control device that looks very much like an automotive connector (Figure 4) but within it a microprocessor and FET provide local interconnect network (LIN) control and high-current solid-state switching that are highly reliable, self-protecting, and cost effective in comparison with a current microPDB containing a relay and fuses (as seen in Figure 5). The micropro-

cessor provides LIN control which eliminates the need to run control lines to each device.

Electrical, Thermal, and Mechanical Testing

Three main tests were performed to evaluate the electrical, thermal, and mechanical performance of the ASEP microPDB. First, temperature rise testing was performed on the package. The ASEP microPDB was powered with 12 volts from 0 amps to shutdown in 5A intervals and 30-minute intervals. Thermocouples were attached to the microprocessor and the FET to measure the temperatures. Tests were conducted at both 85°C and 110°C ambient. According to specification, the temperature rise should not exceed 55°C above the ambi-

ent temperature. In addition to the temperature rise test, both thermal shock and vibration

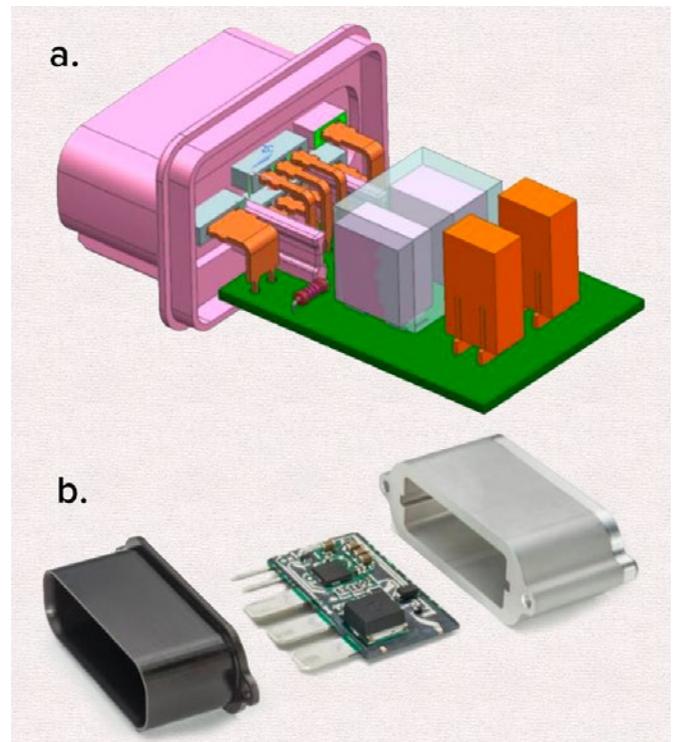


Figure 5: a) Current PCB-based microPDB with relay and fuse; b) an ASEP microPDB with FETs.

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Table 1: Comparison of the PCB microPDB and the ASEP microPDB in design and performance.

Feature	Micro PDB	ASEP Micro PDB	Delta
Size (cm ³)	122.5	51.5	58% smaller
Weight (grams)	64	50	22% lighter
Current Capability @ 110°C	40 Amps	50 Amps	25% higher

(Source: Molex/Ford)

tests were performed according to USCAR 2 revision 6 specification.³

The results show that the ASEP microPDB can carry 50 amps of current at 110°C ambient. The package shuts down at higher currents as the temperature rises more than 55°C above ambient. In addition to a thermal test, the ASEP assembly met all the requirements of the vibration and thermal shock tests.

Table 1 provides a comparison between the size and weight of a PCB microPDB design currently in production and the ASEP microPDB design. The ASEP microPDB is 58% smaller and 22% lighter with an improved current capability at higher temperatures.

Conclusion

ASEP is a design and manufacturing process that allows the industry to take advantage

of the latest injection moldable plastics along with the proven ability of conductive metal frames to remove heat, carry high currents, and to provide reliable electrical interconnects.

The technology is ideal for a modular approach to control in electric vehicles where the control is distributed by its network but there is a need for high current or high voltage while providing cooling for a long-lived, reliable system control. **PCB007**

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1. "Progress in digital integrated electronics," by G.E. Moore, Digest of the 1975 International Electron Devices Meeting, pp. 11–13. Washington, D.C.
2. "ASEP (Application Specific Electronics Package), a Next Generation Electronics Manufacturing Technology," by Victor Zaderej and Richard Fitzpatrick, Molex; Babak Afraei, Ford Motor Co., Proceedings of SMTA Intn'l, 2018, Rosemont, Illinois.
3. Performance Specification for Automotive Electrical Connector Systems, USCAR-2 revision 6.



Happy Holden has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa Westwood, Merix, Foxconn, and Gentex. He is currently a contributing technical editor with I-Connect007, and

the author of *Automation and Advanced Procedures in PCB Fabrication*, and *24 Essential Skills for Engineers*. To read past columns or contact Holden, [click here](#).



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EIPC Technical Snapshot: A European Roundup

Although it was originally proposed to hold a one-day face-to-face EIPC conference in Frankfurt, travel restrictions in Germany made this impractical. But the Technical Snapshot webinar format has proved so successful that it was decided to run an extended version as an alternative—two sessions, with three presentations each. It worked extremely well.



Institute of Circuit Technology: A Novel Approach to Recycling PCBs

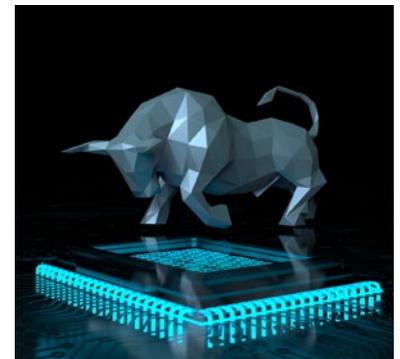


A two-year project funded by an Innovate UK SMART Grant aims to reduce the impact of e-waste using naturally derived, biodegradable

and nontoxic products. Those attending the webinar for the Institute of Circuit Technology's annual meeting on March 2 learned more about the project, as well as statutory paperwork obligations of the UK REACH regulations.

Calumet is Bullish on Additive and Semi-Additive

Calumet Electronics has been a domestic pioneer with additive and semi-additive electronics manufacturing processes. We recently asked Calumet's Todd Brassard and Meredith LaBeau to discuss the state of this technology, which traditional processes that they might replace, and some of the challenges facing OEMs or PCB shops that are considering these options.



IPC Student Director: Three Things IPC APEX EXPO Taught Me

IPC APEX EXPO 2022 was my first in-person APEX EXPO event, and it surely did not disappoint. The show this year was packed with high quality technical courses, engaging professional development courses and, of course, an admirable show floor exhibition. This year APEX EXPO really resonated with me, and I would like to leave you with three insights I learned while attending.



American Made Advocacy: What Happens in Washington Happens to Us All



Like many of you, I've spent the last few years grappling with the challenges posed by a global pandemic. Whether it's staffing a production line or obtaining key materials, PCB manufacturers and their suppliers have had to adapt quickly to a radically changed environment. As an industry, we cannot allow our day-to-day focus to distract us from what is happening in Washington and what it means to the microelectronics ecosystem.

The Right Approach: The Laws of Victory and Momentum



Good leadership always makes a difference; unfortunately, so does bad leadership. This leadership truth continues as we will be talking about Laws 15 and 16 of the 21 Irrefutable Laws of Leadership. Great leaders are committed to victory and make things happen, period. One of the most enduring mantras in leadership is "Never ask a follower to do something you are not willing to do yourself."

Happy's Tech Talk #5: Advanced Boards for Heterogeneous Integration

The expansion of IC functionality usually progresses with the shrinking of IC geometries, called "Moore's Law" after Gordon Moore who first coined the phrase. But now that geometries are below 5 nm, the costs and difficulties are creating a barrier to much further advances.

An Inside Look at an Indian PCB Manufacturer

As a student of the printed circuit board industry, I am always interested in learning more about companies all over the world. When I connected with Abhay Doshi, managing director of Fine-Line Circuits Ltd. in India, I welcomed the opportunity to learn more about him, his company, and the Indian PCB business as a whole.

Bob Neves: IPC Continues Its Global Reach

During IPC APEX EXPO, Nolan Johnson visited with Bob Neves of Microtek Laboratories China and the new board chair of the IPC Board of Directors. Nolan asks Bob about IPC's views on the disruption in supply chain, about restoring PCB fabrication in the United States, and how the IPC is looking to resolve supply chain issues.

TTM Technologies to Build New Manufacturing Facility in Malaysia



TTM Technologies, Inc. announced that it will open a new, state of the art, highly automated printed circuit board manufacturing facility in Penang, Malaysia.

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Qualifications:

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- Liaising with operational and supply chain teams to support customer service

Skills and abilities required:

- Extensive sales, product management, product application experience
- European citizenship (or authorization to work in Europe/Germany)
- Fluency in English language (spoken & written)
- Good written & verbal communications skills
- Printed circuit board industry experience an advantage
- Ability to work well both independently and as part of a team
- Good user knowledge of common Microsoft Office programs
- Full driving license essential

What's on offer:

- Salary & sales commission--competitive and commensurate with experience
- Pension and health insurance following satisfactory probation
- Company car or car allowance

This is a fantastic opportunity to become part of a successful brand and leading team with excellent benefits. Please forward your resume to jobs@ventec-europe.com.

apply now

Career Opportunities



Flexible Circuit Technologies is a premier global supplier providing design, prototyping and production of flexible circuits, rigid flex circuits, flexible heaters, and membrane switches.

Application Engineer/ Program Management

Responsibilities

- Gain understanding for customer and specific project requirements
- Review customer files/drawings, analyze technical, application, stackup, material, and mechanical requirements; develop cost-effective designs that meet requirements
- Quote and follow up to secure business
- Work with CAD: finalize files, attain customer approval prior to build
- Track timeline and provide customers with updates
- Follow up on prototype, assist with design changes if needed, push forward to production
- Work with customer as the lead technician/program manager or as part of FCT team working with an assigned program manager
- Help customer understand FCT's assembly, testing, and box build services/support
- Understand manufacturing and build process for flexible and rigid-flex circuits

Qualifications

- Demonstrated experience: PCB/FPCB/rigid-flex designer including expertise in design rules, IPC
- Demonstrated success in attaining business
- Ability to work in fast-paced environment, on broad range of projects, while maintaining a sense of urgency
- Ability to work as a team player
- Excellent written and verbal communication skills
- Must be willing to travel for sales support activities, customer program support and more.

FCT offers a competitive salary, bonus program, and benefits package. Preferred location Minneapolis, MN area. www.flexiblecircuit.com

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Electrical Engineer/PCB/CAD Design, BOM Component & Quality Support

Responsibilities

- Learn the properties, applications, advantages/disadvantages of flex circuits
- Learn the intricacies of flex circuit layout best practices
- Learn IPC guidelines: Flex circuits/assemblies
- Create flexible PCB designs/files to meet engineering/customer requirements
- Review customer prints and Gerber files to ensure they meet manufacturing and IPC requirements
- Review mechanical designs for mfg, including circuit and assembly requirements, BOM/component needs and help to identify alternate components if needed
- Prepare and document changes to customer prints/files. Work with app engrs, customers and mfg. engrs. to finalize and optimize designs for manufacturing
- Work with quality manager to learn quality systems, requirements, and support manager with assistance

Qualifications

- Electrical Engineering degree with 2+ years of CAD/PCB design experience
- IPC CID or CID+ certification or desire to obtain
- Knowledge of flexible PCB materials, properties, or willingness to learn
- Experience with CAD software: Altium or other
- Knowledge of IPC standards for PCB industry, or willingness to learn
- Microsoft Office products

FCT offers a competitive salary, bonus program, and benefits package. Preferred location Minneapolis, MN area. www.flexiblecircuit.com

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Career Opportunities



R&D Scientist III, Orange, CT

Job Description: The scientist will be a leader in technology for plating chemistry development, electrolytes, and additives. The position is hands-on, where the ideal candidate will enjoy creating and testing new aqueous plating processes and materials to meet the most demanding semiconductor applications related to Wafer-Level Packaging and Damascene. The qualified candidate will work as part of the R&D team while interacting with scientists, product management, and application engineers to commercialize new products for the advanced electronic solution business.

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Prototype Engineer, Sawanee, GA

Job Description: The purpose of this position is to provide direct technical and customer support for the Electronic Polymers (EP) product line of the Semiconductor Solutions Group for existing products as well as new and developmental products. The position is responsible for leading the team with customer builds and proof of concept designs directly engaging with customers. The position will lead a variety of technical, customer support, quality, marketing, process, and production related projects.

[apply now](#)



Regional Manager Midwest Region

General Summary: Manages sales of the company's products and services, Electronics and Industrial, within the States of IL, IN & MI. Reports directly to Americas Manager. Collaborates with the Americas Manager to ensure consistent, profitable growth in sales revenues through positive planning, deployment and management of sales reps. Identifies objectives, strategies and action plans to improve short- and long-term sales and earnings for all product lines.

DETAILS OF FUNCTION:

- Develops and maintains strategic partner relationships
- Manages and develops sales reps:
 - Reviews progress of sales performance
 - Provides quarterly results assessments of sales reps' performance
 - Works with sales reps to identify and contact decision-makers
 - Setting growth targets for sales reps
 - Educates sales reps by conducting programs/ seminars in the needed areas of knowledge
- Collects customer feedback and market research (products and competitors)
- Coordinates with other company departments to provide superior customer service

QUALIFICATIONS:

- 5-7+ years of related experience in the manufacturing sector or equivalent combination of formal education and experience
- Excellent oral and written communication skills
- Business-to-business sales experience a plus
- Good working knowledge of Microsoft Office Suite and common smart phone apps
- Valid driver's license
- 75-80% regional travel required

To apply, please submit a COVER LETTER and RESUME to: Fernando Rueda, Americas Manager

fernando_rueda@kyzen.com

[apply now](#)

Career Opportunities



American Standard Circuits

Creative Innovations In Flex, Digital & Microwave Circuits

Wet Process Engineer

ASC, the largest independent PCB manufacturer in the Midwest, is looking to expand our manufacturing controls and capabilities within our Process Engineering department. The person selected will be responsible for the process design, setup, operating parameters, and maintenance of three key areas—imaging, plating, etching—within the facility. This is an engineering function. No management of personnel required.

Essential Responsibilities

Qualified candidates must be able to organize their own functions to match the goals of the company.

Responsible for:

- panel preparation, dry film lamination, exposure, development and the processes, equipment setup and maintenance programs
- automated (PAL line) electrolytic copper plating process and the equipment setup and maintenance programs
- both the cupric (acid) etching and the ammoniacal (alkaline) etching processes and the equipment setups and maintenance programs

Ability to:

- perform basic lab analysis and troubleshooting as required
- use measurement and analytical equipment as necessary
- work alongside managers, department supervisors and operators to cooperatively resolve issues
- effectively problem-solve
- manage multiple projects concurrently
- read and speak English
- communicate effectively/interface at every level of the organization

Organizational Relationships

Reports to the Technical Director.

Qualifications

Degree in Engineering (BChE or I.E. preferred). Equivalent work experience considered. High school diploma required. Literate and functional with most common business software systems MS Office, Excel, Word, PowerPoint are required. Microsoft Access and basics of statistics and SPC a plus.

Physical Demands

Exertion of up to 50 lbs. of force occasionally may be required. Good manual dexterity for the use of common office equipment and hand tools.

- Ability to stand for long periods.

Work Environment

This position is in a manufacturing setting with exposure to noise, dirt, and chemicals.

Click on 'apply now' button below to send in your application.

[apply now](#)

Career Opportunities



MACHINES FOR PRINTED CIRCUIT BOARDS

Field Service Engineer

Location: West Coast, Midwest

Pluritec North America, Ltd., an innovative leader in drilling, routing, and automated inspection in the printed circuit board industry, is seeking a full-time field service engineer.

This individual will support service for North America in printed circuit board drill/routing and x-ray inspection equipment.

Duties included: Installation, training, maintenance, and repair. Must be able to troubleshoot electrical and mechanical issues in the field as well as calibrate products, perform modifications and retrofits. Diagnose effectively with customer via telephone support. Assist in optimization of machine operations.

A technical degree is preferred, along with strong verbal and written communication skills. Read and interpret schematics, collect data, write technical reports.

Valid driver's license is required, as well as a passport, and major credit card for travel.

Must be able to travel extensively.

[apply now](#)



SMT Field Technician Hatboro, PA

Manncorp, a leader in the electronics assembly industry, is looking for an additional SMT Field Technician to join our existing East Coast team and install and support our wide array of SMT equipment.

Duties and Responsibilities:

- Manage on-site equipment installation and customer training
- Provide post-installation service and support, including troubleshooting and diagnosing technical problems by phone, email, or on-site visit
- Assist with demonstrations of equipment to potential customers
- Build and maintain positive relationships with customers
- Participate in the ongoing development and improvement of both our machines and the customer experience we offer

Requirements and Qualifications:

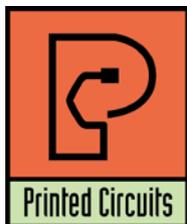
- Prior experience with SMT equipment, or equivalent technical degree
- Proven strong mechanical and electrical troubleshooting skills
- Proficiency in reading and verifying electrical, pneumatic, and mechanical schematics/drawings
- Travel and overnight stays
- Ability to arrange and schedule service trips

We Offer:

- Health and dental insurance
- Retirement fund matching
- Continuing training as the industry develops

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Career Opportunities



Printed Circuits, a fast-growing printed circuit board fabricator, offers:

- Excellent opportunities for advancement and growth
- Dynamic manufacturing environment
- Excellent health, dental and other benefits
- Annual profit-sharing plan
- Signing bonus
- Additional incentives at the leadership level
- Clean facility with state-of-the-art manufacturing equipment
- Highly collaborative corporate and manufacturing culture that values employee contributions

Laminator Technician

Nature of Duties/Responsibilities

- Layup cover lay
- Layup rigid flex
- Layup multilayer/CU core boards
- Oxide treat/cobra treatment of all layers/CU cores
- Shear flex layer edges
- Rout of machine panel edges and buff
- Remove oxide/cobra treatment (strip panels)
- Serialize panels
- Pre-tac Kapton windows on flex layers (bikini process)
- Layup Kapton bonds
- Prep materials: B-stage, Kapton, release sheet
- Breakdown: flex layers, and caps
- Power scrub: boards, layers, and caps
- Laminate insulators, stiffeners, and heatsinks
- Plasma cleans and dry flex layers B-stage (Dry)
- Booking layers and materials, ready for lamination process
- Other duties as deemed necessary by supervisor

Education/Experience

- High school diploma or GED
- Must be a team player
- Must demonstrate the ability to read and write English and complete simple mathematical equations
- Must be able to follow strict policy and OSHA guidelines
- Must be able to lift 50 lbs
- Must have attention to detail

Wet Process/Plating Technician

Position is 3rd shift (11:00PM to 7:30AM, Sunday through Friday)

Purpose

To carry out departmental activities which result in producing quality product that conforms to customer requirements. To operate and maintain a safe working environment.

Nature of Duties/Responsibilities

- Load and unload electroplating equipment
- Fasten circuit boards to racks and cathode bars
- Immerse work pieces in series of cleaning, plating and rinsing tanks, following timed cycles manually or using hoists
- Carry work pieces between departments through electroplating processes
- Set temperature and maintains proper liquid levels in the plating tanks
- Remove work pieces from racks, and examine work pieces for plating defects, such as nodules, thin plating or burned plating
- Place work pieces on racks to be moved to next operation

- Check completed boards
- Drain solutions from and clean and refill tanks; fill anode baskets as needed
- Remove buildup of plating metal from racks using chemical bath

Education and Experience

- High school diploma or GED required
- Good organizational skills and the ability to follow instructions
- Ability to maintain a regular and reliable attendance record
- Must be able to work independently and learn quickly
- Organized, self-motivated, and action-oriented, with the ability to adapt quickly to new challenges/opportunities
- Prior plating experience a plus

Production Scheduler

Main Responsibilities

- Development and deployment of a level-loaded production plan
- Establish manufacturing plan which results in "best possible" use of resources to maximize asset utilization
- Analyze production capacity of manufacturing processes, equipment and human resource requirements needed to produce required products
- Plan operation manufacturing sequences in weekly time segments utilizing production labor standards
- Maintain, align, and communicate regularly with internal suppliers/customers and customer service on key order metrics as per their requirements
- Frequently compare current and anticipated orders with available inventory and creates replenishment plan
- Maintain master distribution schedule for the assigned facility, revise as needed and alert appropriate staff of schedule changes or delays
- Participate in periodic forecasting meetings
- Lead or participate in planning and status meetings with production, shipping, purchasing, customer service and/or other related departments
- Follow all good manufacturing practices (GMPs)
- Answer company communications, fax, copy and file paperwork

Education and Experience

- High school diploma or GED
- Experience in manufacturing preferred/3 years in scheduling
- Resourceful and good problem-solving skills
- Ability to make high pressure decisions
- Excellent written and verbal communication skills
- Strong computer skills including ERP, Excel, Word, MS Office
- Detailed and meticulous with good organizational skills
- Must be articulate, tactful and professional at all times
- Self-motivated

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Career Opportunities

INSULECTRO

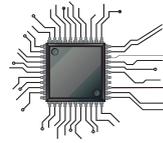


Are You Our Next Superstar?!

Insulectro, the largest national distributor of printed circuit board materials, is looking to add superstars to our dynamic technical and sales teams. We are always looking for good talent to enhance our service level to our customers and drive our purpose to enable our customers to build better boards faster. Our nationwide network provides many opportunities for a rewarding career within our company.

We are looking for talent with solid background in the PCB or PE industry and proven sales experience with a drive and attitude that match our company culture. This is a great opportunity to join an industry leader in the PCB and PE world and work with a terrific team driven to be vital in the design and manufacture of future circuits.

[apply now](#)



MivaTek

Global

Field Service Technician

MivaTek Global is focused on providing a quality customer service experience to our current and future customers in the printed circuit board and microelectronic industries. We are looking for bright and talented people who share that mindset and are energized by hard work who are looking to be part of our continued growth.

Do you enjoy diagnosing machines and processes to determine how to solve our customers' challenges? Your 5 years working with direct imaging machinery, capital equipment, or PCBs will be leveraged as you support our customers in the field and from your home office. Each day is different, you may be:

- Installing a direct imaging machine
- Diagnosing customer issues from both your home office and customer site
- Upgrading a used machine
- Performing preventive maintenance
- Providing virtual and on-site training
- Updating documentation

Do you have 3 years' experience working with direct imaging or capital equipment? Enjoy travel? Want to make a difference to our customers? Send your resume to N.Hogan@MivaTek.Global for consideration.

More About Us

MivaTek Global is a distributor of Miva Technologies' imaging systems. We currently have 55 installations in the Americas and have machine installations in China, Singapore, Korea, and India.

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Career Opportunities



Rewarding Careers

Take advantage of the opportunities we are offering for careers with a growing test engineering firm. We currently have several openings at every stage of our operation.

The Test Connection, Inc. is a test engineering firm. We are family owned and operated with solid growth goals and strategies. We have an established workforce with seasoned professionals who are committed to meeting the demands of high-quality, low-cost and fast delivery.

TTCI is an Equal Opportunity Employer. We offer careers that include skills-based compensation. We are always looking for talented, experienced test engineers, test technicians, quote technicians, electronics interns, and front office staff to further our customer-oriented mission.

Associate Electronics Technician/Engineer (ATE-MD)

TTCI is adding electronics technician/engineer to our team for production test support.

- Candidates would operate the test systems and inspect circuit card assemblies (CCA) and will work under the direction of engineering staff, following established procedures to accomplish assigned tasks.
- Test, troubleshoot, repair, and modify developmental and production electronics.
- Working knowledge of theories of electronics, electrical circuitry, engineering mathematics, electronic and electrical testing desired.
- Advancement opportunities available.
- Must be a US citizen or resident.

[apply now](#)

Test Engineer (TE-MD)

In this role, you will specialize in the development of in-circuit test (ICT) sets for Keysight 3070 (formerly HP) and/or Teradyne (formerly GenRad) TestStation/228X test systems.

- Candidates must have at least three years of experience with in-circuit test equipment. A candidate would develop and debug our test systems and install in-circuit test sets remotely online or at customer's manufactur-

ing locations nationwide.

- Candidates would also help support production testing and implement Engineering Change Orders and program enhancements, library model generation, perform testing and failure analysis of assembled boards, and other related tasks.
- Some travel required and these positions are available in the Hunt Valley, Md., office.

[apply now](#)

Sr. Test Engineer (STE-MD)

- Candidate would specialize in the development of in-circuit test (ICT) sets for Keysight 3070 (formerly Agilent & HP), Teradyne/GenRad, and Flying Probe test systems.
- Strong candidates will have more than five years of experience with in-circuit test equipment. Some experience with flying probe test equipment is preferred. A candidate would develop, and debug on our test systems and install in-circuit test sets remotely online or at customer's manufacturing locations nationwide.
- Proficient working knowledge of Flash/ISP programming, MAC Address and Boundary Scan required. The candidate would also help support production testing implementing Engineering Change Orders and program enhancements, library model generation, perform testing and failure analysis of assembled boards, and other related tasks. An understanding of stand-alone boundary scan and flying probe desired.
- Some travel required. Positions are available in the Hunt Valley, Md., office.

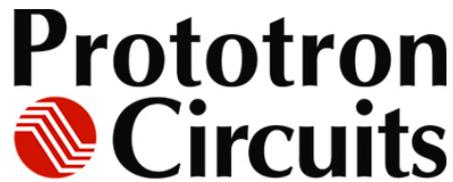
Contact us today to learn about the rewarding careers we are offering. Please email resumes with a short message describing your relevant experience and any questions to careers@ttci.com. Please, no phone calls.

We proudly serve customers nationwide and around the world.

TTCI is an ITAR registered and JCP DD2345 certified company that is NIST 800-171 compliant.

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Career Opportunities



Sales Representatives

Prototron Circuits, a market-leading, quick-turn PCB shop, is looking for sales representatives for all territories.

Reasons you should work with Prototron:

- Serving the PCB industry for over 30 years
- Solid reputation for on-time delivery (99% on-time)
- Excellent quality
- Production quality quick-turn services in as little as 24 hours
- AS9100
- MIL-PRF- 31032
- ITAR
- Global sourcing
- Engineering consultation
- Completely customer focused team

Interested? Let's have a talk.

Call Dan Beaulieu at

207-649-0879

or email to

danbbeaulieu@aol.com

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U.S. CIRCUIT

Plating Supervisor

Escondido, California-based PCB fabricator U.S. Circuit is now hiring for the position of plating supervisor. Candidate must have a minimum of five years' experience working in a wet process environment. Must have good communication skills, bilingual is a plus. Must have working knowledge of a plating lab and hands-on experience running an electrolytic plating line. Responsibilities include, but are not limited to, scheduling work, enforcing safety rules, scheduling/maintaining equipment and maintenance of records.

Competitive benefits package.

Pay will be commensurate with experience.

Mail to:

mfariba@uscircuit.com

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Career Opportunities



eptac

TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

Opportunities are available in Canada, New England, California, and Chicago. If you love teaching people, choosing the classes and times you want to work, and basically being your own boss, this may be the career for you. EPTAC Corporation is the leading provider of electronics training and IPC certification and we are looking for instructors that have a passion for working with people to develop their skills and knowledge. If you have a background in electronics manufacturing and enthusiasm for education, drop us a line or send us your resume. We would love to chat with you. Ability to travel required. IPC-7711/7721 or IPC-A-620 CIT certification a big plus.

Qualifications and skills

- A love of teaching and enthusiasm to help others learn
- Background in electronics manufacturing
- Soldering and/or electronics/cable assembly experience
- IPC certification a plus, but will certify the right candidate

Benefits

- Ability to operate from home. No required in-office schedule
- Flexible schedule. Control your own schedule
- IRA retirement matching contributions after one year of service
- Training and certifications provided and maintained by EPTAC

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SIEMENS

Siemens EDA Sr. Applications Engineer

Support consultative sales efforts at world's leading semiconductor and electronic equipment manufacturers. You will be responsible for securing EM Analysis & Simulation technical wins with the industry-leading HyperLynx Analysis product family as part of the Xpedition Enterprise design flow.

Will deliver technical presentations, conduct product demonstrations and benchmarks, and participate in the development of account sales strategies leading to market share gains.

- PCB design competency required
- BEE, MSEE preferred
- Prior experience with Signal Integrity, Power Integrity, EM & SPICE circuit analysis tools
- Experience with HyperLynx, Ansys, Keysight and/or Sigrity
- A minimum of 5 years' hands-on experience with EM Analysis & Simulation, printed circuit board design, engineering technology or similar field
- Moderate domestic travel required
- Possess passion to learn and perform at the cutting edge of technology
- Desire to broaden exposure to the business aspects of the technical design world
- Possess a demonstrated ability to build strong rapport and credibility with customer organizations while maintaining an internal network of contacts
- Enjoy contributing to the success of a phenomenal team

***Qualified applicants will not require employer-sponsored work authorization now or in the future for employment in the United States. Qualified Applicants must be legally authorized for employment in the United States.*

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Career Opportunities



Arlon EMD, located in Rancho Cucamonga, California, is currently interviewing candidates for open positions in:

- **Engineering**
- **Quality**
- **Various Manufacturing**

All interested candidates should contact Arlon's HR department at 909-987-9533 or email resumes to careers.ranch@arlonemd.com.

Arlon is a major manufacturer of specialty high-performance laminate and prepreg materials for use in a wide variety of printed circuit board applications. Arlon specializes in thermoset resin technology, including polyimide, high Tg multifunctional epoxy, and low loss thermoset laminate and prepreg systems. These resin systems are available on a variety of substrates, including woven glass and non-woven aramid. Typical applications for these materials include advanced commercial and military electronics such as avionics, semiconductor testing, heat sink bonding, High Density Interconnect (HDI) and microvia PCBs (i.e. in mobile communication products).

Our facility employs state of the art production equipment engineered to provide cost-effective and flexible manufacturing capacity allowing us to respond quickly to customer requirements while meeting the most stringent quality and tolerance demands. Our manufacturing site is ISO 9001: 2015 registered, and through rigorous quality control practices and commitment to continual improvement, we are dedicated to meeting and exceeding our customers' requirements.

For additional information please visit our website at www.arlonemd.com

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American Standard Circuits

Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

The CAD/CAM Engineer is responsible for reviewing customer supplied data and drawings, performing design rule checks and creation of manufacturing data, programs and tools required for the manufacture of PCB.

ESSENTIAL DUTIES AND RESPONSIBILITIES

- Import Customer data into various CAM systems.
- Perform design rule checks and edit data to comply with manufacturing guidelines.
- Create array configurations, route, and test programs, penalization and output data for production use.
- Work with process engineers to evaluate and provide strategy for advanced processing as needed.
- Itemize and correspond to design Issues with customers.
- Other duties as assigned

ORGANIZATIONAL RELATIONSHIP

Reports to the engineering manager. Coordinates activities with all departments, especially manufacturing.

QUALIFICATIONS

- A college degree or 5 years' experience is required. Good communication skills and the ability to work well with people is essential.
- Printed circuit board manufacturing knowledge
- Experience using Orbotech/Genflex CAM tooling software

PHYSICAL DEMANDS

Ability to communicate orally with management and other co-workers is crucial. Regular use of the phone and e-mail for communication is essential. Sitting for extended periods is common. Hearing and vision within normal ranges is helpful for normal conversations, to receive ordinary information and to prepare documents.

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Career Opportunities



APCT, Printed Circuit Board Solutions: Opportunities Await

APCT, a leading manufacturer of printed circuit boards, has experienced rapid growth over the past year and has multiple opportunities for highly skilled individuals looking to join a progressive and growing company. APCT is always eager to speak with professionals who understand the value of hard work, quality craftsmanship, and being part of a culture that not only serves the customer but one another.

APCT currently has opportunities in Santa Clara, CA; Orange County, CA; Anaheim, CA; Wallingford, CT; and Austin, TX. Positions available range from manufacturing to quality control, sales, and finance.

We invite you to read about APCT at APCT.com and encourage you to understand our core values of passion, commitment, and trust. If you can embrace these principles and what they entail, then you may be a great match to join our team! Peruse the opportunities by clicking the link below.

Thank you, and we look forward to hearing from you soon.

[apply now](#)



IPC Instructor Longmont, CO; Phoenix, AZ; U.S.-based remote

*Independent contractor,
possible full-time employment*

Job Description

This position is responsible for delivering effective electronics manufacturing training, including IPC Certification, to students from the electronics manufacturing industry. IPC instructors primarily train and certify operators, inspectors, engineers, and other trainers to one of six IPC Certification Programs: IPC-A-600, IPC-A-610, IPC/WHMA-A-620, IPC J-STD-001, IPC 7711/7721, and IPC-6012.

IPC instructors will conduct training at one of our public training centers or will travel directly to the customer's facility. A candidate's close proximity to Longmont, CO, or Phoenix, AZ, is a plus. Several IPC Certification Courses can be taught remotely and require no travel.

Qualifications

Candidates must have a minimum of five years of electronics manufacturing experience. This experience can include printed circuit board fabrication, circuit board assembly, and/or wire and cable harness assembly. Soldering experience of through-hole and/or surface-mount components is highly preferred.

Candidate must have IPC training experience, either currently or in the past. A current and valid certified IPC trainer certificate holder is highly preferred.

Applicants must have the ability to work with little to no supervision and make appropriate and professional decisions.

Send resumes to Sharon Montana-Beard at sharonm@blackfox.com.

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MEETINGS
& COURSES

Jan. 21-26

CONFERENCE
& EXHIBITION

Jan. 24-26

SAN DIEGO CONVENTION CENTER | CA

ADVANCE IN A NEW ERA

technology

cyber security

automation

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packaging

Factory of the Future

networking

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innovation

transformation

Advance in a new era of electronics manufacturing at IPC APEX EXPO 2023. Hear from the best minds in the industry, discover what is new and next, and collaborate with your peers at North America's largest gathering of electronics manufacturing professionals.

See you next year in San Diego at IPC APEX EXPO 2023.

IPC APEX EXPO . ORG

#IPC APEX EXPO

THANK YOU TO OUR SPONSORS, EXHIBITORS, SPEAKERS AND ATTENDEES
FOR MAKING 2022 A SUCCESS!

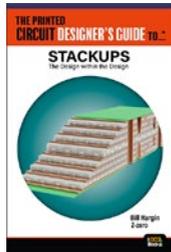
Latest I-007eBooks



The Printed Circuit Designer's Guide to... High Performance Materials

by Michael Gay, Isola

This book provides the reader with a clearer picture of what to know when selecting which material is most desirable for their upcoming products and a solid base for making material selection decisions. [Get your copy now!](#)



The Printed Circuit Designer's Guide to... Stackups: The Design within the Design

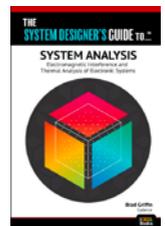
by Bill Hargin, Z-zero

Finally, a book about stackups! From material selection and understanding laminate data-sheets, to impedance planning, glass weave skew and rigid-flex materials, topic expert Bill Hargin has written a unique book on PCB stackups. [Get yours now!](#)

The Systems Designer's Guide to ... System Analysis

by Brad Griffin, Cadence

In this book, the author, Brad Griffin of Cadence, focuses on EM and thermal analysis in the context of data center electronics systems. Be sure to also [download the companion guide](#) for end-to-end solutions to today's design challenges.



I-007eBooks The Printed Circuit Designer's Guide to...



Thermal Management: A Fabricator's Perspective

by Anaya Vardya, American Standard Circuits

Beat the heat in your designs through thermal management design processes. This book serves as a desk reference on the most current techniques and methods from a PCB fabricator's perspective.



Thermal Management with Insulated Metal Substrates

by Didier Mauve and Ian Mayoh, Ventec International Group

Considering thermal issues in the earliest stages of the design process is critical. This book highlights the need to dissipate heat from electronic devices.



Flex and Rigid-Flex Fundamentals

by Anaya Vardya and David Lackey, American Standard Circuits

Flexible circuits are rapidly becoming a preferred interconnection technology for electronic products. By their intrinsic nature, FPCBs require a good deal more understanding and planning than their rigid PCB counterparts to be assured of first-pass success.

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