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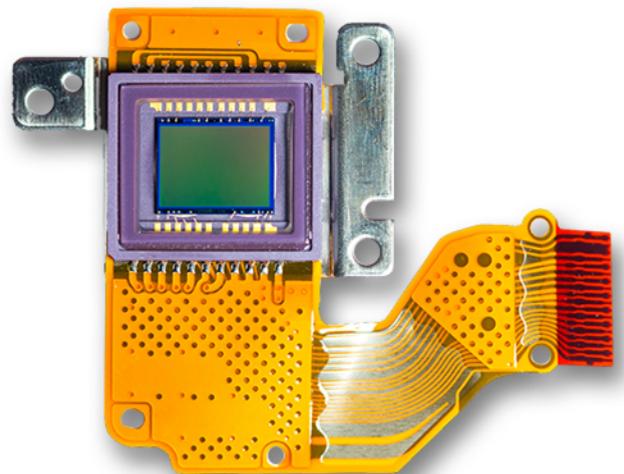
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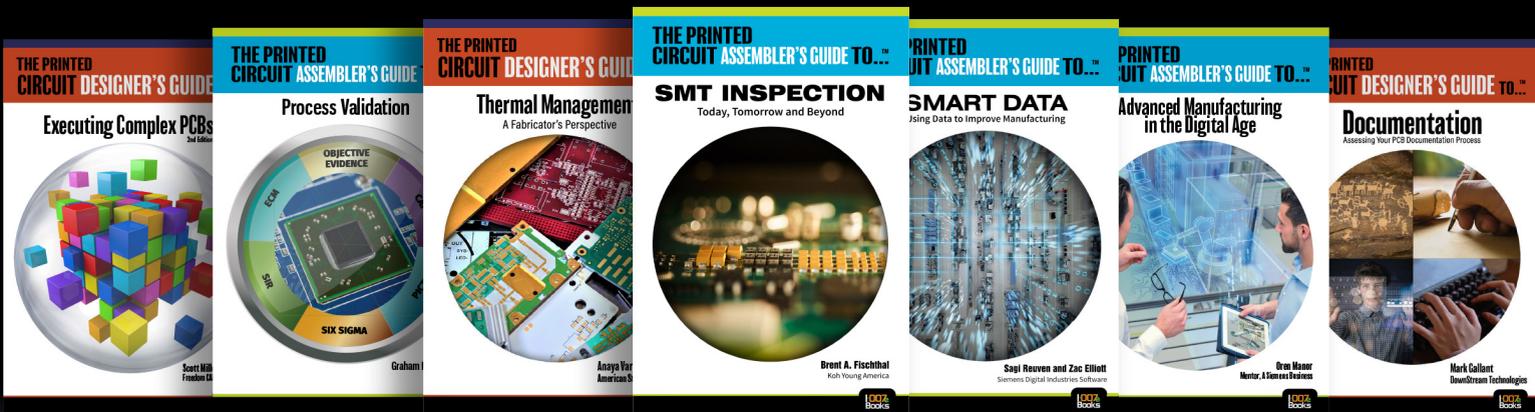
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Operational Excellence

In this issue, we share strategies and techniques for optimizing your manufacturing process, from the business plan to implementation throughout your entire business flow. This includes strategies for training your team, and working with your suppliers and customers. We also explore the value in understanding your company's "greater purpose."

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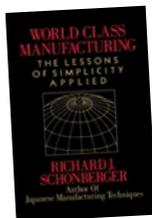
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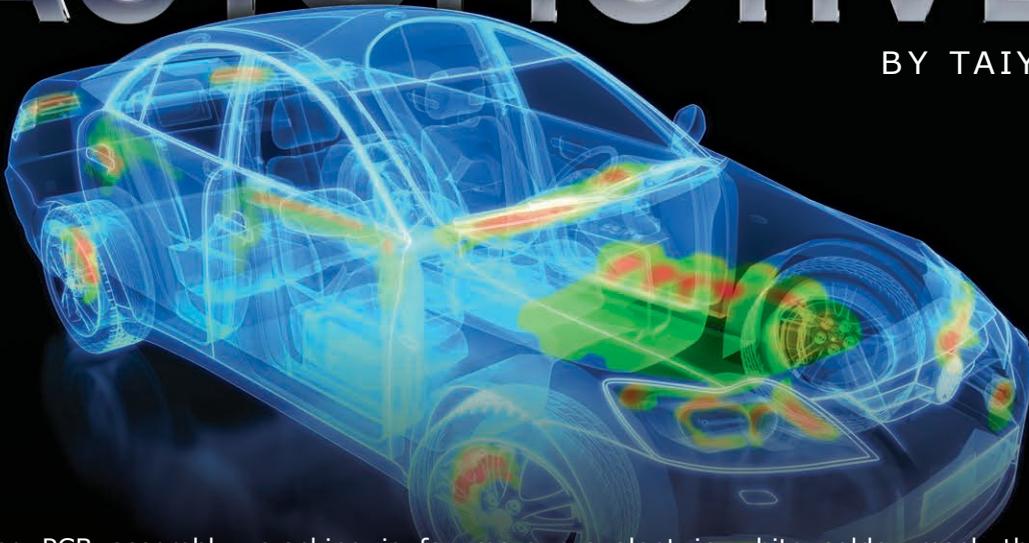
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AUTOMOTIVE

BY TAIYO



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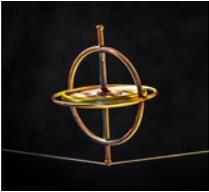
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Operational Excellence

Nolan's Notes

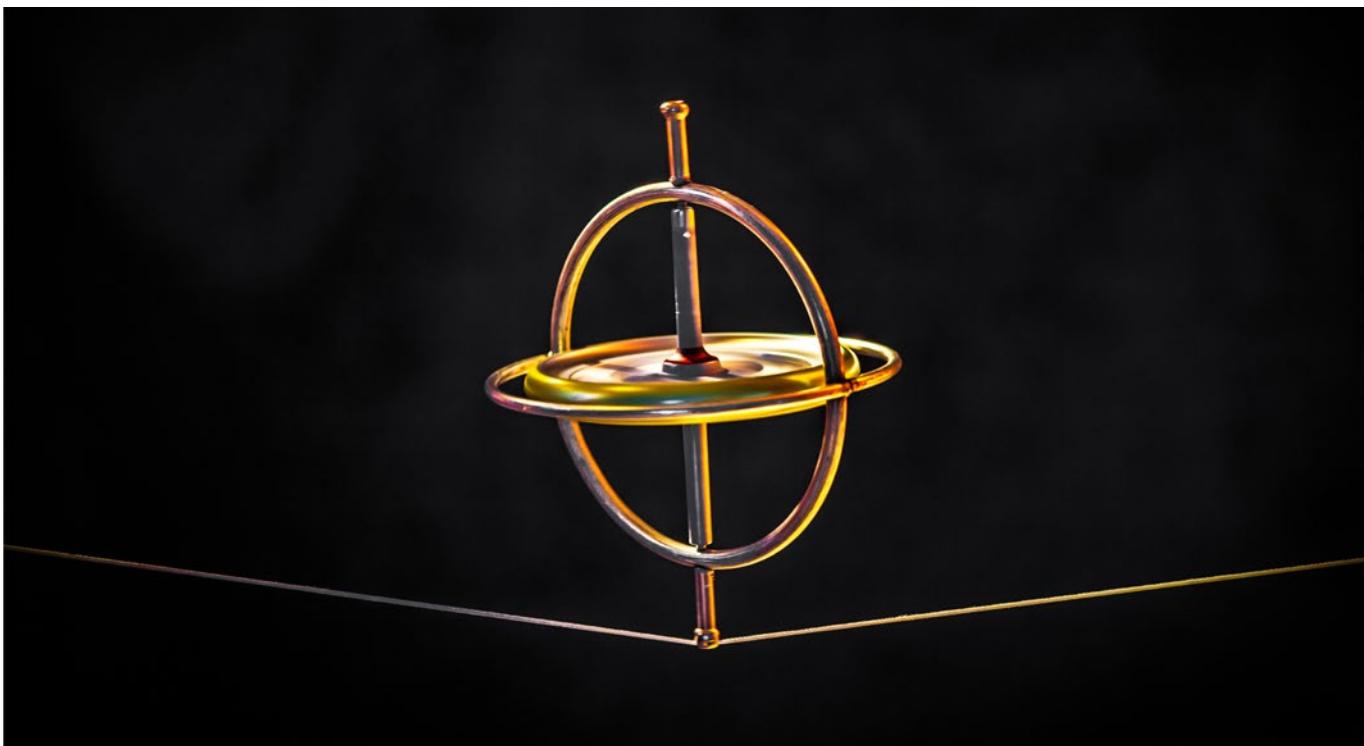
by Nolan Johnson, I-CONNECT007

If you have read my column before, you may have caught me sharing stories about my Mini Cooper, Junebug. She's a 2009 model and has served me well for 12 years and just over 150,000 miles. Junebug's role is changing to now serve as the commuter car for my college-aged daughter. And, at this point in Junebug's life, keeping her running safely and well means regular maintenance and repair.

Last month, Junebug needed some routine work—some wires had broken in a wiring harness and a couple of sensors needed replacing. To my chagrin, my regular shop kept Junebug for 28 days to complete the work. Yes, you

read that right: four full weeks! The work that needed to be done was not challenging, it's just that my mechanic is buried in work. It's a good problem to have, but frustrating for his customers. He has already expanded from his original shop into the building next door; he can't get any bigger without relocating. So how does he possibly increase his capacity? This is why the best bet is to constantly re-examine his processes and his "product flow," which in this case is cars through the bays. Trouble is, I don't think the mechanic thinks in that way.

Junebug is fixed and running like a top again. We really didn't need the Mini back during



that interval, so it wasn't an inconvenience to me this time. There have been other times in my life where that would have been 27.5 days too long. In the future, I'll be switching to another mechanic I know who already has created a more systematic approach to his workload. He's not as convenient geographically, and he's more expensive, but he would have finished the work in a half-day, giving me back 27 more days on the road.

And that is what continuous improvement is all about: increasing capacity, quality, customer satisfaction, your margins, and your profit.

Here, somewhere near the middle of the year, it's worth taking a step back to see what we've learned so far.

This year in *SMT007 Magazine*, we have discussed:

- Continuous improvement overview
- Five keys to smart process success
- Key technical and management topics for process improvement from IPC APEX EXPO
- Process engineering
- Control theory
- Smart processes
- Continuous improvement in your supply chain
- Key traits for a supply chain manager

The *Design007 Magazine* readers have explored the following ways to reduce iterations:

- Reducing re-spins by one
- The journey to a single-spin PCB
- There's no excuse for bad DFM practices
- Design teams must own the stackup
- Stackup planning
- Best practices for footprint design and CAD library management
- Managing footprints with integrated EDA tools
- Using simulation to assist with PCB design
- Simulation stackup and signal integrity

And, of course, here in *PCB007 Magazine*, we have reported on:

- Smart processes in fabrication
- Getting Lean
- Materials-pricing drivers
- Continuous improvement and technical topics from IPC APEX EXPO
- Process survivability and reliability
- E-mobility requirements
- Process benchmarking
- Reinvigorating your manufacturing infrastructure

That makes for quite a lot of valuable food for thought in continuous improvement and optimization. At this point in our industry's history, the value of process optimization and continuous improvement cannot be overstressed. Like my mechanic, whose business is buried in opportunity and thereby throttled by his ineffective processes, we're all finding more work than ever before in our pipelines; continuous improvement becomes so much more important now. Constant attention to our process efficiencies is critical, lest we end up like my poor mechanic.

Naturally, many of these topics are more widely applicable than just with the readers of the magazine in which they appeared. We encourage you to pop over to magazine titles you may not normally read and dive into some of the information there. Cross-pollinate your ideas a little.

And share with us your personal experiences with continuous improvement! Your stories and techniques are of value to the rest of us in the industry. Talk to us about your experiences. Help us continue to improve the content we deliver on this topic for the second half of the year. **PCB007**



Nolan Johnson is managing editor of *PCB007 Magazine*. Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing. To contact Johnson, [click here](#).

New Thought Leaders Program Brings Industry Insight

One World, One Industry

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

As the electronics industry undergoes dramatic change, it is essential for IPC to obtain advice and counsel from experts throughout the industry that help us navigate these changes. To this end, IPC created the Thought Leaders Program (TLP), a select group of experts who will generate ideas and insights in five areas:

- Education and workforce
- Technology and innovation
- The economy
- Key markets
- Environment, health, and safety

These experts will assist IPC on key issues, offering valuable insights to IPC members and key external stakeholders. The knowledge gained from Thought Leaders will allow IPC to be aware of a range of change drivers and how they are interconnected.

IPC will leverage these experts' insights to lead and influence change that will benefit members and the larger worldwide electronics industry.

The Thought Leaders' responsibilities will include providing publishable material in their subject areas, flagging opportunities for IPC engagement, and participating in quarterly roundtable discussions. Each expert is expected to fulfill at least one 12-month term, during which quarterly contributions will be expected.

One of the program's first projects will be a report on the U.S. Defense Department's Cybersecurity Maturity Model Certification (CMMC), an ambitious effort to better protect the cybersecurity of the defense industrial base. The electronics industry supports this initiative but has concerns about its ongoing implementation.



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IPC's Thought Leaders Program will be chaired by Mike Carano, VP of technology and business development at RBP Chemical Technology and a member of IPC's Hall of Fame. He will lead a diverse group of individuals, namely:

- Olivier Coulon, consultant, Decision Etudes & Conseil
- Payman Dehghanian, assistant professor of electrical and computer engineering, The George Washington University
- Bryan Erwin, managing partner, BlueWave Merchant Partners
- Denny Fritz, consultant
- Savita Ganjigatti, VP of Engineering, Sienna ECAD Technologies
- Carol Handwerker, professor of materials engineering, Purdue University
- Matt Holzmann, president, CGI Americas
- Meredith LaBeau, director of process engineering, Calumet Electronics

- Joe O'Neil, CEO, Green Circuits
- Leslie Weinstein, founder/CEO, CMMC Consulting

Follow this [link](#) for an IPC staff interview with Mike Carano, who provides an overview of the TLP program, how it supports industry's migration to factory of the future, and plans for the future projects.

More information about the IPC Thought Leaders Program, including a dedicated webpage, will be available soon. Please direct any questions regarding the program to Chris Mitchell, IPC vice president of global government relations at ChrisMitchell@ipc.org. **PCB007**



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

Thin, Large-area Device Converts Infrared Light into Images

Seeing through smog and fog. Mapping out a person's blood vessels while monitoring heart rate at the same time—without touching the person's skin. Seeing through silicon wafers to inspect the quality and composition of electronic boards. These are just some of the capabilities of a new infrared imager developed by a team of researchers led by electrical engineers at the University of California San Diego.

The imager detects a part of the infrared spectrum called shortwave infrared light (wavelengths from 1000 to 1400 nanometers), which is right outside of the visible spectrum (400 to 700 nanometers). Shortwave infrared imaging is not to be confused with thermal imaging, which detects much longer infrared wavelengths given off by the body.

The imager works by shining shortwave infrared light on an object or area of interest, and then converting the low energy infrared light that's

reflected back to the device into shorter, higher-energy wavelengths that the human eye can see.

"It makes invisible light visible," said Tina Ng, a professor of electrical and computer engineering at the UC San Diego Jacobs School of Engineering.

While infrared imaging technology has been around for decades, most systems are expensive, bulky and complex, often requiring a separate camera and display. They are also typically made using inorganic semiconductors, which are costly, rigid and consist of toxic elements such as arsenic and lead.

The infrared imager that Ng's team developed overcomes these issues. It combines the sensors and the display into one thin device, making it compact and simple. It is built using organic semiconductors, so it is low cost, flexible and safe to use in biomedical applications. It also provides better image resolution than some of its inorganic counterparts.

(Source: UC San Diego)

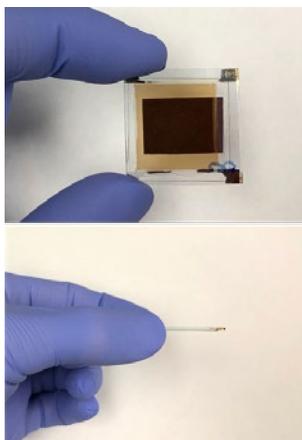
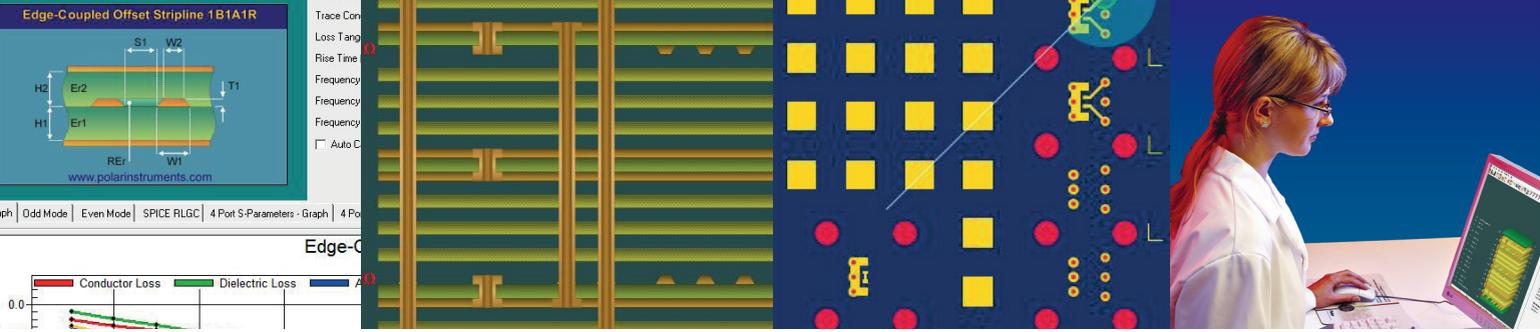


Photo credit: Ning Li

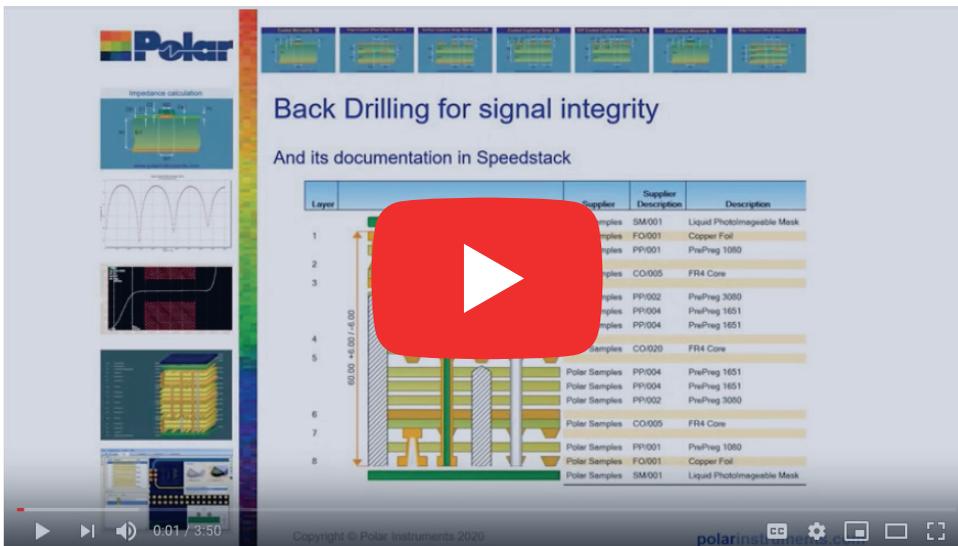


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Defining Operational Excellence



Feature Interview by Nolan Johnson
I-CONNECT007

Nolan Johnson talks with Todd Brassard, VP/COO at Calumet Electronics. They start by discussing the definition of operational excellence, followed by its key components. Then Todd shares a helpful book and AS standard that have become the foundation for Calumet's operational excellence.

Nolan Johnson: Todd, how do you become operationally excellent?

Todd Brassard: Before a company can define how to become operationally excellent, they must define what operational excellence means to them.

Johnson: There's the reaction response which suggests that it's maximizing gross margin, right?

Brassard: Undoubtedly. A mentor once told me, "A company must make enough money to pay the bills today and have enough left over

to invest in the future." We have learned that operational excellence is a journey much more than an end unto itself.

Johnson: How has Calumet's operational excellence evolved over time?

Brassard: I was a contractor for Calumet for five years before joining the company. I remember the telecoms boom when there was so much work the halls were lined with A-frames. I also remember the telecoms crash which I now know cut the company's business by 60% over a very short 18 months. Then offshoring took hold in the U.S. and operational excellence meant just keeping the doors open.

Between 2003 and 2013, Calumet's CEO Steve Vairo pulled off the seemingly impossible by keeping the company alive, growing, and investing while the PCB industry in the United States contracted by 80%. At this point, operational excellence was defined by the company's ability to keep investing in the future while the U.S. industry continued to wither. Over this period, Steve continued to build and refine Calumet's equipment set, improving capa-

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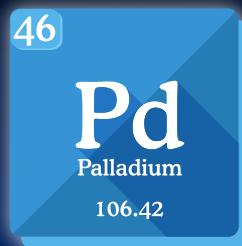
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Todd Brassard

bility and capacity, which would prove to yield dividends in later years as things picked up.

In 2013, with continued uncertainty about the future of the domestic electronics industry, Steve led a deep dive into better understanding the U.S. market, where Calumet fit in that market and where the company needed to go, and how to organize the company to tap into the talent and skills of people to meet upcoming challenges.

At this point, I was given the opportunity to serve the company as its chief operating officer. The company also created new positions and made strategic hires, bringing on Mike Kadlec as VP of corporate development, Dr. Meredith LaBeau as director of process engineering, and Heather Store as director of human resources. We also contracted with the Upper Peninsula Marketing Department, which has been instrumental in everything from market analysis to rebranding the company, from political advocacy to improving the look and functionality of our hallways.

The goal at this time was straight forward—Calumet had to become very good at the work that was safe from offshoring and not going to leave the country.

The period from 2013 to 2018 was all about discovering and defining operational excel-

lence. We learned and continue to learn about what it means to have a company that is engaging in the right activities to move the company forward, albeit slowly, over time. One of the most important lessons we learned is that, in addition to an excellent equipment set, a company needs excellent people. We say, “The right people, in the right seats, doing the right activities.” Much of our focus since 2013 has been building and developing teams of people that are engaged, skilled, and passionate about success and moving the company forward.

Johnson: What are some of the factors that contribute to operational excellence?

Brassard: Do not underestimate the power of reducing strategic thinking to writing. It’s easy to believe that having strategy in your head is the same as having strategy on paper; it’s not, because people cannot read minds. The process of writing a strategic plan helps to crystalize thoughts and organize ideas into executable activities. The process can be time-consuming and frustrating but also clarifying and rewarding. Most importantly, a well-written strategic plan can be disseminated within an organization and to field partners, suppliers, and even customers.

Having everyone within the company on the same page is a powerful driver of forward progress. Without a clearly communicated strategic plan it’s difficult for the teams within a company to differentiate between important tasks and activities vs. distractions and noise that will not advance the position of the company. You must get the plan out of the mind, onto paper, and communicated within the organization. A well-understood corporate strategy enables operational excellence by aligning people, reducing overhead, speeding up activities, and eliminating feedback cycles. With everyone working to the same script, a CEO knows that everyone is mostly working on the right tasks and employees do not necessarily have to run to their bosses asking what to work on or if they are engaged in the right activities.

For example, Calumet generates around 40 quotes and ships about 60 orders per day. With clear objectives and strategy, the sales team can work to shape business slowly over time to better position the company for the future. Also, within this flow of transactional business are gems of opportunity that our sales associates must be able to identify, respond to, or re-direct to specialists within the company. Our strategic plan communicates the industry sectors where the company seeks to grow through clearly defined objectives, strategies, and tactics. This enables our sales associates to use their talent, skills, and experience to great effect to identify important opportunities and take the right actions, because they clearly understand the company's goals and strategies.

Once a company has a written strategic plan it can more easily and safely secure or develop resources with confidence because the plan is steadfast and resilient against tempting but off-mission distractions. Resources take many forms: from human talent to capital equipment to political advocacy or tapping into your local high school's robotics program.

Over the prior decade Calumet has made significant strides with capability and capacity. For example, over the past eight years, Calumet has grown from having four process engineers to having a department of 15 process engineers and technicians. This growth of technical talent didn't happen overnight but was a result of our strategy to rapidly increase Calumet's capability to meet the needs of that part of the domestic circuit board industry that was less likely to be offshored. But it wasn't until we reduced our strategy to writing that the tactic of developing a dedicated R&D/product realization team was identified as an imperative to take on the most challenging engineering and manufacturing projects and product types. Simultaneously, our written plan identified and solidified the importance of developing more and deeper relationships with our customers, especially those seeking to partner with manufacturers in early design stages of very com-

plex technologies, all within the context of establishing long term agreements to improve the visibility and resiliency of future revenues.

Johnson: I'm hearing that it starts with knowing where you want to go.

Brassard: Even before knowing where you want to go, you need to understand why you're in business. Before we defined company objectives, strategies, and tactics, we dedicated a page to listing what is important to our business. We later titled the section, "What's Important and Desired Outcomes," understanding that these two categories were similar but not exactly the same thing. The former made statements about growth and sustainability where the latter addressed topics like the importance of the company having a positive impact on the surrounding community. Once we identified what was important to the company and what outcomes were desired from our efforts, we established just seven top-level corporate objectives. We kept the list short knowing we had limited resources and that we must focus on what was most important, but also understanding that we could change the objectives later.

Johnson: So, the idea is to know what it is you want to do. And that starts with defining your purpose, your mission?

Brassard: This seems obvious, but in the daily hustle of keeping your customers happy, it's easy to drift off mission or lose focus on the big picture. Understanding what's important, where you fit in the market, where you are strong, where you are weak, and who are your stakeholders are important considerations at any point in the journey of a small business. Your list of stakeholders likely goes beyond the owners, employees, and customers extending to your suppliers, local contractors, the high school down the road, and the person who plows your parking lots in the winter.

What's interesting is that the latest Revision D of the AS9100 standard now identifies risks associated with the lack of a sound business plan or contextual awareness of where a business fits into the industry, supply chain, and even local community. The new standard requires companies to define the context of the organization, identify outside factors that cannot be controlled, inside factors that may or may not be controllable, and identify the interested parties or stakeholders in how the company operates. Because Calumet had a written plan that addressed these topics, the company passed the first Revision D audit with relative ease and zero nonconformances.

Johnson: So, it all starts with a very clear vision of who you are, what you stand for, what you're trying to accomplish. Still, it seems like it's too early for implementation. It sounds like it's time for making plans.

Brassard: You do eventually get to the point where you have identified what's important and high-level company objectives. Time to implement, right? If writing a strategic plan was a challenging undertaking, implementing that plan can feel nearly impossible.

If writing a strategic plan was a challenging undertaking, implementing that plan can feel nearly impossible.

Inside companies we find many different leadership styles. Two of the styles I'd like to talk about can loosely be lumped into the categories of intuitive and methodical. The intuitive leaders demonstrate a knack for perceiving opportunities and finding pathways forward, provided they have a clear understand-

ing of the company goals and access to the most current information. The methodical leaders succeed by breaking down the high-level objectives into increasingly granular executable tasks that can be delegated within an organization. Where the intuitive is satisfied when they sense forward progress and that things are going well, the meticulous want S.M.A.R.T. goals, quantitative measures of progress, periodic reporting, and course adjustments. Of course, it's not this black and white, with many people occupying the space between these extremes. Hopefully, your organization allows for the full spectrum.

When Calumet set out to reduce its strategic plan to writing, one of the first steps was to get the intuitive ideas on the whiteboard then methodically work the ideas until a hierarchical expression of objectives, strategies, and tactics emerged. The objectives were derived from what's important, strategies were formulated to meet objectives, and tactics were developed to implement the strategies. Every level of the plan was intentionally brief, often only one or two sentences, and even vague, providing guidance but leaving a significant amount of latitude for people within the company to use their talent, skills, and insights to implement the activities as they see fit. Where the intuitive leaders felt great about having the plan out of the heads of leadership and onto paper, the methodical leaders would go on to develop methods to track and measure progress to ensure the company was in fact moving forward.

Johnson: That's interesting. So, your team is comprised of both styles: the meticulous, methodical; and the more artistic, intuitive styles. And you're having success working with both. Can we compare and contrast this a little bit?

Brassard: The intuitive leader is likely experiencing a good flow of information and is exposed to what is happening in the industry, monitoring changes in demand, reading news, monitoring geopolitical developments, under-



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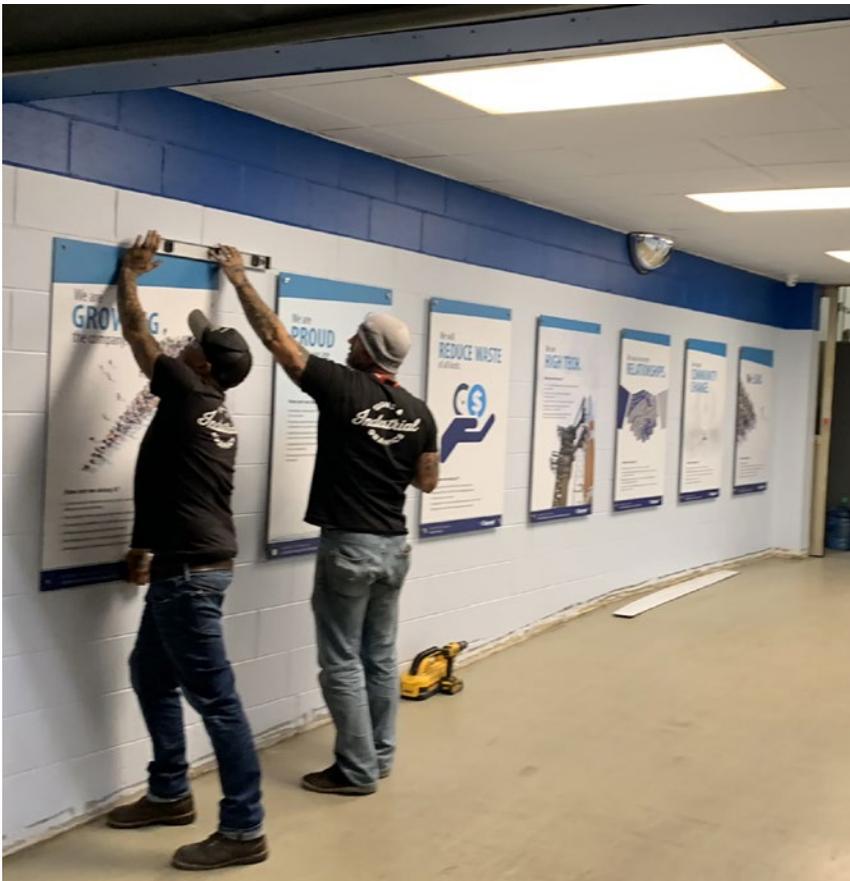
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Improving operational excellence at Calumet Electronics meant defining “What’s Important and Desired Outcomes,” and then communicating that to the entire workforce.

standing what the company is capable of accomplishing, and just processing everything, connecting dots, and drawing conclusions.

A more intuitive mind may comment, “Here’s a clear problem our customers or the industry is facing. Without too large of a commitment, we could build this product solving a problem and generate healthy revenue and margin from the endeavor. Let’s do it!”

The methodical thinkers would respond, “So you think we should get into this product type, eh? Well, let’s start with a market analysis. Where’s the data to support the idea? What’s the ROI and is this a new revenue swim lane or something close to what we are already doing?” Methodical thinkers can be sold on and even enhance intuitive reasoning, but they want a little more data and analysis to be comfortable before adding additional burden or distractions to the company.

The different thinking styles can easily be in conflict. Intuitive leaders want to push forward, knowing they are right, and needing little objective evidence, at least in the short term. And a good intuitive leader is often right. Nevertheless, to be a successful organization one must be able to more objectively measure progress since everything eventually impacts the bottom line.

Over the timeframe of months and years a balance of intuitive and methodical leadership naturally forms. After all, our strategic plan calls for significant continual improvement in on-going operations while simultaneously asking the company to make leaps forward into new relationships and product types. We find ourselves on this teeter totter, slowly oscillating where we deep-dive operations issues for a time

then we focus on capturing future opportunities for a time. I think this is natural for a business, responding to problems and opportunities as they arise. We continue to make measurable progress because everyone is working from the same strategic playbook.

Johnson: You were implying that you’ve got some projects where you tracked the metrics very closely and you were successful. But you also have some projects where you didn’t track the data for three months or so and then as you came back, you got to see the progress over a period of time, and it was successful. My guess is a lot of organizations are going to lean strongly one way or the other and tend to be much more of an intuitive development team or a metrics driven development team, depending upon company culture. It’s interesting to find you’ve got both.

What drives this? Does this seem to be something where you fall into one method or the other based on the kind of technology or the objective you're after? Is this a personal style based on who's in charge? How do you get to the different styles within your organization?

Brassard: I agree that it seems to be personality driven and influenced by the type of work being done. It's important to understand that just because an intuitive personality might be less concerned with having the strategy written down, they do indeed have the strategy in their heads; it's just not easily communicated to others who have less experience or are new to the journey. Diving into new technologies also requires a balance of initiative and methodical thinking to make bold but careful and in-control decisions.

What was transformative for our organization was taking the intuitive knowledge of leadership and reducing it to paper. The impetus for the undertaking stemmed from the work we were doing to improve culture at the company to improve our career paths and opportunities for our employees. We felt it was important that the strategic plan get out of the boardroom and into daily operations. We needed everyone to be on the same page for the company to move faster.

If you have a plan and don't communicate it effectively within your company, you're not only doing your employees a disservice, but you are doing your business a disservice as well. Everyone within an organization needs to know the plan, at least in a general but meaningful sense. What's more is the plan must be communicated in a fashion that people can get their heads around. In the last five years, we've made a number of strategic hires based on the individual's interest and capability with S.M.A.R.T. goals in mind. As we have worked toward operational excellence at Calumet, our interest in metrics and measures has increased significantly. What are the right metrics and how can they be kept simple and actionable?

We literally have developed hundreds of metrics over the past decade; now we are trying to reduce the reports to just what matters most and avoid analysis paralysis.

Johnson: When we talk operational excellence, we start to think about the efficiencies on the manufacturing floor, our overall ability to deliver great yield, to deliver quality product that won't fail in the field, to be able to work well with your customers, to make sure that they receive those sorts of benefits. Those are the systemic things that one thinks of right away when looking at operational excellence. So far, to get there, we've been discussing concepts that are more intuitive.

One of the most significant discoveries that we have made on our journey to get better are the principles of world class manufacturing.

Brassard: One of the most significant discoveries that we have made on our journey to get better are the principles of world class manufacturing. We were first introduced to world class manufacturing at a customer supplier conference. It's very easy to be dismissive when somebody hands you the next book to read, but we did eventually read the book and it began to change how we approached operations, especially on our manufacturing floor. Some of the ideas in the book were completely counterintuitive and we discovered we were doing a few things exactly wrong.

I see world class manufacturing as a superset of lean manufacturing where the focus is more about reducing waste than improving efficiency, although many will argue it's the same thing. For example, we used to believe a machine on our manufacturing floor was only making

money when it was running. Strict adherence to this simple axiom would have you running your machines at maximum throughput all the time, creating all kinds of problems. Instead, we've learned that a machine should only run when it needs to, and not a minute more. This seems a minor change in thinking but applied to 90 processes on a 100,000 square foot manufacturing floor, this minor difference changes how you operate. In this case, keeping the WIP (work-in-progress) on the floor low, resulted in improved yields, shorter feedback loops, less stress for employees, and most importantly shorter cycle-times.

An important indicator of a successful business is cycle time: the amount of time it takes between receiving an order and shipping an order.

An important indicator of a successful business is cycle time: the amount of time it takes between receiving an order and shipping an order. Cycle time is equal to backlog divided by throughput. For example, if you have 14,400 panels on your manufacturing floor at any given time and you complete 720 panels per day, your cycle time is 20 days. By reducing your WIP by 20% or 2,880 panels on the floor, your cycle time just dropped to 16 days. Now you're shipping everything four days earlier than before, giving your company a competitive edge in the marketplace. The ability to maintain a low cycle time is now a standard measure of operational excellence at Calumet because everything must go right to maintain a low cycle time, from employee time and attendance to preventative maintenance on manufacturing equipment.

Johnson: And to that end you made the sacrifice on idle time? You're willing to have more idle time if necessary?

Brassard: That's right. Since the machines in a multi-step process run at different speeds, it makes little sense to run any machine faster than the slowest machine in that process. Doing so would just cause a pile-up of panels, increasing WIP, and increasing cycle time. You need to go slow to go fast when cycle time is the measure of performance. The goal is to reduce WIP as much as possible, with the best possible configuration being conveyORIZED single unit flow, reducing cycle times from weeks to days and days to hours.

Traditional lines of thinking would have you hire an employee per machine, but this only feeds into the idea that all machines must be running all the time. The world class manufacturing approach is to organize areas into "responsibility centers," where a team of employees is responsible for a set of machines for a process. The team runs the right machines at the right time and keeps WIP low and throughput high, yielding a minimal cycle time for that process. Line enough processes up that are each minimizing their cycle time and your factory is minimizing overall cycle time. Also, processes organized in this way tend to require fewer employees and are more resilient to employee absences since people can move around to fill gaps and go where help is needed.

I mentioned this is counterintuitive. Typically, it's the buildup of WIP in a department that creates a sense of urgency that pushes people to work faster and make mistakes. But with responsibility centers, the lack of WIP reduces pressure caused by pile-ups of work, eliminates the time to find the next job, minimizes unnecessary handling, speeds up quality feedback loops, and improves yields. We have, however, found there is such a thing as too lean or too little WIP where a department runs out of work all together. In this case, employees need to go to another department that

needs help. This interdepartmental cross training is a higher order of the responsibility centers concept and is something we are continually working on at Calumet.

The book we are working from is titled *World Class Manufacturing, The Lessons of Simplicity Applied*, authored by Richard J. Schonberger and published in 1986.

When I first received the book, I stuffed it in my bag for the trip home, never opening it. About a year later when the customer started talking about “Chapter 9: Partners in Profit,” I became more interested, but still did not read the book cover to cover. We visited the customer, and I spent a lot of time over three days explaining to them how these concepts couldn’t apply to a PCB manufacturer. On the flight home I finally cracked the book and was horrified to discover on Page 5, “A machine shop, a sheet metal shop, a printed circuit board shop, any shop or factory that makes to order is just the same.” The book apparently did apply to a PCB manufacturer. What an embarrassing display I put on with the customer.

Johnson: Right there? Explicitly?

Brassard: Yep. And I circled it in pen, thinking, “I just spent three days telling our customer the book doesn’t apply to a circuit board shop.” When I arrived at home, I sent an email immediately apologizing for my naivety, because never at any point during the visit did the customer call me out on the fact that I didn’t know what I was talking about. In response they said, “Todd, this book will make you feel like an idiot and a genius all at the same time, but it’s a tough read and it takes a while to see how to apply the knowledge to your own business.”

And it is a tough read: dry, like reading the

owner’s manual for your dishwasher. But if you have problems that need solving, there are answers. Chapters 1, 2, and 6 contain enough to keep you busy for a year. Starting with simple whiteboards to facilitate communication, identifying problems at the spot where they occur, seeing trends with hand drawn Pareto charts, red lights where everyone comes running to solve a problem quickly, and responsibility centers as I discussed earlier.

Johnson: Does this extend beyond the factory floor?



Brassard: The principles of world class manufacturing can apply to many aspects of business—anywhere work in process can accumulate resulting in wasted time or energy. At this point, we have our hands full learning and implementing the concepts on our manufacturing floor.

Johnson: Obviously, Calumet is finding a lot of benefit in pursuing operational excellence. Not only are you run-

ning more efficiently, but you’re also creating career paths. And you have sales opportunities and new markets that weren’t available to you before.

Brassard: As operations improves, a company is better prepared to take on new opportunities and grow. As the products you build become more complex, success requires a greater degree of operational excellence. We are fortunate to have arrived at what we feel is a solid strategic plan, that we are making progress in offering our employees more career opportunities, and that we are learning the ways of world class manufacturing. These initiatives give Calumet a fighting chance to pay the bills today and invest in the future. They are en-

abling us to take on challenging designs, access new markets, and develop customers who will continue to source their electronics domestically.

The United States will never take back the bulk of the work that has moved to Asia over the past 20–30 years; that ship has sailed. Domestic manufacturers must look and plan for the future. The work that will remain in the U.S. will be challenging as OEMs strive to build the most advanced electronics systems domestically. Our plan is to pivot, build partnerships, and offer the most advanced design, layout, engineering, and manufacturing solutions to ensure the company is sustainable for the next 50 years.

Our plan is to pivot, build partnerships, and offer the most advanced design, layout, engineering, and manufacturing solutions to ensure the company is sustainable for the next 50 years.

Johnson: And if you take something and treat it as an obvious given, and you don't include it in your plans and your analysis for operational excellence, you miss it.

Brassard: There is little room for complacency for domestic electronics manufacturers. The United States is out-classed by some offshore manufacturers in virtually every performance metric that matters. The viability of low-cost supply chains has been proven over the last three decades as U.S. industries have all but collapsed. The aggressive measures employed in certain overseas locations to gain technolog-

ical advantage is causing some OEMs to contemplate security concerns with offshore manufacturing, but the marketplace is too massive to ignore and a strong incentive for U.S. OEMs to not work against those interests. If manufacturing circuit boards in America was ever about just keeping your head down and doing the work, to be successful in the modern age requires a plan.

Fortunately, U.S. manufacturers have not given up on U.S. manufacturing. Within the U.S. electronics supply chain are companies that are pivoting, standing up new products and services, and developing technologies that will enable state-of-the-art manufacturing that keeps up with the best Asia has to offer. We see this today like never in the past as these companies are striving and obtaining their own level of operational excellence. We are also seeing new associations, organizations, and working groups forming to take on the challenges that are holding electronics manufacturing back from achieving greatness.

Our journey to achieve operational excellence is far from over. On the contrary we feel we are just scratching the surface in beoming the company we could be when we achieve excellence in our on-going endeavors. We know that a written strategic plan that can be shared with everyone within your company is a big step in the right direction, that diverse leadership styles are necessary to find the path forward and ensure that you're staying on track, that the sometimes-counter-intuitive principles of world class manufacturing provide solutions to real-world problems, and that operational excellence is strived toward but never truly obtained. It's a journey not a destination.

Johnson: This has been a great conversation! Thank you.

Brassard: Thank you for the opportunity to share a few thoughts. **PCB007**

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GreenSource Fabrication on Industry 4.0: A Roundtable Discussion

This roundtable discussion with Alex Stepinski, Robert Zajac, and Lukasz Stepień of GreenSource Fabrication and AWP Group focuses on the development of their new factory software and the collaborative work they've done with SEL and Vicor to help implement captive PCB facilities.

Barry Matties: People look at a smart factory and they see a huge investment. We realized that many people aren't going to do that, and that started us talking about smart processes: take a small bite out of one of your most challenging (or your easiest) processes and bringing some 4.0 data into it. I'd like to talk about smart processes and working as a smart factory, because, ultimately, if you start with one process and move to the next, then over time your factory will evolve into a smart factory. People need to feel the success before they take the final plunge if you will.

Robert Zajac: Actually, this is in line with our typical implementation. One of the key benefits of rolling out in Industry 4.0 style is that you have the feature of capability; it's seamless,

so you don't encounter too many penalties as you implement piece by piece, and in this case, typically you start with a designated work cell where you have the biggest interest. Where it becomes apparent is during the installation and testing. There might be multiple items and features that are missing from the initial concept, so it is beneficial for you to start small and then expand.

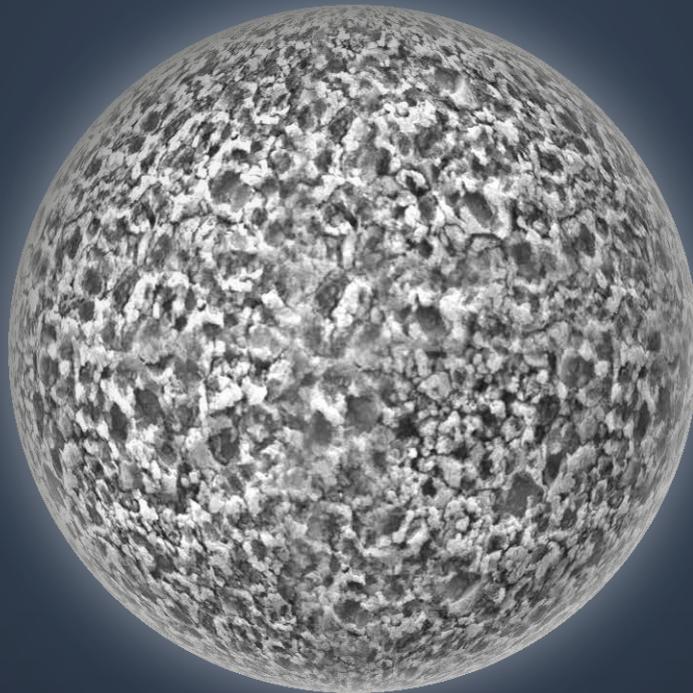
Matties: Right, you're going to learn a lot from starting small and realizing benefits, and that becomes contagious.

Zajac: Companies starting this journey are seeking knowledge at this point. In the moment that they reach out for integrations of this sort, they don't really know their entire set of expectations; as they continue, their appetite grows. It's entirely recommended to start small.

Matties: What does Industry 4.0 mean to you?

Zajac: There are many misconceptions about Industry 4.0 right now. It's a buzzword that is somewhat abused, but the basic gist is allow-

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Robert Zajac

ing for a network of data flow throughout your entire enterprise, making it possible for anything to be stored digitally, and available for anyone involved. For example, in the case of a production floor, consider a quality containment procedure

in which there is a batch of product currently in production. Some of these items roll off the line with some specs out of measurement, and collecting these measurements is critical.

After it is identified and your quality engineer gets the information that something is off, the first thing is to contain the production as there may be many reasons and parameters involved. For instance, consider that the root cause of this quality defect is raw material. To identify the kind of raw material problem you're having, you will probably need your ERP system for this information. Consider you have a typical 3.0 automation stack, or a pyramid if you will, in which at the bottom you have PLCs and control systems, followed by some SCADA and the MES system—if someone has this on paper it is probably completely impossible.

It might take many hours, days, or even weeks for such an engineer to get the information and correlate everything in a stack like this. In some cases, we have heard about containment procedures taking up to two weeks to collect all the necessary people who make the MRP meetings. But, if you can anticipate such a scenario and you have all your data available, you can establish either of the machine-learning algorithms to analyze parameters and correlations in between so that you can stop any batch right away that has a specific feature you are looking for; then, the decision can take seconds. That is a huge advantage to preventing scrap manufacturing, and this is one of the use cases that provides huge benefits.

Matties: Part of the challenge, though, is the skill set: to capture and interpret the data, and to make it meaningful to their process. That's a skill set often missing in manufacturing right now, particularly for bare board fabricators.

Zajac: It is considered uncommon to have this data available, but like the use of Microsoft Excel is now a standard skill throughout the industry, this will be the same skill that is required in the future. Being able to analyze some data related to your scope of interest is going to be critical.

Matties: I think the new role is being labeled as a data scientist. This is a new job title coming into the marketplace.

Zajac: Right. That person will be involved at any step throughout the industry, from production floor through quality engineers, process engineers, and management as well.

Alex Stepinski: Regarding the data scientist job description, I'm doing some mid-career executive education courses right now and the curriculum associated with data science—if you compare it to the curriculum associated with mechanical or chemical engineering—is a subset. It's taking what people with engineering degrees learn and separating it out into a separate curriculum. It's not as rigorous, so someone with a business background can take the course, as opposed to doing differential equations for fun, which Robert does in his spare time every night (laughs).



Alex Stepinski

Matties: I think there's the need for the skill set but there's also the need for a circuit board shop to hire this type of person.

Stepinski: An engineer should have this as a subset of their skills already.

Matties: They just need to make that part of their daily function. What are you doing with this data and why?

Zajac: This is a software platform into which we can enroll all our equipment and other equipment as well; anything throughout the factory can be connected to this as a single pool of information, a “unified namespace.” Consider, your ERP has some data, your MES has some data, your WMS has some data, and you need all this available for you. Part of the system we are building is obviously the MES that will govern the operation, recipe management, and all these activities, but to have this working in tandem with other systems to make the decisions automatically, which would have to be available.

First, we must build the ecosystem for it, so we are currently defining a system that allows for that. Among the features we want to provide are some very advanced control schemes that would otherwise be impossible to do on stand-alone equipment pieces. Some of those would be physiologic, statistical process control, AA recipe management, predictive maintenance, and dynamic recipe corrections. These would be aided by machine learning, and in some cases, could affect some cloud-based data collections for remote troubleshooting in case of maintenance issues. We are trying to put a single blanket over all our product lines with this software and make this a mesh that ties all the pieces together.

Matties: I know this is much broader than North America but if we look at the North American market, a lot of these shops are using equipment that is still 10- or 20-plus years old. Will your system retrofit, or will they need to invest in new lines?

Zajac: There was no necessity for direct replacements. We consider that some of the

equipment might be dated. However, there is still straightforward potential. We provide additional edge devices that allow for interconnection of legacy equipment.

Matties: That makes it a lot easier for them to move in that direction. And in some cases, bringing in new equipment may make more sense. It’s just going to depend on their circumstances.

Zajac: We know that buying equipment directly off the shelf, out of the box, ready to connect will be the most favorable option. But, if you weigh in some of the equipment prices, obviously there will be some necessity for retrofitting.

Matties: When you start talking about dynamic recipe correction, that’s where you’re likely going to see the newer equipment.

Zajac: Right. That would rely on collection of specific recipe parameters. This is hinted at in the wet process in vertical lineup, so you’re going to be able to collect all your parameters that you set up in your recipes and see the outcome. Based on this information stacked historically, the AI or machine-learning algorithm will be able to decipher the impact of all these parameters through your end result and correct accordingly.

Matties: As we’ve talked about with GreenSource, this puts a heavy demand on your front end. You must set up the files to be recipe driven, because you’re not going to be making manual corrections during the process; it’s going to be planned out upfront. How challenging is that? We hear that information from designers never comes in complete, that there is a lot of front-end work, a lot of back-and-forth. How do you help a fabricator get over that hurdle?

Zajac: There is still a necessity for your process engineers to have first say in your recipes. For

instance, you take in the senior process engineer experience to set up some of the initial batches; after processing a sufficient population of items, then you get an idea as to how your processes are running. It's not really one-to-one transferable from factory to factory; obviously there is a certain level that the neural network would have to adapt to specific local conditions. However, over time, you will have the corrections that the AI can provide. Using the base recipe, you will probably get some error in your end result by some margin, and the AI might propose to you, "We're going to alter by this and this," so you can either accept it or put it in automatic exception mode, so that you can get this totally automated. But, as I'm saying that, the first input definitely comes from the process engineer.

Matties: Factories will need to find new discipline to really strengthen that front end to move into this direction.

Zajac: I don't think that many new skills on the front end need to be involved here. I think the typical team that runs front-end will have the same say. It's only that their results become much more accurate, and their mistakes can be rooted out easier. Some of the guesswork is going to be taken out of the equation.

Matties: How do you see Industry 4.0 overlaying the pillars of the company?

Zajac: I hinted at this before that we are planning to have our 4.0 platform be the mesh that ties in all our equipment pieces along with the other manufacturer equipment so that we can have one single ecosystem throughout your entire enterprise. The goal is to be able to provide solutions for the enterprises, but the first step is entire factories. We need to have a place where all the machines, personnel, maintenance, operators, engineers, process engineers, and management can store, speak to, provide data, and then analyze it as they need.

There will be a set of base functions right out of the box. However, we anticipate—and this is by design—some of the features will be specific to a customer's needs; there will be a place to define that so we can make it tailor-made for the customer.

Matties: Is the software a local install or a cloud-based system? How will this mesh inside the factory?

Zajac: Typical installation would be a localized, unified namespace with the ability to have a twin cloud replication. It depends on your perspective on data security, or the need to have your data available remotely. If you had a distributed network of factories, there is probably a high need for you to have your data in the cloud.

Matties: With all the cybersecurity issues, I think that's going to be one of the big questions or concerns people will have.

Stepinski: Security is a huge topic. We have also looked at integrating the AR/VR to help both with security and for service.

Lukasz Stepien: We have dedicated teams working on intellectual property security. This is for the employees interested in security measures that protect data from being extracted. Imagine the factory without any sensitive information available on the floor—you have the example of having the augmented reality, the glasses. The information will be shown to you on the display.



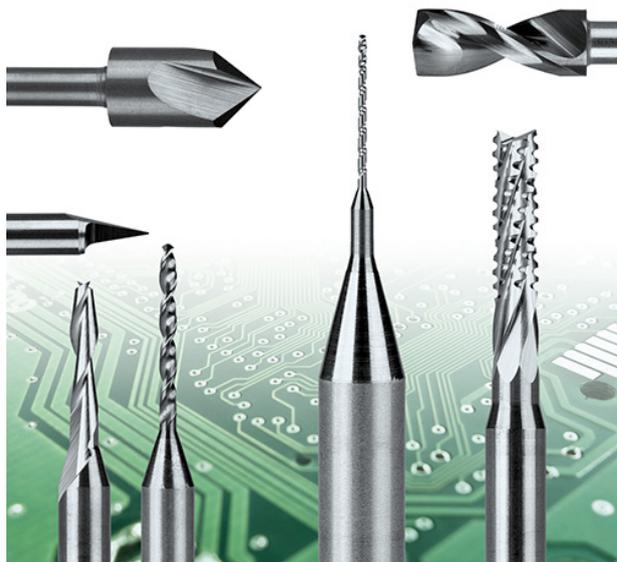
Lukasz Stepien

Stepinski: If you throw a HoloLens on your head, you don't have to document anything in your factory. The HoloLens can acquire a 2D code and give you a heads-up display on what's

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Matties: I thought that's what I heard. One of the things that we hear a lot is "4.0 or smart factories are not for me. I'm high mix, low volume, it's easier for me to go in and set up my drill." On the other side we hear, "We're automated." And when we ask what they mean, they reply, "We have our loaders and unloaders." That's two different levels of automation. One is mechanizing your factory with automation. Yet, with 4.0, we're really talking about automating the process parameters through AI. I think there's a distinction that needs to be made. How would you answer that?

Zajac: It really comes from a lack of understanding about what 4.0 brings to the table. One of the biggest ROIs I've seen was \$25 million in nine months just from implementing 4.0. There is a huge, uncaptured potential in many factories. For instance, analyzing your OEEs (overall equipment effectiveness, measuring the percentage of manufacturing time that is truly productive) brings to atten-

tion that you're probably wasting 60% of your resources or time in production—for a variety of reasons. But only after it becomes apparent can you take action. To succeed, you must at least follow the leaders of the industry like Amazon, Tesla, and Boeing.

Matties: Well, those are extreme resources that most shops don't have. You would need to scale it down to an example like GreenSource—something that people can relate to.

Zajac: Right. Even in the case of GreenSource—a factory with high mix composition of product—it still brings a huge benefit. You are able to have your OEEs ramped up completely, especially in high mix, and for smaller companies with manual labor it helps in thinking about how you can schedule things. This is where you can see the biggest benefits. With high volume, there are probably different benefits, scheduling for example.

Nolan Johnson: Robert, one of the things that intrigues me about moving Industry 4.0 into PCB fabrication is how you set up the AI to monitor your processes. If you look at a traditional manufacturing environment like automotive or other consumer goods, the typical process for setting up the AI is to have human experts go through and give a yes-no type of response to quality examples coming off the line; the AI then builds off that and grows its intelligence. It's a little bit different in wet processes, in that what happens in this tank can affect what happens at that other machine further down the line. How do you envision setting up the AI to track the processes?

Zajac: First, you set the points that you want to reach. For instance, you have a set of mea-

sured parameters, and you must establish your quality factor at the end of this thing to root out the manual judgment of your quality guy. In this case, let's say you have some growing metric measurements of your copper etch rate or something like that, then you compare it against your set points and acceptable thresholds. Then your network can get data that show whether the result is valid. You already have it digitized and at the same time you are stacking this information with a set of parameters that the product was running with. By virtue of having those two in a big enough population, you can provide the teaching sequence for your neural network. It's pretty much the same, but we tried to make it a little bit more automated.

Matties: Does a company have to go all in, or can they piecemeal with your system?

Zajac: Partial involvement is possible, but after the initial install there's going to be an appetite for more.

Matties: But you have to give them the first bite to build that appetite, and they have to be able to see that it's right for them.

Johnson: Robert, I'm curious what your recommendation is to a fabricator who is looking to take steps in this direction. Is there a standard place in their manufacturing line where you would suggest they start?

Zajac: I would start with the part of their production line that is of the biggest interest to them and has the biggest throughput. I think this is the best course of action. It's going to bring the biggest benefit by virtue of having the highest volume we'll put through it.

Johnson: So, you're suggesting working on the part of their process where they have the most throughput, rather than their biggest bottleneck?

Zajac: That's correct.

Matties: Is this software ready for deployment in factories for customers?

Stepinski: The software is being developed for our factory clients and they are receiving it. It is in the scope of these projects, the timeline—and of course there will be upgrades later—but the timescale of these factory projects really facilitates great strategic improvements in industrial capability. If you are a regular equipment manufacturer building one-off machines, you don't have the runway to go ahead and do what Robert is doing right now. You can't just sit back and say, "I have two years to contemplate, put a staff in place, figure out exactly what I want to do, then test, qualify, and implement it." That's not a luxury anybody has.

Johnson: Alex, you were just touching on something that is so interesting about this whole process. When we were talking with Schweitzer (SEL), we asked if they had a pool of talent in their area for PCB fabrication; they said there wasn't. Then, they immediately referred to your training program in which you have some Schweitzer people that you are training. You have them over at a facility where you're helping them gain that knowledge to run their factory. A key part of your whole transition plan is to not only put the facility in place but get that human knowledge up and running quickly.

You were just saying that when you're talking to OEMs, they don't have any history in PCB fab—even the OEMs who were doing fab in the U.S. before. After 20 years, you've lost that talent in your company, nobody remembers, and everybody is new to this again. What's your vision on getting that on-the-floor expertise up and running quickly for a client?

Stepinski: This year, we are really focusing on developing a training program with courses, education tests, and a whole curriculum on getting trained in a PCB shop. SEL is actually

driving this with us because it was a brainstorm I had with them when we first started the project: “Why don’t you send us some of your board business? We will have your people come here. We’ll all build it together, and if you have any concerns with how we’re building it, as we’re designing your factory, we can make changes. We can modify things; we can do it the way you like.” It’s really a big cooperative effort between ourselves, SEL, and Vicor to go ahead and put this training and program in place for all three companies. Then, as we add more factories to our little cooperative, this is going to get easier to do. We will have a program in place and will continue to improve it by adding levels and training.

Johnson: It makes sense to be doing that sort of training for the human operators. Absolutely. At the same time, how much of this gap at your client, the OEM, do you anticipate filling with the AI technology?

Stepinski: We have some initiatives relative to AI, specifically addressing indirect labor in PCB shops where we have skill gaps. One of the biggest skill gaps is in the plating department, copper plating. There is a lot of lost art

there, that’s for sure. There are very few people anymore who really have a clue as to how it works. First, the equipment set is quite old on average, so you’re dealing with archaic equipment, like the “Millennium Falcon of the factory”; without Han Solo it doesn’t run that well. There are not too many Han Solos out there for this area. As part of these factory projects, for instance, we’re making a whole system that mounts on the front of a plating line and we are building plating lines now as well. The system on the front of the plating line has metrology built in. So, you do partial plating, measure before and after, and weigh and image things; we have a whole sequence of metrology pieces that are in this. Then you can say, “Instead of going 100% of the way in one shot and having a good probability of screwing it up, you do a partial plate, analyze the results, extrapolate it out, make a correction, and it’s a simple algorithm.”

Then this is automated. That’s what people do now: They put something in, pull it out, cross-section it, and they make adjustments—or at least that’s what the sophisticated folks do. The less sophisticated folks just pin gauge it or use a CMI probe, but then you’re leaving a lot of things up to chance. We are really focused on

developing metrology that can be used; I think Robert mentioned gravimetric. This is a big initiative from us using gravimetric techniques for indirect measurement. The weight change should always be the same. Nobody is using weight to monitor the process. Why would you use all these sophisticated tools when you can just do a weight loss? It is very simple, and we are trying to keep things simple. That’s a tool that you can use across all processes.



We have several other metrology tools. Confocal microscopy is not used enough. People use SEMs for things that could be done with confocal. Confocal is non-destructive. We are focusing on non-destructive tools, not cross-sections, not SEMs that are gold sputtered and things like that. Everything must be non-destructive in an Industry 4.0 factory so you can get these learning loops in place. You must throw out a lot of the experience and embrace the new tools; it's quite simple to put a scale or a tensiometer inside a machine to check weight. It really is, but nobody thought about it before and we're doing it. It's also quite simple to use confocal microscopy to measure a dimple or check the size of a feature. The units are quite cost-effective and they're very popular in other industries; but in the circuit board industry we're kind of a strange bunch.

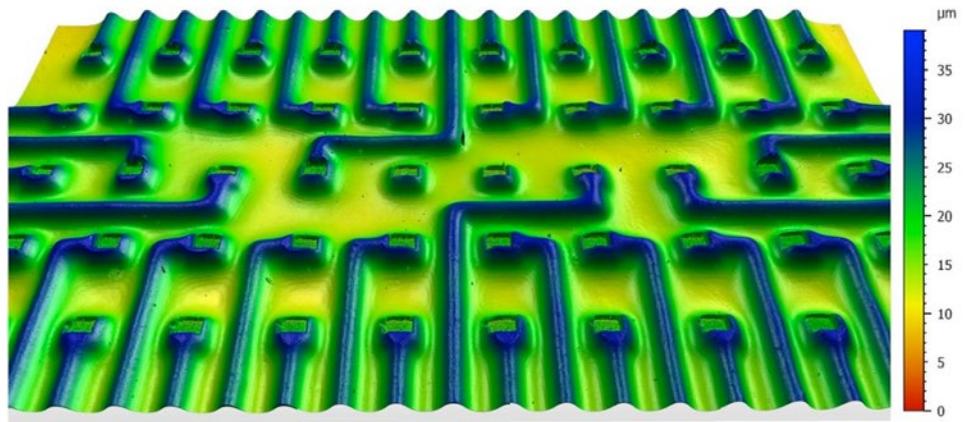
Johnson: How retrofittable are those?

Stepinski: Very easy.

Matties: You need instant feedback if you want dynamic control over your process.

Stepinski: We have many other tools in the works that are a little less developed, but this is the stuff already on the books that we're installing in our clients' factories.

Matties: One thing that was kicking around in my mind is people look for standards, like the CFX standard that is coming out. On the PCB side, the CFX didn't really come into the bare board market. I've heard that they're going to try to move it in there, but all the action is really on the assembly side. Do you see this be-



Laser confocal microscope image of a printed circuit board used for electrochemical testing. (Source: Surface Science Western)

coming an industry standard software, or do you see this as a Beta/VHS kind of thing?

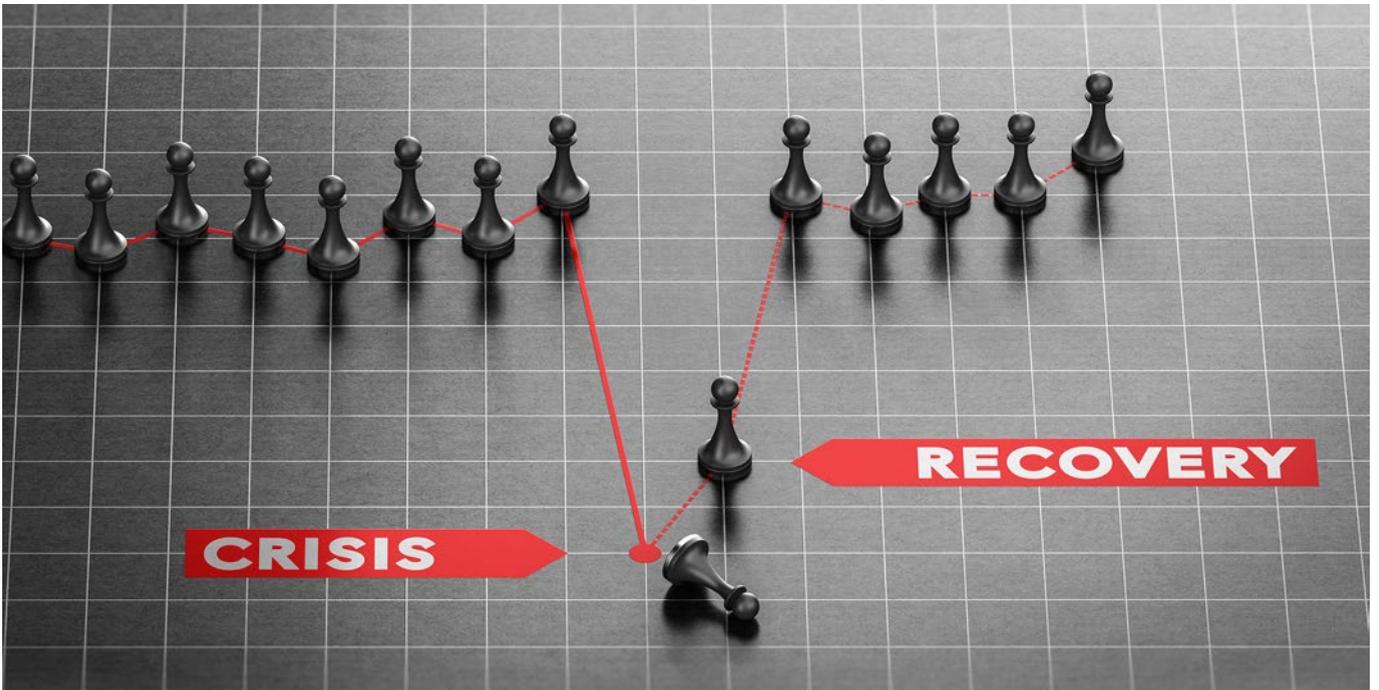
Stepinski: The industry needs to step up and get these things standardized. One of the challenges with standardization is, "Who should be in the room to do standardization?" That's probably the biggest barrier to getting standards done because we could easily have Industry 4.0 software standards in our market. If you've got too many people involved who have no clue what's going on, then the process can be slowed down until there's no point to it. Go to MIT and take a two-day course on what Industry 4.0 is. The course will cost you \$3,600, and then you can participate meaningfully. If we had some qualifications to get into that IPC sponsored room, I think we could have this done in pretty short order, because there's a lot of smart people in our industry.

Matties: We certainly appreciate your time. You're always so generous with your thoughts. We appreciate that, and it is well-deserved success. You've worked hard for this.

Stepinski: Thanks. Really appreciate it.

Matties: Robert, thank you very much.

Zajac: Thank you. PCB007



Process **Optimization** in a Business Continuity Plan

Feature Article by Tim McLean

TXM

An often-overlooked part of a business's key protocols is business continuity planning. These are the steps your company will take when faced with "business unusual," when corporate life or death is a very real potential.

In this article, I will provide an overview of business continuity planning (BCP) and how it can be the difference between your business surviving or failing. We will discuss the risks to your business, what a BCP looks like, and how to implement one.

If you are new to BCP and exploring your options, then you're in luck. I've broken down this article into five parts:

- Defining a business continuity plan
- How to start your business continuity planning
- Defining the risks
- Prevention, Preparedness, Response, and Recovery (PPRR Framework)
- Rehearse, maintain, and review

What is a Business Continuity Plan?

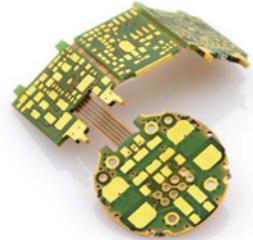
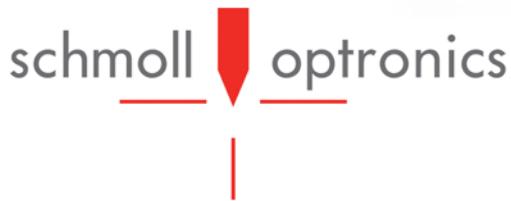
A business continuity plan involves creating a system of recovery and prevention to deal with external factors and potential threats to a company. A company's resistance or resilience to failure is in its ability to withstand external shock waves and still function.

Any external event that impacts the operations of your business should be included in your business continuity plan. Business continuity planning outlines a range of disaster scenarios and the steps to overcome the problem and return to normal trade. Most businesses, however, will be focusing their business continuity management on one disaster—the COVID-19 pandemic.

How to Start Your Planning

Because COVID-19 has turned the world upside down and business-as-usual on its head, it might be time to start your business continuity planning. In manufacturing and supply chain we are seeing a range of outcomes, from businesses struggling with unprecedented-

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ed workloads to others that have seen order books evaporate.

Whatever the scenario your business is facing, it is clear we will face tough times for the next few months. What you do now will dictate how well you come out on the other side. You should be thinking about contingency plans to alleviate any potential impacts to your business. Business continuity planning is the framework that can help you get through to the other side.

A business continuity plan is designed to anticipate and plan for the key risks that may face your business in the coming months. By acting quickly and decisively, you maximise the chances of your business surviving.

What Are the Risks?

When thinking about your business continuity plans you should analyse any potential risks that may have adverse effects on your business. Depending on the industry you are in, these will differ, and you will need to create plans to mitigate these risks quickly and decisively.

Some of the major risks you need to consider are:

- **Customer Risk:** Changes in the nature and behaviour of your customer base. This could include mass cancellation of orders, payment issues, and project delays, but can equally include the need to cope with a rapid ramp-up in output or pivoting to a completely new product range.
- **Employee Risks:** The risk of infection with COVID-19 is the most obvious one to manage and minimise, but there are other risks, such as general absenteeism (many employees are feeling too stressed to go to work); and the motivation, family, and mental impacts associated with working from home.
- **Supply Risks:** Talking to manufacturers, I get the impression that the impact of the interruption of supply from China has been less than expected (probably because the virus shutdown coincided with the Chinese New Year shut down anyway). However, what if your supplier can no longer stay in business? What happens if they have an infection in their business? What are your alternatives?

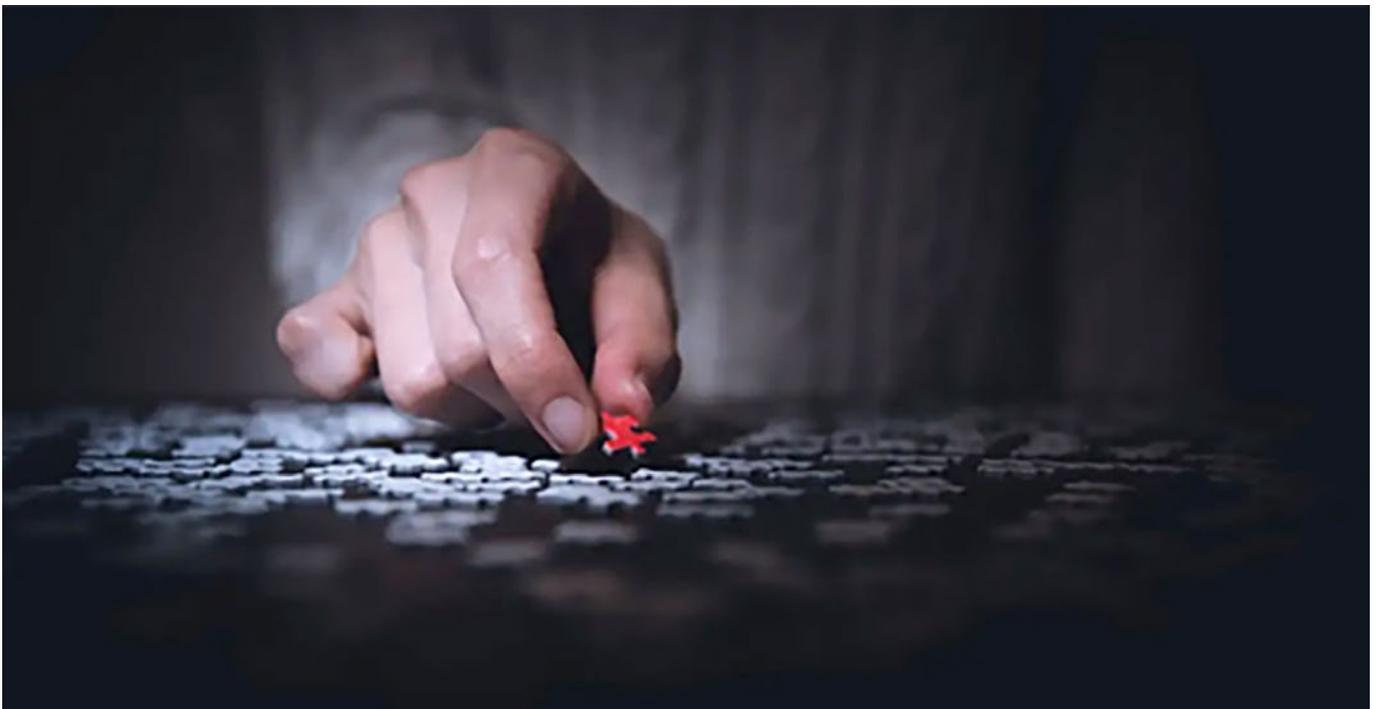


Figure 1: Identify all your risks before deciding on what action to take.

- **Financial Risks:** Cash is king in a crisis. What are the key risks to cash flow? How can you maximise cash flow and minimise outgoings to ensure that you maintain your business as a going concern as long as possible?

I could keep going. The more one thinks about this COVID-19 pandemic, the more risks you will identify. The challenge is therefore to organise and prioritise these risks so that you can focus your resources on mitigating the most serious risks. That is what a business continuity plan is all about and this plan is at the core of your business continuity management.

Prevention, Preparedness, Response, and Recovery (PPRR Framework)

The Prevention, Preparedness, Response, and Recovery (PPRR Framework) can be used to prepare your plan under the four main pillars:

- **Prevention:** Risk management planning, which incorporates the prevention element that identifies and manages the likelihood and/or effects of risk associated with an incident
- **Preparedness:** Business impact analysis, which incorporates the preparedness element that identifies and prioritises the key activities of a business that may be adversely affected by any disruptions
- **Response:** Incident response planning, which incorporates the response element and outlines immediate actions taken to respond to an incident in terms of containment, control, and minimising impacts
- **Recovery:** Recovery planning, which incorporates the recovery element that outlines actions taken to recover from an incident in order to minimise disruption and recovery times

Prevention

You need to identify and analyse the potential risks to your business with a risk manage-

ment plan. Your plan will include events which will have an adverse effect on your business and pinpoint solutions for dealing with each risk you identify.

The questions you need to ask:

- What could cause an external shock?
- How serious could the impact be?
- What are the odds this could occur?
- Can we reduce or eliminate this risk?

Preparedness

As part of your preparedness, you should complete a business impact analysis (BIA). Your BIA will derive information from your risk management plan to calculate the risks and impacts on your critical activities. Critical activities are defined as primary business functions that must continue in order to support your company.

Ask yourself and identify:

- Your critical business activities
- The impact to your business caused by disruption
- How long you can survive without this core business
- How long it will take to recover

Response

Your incident response plan is built to answer to critical events and reduce the impact of these on your business operations. It will also prepare key people to provide an effective response to ensure minimal disruption to operations in the event of an emergency. The type of business you are in will determine your appropriate response to incidents.

Your response plan will have evacuation procedures, your emergency kit, people's roles and responsibilities, key contacts, and an events log.

Recovery

At this stage you are returning to normal business operations before the critical incident. Your core business is back online, and



Figure 2: Just like an aircraft, your BCP must be reviewed, maintained, and rehearsed regularly.

business operations have resumed normal operation.

The recovery plan should outline the intentions of supporting a recovery of the worst-case scenario. You can modify it according to the degree of loss to your business.

Your recovery process should include:

- Developing strategies to recover your business activities in the quickest possible time
- Identifying resources required to recover your operations
- Documenting your previously identified RTOs
- Listing the person(s) who have responsibility for each task and the expected completion date

Rehearse, Maintain, and Review

Now that you have decided on the steps to prevent, prepare, respond, and recover, you can look to rehearse, maintain, and review

your planning to make sure it stays up to date with your current business goals and objectives.

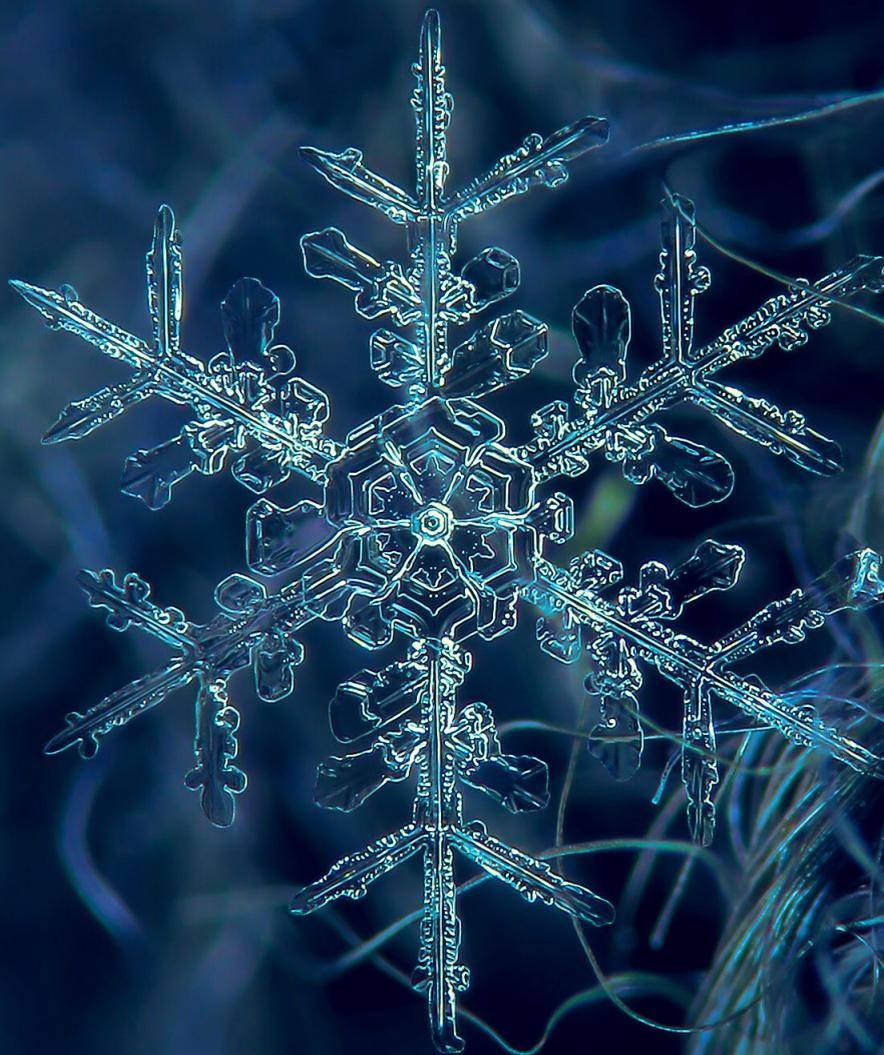
One option is to take a business self-assessment survey, which examines your current vulnerability to a sudden revenue shock.

Business continuity planning can be a daunting undertaking with all the different touch points to think about in your business. However, doing it well and doing it quickly could determine whether your business can survive the current COVID-19 crisis. At TXM, we have developed some tools and resources to help you with business continuity management. **PCB007**



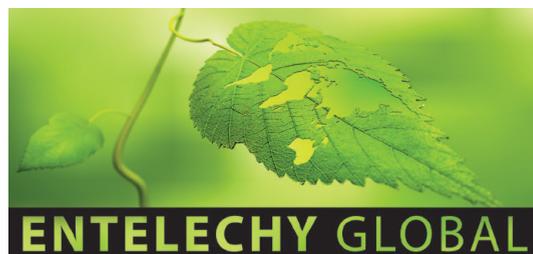
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Operational Excellence from a Design Services Manager

Feature Interview by Nolan Johnson
I-CONNECT007

Jesse Vaughan discusses the key aspects of continuous improvement he sees in his role as manager of design services at ACDi, and the importance of carving out communication channels—both internally and externally to help build operational excellence.

Nolan Johnson: Jesse, you are a manager of design services for ACDi, but let's start with your manufacturing and process experience. How much of that knowledge transferred into your first year as a design services manager? Were you able to bring what you learned from operations into the design team?

Jesse Vaughan: Yes, absolutely. My manufacturing role was on the assembly side, and I was the lead manufacturing engineer for our largest internal customer—a military prime contractor—where I ran over 100 NPIs for a complex product. I would often find issues on the assembly floor, and then be able to troubleshoot that back to design. But I didn't connect the dots at that point because I didn't have the design experience. I only understood it from a 10,000-



foot view; but now, building the product and being able to backtrack, I can take those experiences of, for instance, connectors that need to be select-soldered with passives that are too close to surface mount components.

You end up soldering the connector and losing the passives around it, things like that. There are nuances with spacing requirements, sorts of press-fit, tolerance differences. Right now, we have the benefit of having the service bureau under the same roof as the Frederick (Maryland) operation so we can walk a product literally from inception through design. Obviously, we go to a third party to get the PCB fabricated and then I can bring a designer onto the floor with their data package and watch the product being built so they can get a good understanding. You get the perfect marriage.

Johnson: Was this in the company culture already, or have you helped to cultivate this?

Vaughan: It already existed, but I have helped to accelerate it. When we are more knowl-



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The SMT line at ACDi's Nashville, NC Facility.

edgeable about the issues out on the floor, and we can incorporate lessons learned on the front end of design, then the company is more successful. Obviously, our customers are also more successful, which helps with retention. It's beneficial to have the kind of communication and connection we're going for.

Johnson: Can you quantify how that has improved your NPI process? Can you give some sense of the positive impact it has had?

Vaughan: It's difficult to quantify just based on the data points. This is my first management role, so we had that learning curve of understanding the team. For example, just before I came on board, we brought in a selective solder machine to further automate our process for our current customer base. We used to wave and/or hand-solder all connectors, but as it is with any implementation of capital equipment and a new process, things needed to be tweaked.

I had the benefit of coming on board within that cycle of the selective solder machine. They went to run the first lot and we said, "Hmm, I think we need to make some changes because,

yes, automation will increase efficiency, but not the way the board is currently laid out. We need to make some changes, create some spacing so that we can take advantage of the time savings and the cost savings for putting this machine in place." That is probably the most significant example as far as an overall program. That product line consists of eight separate boards in an entire rack that goes together for a communications system, but that's the main board that drives everything else. They were having some other test-related issues, and while we provide sophisticated test capabilities,

this was not a requirement that was flowed down to us in this particular instance.

They were getting test data feedback, sitting with the designers, the assembly team, and with their manufacturing guys as one big brain trust. There are certain things you can't change due to signal integrity, operability, or reliability reasons. But the areas where we were able to make modifications to have a cleaner run and more efficiency, we were able to implement. It was good being a part of that, but it's hard to quantify it.

Johnson: Your team does a lot of designs. You said several hundred?

Vaughan: Three or four hundred a year.

Johnson: Three or four hundred a year with a team of 10? There is not a lot of time to dwell on a particular design.

Vaughan: It's definitely not your OEM environment where you have more folks all involved in one design and much more feedback with more points of view. Thankfully, half my team has been in and around electronics for 25+

years. While we focus heavily on optimization, we rely heavily on what's in the toolset—running our Valor NPI. That also coincides with being able to capture the latest and greatest ERR files from the PCB houses so that when we're doing our Valor checks, we're doing one-to-ones.

We're not running our Valor check based on eight- or 10-year-old data. As fast as the industry moves—capital equipment, and the efficiencies within the PCB house—we have to keep up. We can dial this thing in and think it's good based on what our recipe says it is, but then we send it over and get back a list of TQs because all the nuances in the processes have changed. It's just really critical to stay on top of the supply base to back-feed us the latest information so that we're keeping up with the design curve, or the acceleration of the technology within the design.

Johnson: Have you gained capacity in what you're able to do with your current staff due to the communication?

Vaughan: Absolutely. One of the main issues was what I would call a bottleneck. For example, our draftsman was required to analyze and create panelization drawings and that communication loop wasn't strong between him and the guys on the floor. Now, for our customers for whom we would assemble, we gave more attention because every CM has a different process and how they like to analyze things. So, it's not advantageous from a labor perspective to bury a bunch of time into something that I already know is going to assembly house XYZ—they will just throw it in the trash and create what they want.

But for our internal customers, we have opened that communication path where my draftsman can walk out with the drawings, sit right there in front of the SMT engineer and the manufacturing engineers, and say, "Here's what we got; here's my concept." They don't have to start from scratch. You can start with a

concept and they can say, "Yes, no, move this here, make a cavity for these connectors," that kind of thing—instead of you kicking it out to the fab house and waiting until it comes back for an array approval and the board is just sitting on hold.

They have to stop everything they were doing, take a look at it, but for us, we are already a third of the way there. We just bring it to them to get their blessing. And now when it gets to the house, it's not on hold anymore for array approval because the array has already been approved. We created it on the front end and that process adds up over time, especially for anything that's in a quick turn and an NPI environment.

Johnson: Right. You get a faster process through there and, simultaneously, you're saving time on the design side. You're saving in the transfer into manufacturing because that goes simpler and easier. And it sounds like you've rearranged some of the steps so that it's more efficient. Undoubtedly, you're saving labor time and effort once it hits the floor through this process.

Vaughan: Yes, because they've signed off on it already. They are building so many different part numbers on a day-to-day basis. Say you got something on a 20-day turn and it comes in 25 days later. It's kind of like the windshield wiper effect. The fact that they don't have to go back in and dig back into that—they've already signed it and they just know they can throw it on the line—it gives them a bit of ease. They don't have to think about it because it's already been thought about and signed off: "Yes, we know that we approved that with Tewodros and Jesse; it's good to go, no need to take a second look."

Johnson: Having a close relationship with the entire chain is a huge advantage. How can an organization that isn't that closely tied achieve the same sorts of benefits? Is that possible?

Vaughan: I would say it's possible, but you have got to put in the grunt work. Specifically, if you have both entities under the same roof, you've got to tell your guys, "Let's put some jackets and straps on, and go out there and get familiar with the equipment. Let's go watch a board get built." It could be one of the senior guys who may have never had the opportunity. It could be an environment where they're siloed—where design is design—and we throw it over the fence and manufacturing figures it out. It's relative to the situation in every company.

But my advice would be that if the channels don't exist at all, carve them out. If they do exist but they're not operating at an efficient level or they exist just to say they do, then put in the work to actually make that connection and to make that an efficient process. They simply may not realize the 20 minutes you take off here saves days on the backend waiting for approvals, TQs, EQs, and such.

It helps when you can understand the queries that you will get from the manufacturing house, no matter who they are—whether they're your 800-pound gorillas or your mid-level guys—generally, they all operate on the same basic set of processes. So, if you can design on the front end, understanding what 70% of your TQs are on the backend, then you eliminate that as well. I think that helps to incorporate efficiency, and that comes with understanding why they ask those questions, why they ask for those deviations, and then being able to incorporate those in the front end on your designs.

Johnson: Seems it is worth the time investment to get a design engineer more than passingly



Vaughan and the ACDi Design team.

familiar with how the boards are going to be manufactured.

Vaughan: Absolutely.

Johnson: That becomes an important part of what gets incorporated into the design decisions.

Vaughan: Yes. I would agree with that statement.

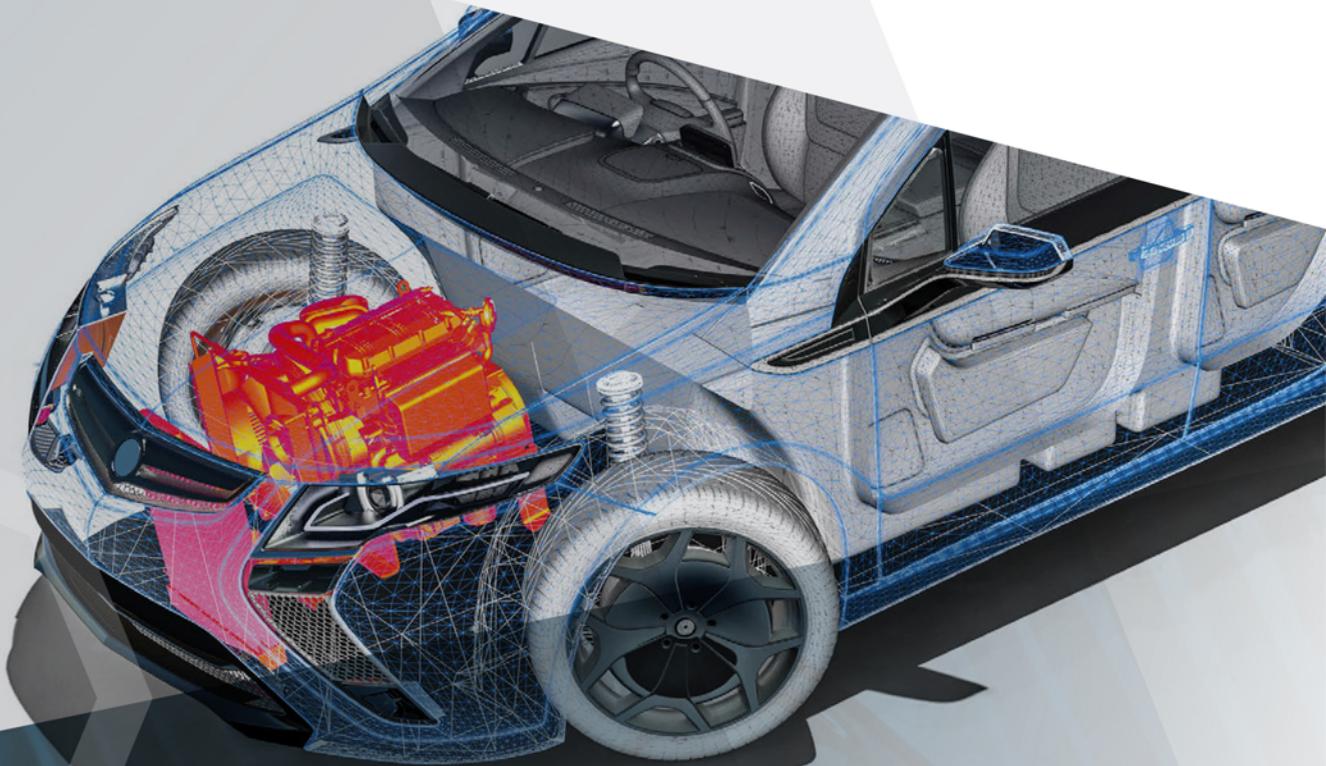
Johnson: You mentioned earlier in this conversation about working with fabs, having processes change and outdated DFM information because everything's changed at your fab. How do you manage that external communication?

Vaughan: We have been somewhat successful, but also somewhat stonewalled. I haven't really figured out what that is. I think it comes down to that they've dialed in this recipe and they don't want it just out there floating everywhere because somebody could be smart enough to take that digital information and then derive from it what they need to improve their process, which then brings the competition up to their level.



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It's understandable, because at the end of the day, they're running a business to retain customers and to beat out the competition. To have your recipe out there for the world to pick apart, I can understand why there's some hesitancy. There's been some pushback in that regard, but we have a few fab houses that we just have a really long-term relationship with, and who have been a little bit more forthcoming or giving of that information.

Johnson: Compare and contrast for me when a fabricator wants to improve that communication. Obviously, fabricators want to get boards that take minimal CAM time for them; they want to get jobs that can pass right through and onto the manufacturing floor. That would be their ideal. It would be in the fab's best interest to make sure that their customers submitting designs are providing designs that are spot-on accurate. As a fab, how much do you divulge? How much do you keep a secret? For you as the customer, you need that information as well so that you can design to what's going to work for them.

Vaughan: Yes. And I think your answer lies in how you summarized it. They want plug and play. They want to be able to get something, import it, export it, build it, and ship it. Just like we don't want the hang-ups on the back-end when we're getting ready to populate it and assemble it, they would prefer not to have the hang-ups on the front end when they're getting ready to CAM it, tool it, and build it. Just like you said, having that mindset that they would prefer to cut down on the labor time of the CAM and all the front end. To do that, you need to communicate to your customer base what you would like to see to make that happen.

It goes back to what I was saying about the internal communication channels. With the external customer base able to be more fluid in that communication loop, almost every fab house will offer it by way of mini-DFMs.

We will do DFM for prospective customers, for customers we already have from a design level, assembly level, and then we will go out to a subset of board houses and we'll choose. Primarily, we often go to the same one or two because they understand that when we order, we're going to place the order with them.

We request many DFMs and that helps a lot, even if you can get a stackup going with them, for example. With that information, knowing that where this design sits now, these are the things that we're going to ask you when you place the order. If you can incorporate this now, when you place the order, we can check those boxes off. We've already answered those questions. That's a big advantage that the board houses have offered. Now you can have them do a full rate and they'll charge you for it. But a lot of times the mini-DFM will shake out a lot of the main issues that they would run into, if you can incorporate those before you place the order.

Johnson: Are you running DFM in-house at your facility or are you relying on the fabricator to do all those for you?

Vaughan: No, we do both, and we run it in our internal Valor as well. When we do that offering, we basically post-process their design. When we get a request for it, we do a table plot review with three or four designers. We'll get their eyes on it, looking at the Gerbers, making suggestions. We run it through our Valor tool to see what it outputs, and then we put together a PowerPoint report.

If there are tests that are required or requested, then we would do a DFT with our test engineers and we provide a full-on package, including what the mini-DFM from a board house may ask and then say, "Here are your majors, you really want to pay attention to them. We would suggest that you make some changes around those for the benefit of everybody in the supply chain involved, including you and your end customer. Here are the minor things,

they aren't going to necessarily stop the show but could make things move along smoother to fix them."

Then the customer should communicate with their electrical engineers and make decisions; everything is going to have trade-offs, nothing's going to be perfect. Then they must have the diligence of, "If we change this, how does that affect ABC down the line?" That, ultimately, is the customer's decision. They either spin the package, they make some changes, or they say, "We're stuck with what we're stuck with. Sorry, you got to build it." And sometimes it happens too. You get all three.

Johnson: So, with rule decks at the fabricator and rule decks in your facility, you can run these checks on both sides, but ultimately, who owns the maintenance of the decks you're using—you or the fabricator?

Vaughan: We rely on the fab house for those because we're going to build our decks to where the processes are in their technology curve in whichever fabrication house you're going to. You have some low-, mid-, and high-complexity guys; and all of their checks are based on the class level that they build to, whether it be one, two, or three. At the end of the day, we're going to rely on the board house for the maintenance of the decks, because they own the process. We're all experts in our own field and they're supposed to be experts in their part. They should all be interconnected to some level so that we're not doing something here that is of no advantage to the next two pieces down the line, and so forth.

Johnson: But I think we're touching on an interesting dynamic. There's that point where



ACDi's SMT line at the Frederick, MD Facility.

it's in the fab's best interests to make as much meaningful information as possible available to you so that they receive quality design data; get good quality information in the hands of your customers and you're going to get better designs coming in to go to your manufacturing facility.

Vaughan: I agree. Absolutely.

Johnson: In your opinion, Jesse, how do we do that better in the industry?

Vaughan: I may get a lot of hate mail for this, but just figure out where that line is, where it crosses over into IP territory. Draw that line, but then communicate as effectively as you can, right up to that line. Do not leaving anything out on the table, nothing open for interpretation. As an industry, we understand that everybody has the right to protect their business. At the same time, we all rely on each other to stay in business. So, let's figure out where that perfect medium is to capitalize on it.

Johnson: This has been good.

Vaughan: I appreciate it. I look forward to seeing the issue. PCB007

A Review of:

‘World-Class Manufacturing’

Feature Article by Nolan Johnson

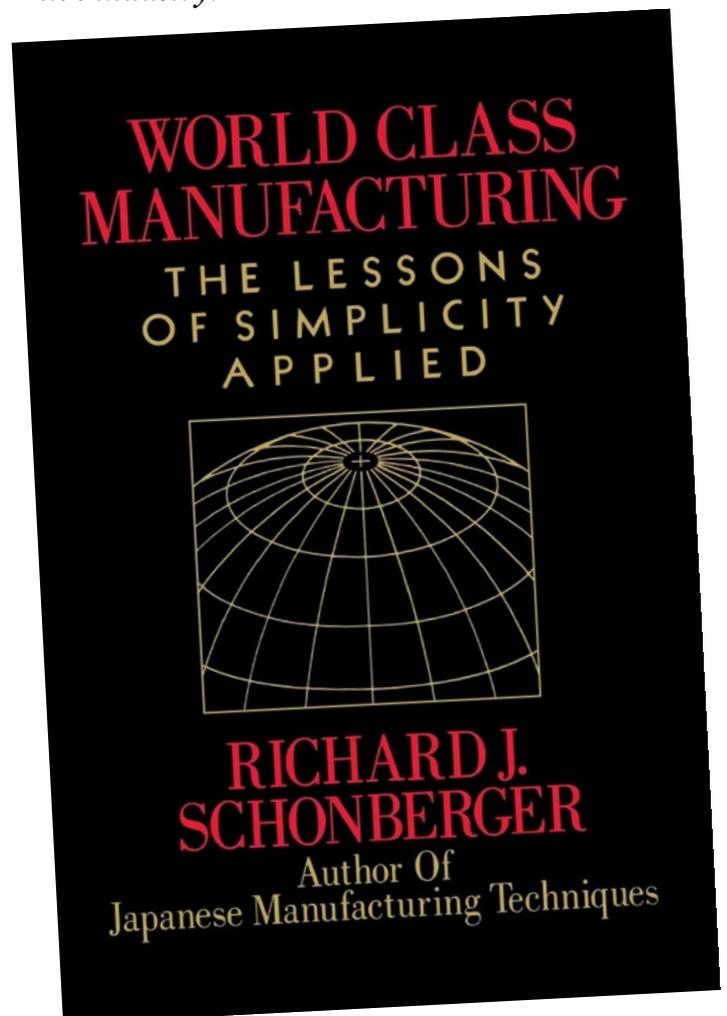
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Whether a piece of content is fiction or nonfiction, it’s still easy for it to be relevant to the general populace. Commentary on true current events, for example, makes for good reading while the news is fresh. But such work has an expiration, a point at which it is no longer meaningful. However, when a piece of content—say, a movie or a novel—continues to be relevant well past its creation, it’s almost always because the themes explored are timeless and true. It is that moment when content bridges the gap and becomes art. What do we call, then, a piece of insightful nonfiction that bridges that gap, maintaining its relevance for more than 35 years? Well, the pragmatist may simply deign to call that content “useful.”

World Class Manufacturing: The Lessons of Simplicity Applied by Richard J. Schonberger was published in 1986 as part of the World Class Manufacturing (WCM) vanguard of the time. And yet, a careful read shows that even though many processes have changed, there are fundamental thought patterns that persist in electronics manufacturing. No wonder, then, that Calumet’s Todd Brassard refers to this resource when discussing process excellence elsewhere in this issue.

But what is WCM? As written in the *IndustryWeek* article, “World Class Manufacturing Methodology Drives Improvement at Case New Holland”^[1]:

“Like Lean, WCM actively engages all employees in the continuous-improvement process and is aimed at driving out waste and production losses in the drive for world-class performance... The WCM methodology may be familiar to continuous-improvement personnel in the automotive industry.”





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In his book, Schonberger writes that “world-class manufacturing depends on blended management—rather than domination by a separate group of managers—which marshalls resources for continual rapid improvement. To achieve world-class status, companies must change procedures and concepts, which in turn leads to recasting relations among suppliers, purchasers, producers, and customers.”

In Chapter 9, “Partners in Profit: Suppliers, Carriers, Customers,” Schonberger writes in one section of the discussion:

“Exact as much as possible at the lowest price from your suppliers and carriers of materials, provide the least possible service at the highest price to your customers. Harsh sounding, but good business? If it ever was, it’s not anymore.”

I-Connect007 readers who follow the columns of Anaya Vardya and Alfred Macha will recall that partnership is an ongoing topic in building not only positive customer relationships but also good supplier relationships. We are, after all, suppliers to our customers, and customers to our suppliers. The current techniques for creating a supply chain partnership are quite in keeping with Schonberger’s comments in the mid-1980s. On page 155, he warns that your partners will not be at their best if:

- You beat down the price so much that your provider or customer is unprofitable, unable to invest in improvements, and perhaps unable to stay in business
- Your withholding of information on capacity plans, product plans, and demand forecasts causes your supplier/carrier to design, buy, build, and ship late—or early
- Your failure to specify requirements clearly makes it impossible for your supplier to assure quality at the source
- Your failure to share your knowledge of best business practices contributes to their inability to keep up and stay attractive as your providers or customers
- Your energy is expended in the search for new providers and customers, which

results in a continual succession of startups and no movement up the learning curve

- Your lack of interest and reluctance to keep in close touch leads them to treat you as an adversary

Schonberger shares examples of how to turn these adversarial tactics around. In one example, programs at Polaroid were put in place so that a supplier’s request for a price increase based on increasing costs was met first by a consulting session with Polaroid experts who often helped the supplier find cost savings in their manufacturing processes to offset the cost increases elsewhere, thereby keeping the price to Polaroid stable.

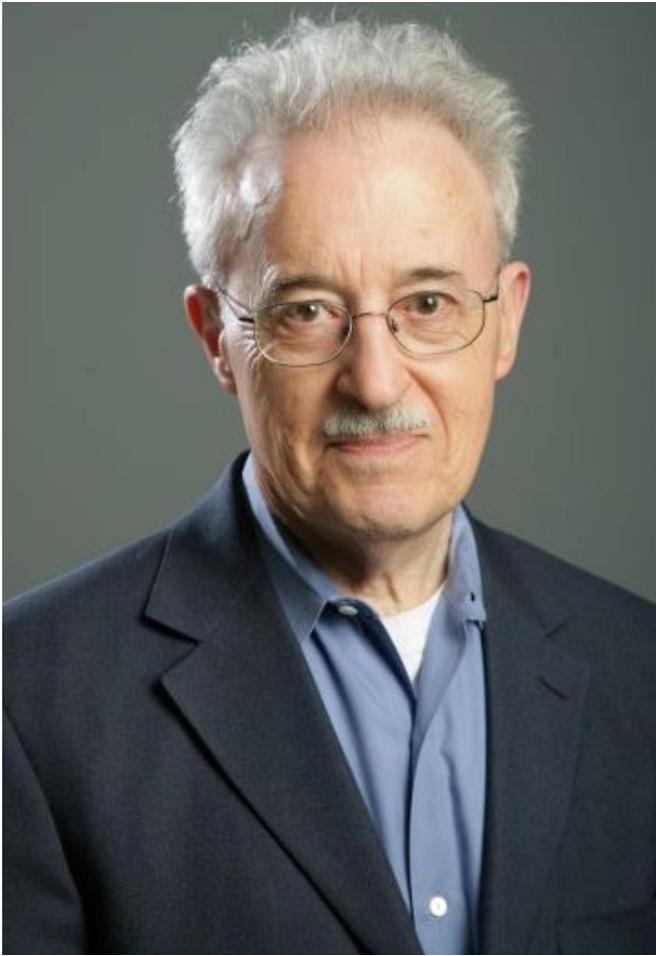
Shrinking your supplier base is an argument that Schonberger supports, pointing out the time and staffing savings by doing so (and citing examples). He also advocated tough contractual requirements to keep the supplier in the mode of continual and rapid improvement.

Shifting this mid-‘80s perspective into the early 2020s, much of the thinking still holds true. Nearly 40 years later, we are still seeing some of the old school management styles and manufacturing thinking that was prevalent in post-WWII manufacturing. In the intervening years, one could argue that purchasing departments concentrated so single-mindedly on price and single-sourcing that the resilience was only offered by a larger number of potential suppliers. The list of bad practices I mentioned continues in play even up to today.

So, how does an OEM firm, designing and specifying electronics assemblies for their products, manage the competing needs of fewer parts and fewer suppliers, and yet still maintain a flexible supply chain?

Recent supply chain revelations have made it clear that good business operations in manufacturing must rely on reliable and resilient supply chains. Yet, in the name of price-cutting, supply chains tend to become more consolidated rather than more dispersed.^[2]

Schonberger offers a possible solution in Chapter 9. He recounts an anecdote from a



Richard J. Schonberger

colleague he identifies as David Taylor, former chief of purchasing at Hewlett-Packard, Greeley. After being tasked with finding two or more sources for each part number, Taylor's boss read up on JIT and changed tack, looking for "one good supplier for each part number."

The solution to this conundrum, Schonberger points out, is to maintain a relationship with multiple vendors, but only manufacture some (or just one) of the parts with each vendor. Schonberger uses an example of a car manufacturer sourcing left-side light assemblies from one fabricator and right-side light assemblies from someone else. Yes, both companies would be able to produce all the needed lighting assemblies. But now, if one supplier suffers a shutdown, the other fabricator can step up temporarily. This reduces buying complexity by sole sourcing, but also preserves much-needed flexibility in times of supplier crisis.

What does Schonberger see as the benefit in this approach? He lists these results on page 156:

- A typical supplier will sell much larger volumes to a much smaller number of customers than before
- Long term contracts, not short-term purchase orders, become the norm
- Suppliers may receive training, advance planning information, and perhaps even financial help
- More contracts specifying a regular daily delivery schedule
- Buyers at the customer plant make the freight arrangements instead of the supplier

We should note that I-Connect007 columnist Christine Davis spoke to the challenges of establishing a partnership with a potential customer stuck in the old way of thinking.^[3]

The customer/vendor relationship is a microcosm of the larger supply chain. Just as the need is there to create parallel channels for resilience, the working relationship needs to be similarly resilient. In this case, it means building colleague-to-colleague relationships throughout both companies. Schonberger stresses that merely communicating between the sales department and procurement is not sufficient. Of course, if you're a reader of Dan Beaulieu's weekly columns, you'll be familiar with this idea.^[4]

It is interesting from the viewpoint of 2021, to read this passage on page 162:

"Most of our larger industrial companies have caught the world-sourcing fever...world-sourcing flies in the face of the WCM concept...develop a few good local sources and stick with them."

He cautions that world-sourcing's risks are significant and must be offset by "substantial" cost/exchange savings. Our contemporary perspective can see that Schonberger's use of the word "cost" really should be "price," as the savings here will be needed to offset the

additional costs in freight, inventory stocking, and the like.

At this point, after standardizing parts and reconfiguring the suppliers, Schonberger turns his attention to shipping. Often overlooked, freight and carriers are critical to implementing a WCM or JIT infrastructure with local sources. It is this one passage in the chapter that shows the passage of 40 years, in that we've made much progress on shipping and carriers since the advent of the e-commerce model.

Processes are key to creating a WCM solution in your company, but that's not the same as automation. When discussing the automation of systems, Schonberger writes that "making maximum use of people and current machinery is a company's first priority; automation, if necessary, should come much later."

While I've only discussed the powerful content in Chapter 9; there are 12 other chapters to consider as well, including:

- "Staff as Supporting Actors"
- "Responsibility Centers"
- "Design Leverage"
- "Training: The Catalyst"

We reached out to Schonberger & Associates via email while writing this review, but had not received a reply by press time. *World Class Manufacturing: The Lessons of Simplicity Applied* by Richard J. Schonberger was published in 1986 by The Free Press. The title is still in print, and Schonberger has continued his writing on this topic.^[5] PCB007

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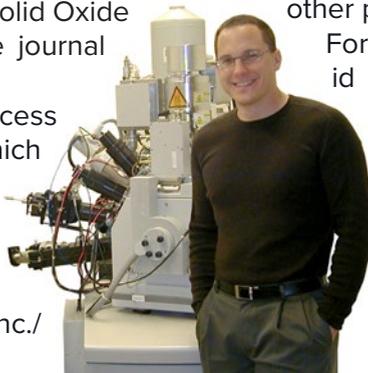
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A Silver Lining for Extreme Electronics

Tomorrow's cutting-edge technology will need electronics that can tolerate extreme conditions. That's why a group of researchers led by Michigan State University's Jason Nicholas is building stronger circuits today.

Nicholas and his team have developed more heat resilient silver circuitry with an assist from nickel. The team described the work, which was funded by the U.S. Department of Energy Solid Oxide Fuel Cell Program, on April 15 in the journal *Scripta Materialia*.

MSU researchers developed a process to create more resilient circuitry, which they demonstrated by creating a silver Spartan helmet. The circuit was designed by Jane Manfredi, an assistant professor in the College of Veterinary Medicine. Credit: Acta Materialia Inc./Elsevier



The types of devices that the MSU team is working to benefit—next-generation fuel cells, high-temperature semiconductors, and solid oxide electrolysis cells—could have applications in the auto, energy, and aerospace industries.

Although you can't buy these devices off the shelf now, researchers are currently building them in labs to test in the real world, and even on other planets.

For example, NASA developed a solid oxide electrolysis cell that enabled the Mars 2020 Perseverance Rover to make oxygen from gas in the Martian atmosphere on April 22. NASA hopes this prototype will one day lead to equipment that allows astronauts to create rocket fuel and breathable air while on Mars.

(Source: Michigan State University)



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Training Your Team and Tools for Success

Trouble in Your Tank

Feature Column by Michael Carano, RBP CHEMICAL TECHNOLOGY

Introduction

While this month's column departs somewhat from my usual topics, the subject matter is no less critical. As someone who has been troubleshooting and problem solving for many years, I have found that the process and tools are extremely important.

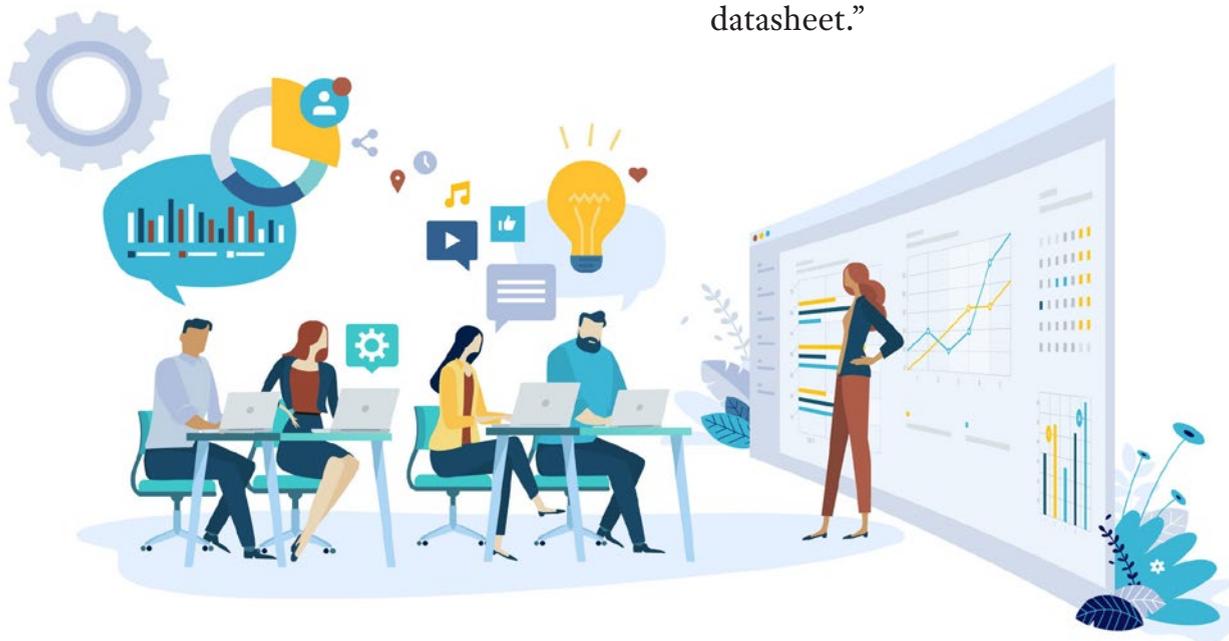
I was asked to consider addressing the topics of optimizing business processes and strategy, process optimization, and training your team. I believe developing critical thinking skills will help engineers troubleshoot technical issues and bring them to a quick resolution as this is certainly a good lead-in to training your team.

Troubleshooting 101

This should come as no surprise to those of you who read my monthly columns or have

met me in your circuit board facility: Remember, time is money. The longer a problem goes unresolved the more money, and certainly future customer goodwill, can be lost. When being called on to solve technical issues—whether it be a delamination situation, copper plating failures, or solderability defects—I stress a few simple rules:

1. Walk the line and watch the operators in action.
2. Review documented work procedures.
3. Check rinse water quality and dwell times—are you rinsing away the contaminants or simply dragging them along with the boards to the next critical process?
4. And the biggest sin: “Yes, everything in the chemistry is being controlled per datasheet.”



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6S methodology is not new. The process is focused and disciplined. The process is DMA-IC^[1]: Define–Measure–Analyze–Improve–Control.

Use various tools, including Pareto charts, histograms, process control charts, and fishbone diagrams. Use logic; think critically and strategically. Basically, it is quite simple: Develop the troubleshooting skills necessary to solve process problems efficiently.

The rule of thumb is to keep the troubleshooting project as manageable as possible. Brainstorm to understand the linkages in the upstream and downstream processes and potential effects of process variation in these process steps. Gather all pertinent information including SPC charts, temperature logs, analysis records (including records of calibration and analytical standards), and the like. Then develop a cause-and-effect diagram. Fishbone diagrams serve this purpose well. At the risk of having hundreds of factors to investigate, only the most likely causes should be investigated first. This is where experience and critical

thinking skills come into play. This will serve to weed out those processes that are not contributing to the defect.

When was the process audit performed, and on what operations within the PWB fabrication operation? Ongoing process audits jointly and separately performed by your supplier and designated individuals in the fabricator’s facility should be standard operating procedure. Process audits alert the manufacturer if a process is “drifting” out of the control window. Suggest your company select an experienced group of operators, engineers, and other science disciplines to be trained in the art of conduct a process audit.

Table 1 shows an example of one such checklist.

Outer Layer Dry Film Developing

A fishbone diagram is another extremely useful tool to conduct root cause analysis of the problem^[2]. Your team can use the fishbone diagram (Ishikawa diagram) to explore the potential causes of a particular issue or defect. Af-

Process Steps	Failure Mode	Effects of Failure	Severity	Potential Cause(s) of Failure	Occurrence	Current Controls in Place	Detection
Lack of uniformity in appearance (A) Skip-etch	Resist stripper spent	Skip-etch	6	Poor solution maintenance	5		3
			6	Faulty controller	3		5
	Poor rinsing after resist stripping	Skip-etch	6		6		5
			6		3		4
	Oxidization on cores	Skip-etch	6		5		2
	High acid in pre-dip	Skip-etch	7		4		3
	Spent pre-dip	Skip-etch	7		5		3
	High sulfuric oxide alternative solution	Skip-etch	7		3		2

Table 1: A sample checklist for conducting a process audit for outerlayer dry film developing process.

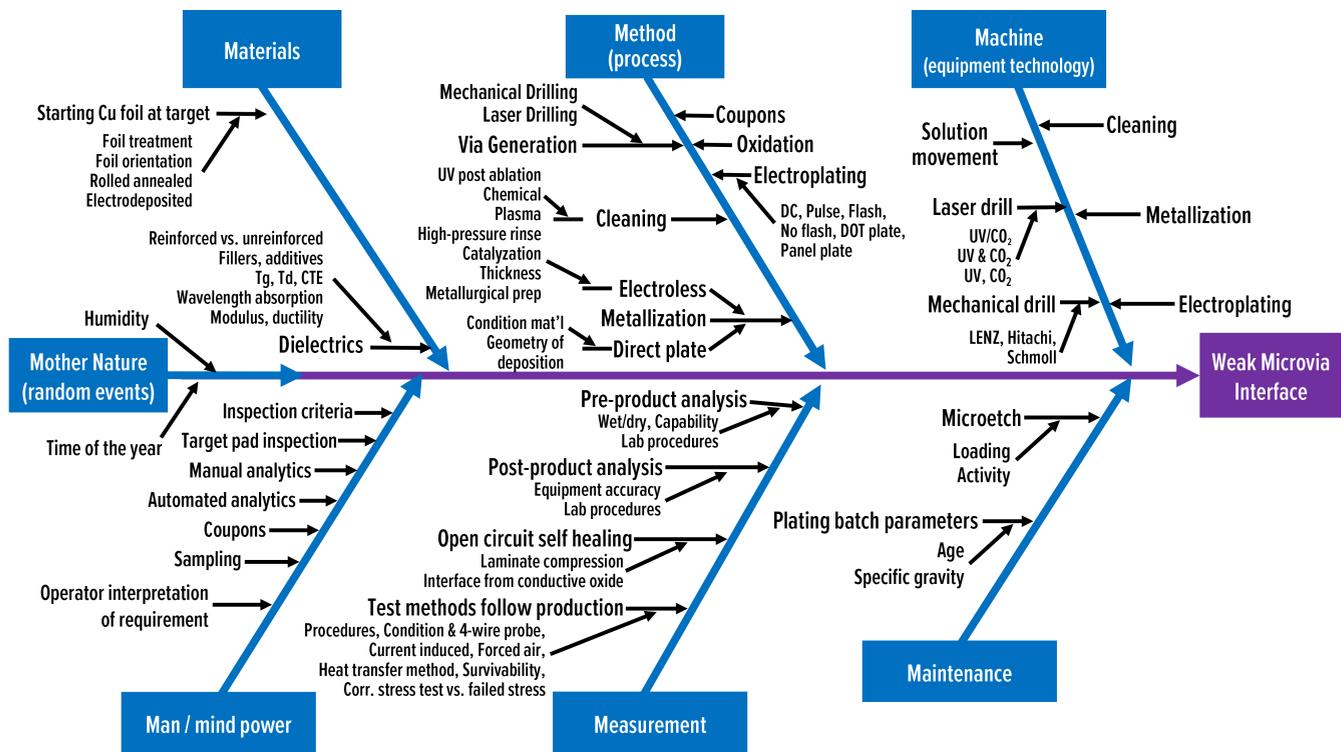


Figure 1: Fishbone depiction of microvia interfacial fracture issue. (Courtesy of IPC-V-TSL and the IPC-V-MVIA committees)

ter brainstorming some ideas and looking for possible linkages, sort them into groupings to better understand the root cause of the problem. A fishbone diagram is particularly useful when you don't have very much quantitative data available, and can only rely on your team's experience. Fishbone diagrams show possible linkages among the critical aspects of machines, materials, people. See an example of a fishbone diagram in Figure 1.

Once the team has set up its test plan based on a narrowing of potential causes, the divide-and-conquer approach will aid in the efforts. For example, if one suspects that thin plating of copper in the hole is caused by problems associated with the electrodeposition process, simply processing the PCB in the acid copper plating solution for the required time and current density should tell whether the copper plating process or the equipment (copper plating anodes, rectifier, or electrical connections, etc.) are the cause. If not, then one must examine the previous steps. Did anyone check the cables leading from the power supply to the plating cell? Are there resistance issues with the

plating racks or other connections that may cause less current to flow into the cell (Figure 2)? Are there discontinuities in electroless copper deposit or direct metallization process causing thin plating? Are there voids in the vias that have not yet been detected? These are just some of the questions to be asked. Only a systematic approach will help solve problems expeditiously.



Figure 2: Acid copper electrolytic plating tank with excellent cable attachments from the rectifier to the bus bars, and multiple connections employed to improve current flow.

Other Essential Skills

There are a few other skills (what we call soft skills) that I see as being absent in many of the facilities I visit. Here are a few of these critical soft skills that one needs to learn:

Design of Experiments

First and foremost, understand how to design an experiment (DOE). This requires brainstorming and certainly a team approach to solving the problem. DOE methods are for engineers to employ during experimentations. Whether it is “problem solving” or “process development,” the DOE experimental methods provide the most efficient means of determining the correct answers, and it is critical for troubleshooting. It also helps one understand those variables that are weighing more heavily on the issue and those that are of little consequence.

Start with a brainstorming session and construct a fishbone diagram or something similar. This will help put in perspective the possible causes of the problem you are seeing. From there, focus on the most likely causes of the defect, then design the experiment to investigate the most likely causes.

TQC/Six-Sigma/Statistics/Curve Fitting

Total Quality Control and Six-Sigma (6S) is the philosophy of continuous improvement through statistical techniques and a commitment to excellence. The PDCA process (Plan-Do-Check-Act) is a central theme using the nine basic tools (cause-effect, process flow, Pareto, scatter, histograms, process capability index, control charts, time-series, and check sheets). A useful book is the free *Statistical Engineering Handbook* available for download

<input type="checkbox"/>	Is the developer chemistry analyzed by the laboratory and is it on a feed and bleed pH controller?
<input type="checkbox"/>	Is ‘breakpoint’ testing performed on the developer for both top and bottom of the core with documented frequency, percent limits and test records?
<input type="checkbox"/>	Is a first article run prior to developing the lot to confirm developer settings and linewidths?
<input type="checkbox"/>	Is there an established frequency that the operator inspects the line for plugged nozzles, conveyor problems and adherences to process parameters?
<input type="checkbox"/>	Is there a manifold nozzle layout and conveyor schedule available and is it used to validate correct equipment setup?
<input type="checkbox"/>	Are there documented maximum final rinse water contamination levels, rinse flow rates and are these verified by conductivity measurements?
<input type="checkbox"/>	Are the panels observed coming off the developer line clean, dry and stain-free?
<input type="checkbox"/>	Is there a documented allowable rework procedure with appropriate quality checks?
<input type="checkbox"/>	Is there a documented O/L strip/rework procedure with proper quality controls and traceability?
<input type="checkbox"/>	Is there a system in place to identify the linewidths to be measured on a panel?
<input type="checkbox"/>	Are Gage R&Rs performed on a routine basis for the linewidth measurement system? If yes, is it current?
<input type="checkbox"/>	Are all repaired boards identified for traceability?
<input type="checkbox"/>	Is there a documented maximum hold time for panels with laminated photoresist before copper plating?

Table 2: An example of just one failure mode related to use of an inner layer bonding process.

from NIST^[3]. A fundamental place to start is with “Select the Right Statistical Tools” (Measurement System Analysis, SPC, Comparative Methods or DOE).

FMEA

FMEA is the failure mode effect analysis^[4] and is critical for problem solving. The link in the reference provides an in-depth overview of FMEA.

An example of just one failure mode related to use of an inner layer bonding process is shown in Table 2. Of course, there are multiple process steps to consider. Here for purposes of illustration, we only show issues related to lack of uniformity of the coating appearance. Note that the higher the value in the severity column, the greater the effect on the defect.

Certainly, there are additional skills I would recommend, including improving one’s technical writing skills. However, what about acquiring additional skills related to PCB fabrication and assembly? This is where IPC comes in.

IPC Standards and Certification

Preparing your workforce to successfully face challenges inherent in today’s complex manufacturing environment may be the most important investment management makes. Certainly, equipment and automation are significant investments. However, without a well-trained workforce, these investments will be very slow to pay off.

This all starts with the standards. Why use IPC standards? First, adoption of IPC standards across the electronics industry supply chain enhances the quality and the reliability of electronics products. Adoption and use of IPC standards drive quality of the finished product as well as the consistency of the processes used in the fabrication of the device including printed circuit board and printed circuit assemblies. Train your employees in the understanding and use of these workmanship standards. When you build product to IPC

standards, there are several other quantifiable benefits to your business. These include:

- Increased customer satisfaction
- Improved production efficiencies
- Improved final yields
- Improved workforce performance

A hidden benefit of improved workforce performance is that the employees associated with the process gain a deeper connection to their job and gain additional pride in what they are doing. When you have a high-quality and consistent manufacturing process, yields go up, product is delivered to the customer on time and in full, and rework is minimized.

IPC has multiple workforce training programs available in various formats including in-person training and through IPC Edge^[5] (the online educational and training portal of IPC).

While this article only brings to light several of the critical skills and tools required for optimizing performance, there are other skills and tools that at some point should be considered. However, if one can acquire or improve on the skills we outlined here, one will achieve a much deeper understanding of critical aspects of the printed circuit board fabrication process and in turn ensuring the product is of the highest reliability. As always, understanding linkages between processes, materials, and manufacturing operations will provide the team with more effective and efficient problem-solving resolution. **PCB007**

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Michael Carano is VP of technology and business development for RBP Chemical Technology. To read past columns or contact Carano, [click here](#).



Increasing Productivity Through Training

Feature Article by Jahr Turchan
BLACKFOX TRAINING

When I think of a manufacturing organization, I think of a “well-oiled machine”—a complex system of unique parts that work together to create something wonderful. This is a funny comparison to me, though, as most times actual machines are being employed to produce or assemble components at some point in the manufacturing process. While this “machine” consists of many working parts—such as systems, materials, actual machines, processes, and procedures—undeniably the most important component is the workforce. Our employees are also where we have the largest opportunity to have a substantial impact on the manufacturing process as we work toward excellence in operational management. Here, I will share feedback from training our clients and students as well as some training best practices.

One might think that such a substantial impact would require massive amounts of resources such as money and time (of which

we all wish we had more), but that is not the case. Repeatedly, research has shown that productivity will increase when proper training is made available to the manufacturing workforce. We know that employees who gain new skills become more confident, get stimulated and engaged, and are more satisfied with their employment. It can also help to revive old skills not practiced in a while. This concept of improved productivity has been studied and proven time and time again. In a study conducted by the National Center on the Educational Quality of the Workforce in over 3,100 U.S. workplaces, they showed that on average if there was an increase by 10% in workforce education, an 8.6% increase in productivity would follow.^[1]

Too often when we think of training our manufacturing workforce, we focus on the shop floor. We look for opportunities mainly with those who are doing the making. We need to cast a wider gaze as the manufacturing process is not limited to the manufacturing floor. Quality, engineering, sales and marketing, logistics, and even accounting/finance are

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Jahr Turchan

all part of the process that starts with a business plan and culminates with your trinket in the hands of your happy customer. All departments make up that “well-oiled machine.”

Training members from one department about the processes and skills required in another department will help those units to work together better. This also leads to an increase in understanding, empathy, and respect between departments. For example, when the quality engineer inspects parts and finds defects, they are more likely to care about why the part is defective and what part of the process failed. This is invaluable, especially when activities such as root cause analysis are required to determine failure modes. They are also less likely to just stamp “REJECT” on the part and kick it back over to manufacturing to deal with. With increased communication comes increased quality. In another example, when your salespeople have a keen understanding of your manufacturing processes, they are more likely to have effective sales interactions, like knowing when a certain opportunity fits perfectly into your niche, or when to walk away and not waste the time of the engineering department.

This kind of cross-training is increasingly easy to implement. Self-paced online courses can be taken anytime and anywhere—such as at an employee’s desk during lunch or on a cell-phone during mid-cycle downtime on the factory floor. At Blackfox, we have seen that employees will complete a significant amount of learning on their own personal time in the evening hours and on weekends, too. They comment that they appreciate when their employer gives them the opportunity to learn and advance themselves. It is probably no surprise that many of these go-getters are also asking to get their hands on the leadership training courses so they can help secure internal advancement.

A common question we see is, “What is the best way to implement training in our organization?” First, a good training partner is an invaluable resource. Solid training partners will be able to suggest and curate the most appropriate content for your training needs. They can help you build a training plan for optimal delivery across your organization, and they will be able to offer multiple mediums from which your employees can receive training. A highly effective scenario is a combination of training mediums such as self-paced training, on-the-job training (OJT) and instructor-led training (ILT).

Self-paced training that happens when time is available is complemented by OJT. The best OJT is structured and aligns with self-paced material, bridging the gap to apply theoretical knowledge to what your company does specifically. When possible, incorporate instructor-led training as well. Bring in outside experts. Your internal experts (who are likely not trained to be trainers) will probably pick up some new stuff too. Outside experts can deliver instructor-led training remotely or in person. This material can also be based on a set curriculum, and some experts train on content and curriculum specific to your company’s needs.

After you implement a new training program—whether it is comprehensive and in-

cludes a multitude of hard and soft skills, or a small and pointed collection of technical skills for a set purpose—you will begin to see a difference immediately. Employees being trained are most often highly engaged. They can't help but find ways to apply it to their daily activities. If the training being delivered was appropriately picked, it will be immediately applicable. Blackfox's training clients have reported that they rapidly see an increase in engagement with students discussing the materials, and an overall increase in morale among the students receiving the training. Similarly, I have gotten personal feedback from students that they like how digestible the content can be, and it allows them to immediately apply it to their job. They also say that it spurs them on to do additional self-appointed research into the topics they are studying.

Conclusion

A document from Honeywell lists the 10 steps to improve operational efficiency^[2], and there is a reason why “Train, train, and train again” is step 2. The immediate operational impact and the countless additional benefits that come from a well-implemented training program will pay dividends back into your company quarter after quarter, year after year. Make training integral to your healthy corporate culture and your bottom line will thank you for it. **PCB007**

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Jahr Turchan is director of Veteran Services and Advanced Manufacturing Programs at Blackfox Training Institute.

Chill Out: Advanced Solar Tech Runs Cooler, Lasts Longer

Australian photovoltaics researchers have made a ‘cool’ discovery: Singlet fission and tandem solar cells—two innovative ways to generate solar power more efficiently—also help to lower operating temperatures and keep devices running for longer.

Tandem cells can be made from a combination of silicon—the most commonly used photovoltaics material—and new compounds like perovskite nanocrystals, which can have a larger bandgap than silicon and help the device to capture more of the solar spectrum for energy generation.

Singlet fission, meanwhile, is a technique that produces twice the electronic charge carriers than normal for each photon of light that's absorbed. Tetracene is used in these devices to transfer the energy generated by singlet fission into silicon.

Scientists and engineers around the world are working on the best way to incorporate tandem cells and singlet fission processes into commercially viable devices that can take over from conventional, single junction silicon solar cells commonly found on rooftops and in large-scale arrays.

Now, work conducted by the School of Photovoltaic and Renewable Energy Engineering and the ARC Centre of Excellence in Exciton Science, both based at UNSW in Sydney, has highlighted some key advantages to both tandem cells and singlet fission.

The researchers showed that both silicon/perovskite tandem cells and tetracene-based singlet fission cells will run at lower temperatures than conventional silicon devices. This will reduce the impact of damage from heat on the devices, extending their lifespan and lowering the cost of the energy they produce.

(Source: ARC Centre of Excellence in Exciton Science)



Optimizing Your Manufacturing Operations

SMT Solver

Feature Column by Ray Prasad, RAY PRASAD CONSULTANCY GROUP

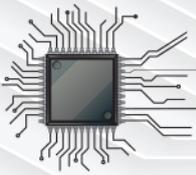
Optimization of manufacturing operations is a broad subject; in fact, it is broad enough that MBA and PhD degrees are awarded in operations management and multiple books have been written on the subject. Operations management is an amalgamation of technical and business issues. We are not writing a book here but if you take a 50,000-foot view of the subject we should ask: What is the focus of manufacturing operations?

The way I see it, there are only two things: quality and delivery. This is essentially the focus on the factory floor. Why? Because the customer cares about getting a quality product and getting it on time. When you analyze feedback from your customers, what are the main complaints the customers have about their suppliers? It's the same: quality and delivery.

To optimize manufacturing operations, you must set up a strong internal manufacturing infrastructure. You need this to deliver high quality products on time, to keep your customers happy, and to run a profitable operation. You cannot do this without the help of your employees and suppliers—two of the major stakeholders in the company besides the owners.

We often see headlines about the current state of poor infrastructure. While not everyone agrees on the definition of infrastructure, most agree that roads, bridges, airports, water, sewer, internet, and the power grid are part of infrastructure. But for the functioning of a modern society, if you include as part of the infrastructure the well-being of the populace in general—not just a privileged few—and the sustainability of our planet, you will find a

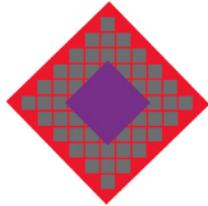




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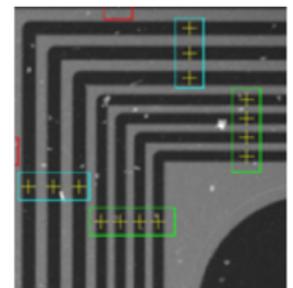
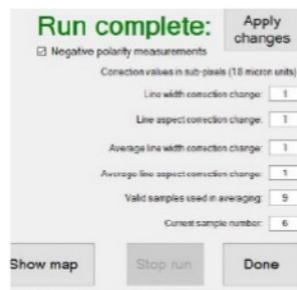
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variety of opinions. I am not an expert in these political and social areas, but it serves as an example to define infrastructure.

Similarly, in the electronics industry, there is no disagreement on the basics of manufacturing infrastructure—appropriate buildings, offices, manufacturing spaces, and all the necessary equipment for building your products. However, you need more than the building and the machines. Having the right machines for the job is important but it is not sufficient to achieve high yield on a consistent basis.

What You Need to Optimize Manufacturing

Machine Characterization

What else do you need besides the equipment? In addition to equipment operating procedures provided by the suppliers, you also need to fully characterize each machine and create an equipment characterization document for each piece of equipment. Since every machine has its own idiosyncrasies, this allows the operator to thoroughly understand all the peculiarities, eccentricities, and quirks of each machine. You know you have fully characterized your machine if you can produce a defect on demand. Of course, you will never do that, but you know you can. Characterizing the machine is about understanding all the equipment-dependent variables and how they impact product quality and output. Very few companies have such documents. In addition to equipment characterization documents, you also need equipment maintenance and calibration procedures to produce a product with consistently high quality.

Process Recipes

Then there is a process recipe that you need for each process on the manufacturing floor. This is not equipment-dependent documentation. It has nothing to do the machines themselves but with the process performed by those machines. Examples of such documen-

tation would be handling and printing of solder paste, and developing the product-specific profile. We need a document for each step of the manufacturing process, such as storage of moisture-sensitive boards and components, adhesive and paste printing and dispensing, placement of components, soldering, rework, cleaning, inspection, and test. These are company specific, internally developed documents and very few companies have these process documents, as is the case for the equipment characterization document mentioned earlier.

DFM Documents

Having the process and equipment documentation is not going to be enough. The products being built must be designed correctly. Just because the defects are seen in manufacturing does not mean that the root cause lies in manufacturing. How the product is designed plays a key role. That means having a company specific, internally developed design for manufacturing (DFM) document that includes component selection, design guidelines, and rules. Unfortunately, DFM is another company-specific document that very few companies have.

Standards and Certifications

There are companies who think that since they are ISO9000 certified, they have all the documentation that they need. If that was true, no one would have quality issues since almost all companies are ISO-certified. Nothing could be further from the truth. The reality is that these days most companies claim to have process recipes since most of them are now ISO-certified. ISO certification is a good thing but very often it is more of a marketing tool and not helpful for building products with high yield. The ISO requirement is, “Say what you do and do what you say.” Most companies do not say much and keep their ISO documents too general with no specific details about the design and process so that they can easily pass and keep their ISO certification when audit-

ed by ISO inspectors. You need specific details and not generalities.

Also, most companies think that since they have IPC standards, that is all they need. No, it's not. Having chaired a half-dozen IPC documents over the years, IPC standards are trying to solve world hunger. What I mean by that is: IPC standards are general in nature to incorporate requirements for all applications. As a company, you are concerned only about your products and applications, so therefore, you need to have your own requirements. Yes, you can use IPC standards where it meets your requirements.

In addition, IPC standards are not specifications. Specifications are written by the company that writes the checks. That means you. You need to have custom documents to meet your product requirements based on the market that you serve. You do need IPC standards but use them as a guideline to develop your own customized process and design document.

Training

Having the right design, good quality incoming materials, and an in-house process document are necessary but not sufficient. Training of personnel at all levels, from senior managers to engineers, operators and purchasing agents is critical for addressing all the issues needed to improve yield. No one gets up in the morning and says, "I am going to screw up three things today." So, it is management's responsibility to provide training at all levels. Again, training is one area where you will see a wide variation in different companies. And what do you need to train your personnel? You need the three documents I discussed earlier. The documents are developed by a few engineers in the company. They know what is in those documents. You need to use those documents to develop your training program and spread the knowledge about those documents across all your employees who need to know.

In addition to leading the SMT team, one of my roles at Intel decades ago was to train engi-

neers (with the help of many of my colleagues). My job was to develop those documents and teach the classes. I did this one every quarter for five years.

A Case Study

Here is another point worth keeping in mind: Even when a board is designed by the customer and built at different locations of the same company, the quality results can be vastly different. And the quality results are also different when the same board is built by different companies. Let me give you a real-life example.

I served as a technical expert in a large legal tax case between the IRS and a major U.S. OEM involving a \$1 billion tax liability. The case lasted over two years and was finally tried in U.S. tax court; the IRS lost the case. In the case, the OEM designed the board in the U.S. and built it overseas in its own subsidiary. They also built the same board at different EMS companies in the U.S. and paid about the same amount for assembly of those boards to all the suppliers, including their own subsidiary.

However, the IRS had a problem with the OEM paying the same amount to its own subsidiary as what it had paid to its U.S. suppliers. According to the IRS, the OEM should have been paying less to its own subsidiary since it was in a low-cost country. According to the IRS, the only reason they were paying an excessive amount to their subsidiary was because the OEM wanted to reduce their profit in the U.S. where profit is taxable, while increasing and their profit overseas where there is no tax on profit.

The IRS had two reasons for their argument: the subsidiary was in a low-cost country, and the board was designed in the U.S. The IRS asserted that DFM is the key to quality, basing this on my book, *SMT Principles and Practice*. As design was the difficult part of the process, manufacturing cost should have been determined essentially by the labor cost.

Well, the OEM was not just going to write them a check for \$1 billion in back taxes, so they sued the IRS. The only reason I got in-

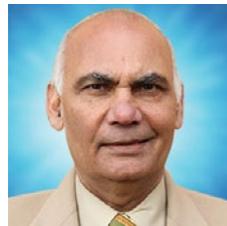
volved in this case was that the IRS was using my book to make their case. The lawyers for the OEM contacted me and wanted to know if I was quoted correctly by IRS. I was not. They quoted only part of a paragraph that dealt with the DFM and conveniently forgot to mention additional paragraphs that discuss the importance of other variables such as manufacturing processes, documentation, and training.

I visited and audited all the major suppliers in the U.S. and overseas who built this board, looking at quality results on this product. The finding, to my amazement, was that all the U.S. suppliers except one had higher defect rates than their own overseas subsidiary. This was a complicated product with fine pitch devices and no-clean flux—a relatively leading-edge technology at that time. The reason their own subsidiary had much better results than anyone else was because of a well-trained workforce, great documentation, and a focus on continuous improvement—essentially a world-class manufacturing operation that deserved the same if not more for producing higher quality product. Selling price is not determined by your cost but your quality. Selling price is determined by the market. Cost and quality are determined by the company.

To make a long story short, after two years of investigation and a trial, the government not only lost the case, but was required to pay a \$21 million refund because the OEM claimed overpayment of taxes. That more than covered their cost of suing the IRS.

Conclusion

Quality and on time delivery are the two main challenges in a manufacturing operation. Having a strong internal manufacturing infrastructure is the key. It involves selecting the right equipment, working with your suppliers and customers, developing company-specific design and process documents, and training of personnel at all levels to produce high quality product on a consistent basis. Having a strong internal infrastructure of written, internally developed design and process documentation is the foundation you need to optimize your process. Producing good quality on a consistent basis requires a strong internal manufacturing infrastructure to succeed in a competitive global economy. **PCB007**



Ray Prasad is the president of Ray Prasad Consultancy Group and author of the textbook *Surface Mount Technology: Principles and Practice*. Prasad is also an inductee to the IPC Hall of Fame—the highest

honor in the electronics industry—and has decades of experience in all areas of SMT, including his leadership roles implementing SMT at Boeing and Intel; helping OEM and EMS clients across the globe set up strong, internal, self-sustaining SMT infrastructure; and teaching on-site, in-depth SMT classes. He can be reached at smtsolver@rayprasasd.com and offers in-depth SMT classes. Details about classes can be found at rayprasad.com. To read past columns or contact Prasad, [click here](#).



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Keep the Tools Sharp

Testing Todd

Feature Column by Todd Kolmodin, GARDIEN SERVICES USA

Quality is not just an action; it is a way of life. We can say we are quality conscious but as the days pass the discipline can fade. The tools become worn, dull, and finally discarded. This is common in the human psyche; when we do not keep focused or refresh on disciplines, we tend to “forget,” skip steps, or ultimately stop the practice entirely. So, we must revisit the tool shed periodically to make sure our tools are razor sharp and at the ready.

In the quality arena, that means brushing up on work instructions, maintenance procedures, training reviews, and overall workplace awareness. We can do this in a variety of ways. This month I’ll outline a few ideas that have worked well for me in the past and may be useful to you as well.

Training

This goes without saying. We cannot produce a product or manage day-to-day operations unless we know what we are doing, right? Having a robust training program is a must. This should include the use of procedures or work instructions. Employees should be able to reference these documents any time they have questions on any of the tasks they are required to perform. However, just having the documentation available is not enough. There should be a periodic review of the employee against the work in-

struction and/or procedure. Just training or scoring them once and setting them free is not enough and can result in difficulties in the later rounds. Employees should be reviewed at least annually for continued proficiency. This is where inconsistencies can be uncovered and corrected.

Quizzes

Creating and providing random quizzes regarding employee tasks or company procedures is a great way to keep important items at the forefront of awareness. These could be compiled as excerpts from specific work instructions, workflow reviews, customer interaction, or company policies. These don’t necessarily have to be performance evaluations but can be more about gauging the pulse of how a specific item is working and whether there needs to be any “sharpening.”

Video Tutorials

We all learn in different ways. Some can simply read a document and be totally fine with it—off they go. Others tend to be visual learners, thus video tutorials can be a strong tool to help these learners. There are many options out there to create tutorials. They can be basic PowerPoint tutorials, humorous doodle videos, or even live footage videos. The options seem endless. This engages the



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students/employees into the activity and provides a strong vector for learning.

Audits

Audits usually strike fear and anxiety when the term is even mentioned. However, this activity is not intended to be feared. This is a valuable tool to review a process, work instruction, or even a production area. The idea is to ascertain whether everything is working as intended and identify any possible challenges that require attention. This can simply be employees in a certain workspace reviewing their tools and supplies, equipment, and general work environment. It also can be more in-depth to review key performance indicators (KPIs) to see whether predetermined outputs are being maintained.

QMS Review

Finally, the actual system should receive periodic reviews. This is a requirement in ISO9001. If the tool shed is in disrepair, how can we tune up our operations? Work instructions, procedures, and company policies should be reviewed to make sure they are always ready to support the team that needs them. We need to make sure our team has the tools they need when they need them.

Stay sharp, my friends! PCB007



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

Tiny, Wireless, Injectable Chips Use Ultrasound to Monitor Body Processes

Widely used to monitor and map biological signals, to support and enhance physiological functions, and to treat diseases, implantable medical devices are transforming healthcare and improving the quality of life for millions of people. Researchers are increasingly interested in designing wireless, miniaturized implantable medical devices for in vivo and in situ physiological monitoring. These devices could be used to monitor physiological conditions, such as temperature, blood pressure, glucose, and respiration for both diagnostic and therapeutic procedures.

Researchers at Columbia Engineering report that they have built what they say is the world's smallest single-chip system, consuming a total volume of less than 0.1 mm³. The system is as small as a dust mite and visible only under a microscope. In order to achieve this, the team used ultrasound to both power and communicate with the device wirelessly. The study was published online May 7 in Science Advances.

"We wanted to see how far we could push the limits on how small a functioning chip we could make," said the study's leader Ken Shepard, Lau Family professor of electrical engi-

neering and professor of biomedical engineering. "This is a new idea of 'chip as system'—this is a chip that alone, with nothing else, is a complete functioning electronic system. This should be revolutionary for developing wireless, miniaturized implantable medical devices that can sense different things, be used in clinical applications, and eventually approved for human use."

The design was done by doctoral student Chen Shi, who is the first author of the study. Shi's design is unique in its volumetric efficiency, the amount of function that is contained in a given amount of volume. Traditional RF communications links are not possible for a device this small because the wavelength of the electromagnetic wave is too large relative to the size of the device. Because the wavelengths for ultrasound are much smaller at a given frequency because the speed of sound is so much less than the speed of light, the team used ultrasound to both power and communicate

with the device wirelessly. They fabricated the "antenna" for communicating and powering with ultrasound directly on top of the chip.

(Source: Columbia University)



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Fein-Line Associates is a consulting group serving the global interconnect and EMS industries, as well as those needing contact with and/or information regarding the manufacture and assembly of PCBs. Dan (Baer) Feinberg is a 50+ year veteran of the printed circuit and electronic materials industries. Dan is a member of the IPC Hall of Fame; has authored over 150 columns, articles, interviews, and features that have appeared in a variety of magazines; and has spoken at numerous industry events. As a technical editor for I-Connect007, Dan covers major events, trade shows, and technology introductions and trends.

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Dan (Baer) Feinberg



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ein Electronics Industry News and Market Highlights



Cisco Embraces Intel Innovation, Updates Server Portfolio ▶

Cisco has announced new server solutions supported by 3rd Gen Intel Xeon Scalable processors to bring new performance and security capabilities to customers' hybrid cloud infrastructure.

WIMI Hologram Cloud's AI Vision Aiming at the 100 Billion Market ▶

MobiusTrend, a market research organization, recently released a research report: "WIMI Hologram Cloud's AI Vision Aiming at the 100 Billion Market and Lidar Has 'New Force.'"

Renesas Collaborates with Qualcomm Technologies ▶

Renesas Electronics Corporation, a premier supplier of advanced semiconductor solutions, has expanded its ongoing work with Qualcomm Technologies, Inc., a leader in wireless technologies, to include 30W wireless charging capabilities for mid-range smartphones powered by the latest Qualcomm® Snapdragon™ 780G 5G Mobile Platform.

A Breakthrough Enables Practical Semiconductor Spintronics ▶

It may be possible in the future to use information technology where electron spin is used to process information in quantum computers. It has long been the goal of scientists to be able to use spin-based quantum information technology at room temperature.

Dye-based Device Sees the Invisible ▶

Scientists in Europe have designed an organic dye-based device that can see light waves in the shortwave infrared range.

European Semiconductor Market Grew 6.8% in February YoY ▶

European semiconductor sales in February 2021 reached US\$ 3.482 billion, an increase of 6.8% versus the same month one year ago, the European Semiconductor Industry Association (ESIA) reported on April 5, based on World Semiconductor Trade Statistics (WSTS) data.

Lenovo Outlines Company Transformation Strategy ▶

During its annual global employee kickoff event broadcast to 63,000 employees, Lenovo unveiled its plans to drive transformation from a global devices company to a technology leader in global devices plus solutions, services, and software.

Cadence Collaborates with Samsung Foundry ▶

Cadence Design Systems, Inc. announced that it has optimized the Cadence® digital 20.1 full flow for Samsung Foundry's advanced-process technologies down to 4 nm.

Researchers Harvest Energy from Radio Waves to Power Wearable Devices ▶

From microwave ovens to Wi-Fi connections, the radio waves that permeate the environment are not just signals of energy consumed but are also sources of energy themselves.

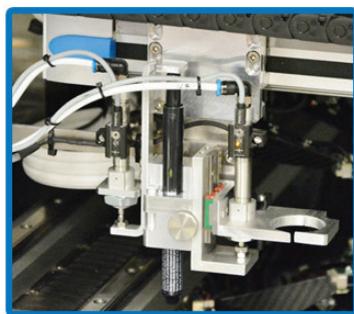
Siemens, SAP Expand Partnership ▶

SAP and Siemens Digital Industries Software announced an expansion of their partnership that will enable both companies to deliver new solutions for the Service and Asset Lifecycle.

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IPC Education Foundation Lessons Learned

Foundations of the Future

by Charlene Gunter du Plessis, IPC EDUCATION FOUNDATION

Looking back on our second year, the IPC Education Foundation (IPCEF) takes pride in how we adjusted our engagement initiatives during the pandemic. We couldn't rely on our original strategy of hosting and attending a range of in-person activities and events. So, we shifted our focus and launched a variety of digital and virtual engagement activities to share information about the electronics manufacturing industry with students, teachers, and anyone else interested in this potential career path.

The Foundation held 10 informative webinars covering a wide range of industry-specific topics, and conducted 28 interviews with IPC student members, IPC Emerging Engineers, industry representatives, and IPC leadership to share knowledge about career paths into the industry; this led to blog posts, articles, and social media campaigns. The Foundation successfully reached more than 110,000 individuals and engaged with more than 5,500 individuals through these activities.

But even though we reached a lot of potential talent, we also realized that these online mediums led to several challenges. COVID fatigue is real: Students receive an overwhelming amount of online content from their classes, organizations, and extracurriculars. There is a lot of information out there and students need to be extremely selective on what to attend or register for. My colleague, program manager Aaron Birney, reached out to our student members and the general consensus was that the students desire in-person sessions and

would welcome time away from their computer or laptop screens. Student members also shared that they would be more likely to attend virtual events if it would directly impact their personal career journeys.

That was the reason behind the IPC APEX EXPO Career Panel for 2021. It was important to find a group of panelists that has extensive knowledge about the industry from well-

IPC | EDUCATION FOUNDATION

**BUILD YOUR FUTURE:
APEX EXPO CAREER PANEL**

Moderated by:
John Mitchell
President & CEO
IPC

Friday, March 12: 12:30pm-2:00pm CT

The IPC Education Foundation will host a panel of engineers and business leaders for 90-minutes to engage students considering a career in the electronics industry.

Joe O'Neil
CEO

Sarah Czaplewski
Reliability Engineer

Brittney Nelson
Product Engineer

Christina Trussell
Production Engineer

Daniel Heitner
Process Engineer

Paige Fiet
Engineering Intern

GreenCircuits | IBM | CISCO

BLUE ORIGIN | SUMMIT | Calumet

Zoom Webinar - Register at bit.ly/3cAp3GL

Figure 1.

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Figure 2.

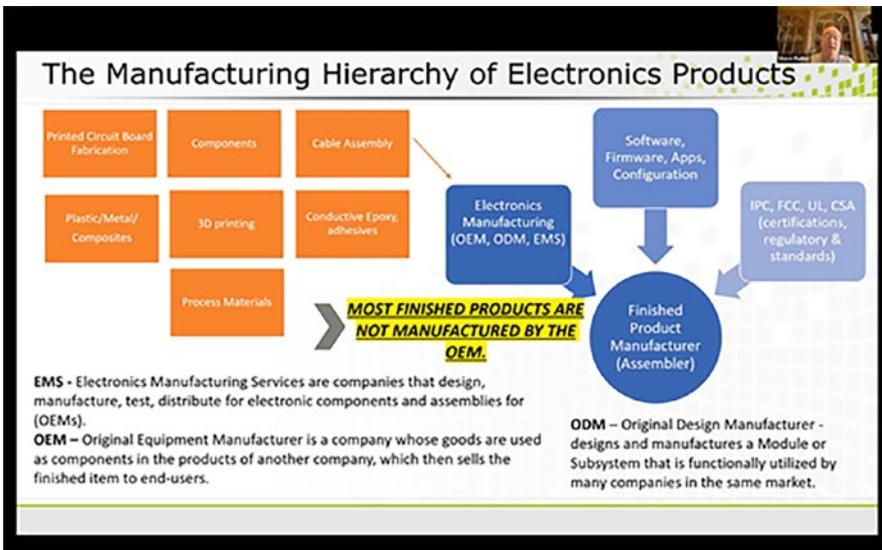


Figure 3.



Figure 4.

tatives: Joe O’Neil, CEO, Green Circuits; Sarah Czaplewski, reliability engineer, IBM; Brittney Nelson, product engineer, Cisco; Christina Trussell, production engineer, Blue Origin; Daniel Heitner, process engineer, Summit Interconnect; Paige Fiet, engineering intern, Calumet Electronics; and Jie Fu, design for manufacturing engineering manager, Apple.

The virtual event kicked off with two presentations aimed at informing students and educators of the entire electronics manufacturing industry, and subsequently pique their interests in the emerging technologies. Two IPC Hall of Fame Award winners accomplished this objective: Steve Pudles, CEO, Zentech Manufacturing, shared an overview of the electronics manufacturing industry, and David Hillman, Engineering Fellow, Collins Aerospace, presented, “The Future of the Industry.” Following this, the career panelists shared their personal career journeys, then answered questions from the attendees. The event concluded with a raffle and prizes for a handful of students and educators.

An estimated 624 individuals attended the Career Panel and the feedback we received has been positive. Ninety-four percent of the attendees indicated that they were satisfied with the event and 96% revealed that the information shared was helpful in assisting students with their career jour-

neys. Some additional feedback included:

- “The event was great as we were able to hear from industry leaders with a wide range of experience!”
- “Awesome presentations and panel discussion.”
- “The panelists’ career journey was impactful for students. I would like more emphasis on preparing high school students for STEM-related careers.”

Another valuable lesson the Foundation learned is how important it is to share afterward the information, content, and the discussions of these online events. Recording the panel or webinars has been invaluable for sharing this information to those who cannot attend a live event. We created our own YouTube channel to house past webinars and events for anyone who couldn’t attend—even allowing some educators to replay parts for a class or assign specific videos as supplements to coursework.

Therefore, the lessons learned from our engagement initiatives are:

- Share valuable industry content
- Host an event during a favorable time, making it easy for students and teachers to attend
- Get participation from high profile companies
- Identify knowledgeable speakers, panelists, or participants

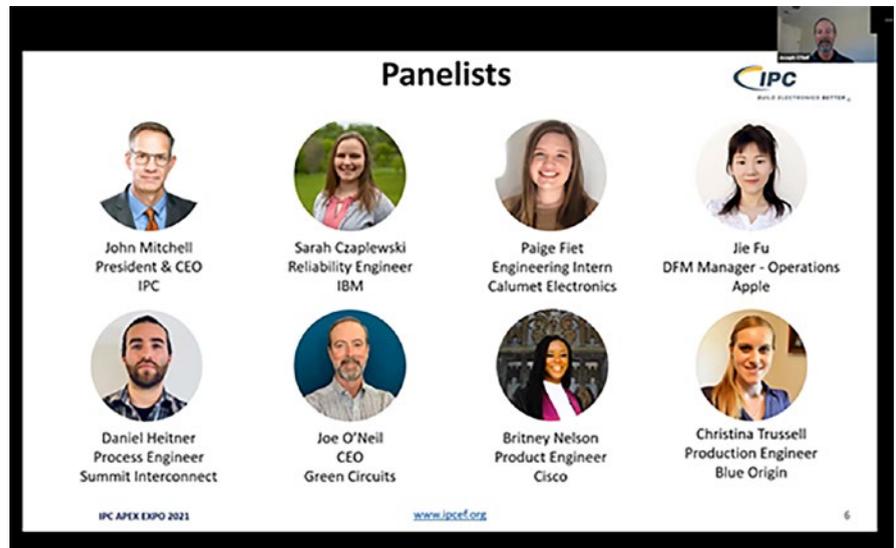


Figure 5.

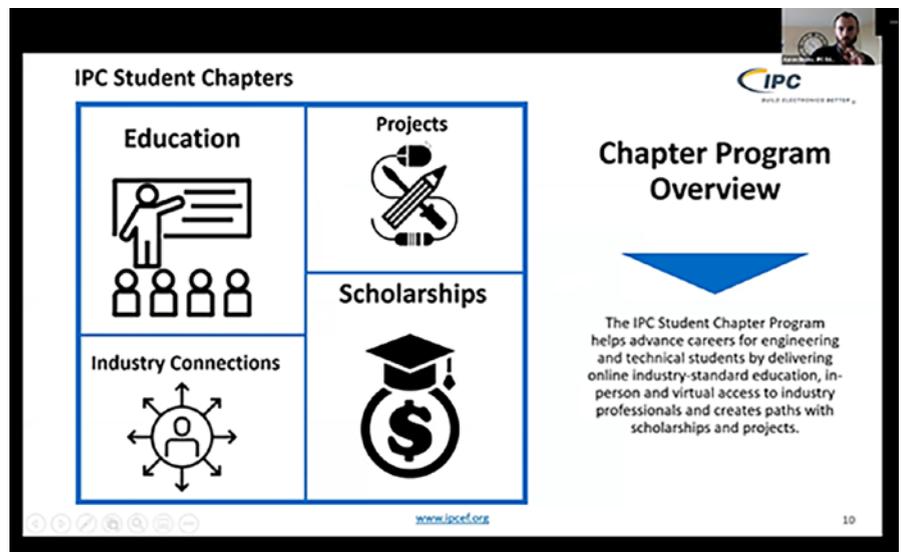


Figure 6.

- Record the session to share afterward
 - Always be willing to receive feedback
- PCB007**



For more information about the IPC Education Foundation, please reach out to **Charlene Gunter du Plessis**, senior director of the IPC Education Foundation at charlenegunter@ipc.org.

To read past columns or contact Charlene, [click here](#).



Alex Stepinski on Zero-Waste Facilities

Interview by Barry Matties

I-CONNECT007

Since he began his work at Whelen Engineering a few years ago, Alex Stepinski has redefined the way we think about manufacturing printed circuit boards.

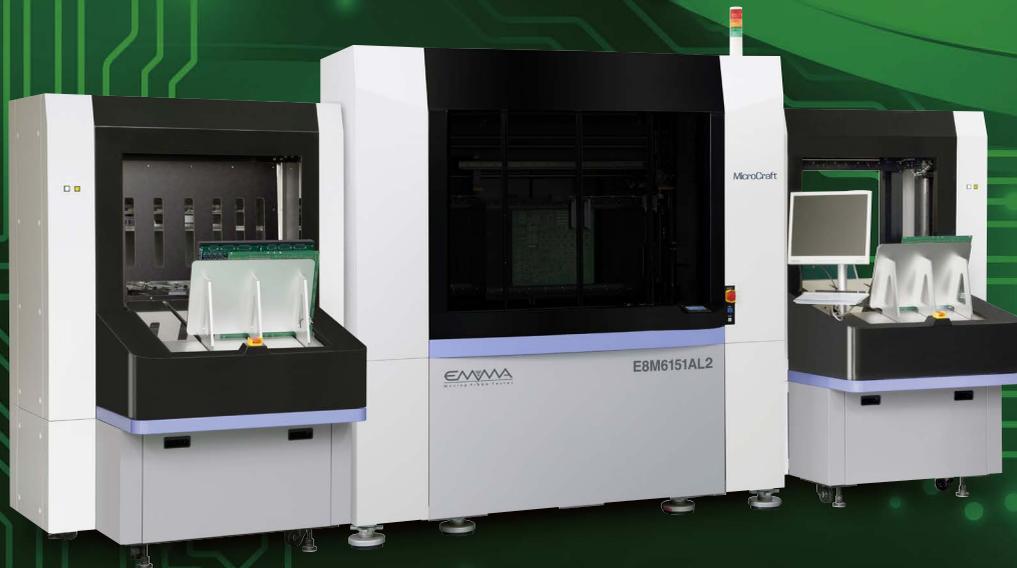
Whelen was a garage startup by George W. Whelen in 1952. The company designs and manufactures warning lights, white illumination lighting, sirens, controllers, and high-powered warning systems for automotive, aviation and mass notification industries worldwide. When Alex joined, his job was to bring printed circuit board fabrication in-house. At the time, Whelen was purchasing its boards from abroad. Alex saw this as a chance to completely reimagine the way boards were produced; his goal became to build an automated factory from the ground up. This was not an easy challenge by any means; in fact the challenge became more complicated when he learned (after he accepted the job) that, due to local regulations, the factory had to be a zero-wastewater facility.

After spending countless hours on airplanes to visit factories and suppliers all around the world, Alex began building the new “zero-waste” captive facility. After only a few years of operation, the factory was a clear success—so much so that the decision was made to upgrade the facility to produce leading-edge boards. This was the birth of GreenSource Engineering. It was decided that the new iteration would be more than a captive facility, it would also be a merchant shop. Alex and team then set out to build a completely new facility and, within in a few years, they transformed the first facility from primarily producing single- and double-sided boards into a facility producing some of the highest tech boards in the world. This was not a simple task. In fact, along the way one of their key equipment suppliers faced challenges that put their entire business at risk. So, mid-stream, GreenSource acquired the company and took on the challenge of both managing the acquisition of a troubled company and building the new facility.

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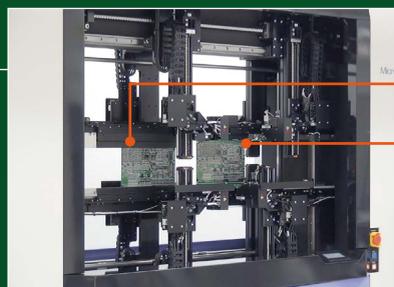
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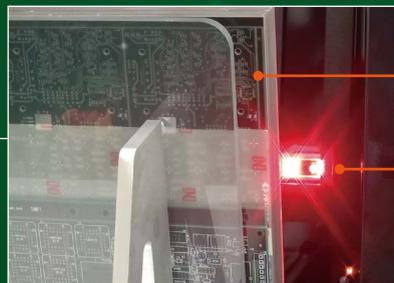


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During this period, Alex also refined the zero-waste system, and made it a commercially viable product for others. It was also becoming clear that—with the zero-waste system and the success of building not just one, but two automated PCB facilities—there was an opportunity to help others set up their own captive shops. As Alex explains, it's much more than just setting up a new facility; the business model GreenSource is bringing provides hands-on training for the staff that Alex's customers need to run their new factory.

Now Alex and team are building boards and the equipment to produce those boards. They are also developing a software business to produce tools that bring Industry 4.0 platforms to other PCB fabricators. This tool, of course, is based on their real-world experience building and running two automated PCB facilities.

The following interview with Alex discusses the two factory projects he is working on with SEL and Vicor, along with an update on the zero-waste system and the software development business.

Barry Matties: Alex, let's start with the new factories you are currently working on.

Alex Stepinski: We have two active projects right now. There are other factory projects in our pipeline that are proceeding; we're not under contract yet, but we're in the early stages. The scale of those projects is anywhere from about 30% less the size of Vicor, to about five times the size of SEL. That's the range of what we've been exposed to so far. For many people we're meeting with, this is their first foray. PCB is like an exotic industry nowadays, especially since we're using a combination of processes that most OEMs aren't used to seeing. This has always been the case with the PCB industry, though; it's been very convenient for them to outsource it somewhere because it's a pain to deal with.

Our solution is to educate the OEMs on how to do it themselves. As we saw at Vicor, learn-

ing the PCB processes and how to make better products improves your product development. Then you start to consider totally new ways to do things, which you can see at Vicor. They did a whole new product line leveraging what were historically PCB processes and taking them into a completely different application. Because of this situation, I don't see that we're the guys who are going to drop an Asian-scale factory in Nebraska, or something like that. That's not us. What we can do, though, is say, "Hey, we can help you design the work cells, we can provide some amount of equipment, and we can help you broker the equipment." We provide consultation to this kind of client, and we can help by making a demo cell; it's really all about the scale.

PCB is like an exotic industry nowadays, especially since we're using a combination of processes that most OEMs aren't used to seeing.

Matties: Is there a particular size company that you are looking to work with?

Stepinski: If it's the same size as what we've been looking at, sure, we can do the whole thing. But if it's for a crazy-large scale, then we're probably just able to offer the recycling technology, the general consultancy for the whole thing, and then some specific pieces of equipment. If they want more from us, then we can take a more integrated approach, scale up, and add resources.

Matties: Interestingly, when we interviewed SEL, they were talking about the innovation

that will come out of their design and product group because they have their own board shop.

Stepinski: GreenSource was a captive facility, and then we started doing some merchant market stuff. The merchant market stuff led to a lot of R&D because we had a “build it and they will come” approach with GreenSource. We saw what the market wanted, and the biggest thing that the market wants from us right now is SAP—semi-additive processing. The big innovation was taking the SAP processes that people have been using for really small, very dense features, and asking the question, “Why don’t we do this on standard products? Why don’t we do this on RF product?” Now we can improve our tolerances significantly because we don’t have etch loss. We don’t have trapezoidal traces; we have rectangular ones. We are applying it now to more standard products, and we are industrializing the SAP process for standard cores and subs. We even integrate it with resistors, as well.

Basically, you improve your Cpk across the board with SAP, and this is why SEL had some interest. Normally SEL had two- to 12-layer products, so why do they need SAP for what they’re doing? Well, if you’re paying attention to impedance tolerance, then wouldn’t it be nice if you had a really high Cpk and you never had to worry about it again? In a typical PCB shop situation with print-and-etch, you’re typically using the entire spec range. Here you have a much more robust process, a higher Cpk, less to worry about; they like this concept. It’s a future where they have the ability to do this now and then scale up a separate line for something like that, if they want to take that path. And they’re definitely interested in it right now.

Matties: Your transformation is from the captive facility to factory builder, and now beyond as a software solutions provider. You own and now build equipment for the PCB industry specifically for your factory; you have a test

bed for that factory and your software really gives you a huge advantage, I would think.

Stepinski: We have a lot of scaled economies from the integration of all these different pillars and initiatives that we have in the business that we’ve accrued.

Matties: The zero waste obviously is a big contributing factor to the captive facilities. Not having to deal with the pollution side of it makes it a lot easier for them.

Stepinski: That’s the fundamental innovation of the company that sparks everybody’s interest and leads us down the path for helping them with software and the other equipment projects that we do. It’s always the door opener, and then we go from there.

Matties: Let’s talk about the company structure. I know you have GreenSource, AWP, and now you have the software. Are you bringing it all under one umbrella, or will these be separate entities? How does that work?

Stepinski: As you know, I’m not the owner of the company. I’m just the founding talent. And for the startup phase, I have been the managing director of all the business entities. Currently, I’m the MD of GreenSource and AWP. We have development plans in place. We’re adding key resources, doing training internally, and developing people into different roles. We’re going to put a proper structure in place this year; you’re going to see a different version of our company with more key people and less “Alex” as the brand. This is key to making a robust organization. After we’ve done all these great innovations, now is the time to strengthen it, make the company more mature and more solid, then exit the startup phase.

Matties: Let’s talk more about the zero waste. That’s something that I would think the indus-

try would be really keen on. Is this ready for delivery to factories who are looking for it?

Stepinski: We've made a new version of our system. The original version I developed was based on ion exchange with some vacuum distillation. The new version of our system utilizes membrane separation, advanced oxidative processes, selective ion exchange for metals, and some electrowinning; it's a different design. The previous system required rinse water segregation. This new design is a zero-sort system. We have no rinse water segregation in this factory; it's a great innovation. It's just like your recycling at home, when you have three trash cans out front and somebody puts the banana peel in the glass-only bin, it's a problem. The garbage guy doesn't want to pick up your stuff and he sends you a nasty note and you have a bad day.

The current system can combine all the rinses together and it then creates two streams. One is ultra-pure semiconductor grade water, and the other is a concentrated waste that's distilled; it's that simple. And all the metals are removed; we don't have any metal in our sludge. We sell it; we recover it all. The metal recovery actually pays the operating cost of the system. If you look at the economics of a normal board shop, the people are shipping out metal and paying for people to take valuable metal. It's insane. With our process, you pay for the whole operating cost just through metal recovery. This is what we found when we did our analysis.

Both the Vicor and SEL shops are getting this new system. The Vicor factory installation is this summer; the SEL one is in Q2 2022. You're probably going to hear soon that we have a much larger scale project for a recycling system in Asia. I think this is something that will hit the news in the next few months.

I would sell the new system to other people in the U.S., but nobody calls us. And we're not really marketing too much because we're pretty busy. I think most of the board shops in

the U.S., though, are not really interested in this sort of system unless they are forced to do something. It's a non-value-added cost, right? It's not helping them make money.

Matties: But it can help them save money.

Stepinski: You must replace something you already have. It's like when you buy a roof from Tesla—why would you go do it if you have a good roof? When the old roof is dead then maybe the solar roof makes sense instead of the panels. It's the same kind of story. A lot of people have fully depreciated, decades-old wastewater systems in place and it's not easy to change. Our system could fit, though, inside most existing systems.

Matties: If they do decide to change, is it a relatively simple installation?

Stepinski: It is. At an Asian scale, we're at 2–10% the size of a typical system in Asia to do the same thing and everything is recycled as opposed to just throwing it out. In the U.S., however, it's a smaller scale; it's probably like about a quarter of the size of a typical U.S. system. Do people have space? A lot of the industry is in California; there are a lot of restrictions on space there. You have legacy wet process permits and things like that. Since this is the wet process area, you can't do too much with it.

I think the interest so far has come from new factories, as well as people who want to promote being green, for some reason or another. There is also the situation where a factory will be shut down by the Chinese government if they don't do something about it. If you must choose between updating your wastewater system or moving your factory to the other side of China, the wastewater system is typically a much simpler solution.

So, this is how the market looks for us. We see that it's really a high growth area, I think, long term. As more and more people become aware, you realize how much industrial waste

is coming out of PCB shops, and there will naturally be a push to get rid of this stuff.

Matties: Regarding the plating or the equipment side, you're setting up factories with all this equipment. Do you have companies coming to you specifically looking for just a plating line or an individual piece of equipment?

Stepinski: Yes. We're not actively promoting it, but Vicor and SEL are both getting our first vertical plating lines.



Alex Stepinski

Matties: One thing that you demonstrate—and this has always stuck with me—is you built your shop from plating outward, using the adage, “If we build it they will come.” You’ve built a shop that is flexible when building high technology, and people just arrived. You didn’t have to go out and sell your services, so to speak.

Stepinski: I believe in “blue ocean” strategies. We want to make our own market whenever we can. That’s how I like to do business. A sales process with the blue ocean strategy—when you are the only boat in the ocean and nobody’s selling anything similar—is a really nice way to exist. It results in more partnership-type situations. You’re the only one out there and people want to work with you.

I’ve been in the industry for 24 years. The GreenSource and AWP customers are the best customer set I’ve ever had in my career, by far. A lot of that is driven by our approach. We do step-by-step engineering, and we are really focused on improving the quality of our engineering. This is a huge focus within the company: product life cycle management and engineering asset management.

OEMs have similar mentalities. This is an OEM approach to improving your engineering quality, and the customers who work with us. They work with us to make new products,

and they work with us to give feedback on existing products to improve current products. They work with us to present problems and say, “Think about this problem. Maybe you can come up with a solution someday for this or just dwell on it.” We do a lot of this—comparing notes and collaborating. That’s how Vicor got this industrialized process from us. They don’t even make circuit boards. This is something totally different, but it ends up being an SAP process at the end of the day. So, we’re doing SAP on top of strange materials, and it’s very interesting.

It is fun doing stuff like that. You’re developing products with your clients; you’re helping them really improve what they’re offering their clients. It’s a great relationship and a pleasure to work with this kind of people, as opposed to the more adversarial relationship you have when you’re a commodity PCB supplier to somebody who’s got a massive supply chain organization, and they’re trying to extract every cent they can out of you. This is where we get our value-add.

Matties: Well, you’ve done a great job, Alex, that’s for sure; you’ve been an inspiration to us in the industry and we greatly appreciate you.

Stepinski: Thank you. PCB007

Leadership 101— The Law of Process

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 discuss the third of the 21 Irrefutable Laws of Leadership^[1], The Law of Process.

Process

The Law of Process is all about growth—personal, professional, and leadership. Leadership is a process, just like anything where you want consistency; follow the process and you will be successful and consistent (the two are indelibly connected). You can't improve your leadership by reading a book, taking a class, or merely thinking about it. The only way to improve is to live it day in, day out. It requires growth with intention. But what does that mean? It means you need to ask yourself, “What can I do today

to improve my leadership skills?” and “What do I need to learn, change, or act on today?” This approach needs to be done every single day. Remember the whole process thing:

Leadership develops daily, not in a day.
— John C. Maxwell^[2]

Five Phases of Leadership

There are five phases of leadership, and to reiterate the intentional part of leadership, you will notice that each phase makes an “I” statement:

1. I don't know what I don't know.
2. I know that I need to know.
3. I know what I don't know.
(What is your plan for growth?)
4. I know and grow—it starts to show.
5. I simply go because of what I know.





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I Don't Know What I Don't Know

If you are any kind of leader, you have asked yourself this question many, many times. Poor leaders fail to recognize leadership opportunities simply because they aren't growing. Poor leaders don't see themselves as poor leaders. They fail to realize the first lesson we learned that leadership is influence, nothing more, nothing less. They also may not feel that they influence anyone, but we all influence others. It's quite simple, as John Maxwell says, "As long as a person doesn't know what he doesn't know, he isn't going to grow."

I Know That I Need to Know

Many people are in leadership positions that require them to actually lead, but are surprised to discover that they just don't have the skill set required. Remember our discussion on the difference between managers and leaders? It happened to me when I was early in my career. I was a good manager but in situations that required true leadership I painfully realized that I lacked the appropriate skills to motivate others to act. It took me a while (years) to appreciate this fact. I learned that I had two options: continue as a good manager or become intentional in my growth and step up my game.

I Know What I Don't Know

I had been a manager for about 10 years when I read my first leadership book. My eyes were opened as I read, and I began to recognize the leadership behaviors in the leaders I admired. The first book led to a second, and a lifelong learning journey that eventually led me to the John Maxwell team. Even though I



am now a certified leadership speaker, coach, and trainer, I am still learning. Being intentional requires a plan to grow. Remember the first law, the Law of the Lid? Your leadership level will be a lid on your leadership skills that will not improve without a plan.

I Know and Grow—It Starts to Show

If you are intentional and have a plan, you will start to see little things that show growth in your skill set. It may be a decision that, prior to your growth, would have been a totally different one because you are now seeing the big picture. Like the motto of my fellow Harley enthusiasts, "It's about the journey, not about the destination." Appreciate the ride, and have a plan so that one day you will look back and realize how far you've come.

I Simply Go Because of What I Know

The first four phases are about being intentional and growth focused. Phase five is when your growth becomes almost automatic, like anything you want to improve, by practice, practice, and more practice. Remember, leadership is a lifelong journey, and the learning never stops.

Process Will Lift Your Lid

In the Law of the Lid, we learned there are many ways to lift your lid. Ask yourself:

- What am I doing right now to build myself into a great leader?
- What book am I reading right now?
- What seminars am I enrolling in?
- What sacrifices am I making to reach my goal?

If you answer “none” to any of these, you are not being effectively intentional in your leadership development. I’ll say it again, the only way to improve your leadership is to live it day in and day out. It requires growth with intention.

I will close with another timeless quote from a leadership giant:

“Before you are a leader, success is all about growing yourself. When you become a leader, success is all about growing others.”

—Jack Welch PCB007

References

1. *The 21 Irrefutable Laws of Leadership: Follow Them and People Will Follow You*, by John C. Maxwell, published by HarperCollins Leadership, 2007.
2. Maxell, John C.



Steve Williams is the 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](#).

Scientists Crack Mysteries of Our Closest Neighbor

New observations from the safety of Earth are lifting the veil on some of Venus’ most basic properties. By repeatedly bouncing radar off the planet’s surface over the last 15 years, a UCLA-led team has pinned down the precise length of a day on Venus, the tilt of its axis and the size of its core. The findings are published in the journal *Nature Astronomy*.

“Venus is our sister planet, and yet these fundamental properties have remained unknown,” said Jean-Luc Margot, a UCLA professor of Earth, planetary and space sciences who led the research.

Earth and Venus have a lot in common: Both rocky planets have nearly the same size, mass and density. And yet they evolved along wildly different paths. Fundamentals such as how many hours are in a Venusian day provide critical data for understanding the divergent histories of these neighboring worlds.

Changes in Venus’ spin and orientation reveal how mass is spread out within. Knowledge of its internal structure, in turn, fuels insight into the planet’s formation, its volcanic history and how time has altered the surface. Plus, without precise data on how the planet moves, any future landing attempts could be off by as much as 30 kilometers.

“Without these measurements,” said Margot, “we’re essentially flying blind.”

The new radar measurements show that an average day on Venus lasts 243.0226 Earth days — roughly two-thirds of an Earth year. What’s more, the rotation rate of Venus is always changing: A value measured at one time will be a bit larger or smaller than a previous value. The team estimated the length of a day from each of the individual measurements, and they observed differences of at least 20 minutes.

“That probably explains why previous estimates didn’t agree with one another,” Margot said.

(Source: UCLA)





MilAero007 Highlights



Defense Speak Interpreted: Industrial Base Evaluation ▶

So, what is an “industrial base” to the Defense Department? And wouldn’t we expect a “battle plan” from Defense, not an “industrial strategy”? We want to review the Defense Industrial Strategy in the January 2021 Report to Congress from the Acquisition and Sustainment section of the Department of Defense.

Standard of Excellence: Finding the Right PCB Partners ▶

The pandemic and also recent shifts in our geopolitical view of the world have changed the way we look at offshore PCB vendor partners, especially those in China. These two factors alone—increase in new technology, and an on-shoring trend for buying more PCBs domestically—have caused a significant paradigm shift in choosing your PCB/vendor partners.

Elbit Systems of America Completes Acquisition of Sparton Corporation ▶

Elbit Systems of America, LLC has completed the acquisition of Sparton Corporation from an affiliate of Cerberus Capital Management, L.P., for \$380 million, subject to customary price adjustments, resulting in a significant expansion of Elbit Systems of America in the United States.

Lockheed Martin, Thales Australia to Develop Sovereign Weapons Manufacturing Capabilities in Australia ▶

Lockheed Martin and Thales Australia have finalized a teaming agreement advancing the delivery of an Australian guided weapons manu-

facturing capability in support of a sovereign national guided weapons enterprise.

FTG Announces First Quarter 2021 Financial Results ▶

Firan Technology Group Corporation has announced financial results for the first quarter 2021. FTG’s long-term market diversification strategy enables the company to mitigate the dramatic downturn in the commercial aerospace market through its involvement in the defense market and other aerospace sectors.

Absolute EMS Completes 2021 for AS9100 Rev D SAE International Aerospace Standard ▶

Absolute EMS, Inc., a leading provider of turn-key and consignment manufacturing services, is pleased to announce that it has completed its 2021 recertification audit for the AS9100 Rev D SAE International Aerospace Standard.

Sensors Collect Crucial NASA Data on Mars Environment With Perseverance Landing ▶

MEDLI2 was one of the crucial technologies onboard the rover’s protective aeroshell that helped document the entry, descent, and landing of the spacecraft.

UK Ministry of Defence Awards \$21M to Support Common Missile Warning System ▶

BAE Systems has received a \$21 million contract from the United Kingdom’s Ministry of Defence to support the Common Missile Warning System over the next four-and-a-half years.

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Building an Ability to Expect the Unexpected

The PCB Norsemen

Feature Column by Raymond Goh, ELMATICA

How do you find techniques and strategies to transform a business plan developed in the boardroom into a living strategy implemented into the company core and mindset of every colleague? And how do you do it when times are hard, as we experienced in 2020?

The answer is having a strategy with goals and objectives, or simply said, implementing good operational management. And when times are hard? That's when you really see what the team can do for operations management.

To understand the factors that influence your workforce and your business—and then act accordingly—operations management must be related to more than cost securing and efficiency mapping. To make sure an organization runs smoothly and efficiently, your workforce must be supplied with not only information on quality, KPIs, and delivery performance, but with soft values like engagement, interest, and attention. I believe this is how your greater purpose can be achieved.

An operational management strategy might sound complicated and something that can

only be achieved by hiring a fancy agency to design; meanwhile, it never gets implemented and is left to collect dust in a desk drawer. Rather, it is something every company needs because it is a strategic way of bringing the company together, providing measurable goals, and determining objectives that make the company stronger.

There is no one-size-fits-all, however. Just as organisations come in different sizes, structures, and cultural backgrounds, there are different styles and schools of thought when it comes to operations management.

A simple and common definition of operations management is the “administration of the best practises in order to achieve the highest level of effectiveness and efficiency through utilisation of the company resources.”^[1]

This involves the responsibility of ensuring that business operations are efficient in terms of using only the most necessary resources to meet the customer's requirements. Operations management is primarily concerned with planning, organizing, and supervising in the con-



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text of production, manufacturing, or the provision of services.^[2]

This means we apply the most appropriate practises: map, implement, measure, and improve. It's a continuous, ongoing process, far away from a dusty map or plan in that drawer. It must have a loop where inefficiencies and undesirable results can be detected (if not prevented), corrected, and improved.

To develop a strategy and stick to it, even when times are challenging, can be hard. The strategy might need alterations on the way, but don't forget your main purpose. Again, it is when times are tough that a team aligned with common goals will make it through. Operations management is not one-quick-fix for all unforeseen futures.

Encourage Early Problem Solving— No Procrastination

Once your management team has agreed on its strategic goals, it's time to establish projects and key performance indicators (KPIs) that will guide the operations toward meeting the goals. We use the SMART strategy (specific, measurable, achievable, relevant, and time-bound) to help us keep track of our performance.

We have found that assigning KPIs to the appropriate department is critical to our success. For example, customer satisfaction is one of our key goals, so the "Customer Delivery Performance KPI" is assigned to our Customer Service Department—the ones who are not making the product nor making the delivery. Rather, they are the "voice" for our customers, and using this internal voice of customers to drive a customer delivery performance from within certainly pays off.

In any organization, there are policies and procedures. These are established so that we can work within a controlled and systematic environment. However, we must allow our employees a certain degree of freedom and encourage innovation and ownership. How? We empower them to make decisions through cross-departmental communication.

Can You Handle the Unexpected?

However, we have all experienced how external incidents can impact your strategies and plans. Of course, I am referring to the ongoing pandemic that has proven that when it comes to operations management, you must always expect the unexpected.

How We Managed the Unexpected

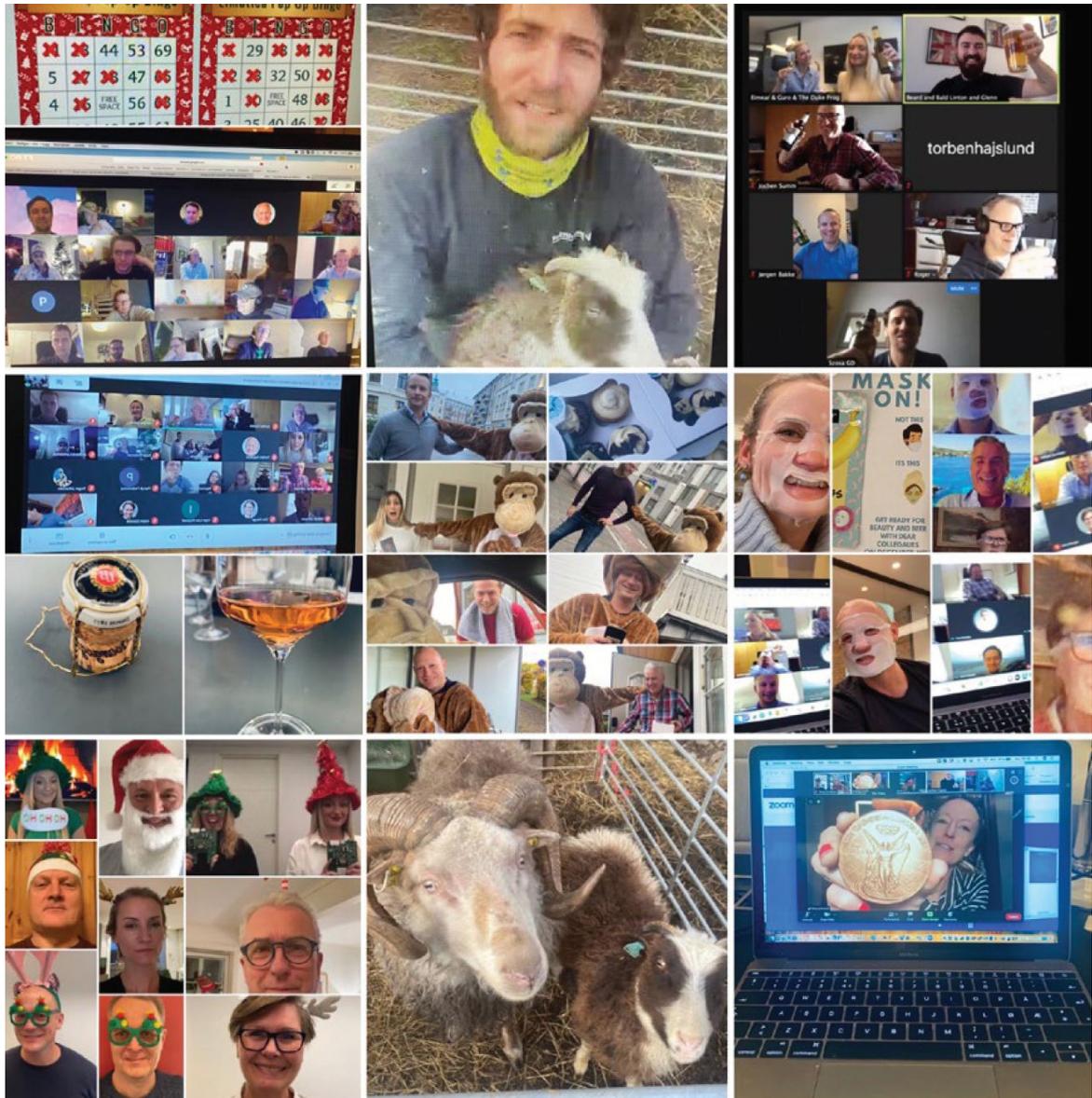
Elmatica has been in the PCB industry since 1971; in fact, we celebrated our 50th anniversary this year. It was not the best year for celebrations, however we do as we always do—we plan, adapt, and move forward. Not only did 2020 turn out as quite a different year, a bit surprisingly it was the best financial year in Elmatica's history.

So, what was our secret to staying aligned with our goals, keeping motivation up, and our colleagues informed and on target? We made sure to keep in mind: lead, plan, support, manage, perform, evaluate, and improve.

It may have taken the wizard from *Oz* to predict the future, but we did our best. We looked at both our customers' demands and our internal demands, and then we merged them to achieve the highest level of effectiveness and efficiency by utilising the company's resources. Once the demands were mapped, the scope set, and the strategy composed, then we had some fun. It was time for implementation—the phase where many tend to fail.

We implemented EQMS—the Environmental and Quality Management System—where all document procedures, responsibilities, escalations, company structure, goals, and priorities are set. This allowed us to spend time in three phases:

1. The first phase was at the officer and board level, where the main pillars and scope were decided.
2. Then, managers were invited into the project with input, feedback, and further development.
3. The last and critical third phase was where



Elmatica created virtual pop-up events to keep staff engaged, especially during times of isolation this past year.

strategies were implemented, and the entire company was involved in the communication through regular town hall meetings, internal newsletters, and ongoing departmental updates.

Once a clear strategy was set and implemented, we could start collecting data from specific KPIs, evaluate, and then improve them. Because we had clear operations documentation integrated into our infrastructure that was easily accessible, it allowed our organisation to function more efficiently; we minimized the time spent searching for information. Research

shows that digitalisation of processes and procedures can be the most effective investment to increase data security, optimize productivity, and reduce costs.

Communication and Implementation

At Elmatica, we have found that communication is one of the most important elements to achieving operational excellence. Everyone must be clear about what the goals are, why we have them, what our measurement of success is, and how we create a feedback loop for improvement.

To do this, we conduct quarterly company-wide town halls, where the CEO reviews our

quarterly financials, reinforces the company goals, and recognizes individuals who have excelled. We also have a Managers Group that meets bi-monthly to focus on KPIs. Apart from these formal meetings, there are frequent informal meetings.

Strong communication has been especially important during the pandemic. When any crisis appears, information is the most valuable asset one can have. We have all been in situations where you are searching for answers and feedback; when you don't get it, this leads to frustration and anger.

Instead, continuous internal communication will help your workforce feel more secure, impact how they perceive the company, and improve the dialogue between departments and customers. You don't want customers getting the wrong feedback, or even worse, no feedback at all because no one knows what they can or can't say to customers.

At Elmatica, we have worked on our internal and external communication the past few years. Once shutdowns occurred in March 2020, we immediately formed a work group that met daily. This group initiated internal newsletters, regular updates on our website, and official letters to our customers and partners. In our official communications, we assured our customers that operations would continue, and offered "tools" in the form of Q&As from the customer service and sales departments. We wanted to be sure we provided information during a time when unpredictability was the only thing that was predictable.

But what about that daily chat around the coffee machine, the short message about one order, one issue with a stackup, a different material working perfectly, or the "not crucial for business but crucial for collegial relationships" update about the cat, dog, or family? The pandemic was a brutal interruption in our lives that often created isolation. How could we ensure that operations would run smoothly, and communication would continue if we weren't face to face?

Our answer was to create virtual pop-up events, such as virtual lunchtime and drink hours. We planned weekly events, from wine tasting and games, to inspirational speeches, virtual tours of historic sites, yoga, playing games like bingo and Kahoot!, face masks for moisturising those dry indoor faces, learning to bind your own fish bait, and even a sheep shearing course.

Are You Ready for the Future?

We would all love a crystal ball that could predict the future. We may not have that crystal ball, but if we learn how to analyse our digital data, we can make some educated estimates. Our experience, backed with data, has helped us make a smart prediction of what is coming. Understanding the customers' demands and patterns has allowed us to better prepare for capacity reservations and customer requirements.

Developing a system tailored to our operational needs, meeting compliance, and data analysis is key. A good traceability system and availability of historical data allow the engineers to carry out the failure analysis more efficiently and effectively.

The challenges of this past year have taught us that to build the ability to expect the unexpected, one needs a strong and committed team, routines on clear internal and external communication, and focus not only on operational management but also on relationship management among partners, customers, and colleagues. Happy employees bring the company forward, and we all need a clap on the shoulder these days, even if it's a virtual one. **PCB007**

References

1. Operations Management, Wikipedia.
2. Same.



Raymond Goh is COO of Elmatica. To read past columns or contact The PCB Norsemen, [click here](#).



Supplier Highlights



EIPC Technical Snapshot: Supply Chain and Material Price Pressures ▶

EIPC's seventh Technical Snapshot webinar on April 14 was timely and appropriate. In the context of current supply chain issues and material price pressures facing the PCB industry, particularly in Europe, the EIPC team brought together an outstanding group of experts—each a leading authority in his field—to analyse and comment upon the areas of concern and to respond to questions raised by a capacity audience. As Alun Morgan said, “If you don't use the European supply chain, you won't have it anymore!”

ICAPE Group Boosts PCB Quotation Process with Ucamco's Integr8tor ▶

Global PCB supplier ICAPE Group, headquartered in France, realized that its PCB quotation process represented a bottleneck for its future growth and business targets, and that this part of its service had to be automated, made more professional, and offer faster turnarounds.

LPKF: Calculating the Savings Potential for Depaneling ▶

With the Panel Layout Optimization Tool (PLOT), LPKF offers a tool for calculating the materials savings that can be achieved with laser cutting.

APCT Increases Technology with Rigid Flex Optical Registration from DIS ▶

APCT Inc has added Rigid Flex Optical Registration™ (RFS), developed by DIS Inc of Islandia, N.Y., to enhance their PCB registration capabilities. The RFS machine is built specifi-

cally to process difficult flex, rigid and rigid-flex jobs. Using DIS, Inc proprietary Optical Registration™ technology in conjunction with SmartWeld, the RFS has the ability to align inner-layers and pre-preg without the use of expensive pin-tooling.

Agfa Announces Price Increase for PCB Phototooling Films ▶

Agfa announces worldwide price increases on all IdeaLINE phototooling films used for the production of printed circuit boards and metal structuring applications.

New Desmear Line from TSK Schill GmbH in Operation at Hofstetter PCB AG ▶

TSK supplies its long-standing and highly valued customer with a new horizontal chemical wet process machine.

Insulectro Promotes Industry Veteran Michelle Walsh to Vice President of Product Management ▶

Insulectro, the largest distributor of materials for use in manufacture of printed circuit board and printed electronics, has promoted Michelle Walsh to Vice President of Product Management.

VARIOPRINT Converts to Peters Solder Resist ▶

In the course of a quality campaign, VARIOPRINT AG relies on the ELPEPCB® Elpermer® AS 2467 solder resist system. The Swiss company will use this solder resist in the future for a large part of their printed circuit board types.

Great Artist Steal: Selecting and Reading the Right Business Books

Article by Dan Beaulieu
D.B. MANAGEMENT GROUP

When my interest began in reading books about business, there were only one or two available, and they were those relatively tedious books by Peter Drucker. Back then, there were no business sections at any bookstores. When I read the Drucker books, however, I fell in love with the idea that books would help me with doing business.

I even joined a business book club as a branch of (remember this?) the Book of the Month Club. I read everything they sent me. When I tried to get my bosses at the time interested in reading some of them, they could not be bothered. That has not changed much.



Then, Tom Peters, and Robert Waterman published *In Search of Excellence...* and the rest, as they say, is history. Now, there are thousands of business books available with more of them being written all the time. Over the course of my career, I have read hundreds of books on business; even today I average about three a week.

When people ask me where I get the ideas for some of the programs I use in my consulting business, I am always happy to tell them that I steal them from all the books I read. The same goes for when they ask me where I get the ideas for the columns I write.

I'm also asked about what books I recommend, and what they should be reading. With this in mind, I would like to share my process for

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ROUNDTABLES

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Test (PICT) Standard**



**Achieving Operational Excellence
in Electronics Manufacturing**



**Use of IMS Thermal Materials
in Multilayer Stackups**

knowing exactly how I choose the right books to read. They might not be the same guidelines you would have, but they are mine and hey, you asked me.

Here are my 16 rules for selecting and reading good business books:

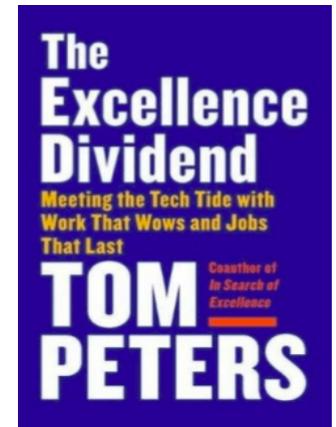
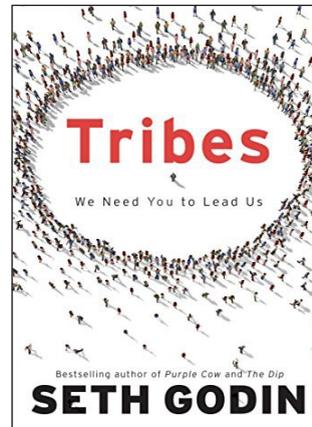
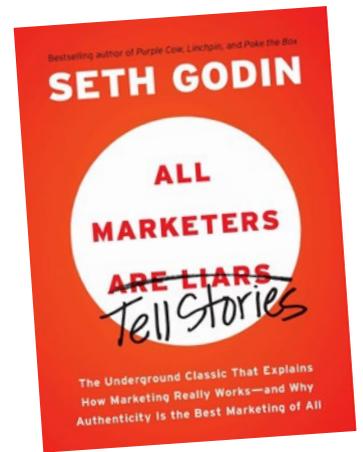
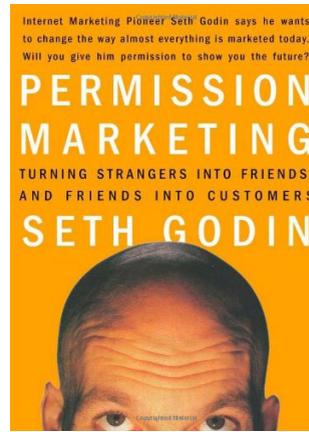
1. **Check the weight of the book.** If it is too heavy or too big with too many pages, I will not buy it. There are too many books to read and too little time to waste on giant textbooks.
2. **Check for charts and graphs.** I will not read a book with charts and graphs. That might have something to do with my interests in sales, marketing, strategy, branding, and leadership.
3. **Avoid number labels.** I never read a book with paragraphs labeled with numbers, like this 1:2:3. That book was written by a left-brained person and left-brained people cannot write. They are the same people who write those unreadable computer manuals.
4. **I never read books by big company guys.** You know, like the head of Honeywell or IBM? Those guys are in their own corporate bubble that has very little to do with my reality or the reality of my readers and customers. Someone running their own \$3 million, \$5 million or even \$20 million company knows a lot more than the head of a multi-billion dollar company. And chances are they didn't even write the book in the first place. Unless the CEO is a very creative guy like Jobs or Gates, they have nothing to teach me.
5. **I never read books published by the Harvard Business School.** They are heavy, full of charts, and erudite as heck. And I never read books with small-print double-column pages.
6. **I only read current books.** Unless it's a classic I never read a book that is over three years old. The world is moving too fast to be reading about mass-faxing.
7. **I love handbooks and small books.***
I like books that I can read in an hour or two, depending on how much note taking (read: idea stealing) I do.
8. **I love and read books by real people.**
People who get to the point.
9. **I read books that have bullet point chapter summaries.** I love bullet points.
10. **I love books by smart people.** I like people who "think different."
11. **I love books that are easy to read and scan.** Remember, business books always have three parts. The first talks about the problems they have that need fixing. You already know this, so you don't need to hear that case being made again and again. The second part talks about what should be done and what fixes are available. And the third part has the meat of the book as well as the sales pitch of what you can do about the problem and how, by using the author's services (which offer the best solutions to the problem), you will solve your problems and become a better company. That's the part you want to read first. Actually, in many cases you can read that part while standing in front of the business book section at Barnes and Noble.
12. **I love very recent books** about new and developing innovations.
13. **I love books that predict the future** including what the world may be like five years from now. (After that, they are just guessing.)

*For more small books check out I-007eBooks.

14. I love books that are irreverent, the ones that have bad words in the title. Those are the best and they are funny as hell, too!

15. When a book is particularly useful, I will buy all three versions—print, e-book, and audio—that way I can steal ideas in all the ways.

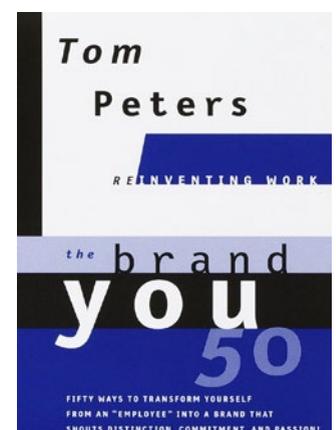
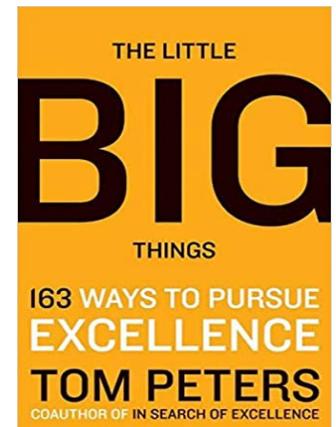
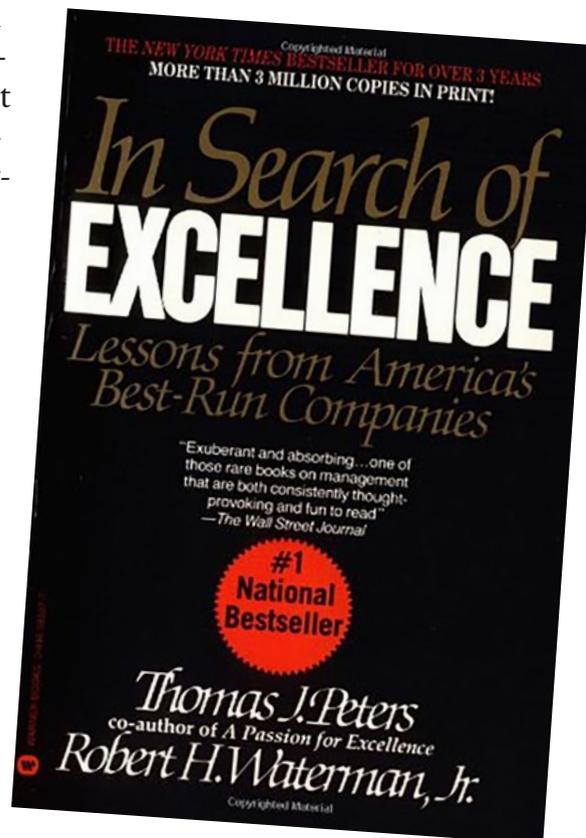
16. Another thing I do is check out the authors on Ted Talks and YouTube.

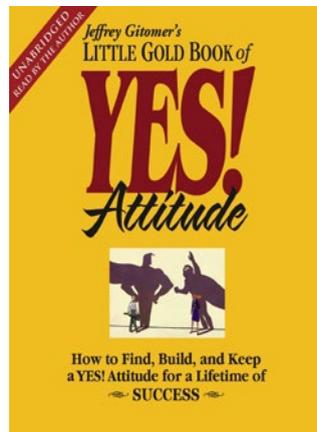
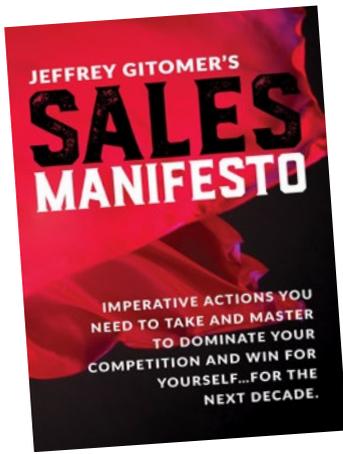


Now, let's talk about some of the books I find not only interesting, useful, and informative, but that are also very helpful and stimulating as well.

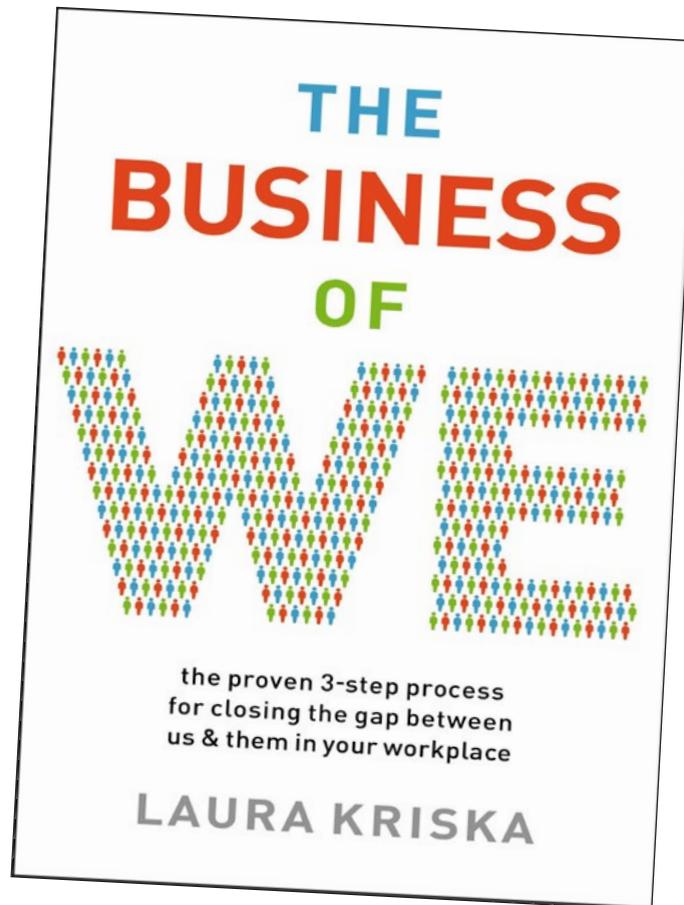
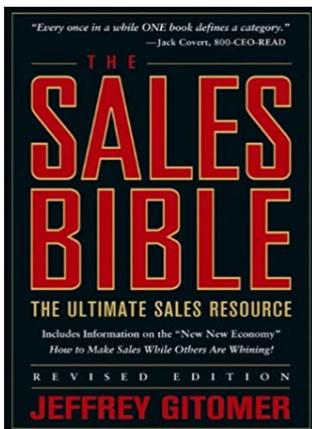
1. Any book by **Seth Godin**. The fact that we are all putting out newsletters to a targeted “tribe” of loyal followers is because of Seth; he literally invented permission marketing. His books are small and easy to read, entertaining, and most of all thought provoking. My three favorites are: *Permission Marketing*, *All Marketers Are Liars*, and *Tribes: We Need You to Lead Us*. Seth is also fun to watch YouTube.

2. **Tom Peters** is a great business writer and an even better speaker. Here are some great titles of his: *The Excellence Dividend*, *In Search of Excellence*, and *The Little Big Things: 163 Ways to Pursue Excellence*. He also has a great series of small handbooks of which my favorite is *The Brand You 50*.

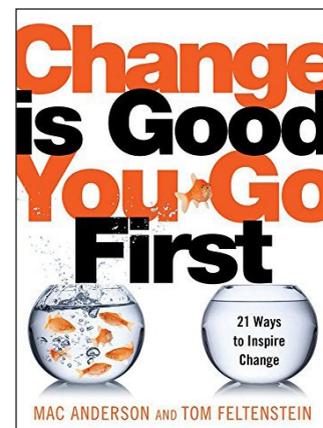
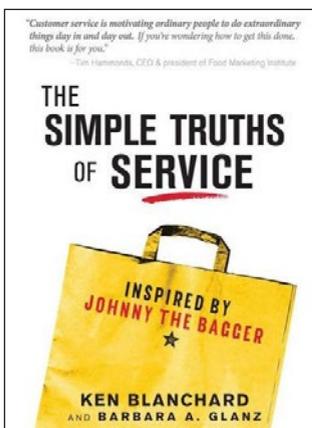
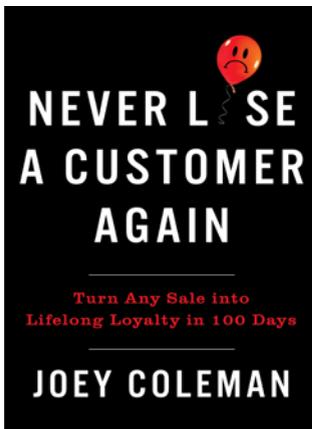




3. If you consider yourself a true sales professional, then the name **Jeffrey Gitomer** must be familiar to you. He is the best writer on sales and sales techniques in the business. You must buy and read all of his books from *Sales Manifesto* to *The Sales Bible*, to *Little Gold Book of YES! Attitude*. Get them, read them, study them and yes, steal from them. If you are a sales manager, give them to your salespeople.

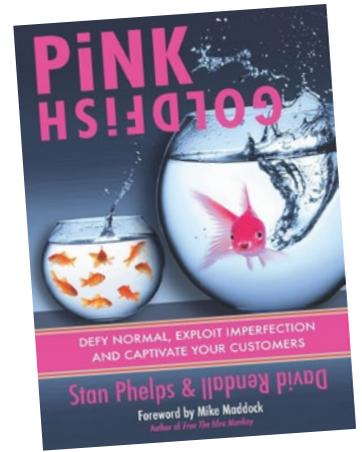
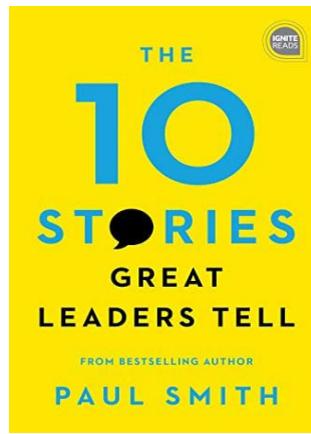


4. I have called **Laura Kriska's** book, *The Business of We*, the most important book you'll read this year, not just for business, not just for sales, but for life itself. Laura is writing about the different kinds of people we have in our workplaces and how we can work together successfully. She talks about all our differences—national, cultural, ethnic, sexual orientation—and how we can increase our sensitivity and tolerances for one another. This is important stuff at a critical time.

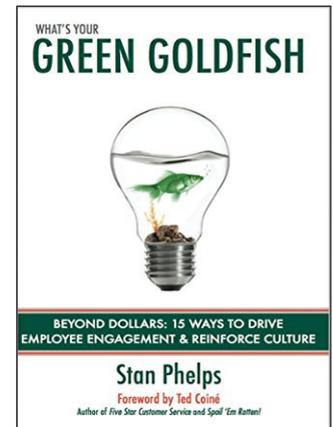
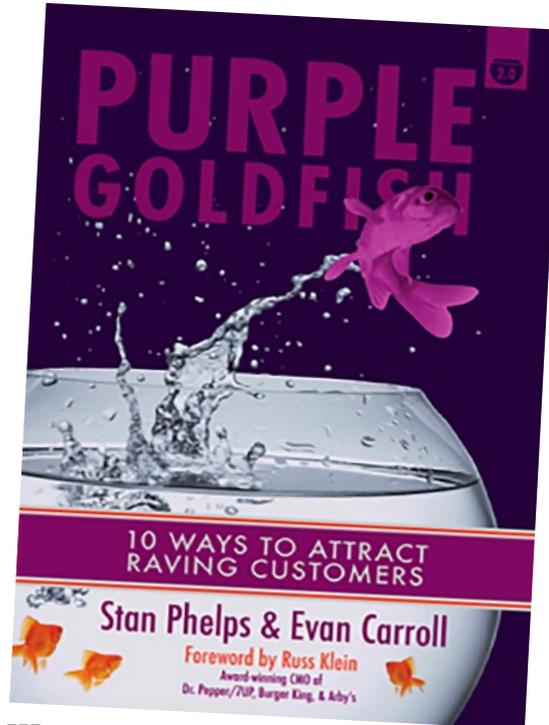


5. Another recent book that I found immensely valuable this year is **Joey Coleman's** *Never Lose a Customer Again: Turn any Sale into Lifelong Loyalty in 100 Days*. I can truthfully say that if you read this book, you will in fact never lose a customer again. This book is filled with great initiatives and suggestions on how to keep customers for life.

6. There is a series of small, thought-provoking business handbooks called **Ignite Reads**. These books are designed to be read in less than an hour and they are filled with great ideas on how to be better at several subjects, from customer service (*The Simple Truths of Service*), to change (*Change is Good, You Go First*), to content and storytelling (*The 10 Stories Great Leaders Tell*). Truth be known, if I ever write a series of business books they will look and feel exactly like these. If you are someone who does not want to spend a lot of time reading, this is the book series for you.



7. One great series that I recently discovered are the **Goldfish Books**. This series consists of books on various pertinent business subjects from captivating your customers (*Pink Goldfish: Defy Normal, Exploit Imperfection and Captivate your Customers*), to customer acquisition (*Purple Goldfish 2.0: 10 Ways to Attract Raving Customers*), to employee engagement (*What's Your Green Goldfish? Beyond Dollars: 15 Ways to Drive Employee Engagement and Reinforce Culture*). There are about 10 of these, and they are all excellent.



8. I have a subscription to a service called **Soundview Summaries**. Every month they send me at least three eight-page summaries of the latest business books. They take about 10 minutes to read and give me a great insight into the books and whether to buy them. It's really my secret weapon when choosing the right books to buy and read.

This should give you some good insights into choosing the right business books for your particular needs. For the past few years, I have been contributing book recommendations to I-Connect007 and will continue to do so. Actually, I am contemplating a regular feature for I-Connect007 called Dan's Business Bookshelf, where I regularly review and recommend books on a twice a month basis. What do you think? **PCB007**



Dan Beaulieu is president of D.B. Management Group. To read previous columns or contact Dan, [click here](#).



Editor Picks from PCB007

1 Technical Conference—Balancing Conventional and Disruptive Technologies ▶

I thought the three keynotes given by IPC President and CEO John Mitchell, Industry Week Editor-in-Chief Travis Hessman, and IPC Chief Economist Shawn DuBravac, were spot on. They all spoke to the fact that the way products are conceived, designed, manufactured, and used is changing rapidly. They all underscored the need for increased industry collaboration to help bring the factory and supply chain of the future to life.

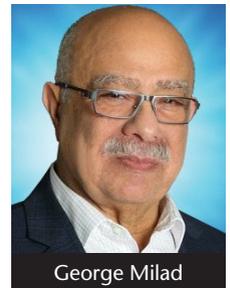
2 Amphenol Completes Acquisition of MTS Systems ▶

Amphenol Corporation, a leading global provider of high-technology interconnect, antenna and sensor solutions, announced that it has completed its acquisition of MTS Systems Corporation (MTS).



3 The Plating Forum: RAIG (Reduction Assisted Immersion Gold) for Gold Surface Finishes ▶

Since its inception, more gold finishes are finding RAIG gold to be a viable alternative to standard immersion gold. RAIG gold is a mixed reaction bath that functions as an immersion gold and with the added reducing agent it also functions as an electroless (autocatalytic) bath.



George Milad

4 Averatek Announces A-SAP License Agreement with FTG ▶

Averatek Corporation has announced FTG as an A-SAP licensee. A-SAP is an advanced PCB manufacturing technology that enables feature sizes of 25 microns and below, effectively providing PCB designers with new opportunities to address the challenges of next-generation electronics.

5 Benchmarking Your Process Engineering ▶

Mark Thompson has been in bare board fabrication for over 30 years. He is now laying out printed circuit boards at Monsoon Solutions, a high-tech design bureau near Seattle, Washington. With Mark's extensive hands-on knowledge of PCB manufacturing, he brings a unique perspective to PCB design.



8 Eltek Reports Full Year and Fourth Quarter 2020 Financial Results ▶

Eltek Ltd., a global manufacturer and supplier of technologically advanced solutions in the field of printed circuit boards, announced its financial results for the full year and fourth quarter ended December 31, 2020.



6 Highlights on a Rousing Virtual IPC APEX EXPO 2021 ▶

What a week that was! I didn't get to endure the 11-hour flight each way, neither did I need my comfy old shoes, but it certainly was a marathon event. And real-time-plus-six-hours gave me a few late nights, but it was such a meaningful experience, and well worth the effort!



9 Isola Releases IS550H Material ▶

Nolan Johnson speaks with Michael Gay of Isola and Chris Hunrath of Insulectro about the release of their new halogen-free, high-thermal reliability material, which they hope fills the gap in the market between epoxies and polyimides.



7 Testing Todd: A Point of Order—Do Not Just Rearrange the Pencils! ▶

In our concentration on continuous improvement, we should look into the order of things. Efficiency comes from streamlining processes, effective training, and the ability to monitor success through KPIs and feedback on deliverables.vides you with in-depth coverage of this year's virtual IPC APEX EXPO 2021.



10 One World, One Industry: How Familiar Are You with ESG? ▶

ESG is the new approach to corporate social responsibility, based on the notion that companies integrating ESG goals into their business decisions and operations are stronger by having accounted for concerns that create liabilities or risk. The financial services community is increasingly relying on ESG ratings and rankings to steer investments.



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Career Opportunities



Is your team growing?

Find industry-experienced candidates at I-Connect007.

For just \$750, your 200-word, full-column ad will appear in the "career opportunities" section of all three of our monthly magazines, reaching circuit board designers, fabricators, assemblers, OEMs, and suppliers.

In addition, your ad will be featured in at least one of our newsletters, and your posting will appear on our jobConnect007.com board, which is also promoted in every newsletter.

Potential candidates can click on your ad and submit a resume directly to the email address you provide or be directed to the URL of your choice. If you wish to continue beyond the first month, the price is the same per month.

No contract required. We even include your logo in the ad, which is great branding!

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Barb Hockaday at barb@iconnect007.com or +1 916.365.1727 (-8 GMT PST)

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GOOD FOR THE INDUSTRY



Career Opportunities



A Flex Company

Sheldahl, a leading provider of flexible interconnect products and electronic materials, is seeking candidates to join their diverse and skilled team.

We are looking for people who demonstrate:

- Intense collaboration
- Passionate customer focus
- Thoughtful, fast, disciplined execution
- Tenacious commitment to continuous improvement
- Relentless drive to win

Positions in America include:

Project Manager – Northfield, MN

Candidate will provide timely cost estimation and project budget definition, be responsible for maintaining customer relations, participate in meetings, etc.

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Program Manager – Specialty Films

Candidate will work with our Specialty Films in the Aerospace, Medical, and Commercial Aviation markets providing timely cost estimation and project budget definition, maintaining customer relations, participate in meetings, etc.

[apply now](#)

Business Development Manager – North America

Candidate will provide leadership in the planning, design and implementation of customers' specific business plans and will provide vision, penetration strategies and tactics to executive managers in order to develop and drive external and internal senior-level relationships.

[apply now](#)



A Flex Company

Sheldahl, a leading provider of flexible interconnect products and electronic materials, is seeking candidates to join their diverse and skilled team.

We are looking for people who demonstrate:

- Intense collaboration
- Passionate customer focus
- Thoughtful, fast, disciplined execution
- Tenacious commitment to continuous improvement
- Relentless drive to win

Positions in Europe include:

Business Development Manager – France

Seeking out-of-the-box thinkers to help us take the ordinary to the extraordinary by cultivating current customer relationships and developing new business opportunities with our European team, based in France.

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Business Development Manager – Germany

Seeking out-of-the-box thinkers to help us take the ordinary to the extraordinary by cultivating current customer relationships and developing new business opportunities with our European team, based in Germany.

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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 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.

View our opportunities at
Insulectro Careers ([jobvite.com](https://www.jobvite.com))

[apply now](#)



U.S. CIRCUIT

Plating Supervisor

Escondido, Calif.-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

[apply now](#)

Career Opportunities



Packaging Engineer

Job description: The Packaging Engineer designs and deploys product packaging to ensure product integrity under varying shipping conditions. This individual is responsible for testing, analyzing, and selecting materials for packaging based on durability, function, ease of use and cost effectiveness. The Packaging Engineer helps ensure that packaging complies with all regulatory requirements.

Requirements: Bachelor's degree in engineering, packaging science and at least one year of related work experience. An equivalent combination of education and related work experience may be considered. Demonstrable skills with computer-aided design (CAD) software and other relevant programs.

Indium Corporation is a premier materials refiner, smelter, manufacturer, and supplier to the global electronics, semiconductor, thin-film, and thermal management markets. Products include solders and fluxes; brazes; thermal interface materials; sputtering targets; indium, gallium, germanium, and tin metals and inorganic compounds; and NanoFoil®. Founded in 1934, the company has global technical support and factories located in China, India, Malaysia, Singapore, South Korea, the United Kingdom, and the USA. Indium Corporation is an Equal Opportunity/Affirmative Action and Minority/Female/Disability/Protected Veteran Employer. We provide a drug-free work environment and a full benefits package.

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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



ventec
INTERNATIONAL GROUP
騰輝電子

Customer Service Representative, UK

We are looking to expand our UK Customer Service/Internal Sales team. As Customer Service Representative you will provide great sales and customer service support and respond to the needs of clients from industries including Aerospace, Defence, Automotive and Pharmaceutical. Duties include:

- Maintain & develop relationships with new and existing customers
- Make rapid, accurate cost calculations and provide quotations
- Accurately input customer orders through bespoke MRP System
- Liaise with colleagues at Chinese HQ and other Overseas Business Units to manage domestic and international requirements
- Assist sales team with reporting, sales analysis and other items at their request

Skills and abilities required for the role:

The ideal candidate is a proactive self-starter with a strong customer service background. Friendly, approachable, and confident, you should have a good phone mannerism and be computer literate.

- Previous experience in a Customer Service background, ideally management or supervisor role
- Experience with MRP Systems
- Good working knowledge of Microsoft Office Tools such as Outlook, Excel etc.

What's on Offer:

- Excellent salary & benefits commensurate with experience

This is a fantastic opportunity to become part of a successful brand and leading team with excellent benefits.

Please forward your resume to HR@ventec-europe.com

[apply now](#)



Micropack Private Limited Sales Representatives

Micropack is a leading Indian PCB manufacturer with a state-of-the-art facility in Bangalore. Our focus on quality and reliability is demonstrated by the fact that we are certified to Nadcap, MIL 31032 & AS9100, apart from many customer approvals.

Catering to both quick-turn and medium volume requirements, our product range covers:

- Double-sided & multilayer PCBs, up to 30 layers
- Rigid-flex PCBs
- High-copper PCBs
- Hybrid PCBs with FR4+ Hydrocarbon Ceramic Substrates
- Heatsink Multilayer PCBs—Metal core and thermal plate PCBs

We are looking beyond our borders for sales representatives to expand our customer reach in the United States, Europe & South America.

Candidates must have previous PCB sales experience and should understand the technical aspects of printed circuit board manufacturability.

Contact us for more information.

mp3@micropack.in

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Career Opportunities



Indium Corporation: Field Sales Representative

Field Sales Representative serves as lead sales contact and customer advocate to maintain existing sales and to drive new qualifications and sales of products and services through effective account management and coordination of efforts throughout Indium Corporation's Metals, Compounds, Solar and Reclaim (MCSR) organization. This position is ideal for a sales- and customer-focused individual with an engineering degree.

- Develop, cultivate, and follow-up with prospective and existing customers to generate orders
- Develop an in-depth expertise of product offerings
- Work to gain insight into customer activities for future R&D developments
- Respond to customer requests for product data, specifications, and service information
- Identify customer requirements, priorities, and opportunities
- Build strong, trusting relationships with key decision-makers and influencers at target accounts
- Gather competitive insight, including pricing, delivery, and performance information
- Visit customer facilities to observe manufacturing processes and exchange information
- Promote industry recognition of Indium Corporation, its products, and its services
- Be a key member of overall team, including worldwide sales organization, product management, operations, engineering, R&D, etc.
- Submit required paperwork in timely manner
- Work within established budget, while increasing market share
- Perform other duties and projects as assigned

Click below for more details on job responsibilities and requirements.

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JOHNS HOPKINS

CAM / Process Engineer

The JHU/APL PCB Fabrication team is seeking a Computer Aided Manufacturing Engineer to support front-end data processing of APL manufactured hardware. You will directly contribute to hardware fabrication in support of National Security, Military Readiness, Space Exploration, National Health, and Research related to fundamental scientific advancement. This position includes a variable mix of core CAM work scope with additional opportunities for hands-on support such as bare board electrical testing, laser drilling, and mechanical CNC drilling and routing.

Responsibilities:

1. Computer Aided Manufacturing for rigid PCB, rigid-flex, and flexible circuits
 - a) Perform design checks, panel layout, coupon generation, file generation, stackups
 - b) Support manufacturability reviews with internal APL engineers (customers)
 - c) Generate work travelers
 - d) Communicate status to supervisors and internal customers
2. Support transition of software tools (Genesis 2000 to InCAM Pro)
 - a) Edit design rules checks and generate automation scripts
 - b) Develop new ideas to further the technical progress of our product
 - c) Develop CAM area through continuous improvement initiatives
3. Interface and inform APL Engineers on PCB design for manufacturing guidelines
4. Operate bare board electrical tester
5. Backup operator for CNC drilling, routing, laser drilling (on-site training)

For more details and to apply:

<http://www.jhuapl.edu/careers> and search for CAM.

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Career Opportunities



We're Hiring! Atlanta Georgia Facility

ADVANCED CIRCUITRY INTERNATIONAL is a world class supplier of RF/microwave and antenna PCBs. We have four state-of-the-art facilities on three continents to serve our customers. From rapid prototype development to large scale production ramp-ups, we supply many notable OEMs and EMS companies around the world.

As we are anticipating rapid growth for 2021 and beyond, we are recruiting for the following positions:

- Manufacturing manager
- Process engineering
- Sales and business development
- Maintenance management

Qualifications:

- 5-10 years' experience working in the PCB industry
- The ability and drive to learn about our unique product offering
- Excellent written and oral communication skills
- Strong, honest work ethic
- Degree in engineering, operations management, or related field preferred but not required

What We Offer:

- Excellent salary and benefits commensurate with experience

If you want to be part of the upcoming **5G** revolution and the growth in RF/microwave and antenna PCB manufacturing, consider a career at **ACI**. We're located in the Northern Atlanta suburbs, where you will enjoy a moderate climate, affordable housing, low taxes, quality school systems and numerous recreational opportunities. Please send your resume in confidence to: Career@aciatlanta.com

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Circuit Engineering Planning Engineer

Experience

- Minimum of 5 years working within printed circuit board manufacturing industry

Responsibilities

- Review Gerber data and talk with the customer when necessary
- Create production traveler based on Gerber data to release the order
- Improve process capability, yields and cost while maintaining safety and improving quality standards
- Work with customers in developing cost-effective production processes

Quality Engineer/Manager

Experience

- Minimum of 2 years working within printed circuit board industry
- Possess working knowledge of the IPC requirements and submitting PPAP reports
- Should have knowledge of working with the A16949 certification

Responsibilities

- Perform defect reduction analysis and activities
- Participate in the evaluation of processes, new equipment, facility improvements and procedures

Sales Associate/Customer Service

- Should have a minimum of 2 years' experience
- Salary plus commission

All positions will be on location at Circuit Engineering, 1390 Lunt Ave., Elk Grove Village, Illinois, not remote!

Contact: Felix Simon: +1 847 806-7777, ext. 109

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Career Opportunities



Senior Account Manager Midwest Region

Summit Interconnect, a leading North American manufacturer of advanced technology printed circuit boards across all end-user markets, is seeking an experienced, dynamic leader to drive new business in the Midwest Region of the U.S.

Headquartered in Anaheim, Calif., with additional locations in California and Toronto, Can., Summit's manufacturing features facility-specific expertise in rigid, flex, rigid-flex, RF/MW, and HDI PCBs.

The ideal candidate is highly motivated and should possess in-depth market knowledge, deep contacts across multiple markets and extensive experience in PCB sales with a demonstrated aptitude in proposing engineered solutions to complex requirements.

Reporting to the VP of Sales, the Midwest Senior Account Manager will be the primary hunter in the region and responsible for monitoring customer, market and competitor activity to build appropriate sales strategies for the region, create a strategic plan to grow existing and new business in the region, and be responsible for interfacing across all levels of the organization.

Preference is for the applicant to reside in region and be located within one-day travel to key accounts in the metropolitan business areas. However, the proven professional able to demonstrate reach into the region will be considered regardless of physical location.

Compensation will be a combination of salary and commission, with a comprehensive, competitive benefits package.

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Our Summit Anaheim, CA, division currently has multiple open positions for planning engineers.

The planner is responsible for creating and verifying manufacturing documentation, including work instructions and shop floor travelers. Review lay-ups, details, and designs according to engineering and customer specifications through the use of computer and applications software. May specify required manufacturing machinery and test equipment based on manufacturing and/or customer requirements. Guides manufacturing process development for all products.

Responsibilities:

1. Accurately plan jobs and create shop floor travelers.
2. Create documentation packages.
3. Use company software for planning and issuing jobs.
4. Contact customers to resolve open issues.
5. Create TDR calculations.
6. Assist in the training of new planning engineers.
7. Review prints and purchase orders.
8. Create stackups and order materials per print/spec.
9. Plan jobs manufacturing process.
10. Institute new manufacturing processes and or changes.

Education/Experience:

1. High school diploma or equivalent
2. Minimum five (5) years' experience in the printed circuit board industry with three (3) years as a planning engineer.
3. Must be able to cooperate and communicate effectively with customers, management, and supervisory staff.
4. Must be proficient in rigid, flex, rigid/flex, and sequential lam designs.

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Career Opportunities

Now Hiring

Director of Process Engineering

A successful and growing printed circuit board manufacturer in Orange County, CA, has an opening for a director of process engineering.

Job Summary:

The director of process engineering leads all engineering activities to produce quality products and meet cost objectives. Responsible for the overall management, direction, and coordination of the engineering processes within the plant.

Duties and Responsibilities:

- Ensures that process engineering meets the business needs of the company as they relate to capabilities, processes, technologies, and capacity.
- Stays current with related manufacturing trends. Develops and enforces a culture of strong engineering discipline, including robust process definition, testing prior to production implementation, change management processes, clear manufacturing instructions, statistical process monitoring and control, proactive error proofing, etc.
- Provides guidance to process engineers in the development of process control plans and the application of advanced quality tools.
- Ensures metrics are in place to monitor performance against the goals and takes appropriate corrective actions as required. Ensures that structured problem-solving techniques are used and that adequate validation is performed for any issues being address or changes being made. Develops and validates new processes prior to incorporating them into the manufacturing operations.
- Strong communication skills to establish priorities, work schedules, allocate resources, complete required information to customers, support quality system, enforce company policies and procedures, and utilize resources to provide the greatest efficiency to meet production objectives.

Education and Experience:

- Master's degree in chemical engineering or engineering is preferred.
- 10+ years process engineering experience in an electronics manufacturing environment, including 5 years in the PCB or similar manufacturing environment.
- 7+ years of process engineering management experience, including 5 years of experience with direct responsibility for meeting production throughput and quality goals.

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Now Hiring

Process Engineering Manager

A successful and growing printed circuit board manufacturer in Orange County, CA, has an opening for a process engineering manager.

Job Summary:

The process engineering manager coordinates all engineering activities to produce quality products and meet cost objectives. Responsible for the overall management, direction, and coordination of the engineering team and leading this team to meet product requirements in support of the production plan.

Duties and Responsibilities:

- Ensures that process engineering meets the business needs of the company as they relate to capabilities, processes, technologies, and capacity.
- Stays current with related manufacturing trends. Develops and enforces a culture of strong engineering discipline, including robust process definition, testing prior to production implementation, change management processes, clear manufacturing instructions, statistical process monitoring and control, proactive error proofing, etc.
- Ensures metrics are in place to monitor performance against the goals and takes appropriate corrective actions as required. Ensures that structured problem-solving techniques are used and that adequate validation is performed for any issues being address or changes being made. Develops and validates new processes prior to incorporating into the manufacturing operations

Education and Experience:

- Bachelor's degree in chemical engineering or engineering is preferred.
- 7+ years process engineering experience in an electronics manufacturing environment, including 3 years in the PCB or similar manufacturing environment.
- 5+ years of process engineering management experience, including 3 years of experience with direct responsibility for meeting production throughput and quality goals.

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Career Opportunities



Sales Account Manager

Sales Account Management at Lenthor Engineering is a direct sales position responsible for creating and growing a base of customers that purchase flexible and rigid flexible printed circuits. The account manager is in charge of finding customers, qualifying the customer to Lenthor Engineering and promoting Lenthor Engineering's capabilities to the customer. Leads are sometimes referred to the account manager from marketing resources including trade shows, advertising, industry referrals and website hits. Experience with military printed circuit boards (PCBs) is a definite plus.

Responsibilities

- Marketing research to identify target customers
- Identifying the person(s) responsible for purchasing flexible circuits
- Exploring the customer's needs that fit our capabilities in terms of:
 - Market and product
 - Circuit types used
 - Competitive influences
 - Philosophies and finance
 - Quoting and closing orders
 - Providing ongoing service to the customer
 - Develop long-term customer strategies to increase business

Qualifications

- 5-10 years of proven work experience
- Excellent technical skills

Salary negotiable and dependent on experience. Full range of benefits.

Lenthor Engineering, Inc. is a leader in flex and rigid-flex PWB design, fabrication and assembly with over 30 years of experience meeting and exceeding our customers' expectations.

Contact Oscar Akbar at: hr@lenthor.com

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Senior Process Engineer

Job Description

Responsible for developing and optimizing Lenthor's manufacturing processes from start up to implementation, reducing cost, improving sustainability and continuous improvement.

Position Duties

- Senior process engineer's role is to monitor process performance through tracking and enhance through continuous improvement initiatives. Process engineer implements continuous improvement programs to drive up yields.
- Participate in the evaluation of processes, new equipment, facility improvements and procedures.
- Improve process capability, yields, costs and production volume while maintaining safety and improving quality standards.
- Work with customers in developing cost-effective production processes.
- Engage suppliers in quality improvements and process control issues as required.
- Generate process control plan for manufacturing processes, and identify opportunities for capability or process improvement.
- Participate in FMEA activities as required.
- Create detailed plans for IQ, OQ, PQ and maintain validated status as required.
- Participate in existing change control mechanisms such as ECOs and PCRs.
- Perform defect reduction analysis and activities.

Qualifications

- BS degree in engineering
- 5-10 years of proven work experience
- Excellent technical skills

Salary negotiable and dependent on experience. Full range of benefits.

Lenthor Engineering, Inc. is the leader in Flex and Rigid-Flex PWB design, fabrication and assembly with over 30 years of experience meeting and exceeding our customers' expectations.

Contact Oscar Akbar at: hr@lenthor.com

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Career Opportunities



SMT Operator Hatboro, PA

Manncorp, a leader in the electronics assembly industry, is looking for a **surface-mount technology (SMT) operator** to join their growing team in Hatboro, PA!

The **SMT operator** will be part of a collaborative team and operate the latest Manncorp equipment in our brand-new demonstration center.

Duties and Responsibilities:

- Set up and operate automated SMT assembly equipment
- Prepare component kits for manufacturing
- Perform visual inspection of SMT assembly
- Participate in directing the expansion and further development of our SMT capabilities
- Some mechanical assembly of lighting fixtures
- Assist Manncorp sales with customer demos

Requirements and Qualifications:

- Prior experience with SMT equipment or equivalent technical degree preferred; will consider recent graduates or those new to the industry
- Windows computer knowledge required
- Strong mechanical and electrical troubleshooting skills
- Experience programming machinery or demonstrated willingness to learn
- Positive self-starter attitude with a good work ethic
- Ability to work with minimal supervision
- Ability to lift up to 50 lbs. repetitively

We Offer:

- Competitive pay
- Medical and dental insurance
- Retirement fund matching
- Continued training as the industry develops

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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



American Standard Circuits

Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

Summary of Functions

The CAD/CAM engineer is responsible for reviewing customer supplied data and drawings, performing design rule checks and creating 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 CAM tooling software, Orbotech GenFlex®.

Physical Demands

Ability to communicate verbally with management and co-workers is crucial. Regular use of the telephone 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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MANUFACTURERS OF QUALITY PRINTED CIRCUIT BOARDS

Pre-CAM Engineer

Illinois-based PCB fabricator Eagle Electronics is seeking a pre-CAM engineer specific to the printed circuit board manufacturing industry. The pre-CAM Engineer will facilitate creation of the job shop travelers used in the manufacturing process. Candidate will have a minimum of two years of pre-CAM experience and have a minimum education level of an associate degree. This is a first-shift position at our Schaumburg, Illinois, facility. This is not a remote or offsite position.

If interested, please submit your resume to HR@eagle-elec.com indicating 'Pre-CAM Engineer' in the subject line.

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Process Engineer

We are also seeking a process engineer with experience specific to the printed circuit board manufacturing industry. The process engineer will be assigned to specific processes within the manufacturing plant and be given ownership of those processes. The expectation is to make improvements, track and quantify process data, and add new capabilities where applicable. The right candidate will have a minimum of two years of process engineering experience, and a minimum education of bachelor's degree in an engineering field (chemical engineering preferred but not required). This is a first shift position at our Schaumburg, Illinois, facility. This is not a remote or offsite position.

If interested, please submit your resume to HR@eagle-elec.com indicating 'Process Engineer' in the subject line.

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Career Opportunities



BLACKFOX

Premier Training & Certification

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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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

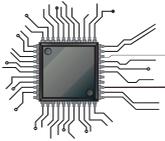
- A love of teaching and enthusiasm to help others learn
- Background in electronics manufacturing
- Soldering and/or electronics/cable assembly experience
- IPC certification a plus, but will certify the right candidate

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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Career Opportunities



MivaTek

Global

MivaTek Global: We Are Growing!

MivaTek Global is adding sales, technical support and application engineers.

Join a team that brings new imaging technologies to circuit fabrication and microelectronics. Applicants should have direct experience in direct imaging applications, complex machine repair and/or customer support for the printed circuit board or microelectronic markets.

Positions typically require regional and/or air travel. Full time and/or contractor positions are available.

Contact HR@MivaTek.Global for additional information.

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APCT

Passion | Commitment | Trust

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.

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Career Opportunities



U.S. CIRCUIT

Sales Representatives (Specific Territories)

Escondido-based printed circuit fabricator U.S. Circuit is looking to hire sales representatives in the following territories:

- Florida
- Denver
- Washington
- Los Angeles

Experience:

- Candidates must have previous PCB sales experience.

Compensation:

- 7% commission

Contact Mike Fariba for
more information.

mfariba@uscircuit.com

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+1 916.365.1727 (PACIFIC)

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Introduction to PCB Design II

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8/31 to 10/21

Advanced Packaging

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3/22 to 4/28
11/8 to 12/15

Military & Aerospace Applications

Upcoming class:
8/30 to 10/6

Rigid-Flex Boards

Upcoming classes:
5/25 to 7/1
8/30 to 10/6

Extreme Environments

Upcoming class:
7/5 to 8/11

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Webinar: For more information about the iamcam concept, please request the iamcam webinar video via presales@ucamco.com.

REALTIME^{with...} IConnect007

ROUNDTABLE DISCUSSION FEATURING:



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Ventec International Group



Rax Ribadia
Excello Circuits



Denis McCarthy
Ventec International Group



Pete Starkey
I-Connect007

Video  An IMS Thermal Materials Discussion

Roundtable: “Use of IMS Thermal Materials in Multilayer Stackups for Power Applications” with Ventec International Group and Excello Circuits.

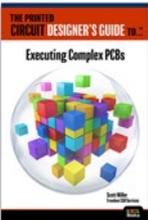
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Thermal Management: A Fabricator’s Perspective

by *Anaya Vardya, American Standard Circuits*

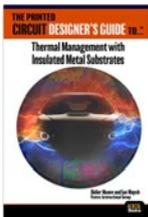
Beat the heat in your designs through thermal management design processes. This book serves as a desk reference on the most current techniques and methods from a PCB fabricator’s perspective.



Executing Complex PCBs

by *Scott Miller, Freedom CAD Services*

Readers will learn how to design complex boards correctly the first time, on time. This book is a must-read for anyone designing high-speed, sophisticated printed circuit boards.



Thermal Management with Insulated Metal Substrates

by *Didier Mauve and Ian Mayoh, Ventec International Group*

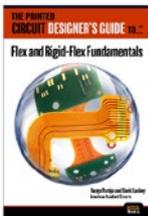
Considering thermal issues in the earliest stages of the design process is critical. This book highlights the need to dissipate heat from electronic devices.



Fundamentals of RF/Microwave PCBs

by *John Bushie and Anaya Vardya, American Standard Circuits*

Today’s designers are challenged more than ever with the task of finding the optimal balance between cost and performance when designing radio frequency/microwave PCBs. This micro eBook provides information needed to understand the unique challenges of RF PCBs.



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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PUBLISHER: BARRY MATTIES
barry@iconnect007.com

MANAGING EDITOR: NOLAN JOHNSON
(503) 597-8037; nolan@iconnect007.com

EDITOR | COLUMNIST COORDINATOR: MICHELLE TE
michelle@iconnect007.com

CONTRIBUTING EDITOR: PATRICIA GOLDMAN
(724) 299-8633; patty@iconnect007.com

TECHNICAL EDITOR: PETE STARKEY
+44 (0) 1455 293333; pete@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: DAN FEINBERG
baer@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: HAPPY HOLDEN
(616) 741-9213; happy@iconnect007.com

SALES MANAGER: BARB HOCKADAY
(916) 608-0660; barb@iconnect007.com

SALES: ANGELA ALEXANDER
(408) 489-8389; angela@iconnect007.com

MARKETING SERVICES: TOBEY MARSICOVETERE
(916) 266-9160; tobey@iconnect007.com

PRODUCTION MANAGER: SHELLY STEIN
shelly@iconnect007.com

MAGAZINE LAYOUT: RON MEOGROSSI

**AD DESIGN: SHELLY STEIN, MIKE RADOGNA,
TOBEY MARSICOVETERE**

CREATIVE TECHNOLOGIST: BRYSON MATTIES

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PCB007
MAGAZINE

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