

October 2015

34 **Whelen & IPS: A Strategic Partnership—A Winning Combination**

36 **Mutrax: First Install Achieves CAM to Etch in 5 Minutes**

48 **Practical Application of Lean Six-Sigma to Drive Cycle Time Reduction, Part 1**

Much More!

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the **pcb** magazine

cycle time
reduction



WHELEN ENGINEERING

Reduces Cycle Time by
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This Month's Feature Articles

Cycle Time Reduction

This month we are paying attention to cycle time and the many ways to reduce it in your process—whatever your process may be. From automation to value stream mapping to lean six-sigma, our contributors have it covered.

12 Whelen Engineering Reduces Cycle Time by Building a New Automated PCB Factory

by Barry Matties and Bryan Bernas



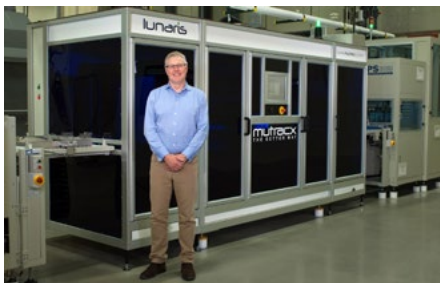
34 Whelen & IPS: A Strategic Partnership—A Winning Combination

by Bryan Bernas



36 Mutracx: First Install Achieves CAM to Etch in 5 Minutes

by Barry Matties



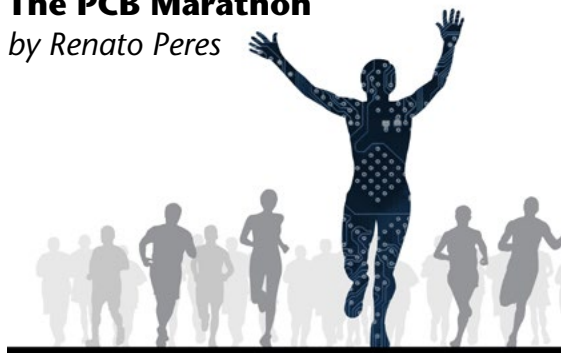
48 Practical Application of Lean Six-Sigma to Drive Cycle Time Reduction, Part 1

by Kathy Nargi-Toth



60 The PCB Marathon

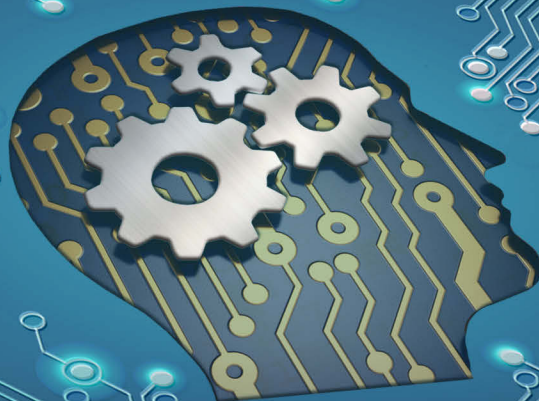
by Renato Peres



76 MacDermid: Redefining Global Strategy

by Barry Matties





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CONTENTS

FEATURE COLUMNS

8 Cycling Around

by Patty Goldman



42 The Economics of Reducing Cycle Time in PCB Fabrication

by Jason Marsh

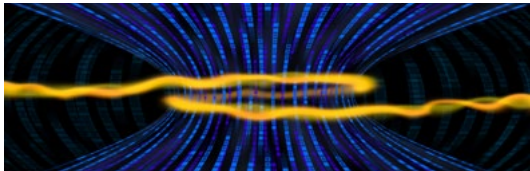
56 Cycle Time Reduction in a Flexible Circuit Facility

by Dave Becker



70 Breaking the Bottleneck: Electrical Test Cycle Time Reduction

by Todd Kolmodin



92 Tips for Time-Critical PCBs

by Tara Dunn

ARTICLE

96 Plant Culture: a Direct Contributor to Quality, Output and Predictable Manufacturing

by Andy Thomson

SHORTS

46 New Assessment of Silicon for Next-gen Batteries



74 4-D Technology Allows Self-folding of Complex Objects



100 Disappearing Carbon Circuits on Graphene Could Have Security, Biomedical Uses



HIGHLIGHTS

40 Market

68 Supply Line

90 MilAero007



102 Top Ten PCB007 Highlights

EXTRAS

104 Events Calendar

105 Advertisers Index & Masthead



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VLP-2 (2 micron Rz copper)	Standard	Standard	Available	Available
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Cycling Around

by Patty Goldman

I-CONNECT007

Well, it's tough to beat last month's focus on the great things happening in [automotive electronics](#), which was a lot of fun to read. But we still have work to do. Yeah, it's time to focus inward again and beat down a few more alligators. We focus on cycle time reduction in this issue, and that's a bugaboo for everyone. I've been thinking about it and I truly can't come up with a scenario, at least in business, when a longer cycle time is better than shorter.

And it's not just about manufacturing, though that is the first thing that always comes to mind. In fact, while we can talk about the cycle time of an isolated process, we also have to think about the overall cycle time, from start to finish, or from initial order to final shipment, or from initial sales contact through delivery to customer. Whatever the process or system that you choose to focus on, we have assembled experts from many parts of the PCB fab industry to help you address cycle time reduction (CTR).

In preparation for this issue, we did a survey of our readers to find out what issues they are having with CTR and the results were...interesting. While almost everyone said reducing cycle time was very important, methods for dealing with problem areas were all over the map. By that I mean the tools used ranged from brute force to time/motion studies to value stream mapping and everything in between. When we asked about bottlenecks, again, the entire PCB process was covered, from sales/marketing to front-end engineering and on through every process step, including final test.

When we asked what you wanted to learn, the answer was everything! You want tips on everything from improving



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CYCLING AROUND



efficiencies to new techniques and best practices. I think we can help with that right here and now in this issue. But if we do miss something, be sure to check our sister magazines this month [SMT Magazine](#) and [The PCB Design Magazine](#), which cover cycle time reduction in their respective topic areas.

Our October issue begins with an in-depth look the new Whelen Engineering plant in New Hampshire, a brand-new, captive PCB manufacturing facility. In fact, I believe it is the first new captive facility built in the U.S. in the last 30 years or so. When Whelen made the decision to reshore their PCB manufacturing operation and bring it in-house, they found the only way to do it successfully and profitably was by automating the entire process. This in-depth interview conducted on-site by Publisher Barry Matties—including a couple of short videos—is impressive. The sidebars, which explore a couple of their key suppliers, offers an even more complete picture.

Now, how about your company? You probably know what you need to do and where your problems are...or maybe not. So let's get you started down the road to CTR, which means getting the waste out of your processes. Insulec-tro's Jason Marsh has written a bang-up column, with actual case studies to illustrate the details, along with his summary of the overall picture.

We get some nitty-gritty how-to from Kathy Nargi-Toth of NCAB, who wrote a down-to-earth discussion of Lean Six Sigma. Follow her instructions line by line and you will surely improve your process flow(s) and reduce your cycle time.

Dave Becker of All Flex Flexible Circuits uses his column to further the discussion with much practical how-to on using Kanban in a high-mix operation. While he writes from a flex circuit manufacturer's perspective, most, if not all, is applicable to any PCB fabricator.

The discipline of CTR is further illustrated by Renato Peres of Circuibras LTDA, a Brazilian PCB manufacturer. He speaks from firsthand experience and the article title reflects that: "The PCB Marathon." Nobody said it would be easy, but they all agree the results are well worth the effort.

Next up, Todd Kolmodin of Gardien Services provides guidance for reducing cycle time in electrical test. His methodology could be applied to other processes as well.

We also get the full scoop on what's up with MacDermid and their recent acquisitions in an interview with Directors Don Cullen and Steve Kenney. Much is happening there and you can also learn about their efforts at CTR.

Omni PCB's Tara Dunn, in her regular column, discusses cycle time from the customer's point of view, with a to-do list to make one's PCB order go smoothly through a facility. Perhaps you will want to include this in your future conversations with customers.

And bringing up the rear, we have a concise piece by EchoStar's Andy Thomson on organizational culture and its influence on manufacturing. No, it is not dull; rather, the four cornerstones discussed are very apropos to our focus this month, not to mention just plain good info.

In the end, reducing cycle time is absolutely necessary to stay afloat and profitable. It's a never-ending process, so buckle down and keep doing it! Next month, we follow up with an in-depth look at data collection and management. We're calling it The Power of Data. [Subscribe](#) if you haven't already and get it hot off the virtual press. **PCB**

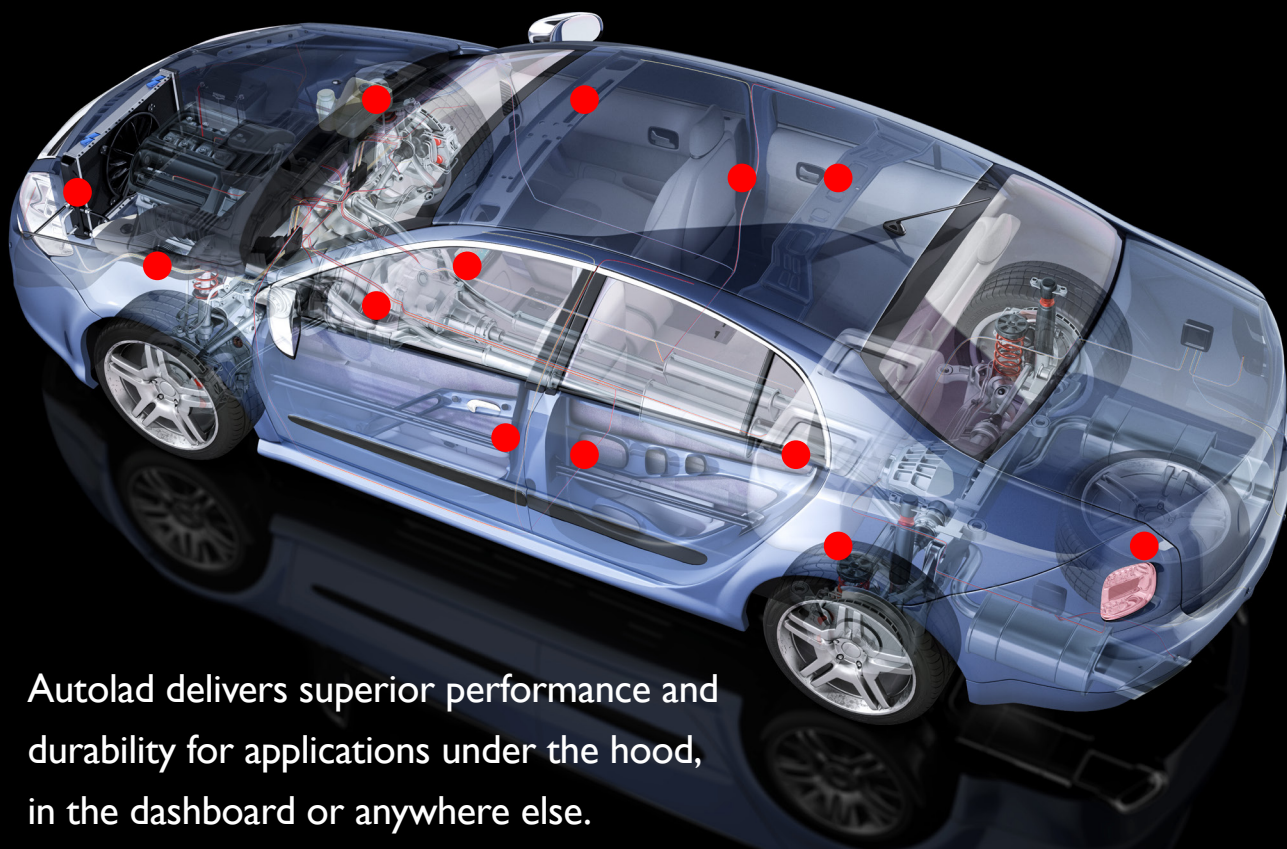


Patricia Goldman is a 30+ year veteran of the PCB industry, with experience in a variety of areas, including R&D of imaging technologies, wet process engineering, and sales and marketing of PWB chemistry. She has worked actively with IPC since 1981 and served as TAEC chairman, and is also the co-author of numerous technical papers. To contact Goldman, [click here](#).



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Whelen Engineering Reduces Cycle Time by Building a New Automated PCB Factory

by **Barry Matties and Bryan Bernas**

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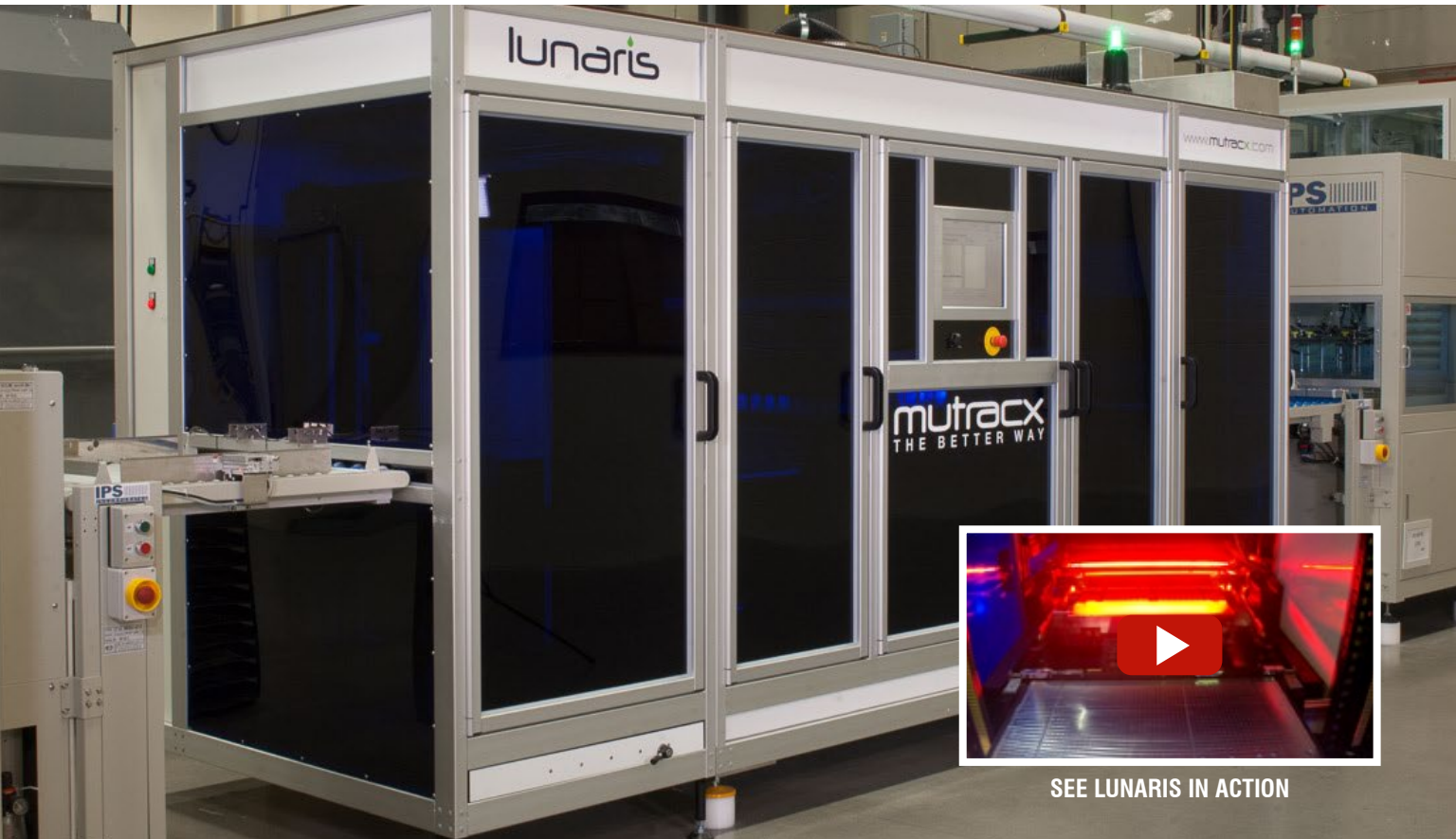
With the Chinese stock market in turmoil and China's wage scales still rising, one might think this would fuel new hope for U.S. PCB manufacturers trying to gain traction in a marketplace that's been dominated by their Asian counterparts for the better part of two decades. But despite chatter about reshoring of late, the general consensus in the industry doesn't seem overly optimistic that substantial change will occur.

While some business is certainly making its way back to the U.S., most people expect the bulk of it to relocate to the next-best location with low-cost wages, like Vietnam, Mexico, etc. To remain competitive, China's government and manufacturers didn't hesitate to call for more automation from its factories once it lost its cost advantage. It begs the question: If China is turning to automation to retain busi-

ness, what might the same type of automation do for America's reshoring effort? In the case of one such North American company, the results have been breathtaking.

The future of American manufacturing might be found in the small community of Charlestown, New Hampshire, at Whelen Engineering. A company founded and headquartered in Connecticut in the 1950s, Whelen is a leading manufacturer of all things relating to emergency lights and sirens for the automobile and aviation industries. For years, Whelen had been spending about \$7 million annually on PCBs from China, but being a strong advocate for bringing jobs and dollars back to the U.S., two years ago they decided to purchase their PCBs in America.

Who did they choose as their new supplier? Well, that's where it gets interesting. Whelen chose to be their own PCB supplier. Where does a company specializing in audio and visual warning equipment get off making their own PCBs?



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THE BETTER WAY

WHELEN ENGINEERING REDUCES CYCLE TIME BY BUILDING A NEW AUTOMATED PCB FACTORY



Aerial view of one automated process.

Enter Alex Stepinski, a long-time PCB industry veteran hired by Whelen to design and oversee the building of the first captive PCB manufacturing facility in North America in years.

Alex has been in the industry for many years, working at iconic factories like TTM and Sanmina. When Whelen contacted him to lead the effort, he was excited, and rightfully so. Imagine being given a \$12M budget with an empty 45,000 square-foot blank canvas to design a PCB line of your choosing, from the ground up. Whelen didn't micromanage or overburden Alex with requirements either—they gave him complete freedom to design the factory as he saw fit as long as there was a reasonable ROI and the line could handle their typical work of single- and double-sided boards, with a few multilayers mixed in. The company manages about 2,500 different part numbers in their product lineup. These were their basic requirements, and what they got in return was so much more.

When it's all said and done, Whelen will have the world's first fully automated in-line, lights out, zero-liquid discharge, 100% digital PCB factory. Alex saw this as a great opportunity to not just build a PCB manufacturing process, but a completely automated PCB manufacturing process. The interesting thing to note is that Alex chose the automation route

primarily because it offered him the quickest ROI over every other option available. It's an extremely impressive setup, and unlike any other PCB fab facility you've likely ever seen. The whole line is rectangular, with a control tower-type building in the middle, allowing you to follow a board through the entire cycle. It's a conveyor belt process where you load a drilled board on one end and about 4.5 hours later a completed PCB emerges at the other. Forget having to

send boards across the ocean; Whelen reduced their cycle times from days to hours. Whelen designers can have their test and prototype boards in hand by the end of the day. At first glance, what is most noticeably lacking is manpower. The open-space layout makes it easy to look down the length of the line and see two operators where you would normally expect 8–10 people in a typical board shop.

To cut down cycle time, the new facility features a substantial amount of innovation—much of which is new and unproven and comes with considerable risk. Alex did not take the safe approach when doing this; he wanted to not only automate, but also reduce the overall cycle time by bringing in new technology like Mutracx's Lunarix primary imaging equipment, an impressive piece of technology that prints the primary image on the board in about two minutes—prior to plating. The machine plays a key role in the process, printing around 50 double-sided panels an hour, as well as having a built-in AOI.

From there, the board goes into an automated plating line provided by Integrated Process Systems (IPS), who not only built the plating line, but were selected by Alex to be the primary equipment partner, supplying over a third of all of the equipment installed there. The factory

WHELEN ENGINEERING REDUCES CYCLE TIME BY BUILDING A NEW AUTOMATED PCB FACTORY



IPS fully automated plating line.

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features an impressive line-up of equipment and technology supplied by 39 different companies, almost all of which was purchased from U.S. suppliers. Not only did IPS build much of the equipment, they also played a key role its integration, engineering the software that connects and controls the manufacturing process and helping design and implement all the overhead utilities.

And they are gorgeous overhead utilities, all clearly labeled, color-coded and snugly attached with U brackets. Our PCB007 team gets to visit factories all over the world and let's just say it's not commonplace to leave a shop saying, "Yeah, but those utilities, though!" In a factory like this, with so much to take in, something like the choice for overhead utilities almost gets forgotten among other notable takeaways, like the waste treatment system that allows the factory to have no permits, or the Whelen-made alarms that sound when a certain part of the line has an issue, featuring a custom alarm for each process that enables the operators to easily pinpoint the problem.

Things are done differently there, and with this kind of new technology and integration comes trial and error, as we saw firsthand with the soldermask portion of the line. But from the top down, Whelen seems like a company willing to take certain risks in order to bring manufacturing back to America and no longer be re-

liant on China. By taking a chance and giving Alex the go-ahead, they took that \$7 million a year going to China and invested it back into American manufacturing and American jobs.

The Whelen model gives fabricators plenty to consider for cycle time reduction through automation, and it might even persuade some OEMs to contemplate the possibility of a captive shop. But what makes the Whelen factory a true triumph in American manufacturing is their willingness to share innovative solutions with other North American PCB fabs for the good of the industry and our country as a whole. Being a captive facility, Whelen isn't worried about competition stealing business or certain processes, and this makes it an extremely valuable resource for other fabricators wanting to see new equipment like the Lunarix in a working manufacturing environment before considering it themselves. There's so much to be learned from a factory like this as management continues to prove these solutions are viable. Alex Stepinski and Whelen have set the standard for automated PCB manufacturing in North America; perhaps others will be inspired to innovate similarly through automation and further strengthen the reshoring movement.

Following is the full interview with Alex, who gives a rundown of the Whelen factory, including which processes he thinks every fab shop should automate first.

Barry Matties: *Alex, we're sitting here, in a building that was empty not too long ago, with a completely automated circuit board fabrication line. Please walk us through how this came about.*



Alex Stepinski: Well, I was hired a little over two years ago to develop a plan to see if it made sense for Whelen to make their own circuit boards in-house. After about six weeks of investigation, I drafted a business plan as well as a drawing and met with the management

WHELEN ENGINEERING REDUCES CYCLE TIME BY BUILDING A NEW AUTOMATED PCB FACTORY



Circuit Automation's silkscreening process.

here. I had design work done, and I had selected all the long-term lead time items in case the decision was made to go forward. They wanted to get the capital in here before the end of the year so they could get the appropriate tax breaks for 2013. Six weeks later we had a meeting and the decision was made to go forward.

Matties: *What was their mandate? Did they come to you and put forward any requirements?*

Stepinski: They wanted to know what it would take to build their own boards, and I had to come up with a plan in my mind that had an ROI that would make them interested in the investment. That's how this came about. This was the only solution I could arrive at that had an ROI that was within a reasonable range.

Matties: *When you came up with the solution, it wasn't because they said, "We want a fully automated system." They just wanted something that would give them payback.*

Stepinski: Yes, and this was the only solution I could arrive at that would give a payback.

Matties: *Is this something that you had been thinking of previously?*

Stepinski: No, this was a new problem. I had never worked in low-tech circuit board manufacturing before.

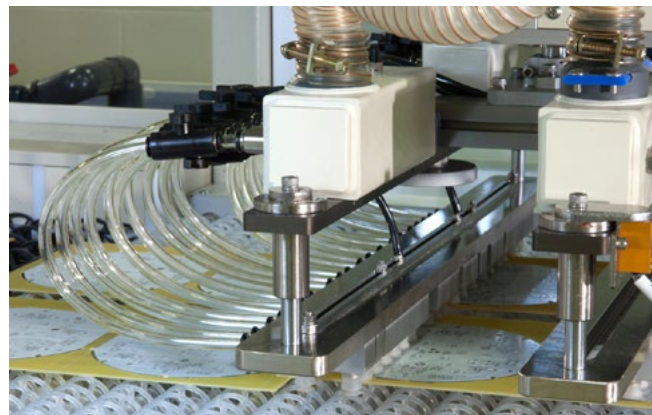
Matties: *Tell us about the product that's being built here.*

Stepinski: It's primarily double-sided as well as single-sided metal core. A few percent are rigid-flex, and a few percent are multilayer rigid, but in general the technology is quite simple.

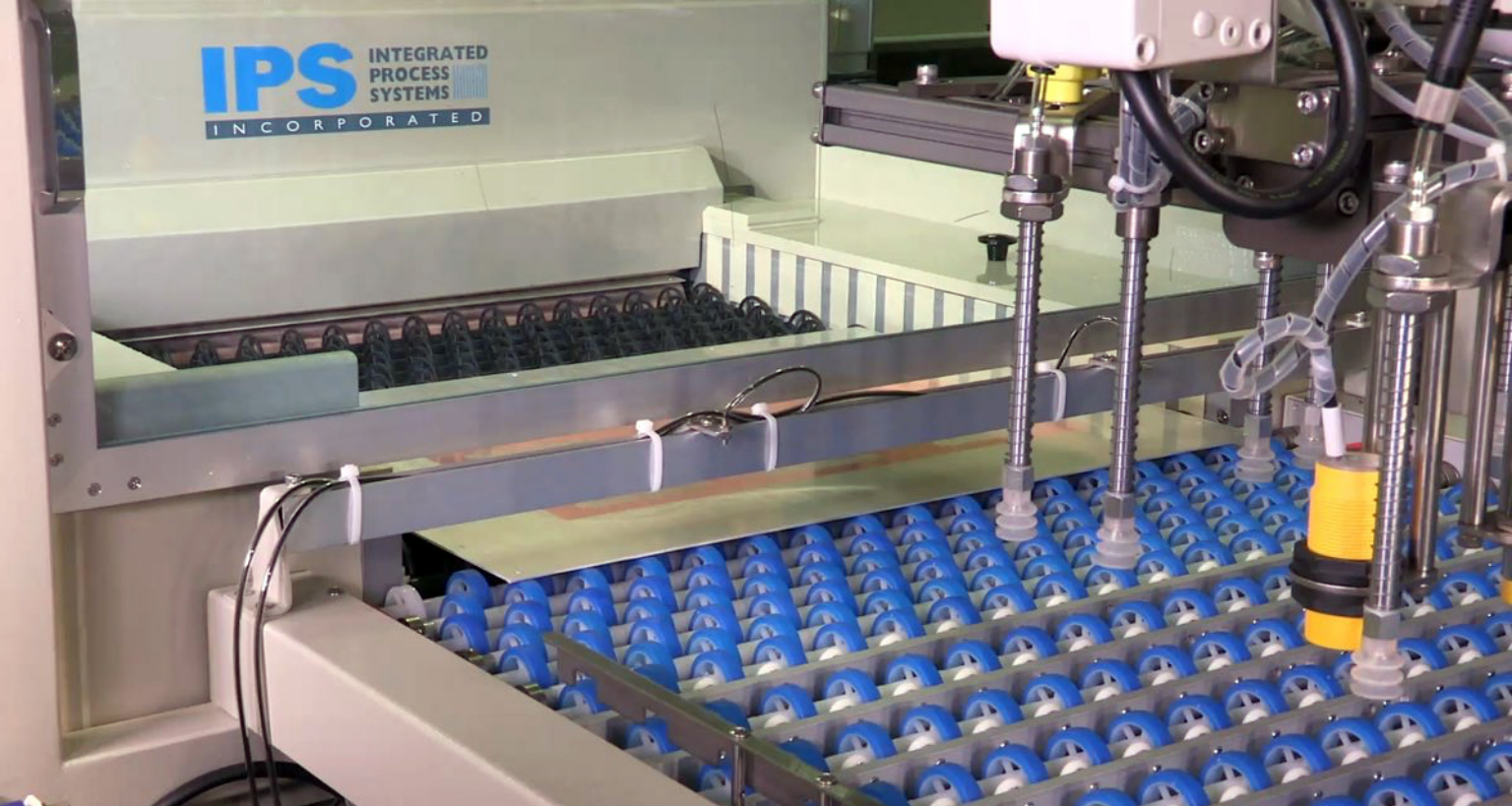
Matties: *You were saying you have about 2,500 different part numbers that you run through.*

Stepinski: Yes. It's a lot of different part numbers and it's difficult to get economies of scale on that over in the Far East. One of the challenges was to create a process that eliminated the setup cost associated with all those part numbers. To do that I made a totally digital continuous factory that basically saw every part number as a widget and we eliminated all the setup costs associated with it, aside from initial tooling.

Matties: *You had to build something that was extremely flexible, because you can't stop for tooling changes and such. What was the greatest obstacle in your design when you first set out?*



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Stepinski: Initially, the greatest obstacle was just to get to the cost points. That was step one. I looked at various alternative technologies and no technology on its own got us there. It was through the integration of everything where we gained the cost benefits. One of the biggest initial challenges was the soldermask process, which is very manual—it's much more manual than many other things out there. To get that to the automated stage, which we're still developing, took considerable effort in the beginning. During the installation phase, the tweaking and experimentation with the inkjet processing was also a significant engineering investment, as was the etch recycling.

Matties: Previously, how long did it take for Whelen to get a circuit board?

Stepinski: Six weeks on average.

Matties: And now, start to finish?

Stepinski: Our cycle time from deburr through final finish is four and a half hours for a panel, and we produce a panel every minute and 15 seconds in fully automated mode. With drilling, routing, and testing, on average, we're going to add another two hours for that.

Matties: For your drilling you have Schmoll machines, all single heads. You have eight of



Schmoll Maschinen Moduls—Single-head drill machines.



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.....
them sitting out there and they're auto load and unload?

Stepinski: Correct.

Matties: I see a stack of drilled boards, ready to go to the process. It looks like you queue up the drilled panels.

Stepinski: We designed the drill area to be the bottleneck for the factory, and we designed the wet process area to be scalable for the next 10 years, so the limiting factor is the addition of drills and drill machines and drill heads as demand increases. And that is because having the addition of wet process equipment as your constraint when you initially build the factory is a very poor idea. That's not very scalable. But independent drill machines are very scalable. Our central system for vacuum power can handle up to 28 drill machines. Right now, we have eight on-site.

Matties: After they are drilled, the boards go into the process and then for primary imaging you're using the Mutracx Lunarix process. That's a new process—the first of its kind and unproven. You're bringing in really new technology, which seems kind of risky for a startup. What was your thinking there?

Stepinski: The traditional process was not that amenable to the cost points. This was by far the most amenable. When we look at cost, we look at total cost as well. We look at the waste treat-

WHELEN ENGINEERING REDUCES CYCLE TIME BY BUILDING A NEW AUTOMATED PCB FACTORY

ment impact, all of the environmental impacts. This factory is the first green circuit board factory in the world. We only use 500 gallons of water a day. We don't have a wastewater permit, and we don't have any air toxics. We don't even generate hazardous waste. We have designed all those issues out.

Matties: *Something is being generated. How are you handling that?*

Stepinski: Every process has its own engineering controls to eliminate the waste to the greatest level possible—waste minimization. Some processes have no waste at all and some do, and we deal with that in a very non-hazardous way. The solids at the end come out non-hazardous and they are recyclable.

Matties: *No permits are required. You already had a building. They had an empty shell here that they gave you to work with, so you had some design constraints but you built a nice, rectangular flow.*



Detail of custom piping.

Stepinski: We did that to fit inside the walls, and the idea was that deburr through final finish would be run by four people at any one time.

Matties: *Let's talk about the labor. I think a shop like this, producing this level of product, would typically take something like a 75–100 people. Labor is not really a factor in this equation.*

Stepinski: We have 17 people inclusive of all overhead, including myself. One of the things that clearly needed to be done was we needed to minimize the labor in order to get to that cost point. The labor we have is primarily focused on maintaining these systems in place. We have a very minimal amount of manual transactions and we have a very skilled labor force here.

Matties: *When did Whelen start?*

Stepinski: We started in the 1950s, in Connecticut.

Matties: *That's great. There's longevity here and it looks like they're willing to take some risks in their business.*

Stepinski: Yes, all of the processes that we ended up procuring and installing, all the feasibility testing for those processes was completed in that first six-week time period. We validated that every individual step would do what it needed to do as a portion of the whole project. The details and the alpha and beta testing were worked out later, but the feasibility testing was fit in up front to minimize the risk and to make sure that when I took the business plan to the CEO, we had enough confidence in that plan.

Matties: *Right, and when I say it was an empty shell, you had nothing in here.*

Stepinski: It was dirt.

Matties: *You guys put in all the plumbing, electrical, every component that you needed. Integrated Process Systems came in and it sounds like they were an important partner in this.*

Stepinski: Yes, they got about a third of the project and they contributed the in-line auto-

WHELEN ENGINEERING REDUCES CYCLE TIME BY BUILDING A NEW AUTOMATED PCB FACTORY



Atotech Uniplate Integrated Horizontal System.

.....
 mation and a substantial portion of the wet-process equipment.

Matties: *In terms of the way you're managing all of your utilities, they're all overhead: It's concrete floor, well-polished, no trenches, and everything's dry and contained. What was your thinking there?*

Stepinski: Having worked in a lot of different shops, I saw the trench as a liability. If you have a trench then it's going to get filled with solution and leaks will not be addressed when they happen. That's number one. Number two, when you have a trench you tend to collect all your waste into central pipes, so if you're actually running the waste treatment system and have a problem, troubleshooting is extremely difficult. You end up having to go to every single process step in a lot of cases to try to find the source of the problem.

When you have everything in separate lift stations, segregated, you can immediately find which lift station it's coming from and address that process. The troubleshooting time is vastly reduced. That's the justification for that system. Without a trench you're eliminating that potential for having a crack down there that goes unnoticed for a long time, because it's not easy to inspect some trenches.

Matties: *Right. So you have only 17 staff members, and this is a captive facility. I think this is the first captive facility coming to America in many years. Do you think this is going to become a trend now that there's a model like this in place?*

Stepinski: I hope that what we've done here at Whelen, as the proof of concept, can be done in other factories at different levels. I think what we've proven here is that you can compete with the Asian Pacific region on price and you can do it in a very responsible way. I hope it's a model for continuing to reshore business here in America.

Matties: *You guys have been very welcoming. You've opened your doors, let us look under the hood and shoot video, ask questions, talk to your people, etc. Why are you so forthcoming with that? What's the motivation to share this?*

Stepinski: We actually do want to share the technology so that other factories and companies in the Western world can learn from us and continue that trend of bringing manufacturing back. Our CEO is a tremendous advocate of manufacturing in America and he's really into promoting reshoring.

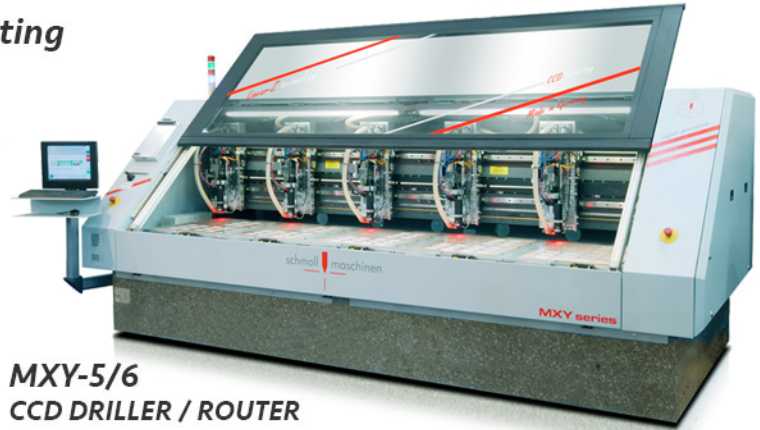
Matties: *I see a lot of American equipment here. I do see some international equipment like Atotech and Schmolz and such, but it's mostly American. Did you go to look for American companies first?*



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Stepinski: Our first choice was always to go with American companies if we felt the capability was there to meet our requirements, so we chose American suppliers wherever that situation existed, but we went overseas if we needed a capability that was not here. There are 39 different suppliers contributing to the factory equipment set.

Matties: How much did it cost to put this factory together?

Stepinski: The cost of all the equipment in the factory was around \$12 million.

Matties: What sort of timeframe did it take from breaking ground to running your first board?

Stepinski: Approximately 15 months.

Matties: Is that because a lot of engineering was happening as you were building or was it just cycle time for getting equipment?

Stepinski: It was limited primarily by equipment cycle time, the arrival time for equipment.

Matties: The other thing that you've done here is factory software integration from process to process. When we talk about the automated process, what you built is a conveyor belt. These boards aren't queuing up necessarily, they're going through one at a time into the plating and they just conveyor around—you're not storing them. How did you manage that and plan it all?

Stepinski: If you look at a conventional board shop, in my opinion, the majority of the cost is associated with all the non-value-added steps that are between processes, whether it's inspection, handling, putting cleaners and micro-etchers at the beginning of the next process to compensate for the handling in-between, or anti-tarnishes at the end of the preceding process.

If you design all that out, your line is a lot shorter and you need a lot less equipment—there's cost savings there. Things like the sizing and determination of speed-matching and recipe-matching were all planned up front. We worked with our suppliers to develop the chemical parameters and the mechanical parameters, so we would have a continuous half a meter a minute line. That's what we have here is half a meter a minute line. Approximately 50 panels an hour, with the space to add pieces to the line and increase that, if needed.

Matties: All right, so it's not really capable of going higher than that without additional equipment.

Stepinski: Yes, but we are only planning a 50-hour work week with the current demands. We have tons of upside for expansion without adding equipment to the wet process line. The wet process line was specifically oversized knowing that we have a pretty strong growth curve here.



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Boards in transit.

Matties: Alex, what's your background? How did you get to be so qualified to do this?

Stepinski: I've worked for quite a few different board shops. I've worked in many different positions in those board shops, from working waste treatment, working in the lab where I started, to running engineering for companies, from being the general manager of a company to working in quality, running manufacturing, doing purchasing, etc. By working in many different shops and in many different functions, I was able to compound all the experience to somehow be qualified, I guess.

Matties: How many years have you been in the industry?

Stepinski: It will be 18 years this year.

Matties: What other issues should fabricators take into account?

Stepinski: I would think the green side of things must be taken into account. A lot of people miss how cost-effectively they can improve their lot in life from an environmental health and safety perspective. Our capital cost was less than what an average facility pays for a conventional waste treatment system that has significant waste water discharge and air toxics. I think that's something that a lot of people can look at and improve. If they looked at how we did it over here, with a lot of point source solutions with recy-

cling the etch and recovering all the copper, not having any waste is significant.

I think we really put a stake in the ground here that the industry needs to look at, in terms of how to be totally clean, keep operating costs far below a standard factory for wastewater treatment and environmental control in general, and spend less money on it, just by looking at how waste integrates with the process. When you engineer a process, look at the waste. That's my message. I don't think anybody really does it very much.

Matties: Talk about your process. I notice that you're using the DIS pinless lamination system. How's that working out?

Stepinski: We've only used it a few times because we're focusing on ramping up the double-sided before we move to multilayer, but initially all the results passed. Eliminating pins in our system and using vision-based alignment for everything is a key point of the factory. Every stage in this factory is vision-aligned, whether it is layup, drill, rout, score, imaging with inkjets, legend, or soldermask—everything is vision aligned. Where the image can be scaled, we scale it sometimes to meet the final print. We may add some for manufacturing tolerances, but everything, if it's not scaled, is still rotated and shifted, zero-corrected to the optimal alignment to the image that it needs to align to, preceding.



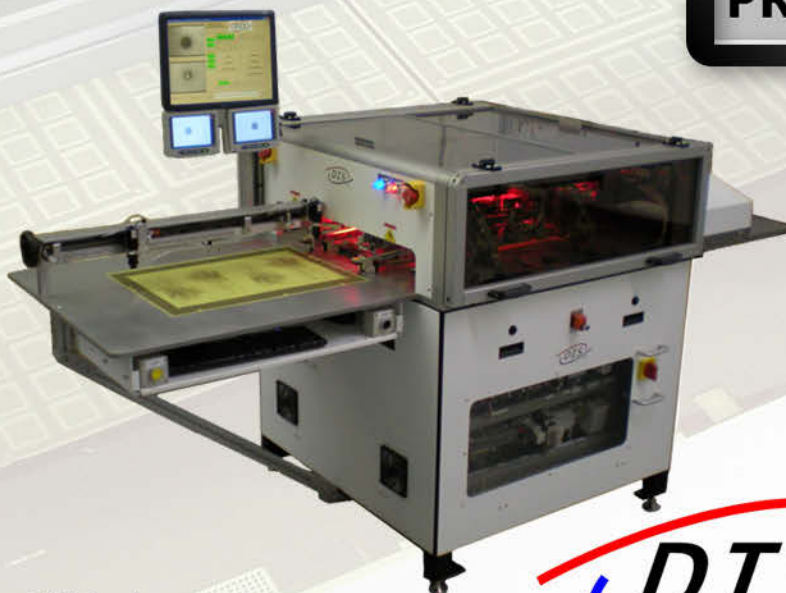
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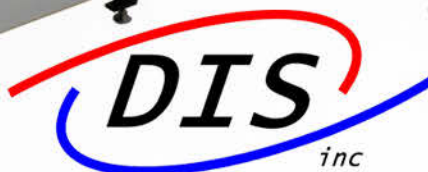
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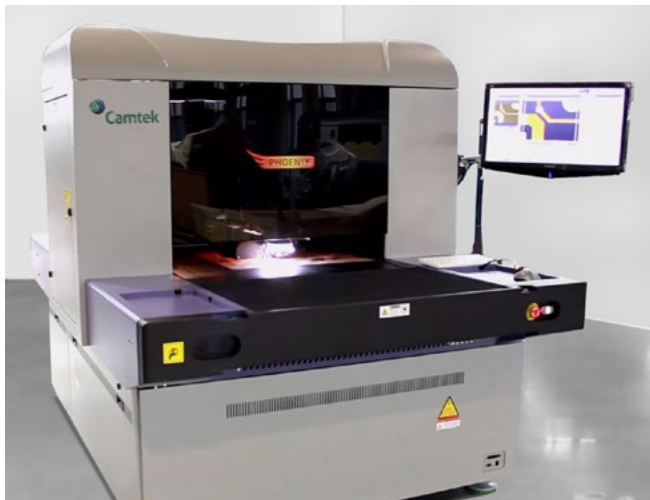
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Camtek AOI machine.

Matties: *With regard to inspection, I think you only have one AOI in your system.*

Stepinski: Yes, we use a Camtek AOI to qualify individual part numbers. Once we qualify a part number, we say it's good to run in production and then we continue to do spot inspections as new parts come into the system. So we're actually sampling our production on a regular basis to know if there are any potential problems, but we do not do 100% inspection. We only sample based on our product technology and based on the robustness of the process, that's all that we need to do.

Matties: *What sort of fails do you have or what are your yields?*

Stepinski: We continue to learn some of the design rules for our products. How we apply tooling to the products, with certain features doing things a little bit differently, seems to be the root cause of 99% of what we have for issues now. We mitigate that by running a test lap first when we get new tooling and learning from it. That's not a long-term solution. That's only for the next couple of months until we feel our design rules are robust, based on feedback from that process. Once we get 10 or 20 part numbers that are clean in a row, off we go.

Matties: *I would think that for your circuit design and new product development team this is*

an amazing resource to have, because they can come and test a design and within hours have some prototypes.

Stepinski: Before they would take days to get prototypes, and now we can do multiple iterations in the same time it took to get one prototype done.

Matties: *That's a huge advantage.*

Stepinski: It's a huge advantage for debugging when they're doing a box build.

Matties: *So you've done it—you did the planning, the execution, and it's running. What would you have done differently?*

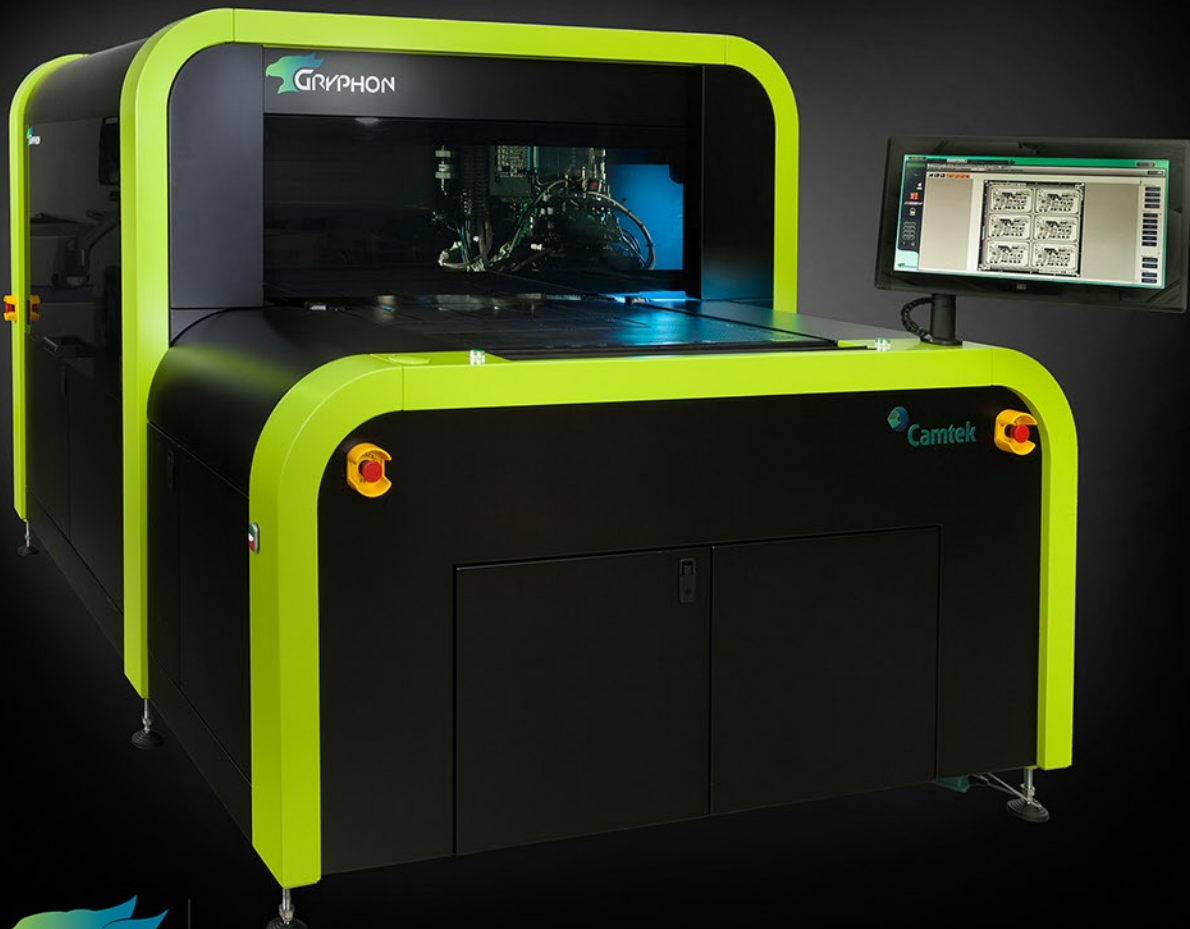
Stepinski: What would I have done different? Because of the time constraints for the design phase of the project, I did a lot of concurrent engineering. I did the high-level design in a very short time, and then the details were worked out over the course of time. As the equipment was being built I'd be in regular conversations with suppliers going through a lot of details, and if I had a little bit more time to have done that all up front instead of doing it concurrently, I probably would have reduced the cost by another 10%. I probably would have been able to reduce the capital cost by 10%, and probably the operating cost by the same amount if I'd had a little more time. But that's the nature of schedules. We can't all have infinite time to do things.

Matties: *But the next time you do this, I'm sure your knowledge and attention will be in high demand. Because a lot of people will look at this and just be blown away by what you have achieved. I've been in this industry for almost 30 years and I've talked with people about doing this, but I don't ever recall seeing anyone do it to this extent.*

Stepinski: We needed to do something different in this industry. Nobody's built low-tech boards in mass production in the U.S. this century, profitably.

Matties: *You're profitable, you're healthy, it looks like you have a few bugs you're working*

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out but you guys are really close to just turning this thing on and letting it roll. Congratulations.

Stepinski: Thanks.

Matties: *In general, I see that Mutracx is really the primary imaging over there. You were saying you've already run some 14,000 panels through there?*

Stepinski: We have about two-thirds of the process basically fully automated. That means one person can run from deburr all the way through soldermask pre-treatment, and we're working on finalizing the soldermask process in the short term right now.

Matties: *What about chemical management? I see all these dose stations.*

Stepinski: After having worked in a lot of different factories, I was not excited about having drums and containers partially full and having people checking inventory on things like that, having to deal with the potential safety issues of a lot of chemical transactions. What I mean by that is in the typical industry process you do an analysis and you potentially need to make an add. So you go to the drum and you make the add, which means a person has to handle the chemistry.

I always worry that someone's going to have a bad day and put the wrong chemical in the



Chemical dosing stations.

wrong bath. I've seen it happen enough over my career that I wanted to minimize the risk of that as much as possible. We don't have any open drums here. We have day tanks for everything. They're all sized for the packages, they're all double contained, and they're all vented.

When we get a package in, like a drum, we transfer the whole drum into the day tank one time with a two-person team checking each other. We've minimized the transactions because of that and then we have metering pumps on those day tanks that go to whatever location needs the chemistry. It's all controlled by the PLC, so there's nobody pumping anything. That reduces the transactions by well over 90% and increases our safety factor and reduces risk.

Matties: *Sounds like health and safety are big issues here. You have one lab in the center of your facility and one person that just maintains your baths, but that's not automated, right?*

Stepinski: We have automation in the lab itself to improve things. Most circuit board shops don't have an ICP, an inductively coupled plasma spectrophotometer. They use AA, which means you have to analyze every element individually and sit there for long periods of time to do that. We have an ICP which allows us to just put the sample in the auto sampler and walk away and do other things at the same time.



Mutracx Lunarix system.

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Just a couple of days ago we analyzed some samples for 32 different elements at once, and you're able to walk away. We have auto titration. We pick the program, put the sample in, and walk away. With all of that automation in there, one person is able to spend no more than six hours a day maintaining all of the chemistry in the factory as well as doing all of our cross-section work. That person still has time to do other things at the factory.

I didn't want to manage a factory where I didn't feel good about coming to work. The health and safety of the employees comes first.

Matties: *I should note that you guys are sitting out here in the middle of nowhere, really. You're the largest employer in this area.*

Stepinski: Yes, the largest in the valley.

Matties: *The people I've talked to here are really excited about working for this company. Many have been here for many years and it sounds like a few have moved into this new division. The other thing that I noticed is several young people here—it looks like you're really helping these people.*

Stepinski: I'm 39 and the average age here I think is about 37, according to my calculations. We have a full range and a nice bell curve of experience here.

Matties: *Are you doing a lot of cross-training in this factory?*

Stepinski: Yes, the idea is that the people here are able to do just about every job needed to support the manufacturing operation. With so few people, you have to have that level of cross-training to tolerate a vacation (laughs).

Matties: *Exactly! Now, in this process I know there are a lot of steps, but what was the thing that most surprised you? Was there anything that you didn't plan for and it was just like, "Wow this really worked out better than I expected"?*

Stepinski: Actually, the waste water system. When we first started, it was planned to have a waste water discharge. We were actually in the permit application process to have a waste water discharge, and the more and more I got into the details of the engineering, I actually ended up not having one and continued to realize the benefits that could be had with very minor process adjustments to eliminate waste.

That was something I had never done before. I had never developed a waste water process or an environmental control process in general, along with the manufacturing process at the same time. Normally, you have something preexisting and you're adding onto it in a brownfield operation.

From a greenfield perspective, doing both at the same time, the benefits were huge. After doing it, you realize that it can be applied to a brownfield as well after all the things you learn here.

Matties: *We've been here for three days and you all have been quite accommodating and welcoming, and we greatly appreciate that. I think you may have a lot of disruptions in the future because a lot of people will want to see what you're doing here.*

Matties: *We've been here for three days and you all have been quite accommodating and welcoming, and we greatly appreciate that. I think you may have a lot of disruptions in the future because a lot of people will want to see what you're doing here.*

Stepinski: We hope it helps the industry in the West.

Matties: *I think it will. I can't imagine someone not being inspired by this and looking to do this else-*



WHELEN ENGINEERING REDUCES CYCLE TIME BY BUILDING A NEW AUTOMATED PCB FACTORY



Burkle WorkCell lamination system.

where. Although a lot of fabricators, as you know, are already in place, and it's hard to say "We're going to start fresh with a clean piece of paper."

Stepinski: I think in a brownfield operation it is difficult, but it's not impossible. One way to look at it from a brownfield perspective is you have process segments that you can certainly automate. If you just were to look at individual process segments like pre-clean through strip, for instance for innerlayers, that segment should always be automated. There's no good reason why it should not be automated.

A lot of people say, "Well there's product variation, or there's fine lines," and things like that. You need to just spec the equipment out appropriately so it's robust for that application. You need to do pretesting. All of that equipment is on the market now from a host of different suppliers and you can also make it so there's no waste from the system.

It's all available. Our research showed that and we've done a proof of concept here, and this is applicable to multi-layer applications. The innerlayer applications, the easiest ones, are automated. We actually automated the whole outer layer process here. People have tried to do innerlayer processing before with varying degrees of success, but outer layer is much more difficult. If you can do that, you can do an innerlayer.

Matties: What sort of line spaces are you getting down to?

Stepinski: The minimum we do here is three and three.

Matties: Can you go lower with the technology you have here if needed or is that just what you designed to?

Stepinski: That's what we designed to.

Matties: But if someone needed to go lower, they could certainly go to whatever they need to.

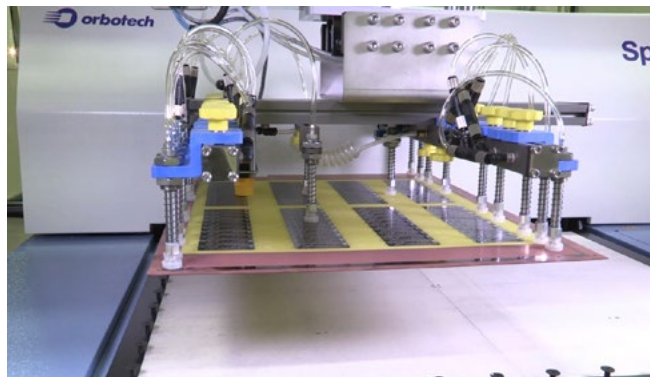
Stepinski: Yeah, and there are all different processes that can be employed to go lower and all of them are robust. A lot of this stuff is used in Asia all the time now.

Matties: You know, I'm looking at it and really, I only see a couple of really new pieces of technology in the Mutracx system, but everything else...

Stepinski: Everything else has just been integrated. We took equipment that has been around for a while as a standalone and we integrated it.

Matties: For the primary Mutracx process, what sort of reduction in cycle time did you gain there?

Stepinski: One of the challenges with a conventional photolithography process is if you're using artworks you're worried about repetitive defects and things like that. The Mutracx process



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has a built-in AOI step and it's fully digital, so you don't have to worry about repetitive defects from a contaminated setup. Then you might say, "Well, why not LDI?" LDI is not the most cost-effective solution. The materials associated with it have a higher cost.

Then you have to really look at the indirect cost. With a dry film process in general, no matter how you image it, you have to develop the image. The developer is actually a pretty terrible limitation on the process. You'll hear from the imaging equipment suppliers, "We can hold this spot size, or we can hold this tolerance." Then when you develop it, you're putting it through a very primitive technology. With a dry film the thickness of the dry film is uniform, and if you look at an inkjet image, you'll see that it's not uniform.

Someone that's used to looking at dry film might say, "Well there's something wrong with the inkjet image." In fact, it's much better because it tapers down from the center of the line to the edge, so that where you're actually etching there is no profile—it tapers down to the copper. The actual difficulty of etching is less with inkjet versus dry film because the aspect ratio of the channel you're etching is less. What we find with inkjet technology is we can hold equivalent etched tolerances to laser direct imaging because we don't have to contend with the aspect ratio of a channel and we don't have to contend with the developer. There are a lot of benefits to that.

We also don't have to deal with thousands and thousands of liters of waste developer solu-



Inside view of automated Orbotech inkjet legend printing line.

tion every week that needs to be treated in some way, or need a permit that's regulated and need an outfall to the river or the POTW.

Matties: *You said innerlayer pre-cleaning through stripping is the first line they should automate.*

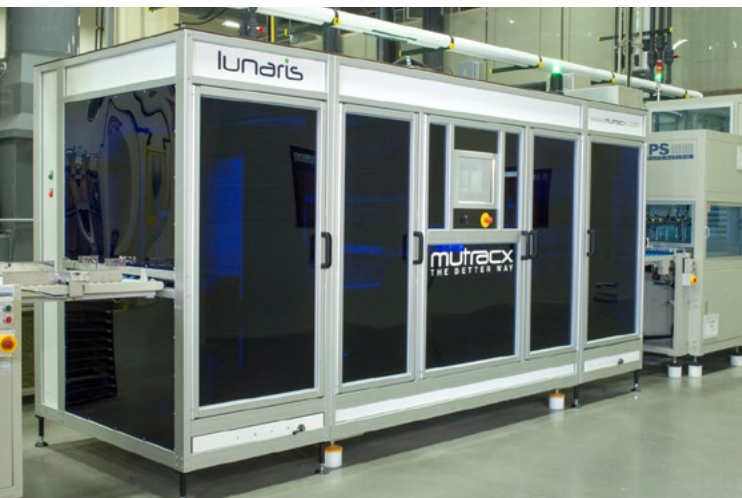
Stepinski: That should be automated in every factory.

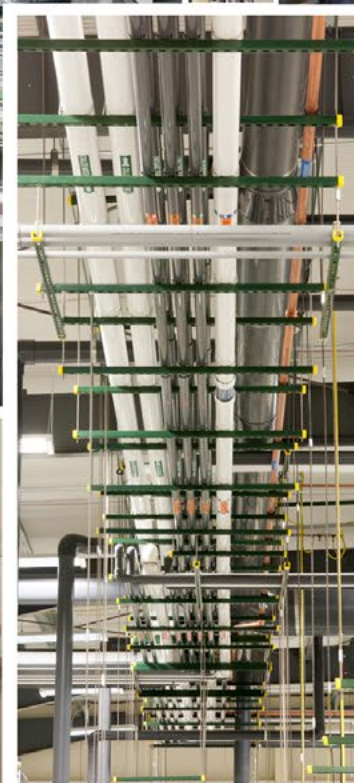
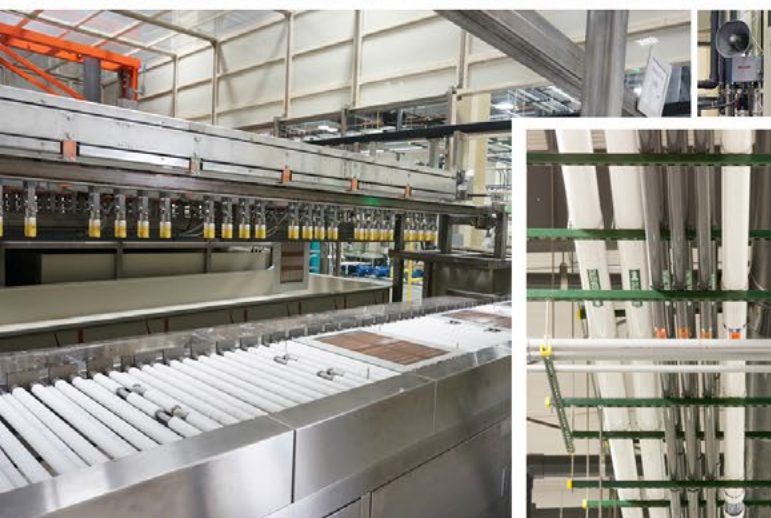
Matties: *What would be the second line you would go after?*

Stepinski: It depends on the factory and the space. You have to look at what the space constraints are. Typically most people have an innerlayer process pretty close to each other or somewhat in line as it is. You find that in most applications, and why it's broken up is a really good question. A lot of it's because the equipment is being bought piece by piece. It's not being looked at as a complete system to be integrated. Stepping back a little bit and pausing and looking at the big picture can save tremendous amounts of capital investment and tremendous amounts of operating cost later. I think that's what people miss.

Matties: *Thank you so much for everything.*

Stepinski: You're welcome, Barry. Thank you. **PCB**





WHELEN & IPS:

A Strategic Partnership—A Winning Combination

by **Bryan Bernas**
I-CONNECT007

Integrated Process Systems, Inc. (IPS) is a manufacturer of automated wet process equipment and material handling systems in Cedar City, Utah. IPS was formed in June of 1996 with a philosophy of being a multi-product, multi-industry company. In 1996, IPS purchased the assets of VCM for its vertical process equipment, and in 2000, purchased the assets of Western Technology Associates Inc. (WTA) for its horizontal process equipment and VRP technology. The result is the establishment of IPS as a state-of-the-art product line that offers a turnkey solution to all wet process and material handling requirements.

Of the 39 suppliers Whelen chose to use, none were as integral to the automation and overall design and layout of the line as IPS, with its team led by President Mike Brask. In February 2014, IPS approached Whelen at a very early stage, to put the required infrastructure in place before any of the equipment could be installed. This involved the design and installation of all

the overhead utilities: the blower on the roof for exhaust, the process piping, as well as all the Unistrut framing (yellow and green for Mike's favorite Green Bay team—a playful jibe for a factory located in the heart of New England Patriot territory). IPS also hired local mechanical contractors to run the plumbing, which would later be connected to pump stations (also installed by IPS) scattered throughout the factory. From start to finish, the Whelen project took the IPS team approximately 18 months.

Speaking about taking on such a large project, Brask said, "From an engineering point of view, the challenge was thinking through all the process flows and automation details that needed to happen; Alex Stepinski had his flow charts and his logic worked out, but what does that tool have to look like? That's where we came in. He did a very good job spec'ing the process, which made it a lot easier, but then configuring the tools to do each one of those functions—that took some time. Another big challenge for us was that normally, equipment manufacturers in the U.S. don't get huge orders like this every day. We had to ramp up to keep up with the

WHELEN & IPS: A STRATEGIC PARTNERSHIP—A WINNING COMBINATION



IPS Conveyorized horizontal wet processing line.



IPS panel accumulator.

capacity we needed to build this along with our other projects and try to balance it all.”

The IPS equipment made up about one-third of Whelen’s equipment spend. Overall, IPS installed 52 machines at Whelen. One of the key technical challenges was working with other vendors to integrate their tools into the software management system. IPS had the responsibility of integrating these tools for the line to run as a turnkey solution. This involved writing software drivers to work with each supplier’s unique formats and languages that, in some cases, weren’t developed at the time the orders were placed with IPS. All systems needed to be programmed so the user could define the process flow of each job in a tray that could be independently routed and tracked. This software and hardware allowed the line to run as a continuous system.

All IPS equipment was manufactured in the U.S. in Cedar City, Utah, except for the handling equipment, which was made by IPS’ Taiwanese partner, WorldTech. It makes up an impressive automated conveyor system that tracks very smoothly and is filled with IPS loader/unloaders, buffer systems, etching and stripping systems, and so on. But perhaps the most impressive IPS system is the vertical electrolytic plating machine. Being fully automated, this machine has the biggest cycle time gain; in 30–40 minutes Whelen is able send a panel through the entire process. After all of the equipment was installed, IPS also worked with Proface, their

touchscreen provider, to develop software that coordinates all the machines and allows the system to monitor each job in real-time.

Within the budget Whelen set, Alex dreamed up a remarkable factory, but it was IPS that played a central role in making it a reality.

“We’re in a redefining moment,” Brask said. “We had our initial business plan that we started the company with—to be multi-product, multi-industry. We’ve always stuck with that philosophy. That has gotten us through the downturns and the recessions. We’ve been fortunate enough to always be stable. Now what we’re doing is we’re redefining the business plan to basically bring to the table integration and automation. It’s what the future market needs in the U.S. for circuit boards.” **PCB**





MUTRACX: First Install Achieves CAM to Etch in 5 Minutes

by **Barry Matties**

I-CONNECT007

While visiting Whelen Engineering, which had just installed Mutracx's new Lunar is machine. I met with Mutracx Sales and Marketing Director Peter Coakley, who showed me how the new machine works and explained how it can save time and money on the shop floor.

Barry Matties: *Why don't you just start by explaining the Lunar is imaging process?*

Peter Coakley: What you are looking at here is our digital inkjet printer, a key component of the automated process. At Whelen, it is used for etch resist (inner layers), and plating resist applications (outer layers). This process replaces many costly steps in the traditional photolithography and provides significant reductions in process time, massive cost savings in materials and labour, and is fully compatible with supporting "green" manufacturing ethics and the environmental requirements demanded here at Whelen.

In a production environment, we go from a file that the CAM operator prepares to inkjet

printing and subsequent etch or plating process in five minutes. That's what we offer, the flexibility and full batch automation that lets you actually print, on the panel, the exact circuit design you need in a short time.

With the conventional process, you would have to laminate the panel with dry film, manufacture a set of artworks and then expose that dry film using these artworks on a separate process followed by a developer process to wash off the majority of that unexposed dry film.

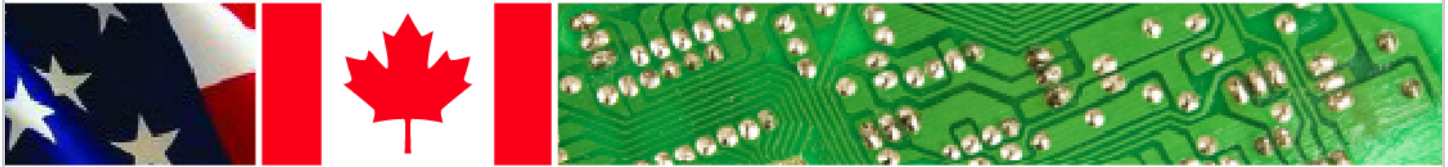
Matties: *And it's done inline as well?*

Coakley: It's automation that lends itself to in-line volume production. Due to the flexible CAM interfacing without set up time it's perfect to manufacture in a high-mix environment, even running prototypes between the main production volume.

Using the automated line buffers, you can stop a job part way through and switch production types and lots, so it has the flexibility built in to switch jobs and print either a negative image for subsequent plating or an inner layer positive image prior to etching.

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MUTRACX: FIRST INSTALL ACHIEVES CAM TO ETCH IN 5 MINUTES

Let me just emphasise again, that the inkjet process does not require a developing process as you only use the minimum of ink resist needed to produce the circuit design, thereby again reducing processing time, materials and wastage.

Matties: *How does it know which job? Does an operator have to come in and select?*

Coakley: In the basic manual operation mode that is possible, but the system is designed for full automation by referencing panels in barcoded trays at the very start of the manufacturing process. It uses the master database to print the right image design on the right panel with minimum intervention.

Matties: *Can you explain the inkjet printing process in simple terms?*

Coakley: The panel, either for PTH or inner layer, enters the machine after standard pre-clean process and alignment. Once inside, the panel is picked up by a gripper bar that transports the panel into position on a vacuum table or chuck.

The table and panel are then moved to an inclined (60°) position for an alignment process using punched fiducials for inner layers or using pre-existing drilled fiducial holes in the case of PTH boards.

The panel is then transported, again with a gripper bar, onto the printing stage and aligned with the scanner prior to inkjet printing. These alignment steps ensure high front to back accuracy.

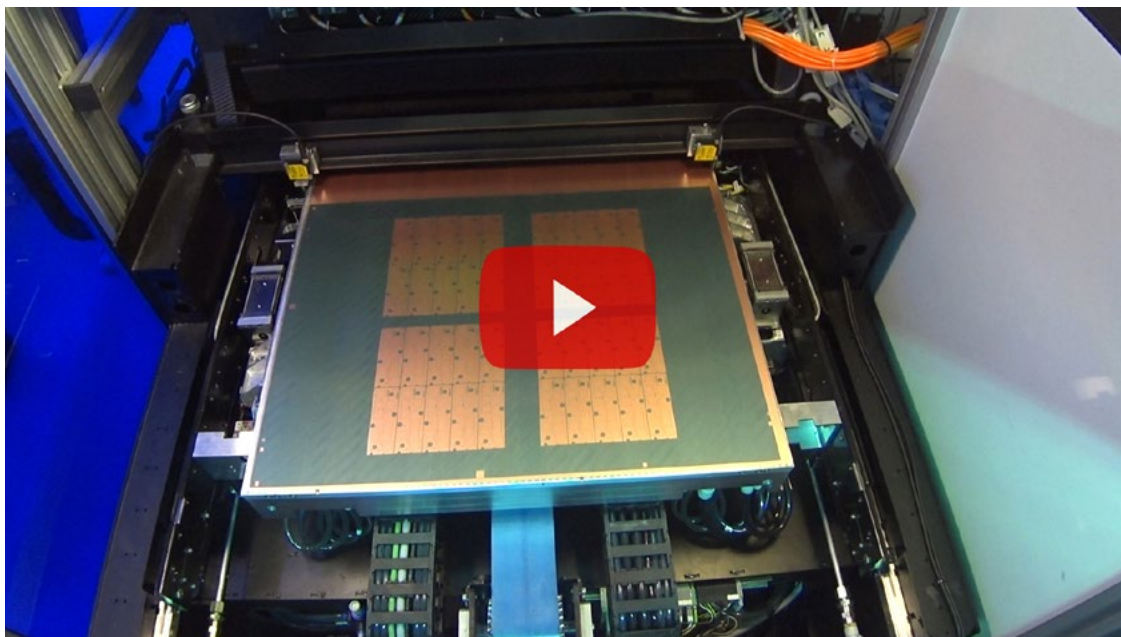
Inkjet printing takes place by moving the panel in a number of swathes under the print head assembly, containing 60 print heads, to print the image. Mutracx use a unique print strategy and algorithms, with built-in print head redundancy, to ensure quality printing with the minimum of heads.

After inkjet printing the panel goes through the internal AOI system to verify the printed pattern matches the CAM file and is free from printing defects; this automated AOI step ensures higher yields.

The panel is then transported onto a turn buffer table to rotate the panel into the vertical position for the UV cure cycle to cure the printed resist. Once cured the panel is returned to the alignment stage ready for the bottom side print cycle.

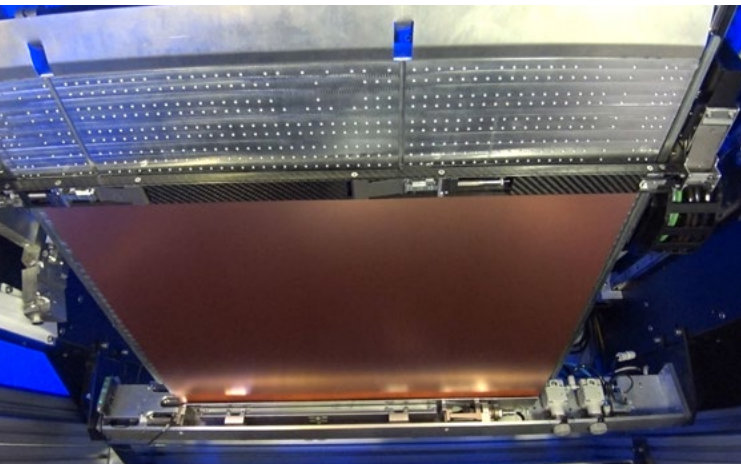
The printing swathes are repeated, along with the AOI function to check print integrity and then back into the UV cure stage to cure the bottom side.

Matties: *How many panels are processed at any one time?*

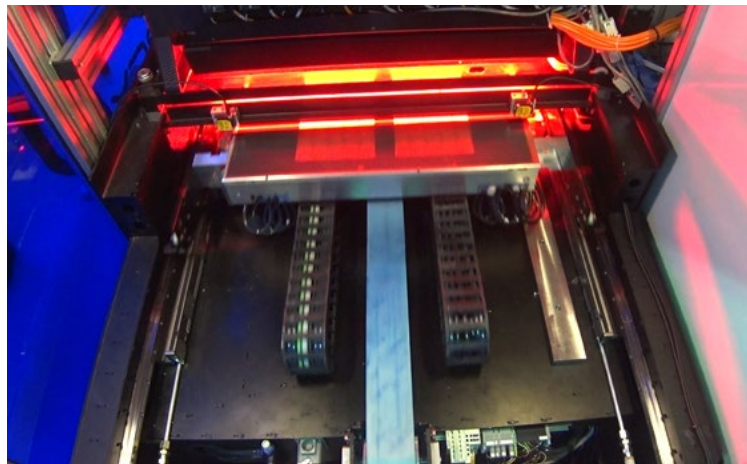


Mutracx demonstration video. (2:31)

MUTRACKX: FIRST INSTALL ACHIEVES CAM TO ETCH IN 5 MINUTES



Vacuum chuck.



Proprietary built-in AOI system.

Coakley: The system processes a maximum of three panels at any given time in order to achieve the high productivity required for volume production.

Matties: *What about the ink? Is this a proprietary ink from a single source?*

Coakley: The ink resist is a hot melt wax formulation that requires UV cure and the resist is suitable for acid or alkaline etching and for tin plating as used here at Whelen.

The ink is supplied to us by our strategic partner, Dow Chemicals, based here in New England. We then supply the inkjet engine and the resist in one package to the customer.

Matties: *And you resell it?*

Coakley: What the customer buys is a good board and maximum potential yield into the subsequent process; this is paid for in a unique commercial model called “Pay for click,” which is adapted from the graphic print industry. It ensures the customer only pays for good panels printed that have met stringent quality controls.

The click payment not only includes the resist to produce a good panel, but replacement print heads as required, all spare parts, preventative maintenance and full on-site service support and can be structured for single or double-sided printing. It keeps control of related process costs plus equipment consumable and servicing costs throughout the life of the system.

Matties: *It's reliable, hands off, and it needs limited customer intervention?*

Coakley: Yes, that's the design brief and the practical day-to-day experience at Whelen today. At the start, we supplied extensive engineering and operator support as you would expect in the early days, but today, Whelen has taken full responsibility for daily production with limited and sometimes only remote intervention from our Dutch team.

High-reliability has been built into the system and combined remote diagnostics and “machine-to-world control.”

Matties: *This is your first installation, correct? Has it gone the way you thought it would?*

Coakley: Yes, Whelen is our first installation and we are honoured to be a valued supplier for such a key component in this groundbreaking project.

The concept to change the face of PCB manufacturing with inkjet technology in such a short space of time has been a challenge at times and many valuable lessons have been learnt for future installations.

We, along with our partners, plus great support from Whelen, have ensured this first project has been a resounding success and all parties can be proud of the joint achievement.

Matties: *Thank you very much*

Coakley: Thank you. **PCB**

Electronics Industry News

Market Highlights



NAND Flash Suppliers Aggressive in Cutting Prices on Weaker Demand

Smartphone, tablet and notebook vendors have marked down their shipment targets in response to the slowing of the global economic recovery in the second half of 2015, according to the latest research from DRAmEXchange, a division of TrendForce.

Global Embedded System Market to Reach \$233.13B by 2021

According to a new market report published by Transparency Market Research, the global embedded system market was valued at \$152.94 billion in 2014 and is estimated to grow at a CAGR of 6.4% and reach \$233.13 billion by 2021.

China Now Third Largest Importer of Defense Equipment

China's defense budget is expected to almost double by the close of this decade, according to new analysis released today by IHS Inc.

Patterning Material Market at \$3.86B by 2020

The global market size for Patterning Materials in terms of value is projected to reach \$3.86 billion by 2020, at a CAGR of 5.85% from 2015–2020, according to MarketsandMarkets.

Smart Cities Market to See 22.5% CAGR Growth to 2019

The global smart cities market is forecast to hit \$1,134.84 billion by 2019, at a compound annual growth rate of 22.5% during the forecast period 2014–2019.

Apple Uses 20% of Worldwide Sapphire Capacity

Sapphire is the key material for LED manufacturing. In 2015, 20% of sapphire will be used in Apple's iPhone for the camera lens, fingerprint readers, heart rate monitor covers, and the Apple watch's window.

RF Power Semiconductor Device Sales for Wireless Infrastructure Tops \$1B in 2014

Just when the industry thought that things were pretty good in 2013, the RF power semiconductor market for wireless infrastructure blew off the charts in 2014. China and the Asia-Pacific region in general continue to be the main driver for the RF power chips that are sold into the mobile wireless infrastructure segment.

Tablet Shipments to Slide to 163M in 2015

The latest tablet shipment report from TrendForce projects the 2015 global tablet shipments to reach 163 million units, a 14.9% year-on-year decline and a downward revision from the previous estimation.

Power Module Market to Reach \$17B in 2015

The global power module market is projected to comprise nearly one third of the power semiconductor market by 2019, growing at twice the rate of power discretes, from 2014–2019.

Automotive Industry Now the Third Largest End Market for Power Semiconductors

In 2014, the automotive sector significantly outperformed the overall market average for semiconductors. In fact, the automotive market overtook data processing to become the third largest end market for power semiconductor applications, according to market analyst IHS Inc.



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PUTTING IT ALL TOGETHER

The Economics of Reducing Cycle Time in PCB Fabrication

by Jason Marsh

INSULECTRO

The area of cycle time most visible to the market is the total product cycle time through the fabrication process. This is an area of great importance to both OEMs and bareboard customers. As circuit board fabricators are constantly pressured for cost reductions, speed is definitely one thing worth paying for in 2015. For North American fabricators, there is a great deal of emphasis on quick-turn and development work, resulting in a high-mix, low-volume market whereby job setup is a key factor in the cycle time. In fact, it is not uncommon for 10–20% of the total product cycle time to be eaten up during layout, CAM and planning, which must be completed prior to releasing a job.

Leaders in the quick-turn and prototyping market reserve a significant percentage of their capacity for supporting this demand. Even so, they realize it is important to reduce cycle time for steps like sequential lamination, drilling, imaging, and final test.

Following are actual examples of industry practices that successful fabricators in the quick-turn market embrace that can help those companies who want to reduce cycle times in their operations.

Less is More

Some fabricators, such as Streamline Circuits, differentiate themselves by running a largely toolless process, which means that everything is digitized from laser drilling to LDI imaging and from LDI solder-mask to digital legend printing, and finally to flying probe testing at the end of the line.

With a 100% filmless process, Streamline can tool more than 20 jobs per day, which, once released, can move rapidly through the shop from start to finish without waiting on test fixtures, phototools, or legend screens. Investing



Figure 1: Streamline's Orbotech Nuvogo dual wavelength LDI unit, capable of 18 micron resolution.

in the latest equipment, such as a digital legend printer, 25-micron AOI, and 18-micron LDI capability and increasing press capacity also contributes to improved cycle time.

The Importance of Culture

Another critical aspect for cycle time that can't be conveyed in a brochure, is culture. An example of this is at APCT Inc., in Santa Clara, California, where a healthy culture is embodied throughout every level of the company. Everyone, from top management to shop floor operators, is committed to quick-turn, including the theory of constraints mindset and a sense of urgency, which will contribute to the customers' needs being met day in and day out. This approach has allowed APCT to establish a core competency as a high-speed HDI operation, one that can consistently produce a 10-layer board,

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THE ECONOMICS OF REDUCING CYCLE TIME IN PCB FABRICATION

with vias on every layer and five sets of copper-filled laser micro-vias, and four lamination cycles, within a week (Figure 2).

APCT is unique in that they confirm the raw material delivery date from their supplier before they will quote turn time to their customer for the job. Other quick-turn specialists employ consignment inventories and close communication and partnership with their material suppliers as a means of delivering on the speed requirements in today's market.

Benefits of On-Site Assembly

One benefit of having on-site assembly, which Advanced Circuits Inc. (ACI) has in their Colorado location, is that it allows vertical integration, and consequently, speed. The company also distributes proprietary layout software (as a

free download) that generates automated files optimized for their production process. The result is that ACI can support double sided builds for same day shipment and 4–6 layer boards for next day production.

Creative Technology

However, in order to provide world-class cycle time through your shop and differentiate the shop from overseas competition, it is critical that the cycle time of each of the component steps of your board production be balanced. One way to pull ahead from the competition is to employ creative technology approaches to building boards. For example, Prismark modeled a 10-layer smartphone build for Ormet using a parallel lamination technique that resulted in 28 hours of cycle time versus the 107

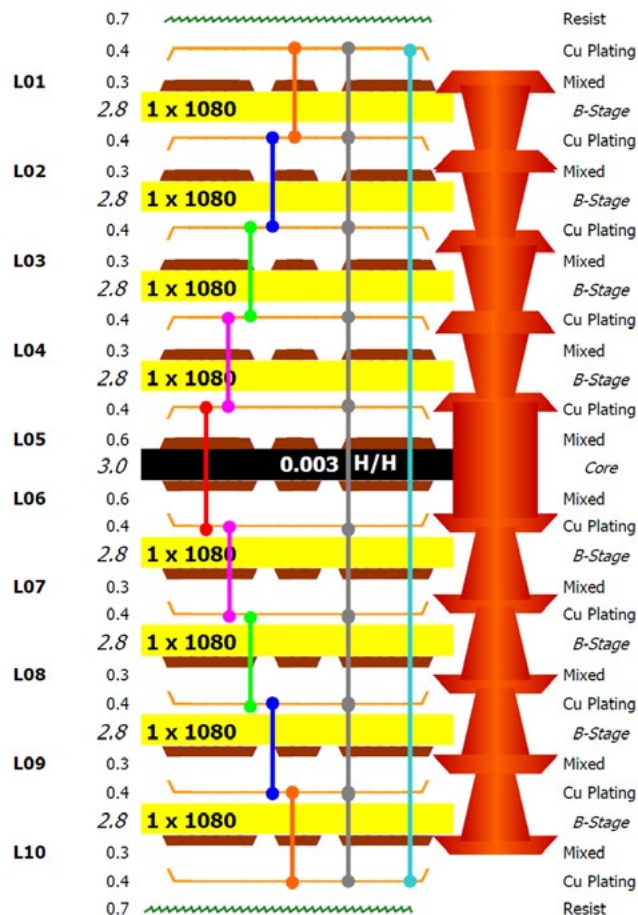


Figure 2: Stackup of a typical 10-layer APCT HDI one-week turn-time job.

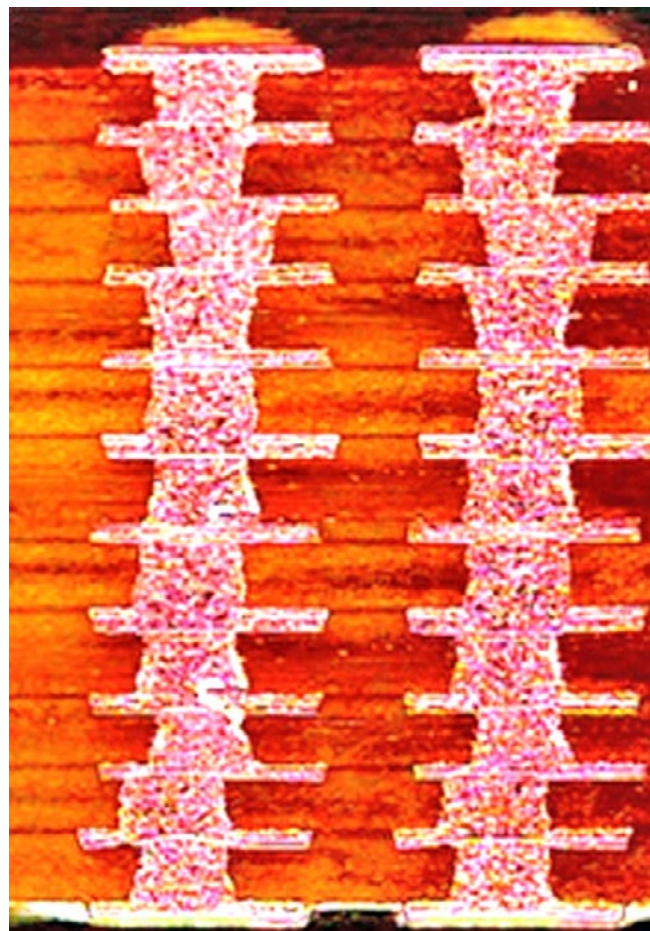


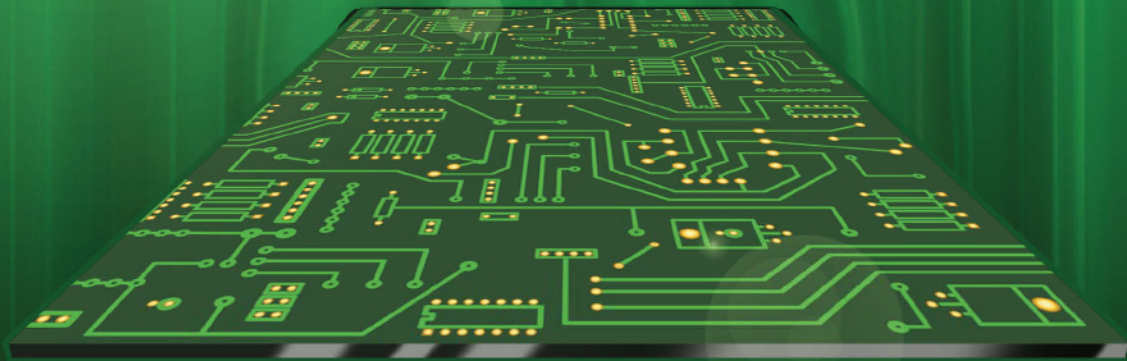
Figure 3: HDI buried via application using parallel lamination.

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THE ECONOMICS OF REDUCING CYCLE TIME IN PCB FABRICATION

hours it that a sequential lamination approach would have taken.

Optimizing cycle time eliminates bottlenecks and provides the added benefit of improving equipment utilization and thus the businesses' profitability and the ROI for any capital equipment investments.

Materials

Materials also play an important part in cycle time. One trend that is happening in 2015 is that many shops have balanced their process during the last few years around common lead-free epoxy press cycle conditions (for which a typical press cycle may run at 360°F for 70 minutes under 250 psi). However, according to some fabricators, more and more jobs are coming in asking for low-loss, high-speed digital (HSD) materials (the most popular of which can require temperatures up to 385°F for 120 minutes and pressures as high as 580 psi). As a result, fabricators are finding that their lamination cycle time has become a throughput constraint as their work mix changes. This is good

news for people selling lamination presses and also creates opportunity for some next generation materials that will have comparable electrical properties to the current HSD offerings but process under conditions closer to lead-free epoxies.

Of course, even the highest velocity, and most finely balanced operation does not help if you have to restart a job because it fails at final testing. Controls in your process, the quality of the materials you use, and training of your people are fundamental requirements, critical to your differentiated value proposition. The payoff of course is that a quick-turn premium can fetch 200% or more of the price of a standard lead time for the same board. **PCB**



Jason Marsh is vice president of product management at Insulectro.

New Assessment of Silicon for Next-gen Batteries

A detailed nano-mechanical study of mechanical degradation processes in silicon structures containing varying levels of lithium ions offers good news for researchers attempting to develop reliable next-generation rechargeable batteries using silicon-based electrodes.

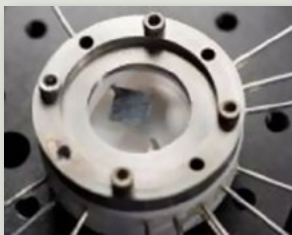
Anodes—the negative electrodes—based on silicon can theoretically store up to ten times more lithium ions than conventional graphite electrodes, making the material attractive for use in high-performance lithium-ion batteries. However, the brittleness of the material has discouraged efforts to use pure silicon in battery anodes, which must withstand dramatic volume changes during charge and discharge cycles.

Using a combination of experimental and simulation techniques, research-

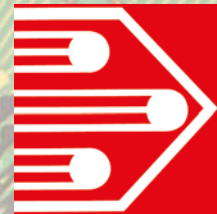
ers from the Georgia Institute of Technology and three other research organizations have reported surprisingly high damage tolerance in electrochemically-lithiated silicon materials. The work suggests that all-silicon anodes may be commercially viable if battery charge levels are kept high enough to maintain the material in its ductile state.

"Silicon has a very high theoretical capacity, but because of the perceived mechanical issues, people have been frustrated about using it in next-generation batteries," said Shuman Xia, an assistant professor in the George W. Woodruff School of Mechanical Engineering at Georgia Tech. "But our research shows that lithiated silicon is not as brittle as we may have thought. If we work carefully with the operational window and depth of discharge, our results suggest we can potentially design very durable silicon-based batteries."

Supported by the National Science Foundation, the research was reported September 24 in the journal *Nature Communications*.



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The True Figures

Practical Application of Lean Six-Sigma to Drive Cycle Time Reduction, Part 1

by Kathy Nargi-Toth
NCAB GROUP USA INC.

Introduction

One of the most systematic and successful approaches to the challenge of cycle time reduction can be found in the principles and tools of lean six-sigma methodology. The success of this strategy requires commitment. It is not a quick fix, nor will it be effective if it is only used as an occasional housecleaning activity. To be successful requires a long-term commitment of time and resources and a tireless dedication to improvement. As a result you should expect and welcome change as your company focuses from inward (my product) to outward (my customer), with a goal of total customer satisfaction. It's a win-win solution.

Some might argue that Walter Shewhart was the inspiration for the concept of six sigma.

It was Shewhart who in the 1920s identified common and special cause process change and introduced the control chart. The credit however for the term “six sigma” is given to Bill Smith and co-founder Dr. Mikel Harry of Motorola. In the mid-1980s, Motorola CEO Bob Galvin supported a quality initiative based on six sigma methodologies that changed the way Motorola did business, which improved quality, increased customer satisfaction and ultimately saved hundreds of millions of dollars in the process.

Motorola's six sigma concept began with four basic principles: measure, analyze, improve, control (MAIC). The D (define) of DMAIC was added later by GE. Today, six sigma includes lean principles (Figure 1) as well as methods that introduce six sigma earlier into the design phase of the process, which enables faster time-to-market with products that better



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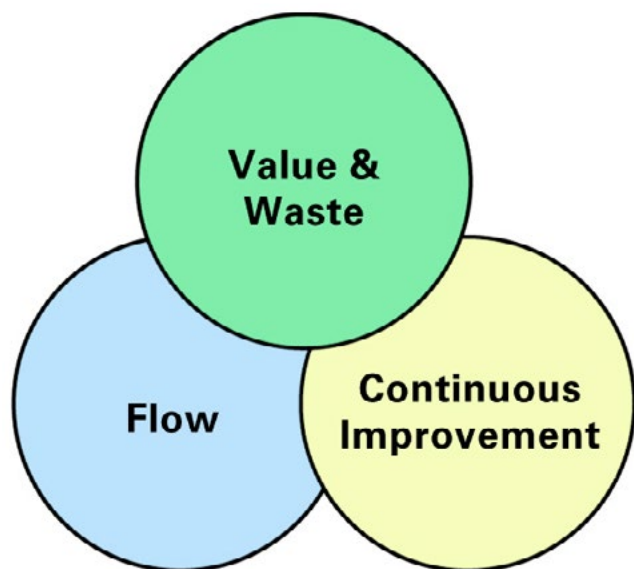


Figure 1: Key elements of Lean.

meet the customers' specific requirements. By using six sigma principles and lean techniques together, PCB manufacturers can reduce both process variation and cycle time together effectively.

Getting Started

The PCB manufacturing process is by nature a batch process, following a predetermined sequence that is developed to meet the products' specific design requirements. In PCB manufacturing not all products go through the exact same process, which complicates the task of cycle time reduction. As an example, a standard multilayer board will probably not be laser-drilled or plasma-etched unless it has some very unique characteristics. And HDI products may cycle through lamination, drilling, laser drilling, plating and etching two or more times before moving on to solder mask application. Cycle time reduction efforts for these two products will require individual evaluation.

At first glance we might say that the overall manufacturing operation cannot be "leaned" because lean doesn't lend itself to batch processing or multiple process sequences, but this is not correct. Any process can be made leaner and a batch process can certainly be lean. Mul-

multiple process sequences are routinely managed in a lean environment as long as each are evaluated separately and each piece of equipment, process step and work-hour can be accounted for. The key concept to lean is keeping the process flowing consistently, be it batch or individual piece. To be truly lean a process must flow continuously, with a minimal amount of non-value added processes. The real hindrance to lean is not a result of batch processing but of waste—both time and resources—that can sometimes result. One last point on batch processing: Smaller is usually better. Reducing the batch size will most likely be a part of the final cycle time reduction solution.

The next question is this: How do we improve flow and remove non-value added waste? First, we need to look at the overall production process. PCB manufacturing is for the most part a series of production lines. In a greenfield facility we can expect that the layout has been optimized to reduce steps and minimize waste. In facilities where new processes or capacity have been added after the initial layout was completed the result may not be optimized and waste may be inherent in the system. Whenever possible this waste needs to be removed.

In a lean environment the product is produced only when it is needed. Producing any more or less results in waste. Each PCB manufacturer will need to determine both takt time and cycle time to determine the correct rate for production. Takt time is customer demand leveled against the actual time the factory has to produce the product. Cycle time is the working time it takes to complete the process. It's takt time that sets the rhythm for manufacturing. Most factories will then use a pull system (Kanban) that minimizes the work in process to achieve continuous flow. To be successful in maintaining continuous flow once it has been established the processes must be capable and reliable, which is where six-sigma adds its value.

Process Flow Diagrams

Many companies have embarked on lean training and use lean principles to remove waste and lower manufacturing cost. We have all been involved in a 5S housecleaning or par-

PRACTICAL APPLICATION OF LEAN SIX-SIGMA TO DRIVE CYCLE TIME REDUCTION, PART 1

ticipated in a Kaizen. Most companies, however, do not add the quality discipline of six sigma to the process and therefore do not effectively measure the small continuous improvements and reduction in process variation that should be at the core of every company's lean initiative.

It all begins with a process flow diagram. One of the most frequent mistakes a company makes while developing the process flow diagram is that it is completed in a vacuum, by the process owner or engineering support person. To be robust and accurate, the process flow diagram must be developed as a team activity. Team members should include process owners, technical experts, production operators, supervisors, and support individuals such as management, engineering, quality, etc. The inputs for the process flow diagram include observations, brainstorming, work instructions and a complete review of the 6Ms: man, machine, material, measurement, method and mother (nature). Every step, no matter how small, must be included. This includes inspection, go/no-go decision and data collection point—in effect—everything.

When developing the process flow, observation techniques are critical. We all know what we think the process is. We can refer to our SOPs and find what the process should be. But we often find that the actual process flow has changed somewhat from these views—to what the process actually is. This is the flow we must diagram. In a complex manufacturing environment the process operators are often the people with the most accurate information. They need to understand that their contribution to documenting the accurate process flow diagram as of today is necessary, and that any undocumented changes they may have made to facilitate the operation need to be documented now. So observe and record. Observe over all shifts and on all machines. Observe all operators and verify all process parameters and machine settings meet the previously documented requirements. If anything has changed, only document the current situation.

With the process flow diagram complete we begin the task of identifying which are the value add processes and which are not. Value-

added process steps will change the form, fit or function of the board. As an example, the drilling process is a value-added process. We need to put the holes in the board—without the holes the board will not function and the customer's requirements will not be satisfied. By contrast, waiting for someone from the drill storeroom to bring the correct size drill bits so that we can start the job is a non-value added process. It's waste. Wait time is wasteful and non-value added.

A well-defined process flow diagram will provide a tool that can highlight all types of waste as well as hidden factories. Hidden factories abound in the PCB manufacturing environment and include those workarounds we create when things aren't functioning correctly or any

.....

“When developing the process flow, observation techniques are critical. We all know what we think the process is. We can refer to our SOPs and find what the process should be.”

.....

type of product rework. Some examples of waste are over-production, wait time and of course defects. These are all areas for improvement. If you are doing touch-up after imaging or removing unetched copper at AOI inspection, your process has a hidden factory. Hidden factories have become such a part of our manufacturing expectation that we have even developed specialized equipment to complete the hidden factory tasks instead of fixing the process and eliminating the waste.

The Value Stream

The next step in the process is to complete a value stream analysis. The optimized value stream will only include the actions that the

PRACTICAL APPLICATION OF LEAN SIX-SIGMA TO DRIVE CYCLE TIME REDUCTION, PART 1

Process/Machine Name		Drilling													
		Study Number													
		1		2		3		4		5					
Detail Process Step	Operator	Total Time	Step Time	Total Time	Step Time	Total Time	Step Time	Total Time	Step Time	Total Time	Step Time	Best Step			
		Receive Product	NP	6	1	8	1.5	12	1.2	5	1.5		7	1.2	1
		Kit Product	NP	8	8	9	7	7	6.5	11	9		10.5	9	6.5
		Machine Set-up	NP	12	11	14	11.5	15	12.5	11	10		13	12.5	10
		Programming	NP	5	1.5	5.5	2	6.5	1.7	4.5	2.2		5	1.8	1.5
		Start	NP	1	1	2	1.5	2.5	1.7	1.5	1.2		2	1.7	1
		Program Run Time	NP	56	40	48	42	50	41	46	44		48	43	40
		Breakdown	NP	11	9.5	10	9	8	7	8	6.8		8.5	7.4	6.8
		X-Ray Inspection 1 st Article	NP	10	4	11	3.5	12	3.6	11.5	2.4		9.5	4	2.4
TOTAL CYCLE TIME		109		107.5		113		98.5		103.5		69.2			

Figure 2: Time observation sheet: drilling.

customer would be willing to pay for to bring the product or service from start to finish. If we remember the drill room example from the previous section, most customers will not be willing to pay for a wait time created by not having the tool ready when the boards arrived at the drill machine. The customer would also not be willing to pay for the rework process to correct the defect of unetched copper.

We begin the process by recording the information we need using a standard work sheet that documents the physical area layout and flow of material through all of the process steps. This can be looked at either by part flow or by showing people movement. Next is the time observation sheet (Figure 2) which is just what it sounds like: a tool to collect the process times for one cycle. Time observation records the time it takes to make one piece or batch, to do one task or one set-up. We can use time observation sheets to subdivide our work into product types such as HDI or flex as an example. The

time observations sheets should record the time and process differences for each unique product type. We can also use it to differentiate between different workers.

Data from time observation can be used to predict cycle time based on basic steps in the production cycle. As an example, if the process has one set up, one break down, and will generate 18 production panels that contain 10 PCBs each (180 boards), the predicted cycle time is:

$$\begin{aligned} \text{Cycle Time} = & \\ & (1 * \text{Set-up Time}) + (180 * \text{Piece Time}) \\ & + (1 * \text{Breakdown Time}) \end{aligned}$$

Next is the percent loading chart (Figure 3) using the time observation information. When there are multiple people involved in a process we use a percent loading chart to show the relationship of multiple people's contribution to the process. Once the time observations are

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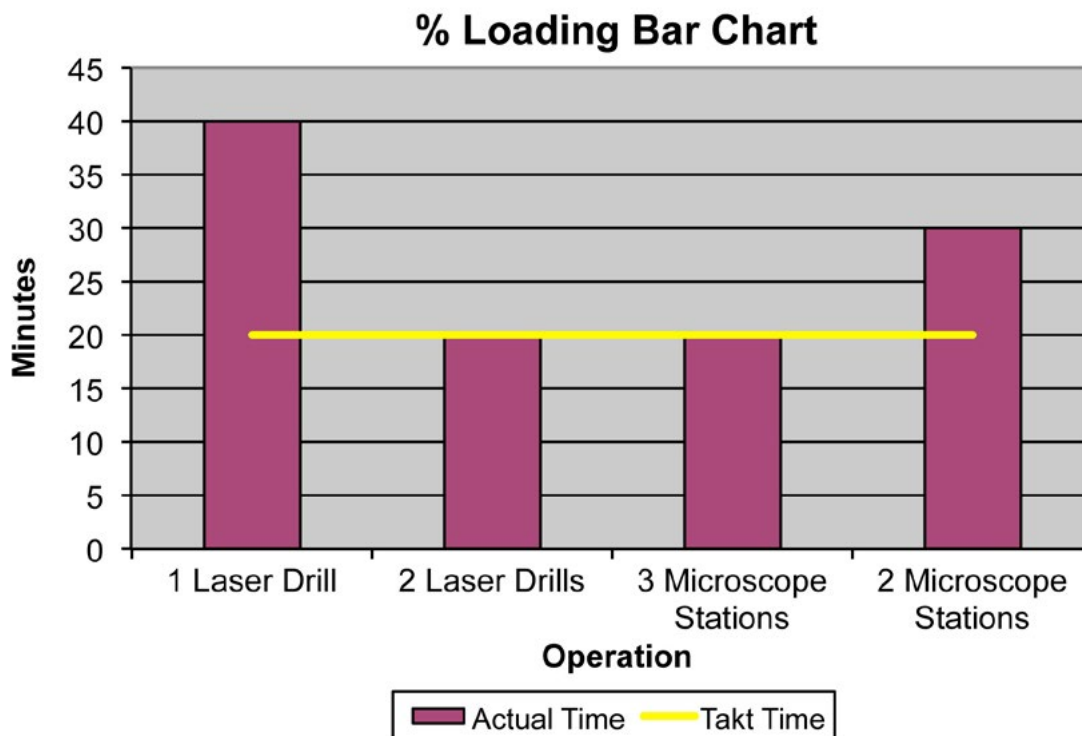


Figure 3: Percent loading bar chart – laser drilling operation.

completed and we have determined the estimated cycle time, we can review the variation in time required between the various processes and process operators.

Lastly, the standard work combination sheet provides a detailed description of what an individual does and the time it takes to perform one production cycle. The standard work combination measures the people doing the work. The standard work combination sheet will show manufacturing metrics including runtime, value added activity, set-up time and wait time. Items like set-up time and wait time can be calculated as a percent of total time to determine what areas need improvement.

As we map the process we are looking for waste. The classic waste areas are defined as: overproduction, waiting (either for product or by people), transportation, inefficient processing, excessive inventory, unnecessary motion, making defective products, and underutilization of people or equipment (Figure 4). These wastes often occur in the manufacturing environment but they can also occur at the front end of the process in preproduction engineering.

Introduction to Value Stream Mapping

In value stream mapping (VSM) we identify all of the activities that will occur along a given value stream for a specific product. Value stream mapping requires segregation so that we can review only those products that are similar. These groupings will use the same equipment sets, process flows and resources. Lean language commonly refers to this as a product family. When undertaking a complex manufacturing process like PCBs, the best approach is the look at the product family that is most essential to the company's business. This can be achieved by reviewing business plans and company goals, brainstorming on how your company brings value to its customer or which markets the company most effectively serves.

Value stream mapping, like the process flow diagram, cannot be generated in a vacuum. It requires a team to properly develop the information for the current state map and determine what can be achieved in a short time for the future state map. This team needs time and resources to complete the process. Value stream

PRACTICAL APPLICATION OF LEAN SIX-SIGMA TO DRIVE CYCLE TIME REDUCTION, PART 1

Waiting	Usually refers to people. Waiting for PO confirmation, EQ conclusion, for materials, for product, for approval, data, information, pricing, tools, inspection
Transportation	Moving materials between departments, uploading files. Material movement is the #1 cause of handling damage / scrap and rework
Over processing	Excessive analysis or QC checks, unnecessary paperwork, duplication of information, incorrect data, drawing, information
Motion	People movement not related to process, such as getting tools, obtaining forms, paperwork, taking product to specific machine for testing
Overproduction	Making more than needed or before it is needed
Inventory	Raw materials, work in process, finished goods, packaging materials
Defects	Nonconforming product, making the product incorrectly and then having to reworking it. Or scrap
Underutilization	Usually people, not including operators on Lean teams, too rigid job descriptions, unwilling of people to expand job roles

Figure 4: Eight types of waste.

mapping is most often completed as part of a Kaizen Event, a 3–5 day workshop where a cross functional team from within the company works on a product family within a specific process. The objective is focused on redesigning the process or production area to better meet the company's goals, which of course ultimately come back to improving customer satisfaction.

To prepare for VSM the first task is to define the scope and goal for the Kaizen team and identify a few key performance indicators that can be used to measure progress against that goal. The scope will identify the specific value stream selected and also clearly define why this area has been selected. The team should already be thinking about how they can improve the key performance indicators. In preparation for the value stream mapping, consider plant safety, quality (internal audits, rejects, scrap, and rework), overall performance, delivery performance, throughput time, productivity, WIP inventory, finished

good inventory, in-process materials and raw materials, as an example. Find the actual data on customer demand, output, work time, throughput time, work in process, and backlog. Questions that should be asked include: What are the top five production problems, and what are the top three quality problems? Make sure that you have the current information on customer demand, any recent audit results, and all scrap and rework data in the area that will be mapped.

In Part 2 we will look further into value stream mapping and the use of lean six sigma tools through some examples of projects with goals to reduce cycle time by removing process waste. **PCB**



Kathy Nargi-Toth is vice president of Quality and Technology at NCAB.

Cycle Time Reduction in a Flexible Circuit Facility

by **Dave Becker**

ALL FLEX FLEXIBLE CIRCUITS LLC

Managing product flow and cycle time across a wide range of product constructions and volumes in a high-mix flexible circuit fabrication facility can be extremely challenging. It can also be a critical success factor, so the only option is to accept the challenge! Many processes are capital-intensive as well as facility-limited, so using cellular manufacturing as an absolute solution is simply not feasible.

During the time I have spent in this industry (let's not talk about how long), I have witnessed a substantial improvement with companies able to achieve significant cycle time reduction. This is done in several ways—with better processing equipment, faster design times, more predictable yields and improvements in material flow methods. Clever improvements in processing are myriad across many fabricators, but no single system seems to be a good fit for the challenges of a high-product-mix circuit fabrication facility.

What seems to work best for a high-mix factory with a wide range of part numbers is a tailored hybrid system. Concepts can be adopted from classic just in time manufacturing (JIT), theory of constraints (TOC) and quick response manufacturing (QRM). Four critical elements de-

fine cycle time management in a PCB factory:

- Material movement by Kanban (visual signal)
- Product mix control
- Short term capacity/workflow planning
- Daily management

Kanban

The basis of any cycle time reduction is to reduce work in process (WIP). The more work in process, the longer the overall cycle times.

One controls WIP by controlling the amount of work introduced and flowing through the system. A common method is Kanban, where material movement is based on a visual signal indicating work is to be “pulled” from an upstream operation.

There are many versions of Kanban that are used successfully in manufacturing. One simple method is to Kanban from one operation or work center to the next. Signals are arranged so work is pulled into the next work

center when it is ready to process it. This method works very well when the product flows tend to be homogeneous. Cellular manufacturing techniques tend to group operations by prod-



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CYCLE TIME REDUCTION IN A FLEXIBLE CIRCUIT FACILITY

uct family, which creates a near homogeneous product flow. Another method is using theory of constraints (TOC), where a critical work center is identified and work is introduced into the system based on the output of that constraint. Some companies simply have a Kanban based on what goes into finished goods. Material is introduced at the front end based on what gets completed into stock.

While all these methods will control WIP, they tend to struggle when a high product mix goes through the same work centers; this situation is very common for manufacturing that requires chemical processes and high capital cost equipment. The problem is that as product mix changes, the WIP will accumulate at different

“Some companies simply have a Kanban based on what goes into finished goods.”

processes. The constraint moves around, while other critical work centers are starved for work. In this case cycle time reduction comes at the expense of overall throughput.

Product Mix Control

A hybrid system uses Kanban with a product mix control. The factory is divided into process “loops.” Material is introduced into a loop based on the completion of a lot going through that loop, but with a “twist”—each product family has its own Kanban card. When a single-sided circuit is completed in the loop, another lot of single-sided product is introduced. Likewise, when a double-sided lot is completed in the loop, another lot of double-sided is introduced, and so on for the various product families. Lot size for each product family is determined by impact on the loop capacity. This system controls WIP and keeps the product mix constant, making it easier to manage overall capacity and maximize throughput.

Short Term Capacity/Workflow Planning

Of course the above technique would break down as demand changes and the product mix changes to meet the demand. This is where capacity/work flow planning comes into play. The product mix control system can be adjusted weekly to accommodate changes in demand. An essential requirement is a good MRP system with accurate capacity loads. The Kanban system of each loop is adjusted as needed, based on changes in product mix.

Daily Management

The above tools fall into the “necessary but not sufficient” category. A strong daily management system that involves management, operators, engineers and planners reviewing critical shop floor metrics is a final piece of the puzzle. Cycle time and WIP are reviewed, along with quality and safety metrics. Any metric outside predetermined control points requires an action plan with follow up. Action plans and results are reported monthly at the management quality review meetings, where all critical metrics and performances are reviewed and discussed with top management.

This system incorporates the “plan-do-check-act” principles made popular by W. Edwards Deming back in the late 80s. Short term capacity/flow planning system establishes the product mix control (plan). The Kanban system executes the shop floor flow (do). The daily management system checks results and creates action plans to adjust (check-act).

The key to successful implementation of any cycle time reduction program is making sure it fits, or is tailored to, an individual situation. Some factories build relatively homogeneous product, others a wide variety. And that can change with the variability of customer product mix. The adoption of the above methods will be most successful when tailored, and continuously improved, based on the changing environment. **PCB**



Dave Becker is vice president of sales and marketing at All Flex Flexible Circuits LLC.

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THE PCB MARATHON



by **Renato Peres**

CIRCUIBRAS CIRCUITOS IMPRESSOS PROFISSIONAIS

By the '90s, Asia had become a great player on the electronics industry, driving companies all over the world, especially those in Europe and the Americas, to compete against its low prices. More recently, Asian manufacturers have been delivering more high-quality products to the market. These phenomena resulted in little space for mass production companies in Western countries and an increasing need for quick-turn production and prototypes of medium- to high-complexity PCBs.

Printed circuit board shops have been driven to build new business strategies that overcome the paradigm of trade-offs, in which customers had to choose between one characteristic or another, into a new way of doing business in which an equilibrium is found that meets customer needs.

Having said that, flexibility has turned into a slogan for Western companies and despite being largely spread in our culture, very few organizations handle it effectively.

Why do some companies get outstanding results while others struggle to survive? Why do some always seem to be ahead of their time, while others are always running behind? Is it all about money?

Certainly, money is a good portion of what is needed to achieve better results. Money buys new technology and helps develop highly skilled people. However, consider Toyota as an example from the '50s. They turned from a small company in a country destroyed by WWII into the most lucrative automaker in the world. They found a way to compete against economies of scale, huge amounts of money invested in new technology, skilled engineers, and low costs of production per unit, just to cite some of the challenges Toyota faced. In that scenario, reducing cycle time to produce better and faster was a live or die battle. Everything that followed those events has become part of the history that is still being written by Toyota.

The PCB market that Western companies face today has some similarities with the automotive market Toyota faced in the '50s, but a bit more challenging. All in all, the principles remain the same.



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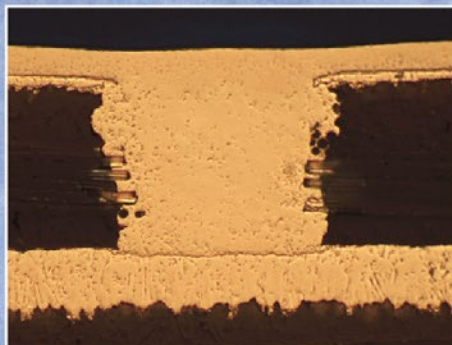
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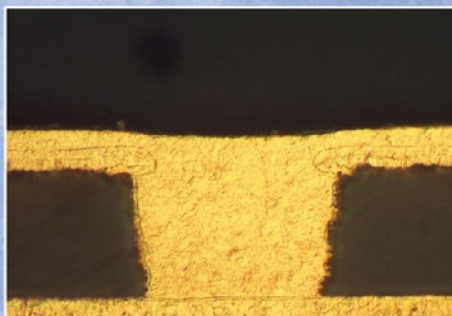
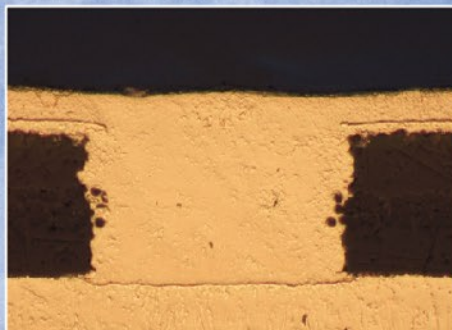
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THE PCB MARATHON

Old-Fashioned Operational Strategy				Customer Driven Strategy		
EITHER	... short delivery time	OR	... reliable PCBs	On time delivery	YET	Quick turn production
			... complex products	Complexity		
EITHER	... simple PCBs	OR	... very expensive ones	Small Batch Sizes	YET	Affordable Pricing
EITHER	... quality	OR	... delivery on time	High quality products	YET	Having flexibility to attend customers demand.
EITHER	.	OR	.	.	YET	.

Figure 1: Contrasting strategies and trade-offs.

What are Customers Willing to Pay For? (Value Stream Mapping)

First of all, managers and engineers must know exactly what is happening on the shop floor, and being told is not enough. They must take time to go to the shop floor, analyze the whole system, talk to people, encourage them to speak truthfully, get to know each area in detail, and look at the factory with the customers' eyes. They must not try to find excuses for the real state, but see opportunities in each difficulty. This is not a one-day walk, but an activity every single industrial engineer and manager should incorporate into their daily routine.

Once done, it is time to design the value stream mapping (VSM), in which the current state is contrasted with the future state—the desired one. When designing a VSM, team leaders should put themselves in the customers' shoes, including the internal customers, asking questions like: What is the customer willing to pay for? When do they want to receive their parts? What should I do to deliver parts on time? Each feature that the customer is willing to pay for is called value-added; everything else is defined as non-value added, or waste.

Developing a VSM requires team cooperation, and collecting data such as number of operators, shifts worked, working time, and cycle

time are needed.

There are basically two different, but converging, concepts regarding cycle time. The first one is related to a specific process such as plating, where cycle time is defined as the production rate of the entire operation, including setup, loading and unloading.

On the other hand, there are some people who define it as the production rate of a part from the beginning to the end (e.g., from raw material preparation to final quality control). Nevertheless, it does not change the fact that working to reduce the production rate of the bottleneck will reduce the cycle time of the whole operation.

Having done this, engineers are able to have an overall look at the entire process and should start working on what most impacts the company throughput—the bottlenecks. Each company will have its own bottlenecks, and talking about PCBs, we might identify several bottlenecks depending on the PCB layout.

Eliminating or Mitigating Everything Else (Waste)

Eliminating wastes are the heart of the Toyota Production System^[1].

As we see in Figure 2, most of the activities we do in a production line are non-value-added,

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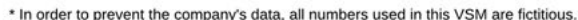


Figure 2: Example of value stream mapping.

Toyota numbered seven basic wastes on their industry: overproduction, waiting, unnecessary transport, incorrect processing, excess inventory, unnecessary movement and defects. Besides overproduction, which means producing when there are no orders, which is not applied to the PCB industry that works in a make-to-order manner, all the other categorized wastes can be found in a PCB shop.

businesses run. I have heard this a lot, but I am not convinced it is true.

If we take a careful look at the factory through our customers' eyes, we will see that most of PCBs go through a similar process.

Based on that, we must drive our efforts to work hard on process stability in order to get the PCB built right the first time. Having a process-driven company will allow you to produce faster and better products as well as eliminate wastes.

Although wastes will never be totally eliminated, they can shrink significantly after you start working on them. That is why the next topic is of paramount importance.

Continuous Improvement (Long Term Results)

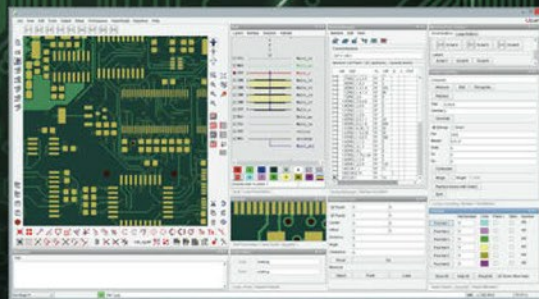
Nothing in this article will make such an impact on your company as the continuous improvement philosophy. I have covered a couple of management innovation tools, applying

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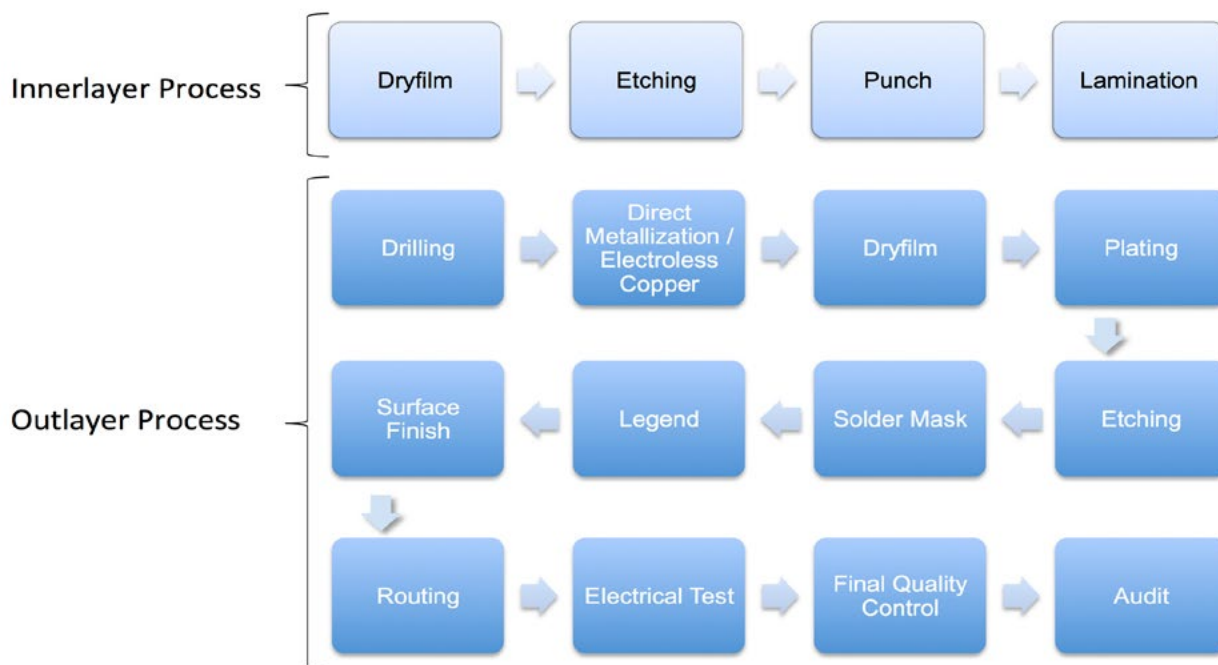


Figure 3: The PCB process.

those that were in vogue in the business administration and capable of delivering fast results, but without any consistency.

There is a principle in statistical process control (SPC) that fits perfectly with the concept of continuous improvement which says: Making improvements on an unstable process will produce random results, while making improvements in a stable process, no matter how bad it is, will produce stable results that are able to be managed and improved.

In other words, PCB shops must create and follow rigid procedures before thinking of continuous improvement, and this is totally different from saying companies must be static.

Conclusion

In order to reduce cycle time, companies must focus their efforts on identifying their bottlenecks, eliminating wastes and working hard to make the best use of their processes.

Unfortunately, especially in the PCB industry, the bottlenecks change rapidly from one PCB to another, according to its layout. So, it is not uncommon to have different bottlenecks in the same factory and managers saying that TPS (Toyota Production System) principles cannot

be applied to the PCB industry due to its complexity and fast environment changes. I would rather suggest another response to that.

When working in such a complex industry, leaders must have fanatic discipline to apply everything presented in this article and go beyond it to find solutions to attend to customers' needs, one step at a time. Instead of copying every single tool Toyota has created, organizations need to understand the philosophy behind it and search for their own way of doing business.

Improvement is similar to a marathon: the running is long, not easy, and full of obstacles; you may go slow, but never stop.

I hope I have encouraged you to start a new journey in your business. What are you waiting for? Take the next step! **PCB**

References

1. [Liker, Jeffrey K.](#), 2004.



Renato Peres is an industrial engineer and production coordinator at Circuibras Circuitos Impressos Profissionais.

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PhiChem Joins UL Standards Technical Panel 796 for PWB

Dr. Jin Zhang, president of PhiChem Corporation, announced today that PhiChem has been accepted as a member of UL Standards Technical Panel (STP) for Printed Wiring Boards STP796, which covers standards UL746E and UL796.

Laminate Supplier Shengyi Expands U.S. Presence

Shengyi Technology Co., Ltd., one of the largest laminate suppliers in the world, is committed to increasing its market share in the U.S., while enhancing its relationship with end users and PCB manufacturers.

Mentor Debuts Version 8.1 of ODB++ Product Model for PCB Mfg

Mentor Graphics Corporation has announced the newest version of the industry-leading ODB++ intelligent product model, a single and open data structure for transferring PCB designs into data for fabrication, assembly and test.

LPKF Strengthens Strategic Structures for LDS and Rapid PCB Prototyping

LPKF Laser & Electronics AG enhances its structures in two relevant divisions. Two experienced engineers take over new positions of important interfaces with customers.

Multilayer Technology Invests in Orbotech Sprint 120 Inkjet Printer

Multilayer Technology (MLT) located in Irving, Texas has added a new Orbotech Sprint™ 120 Inkjet Printer to its growing list of equipment upgrades. This Orbotech is the current state-of-the-art in the area of high-viscosity ink jet printing.

DYCONEX Invests in MXY2 Drilling and Routing Machine from Schmol

DYCONEX AG, an MST company and the world's leading supplier of highly complex circuit board solutions, has made a major investment in the MXY2 drilling and routing machine from Schmol Maschinen GmbH. With this move, DYCONEX has made a further step in the development of ever smaller structures and meeting the requirements for even higher accuracy.

SouthCom Technologies Wins Distributor of the Year for Pulsonix

"Since the appointment of SouthCom in North America three years ago, we have seen exponential growth in North America. Year-on-year sales have accelerated beyond our expectations as more and more engineers come into contact with Pulsonix," said Marketing Director Bob Williams.

Fast Interconnect Announces Multi-Platform Design Services

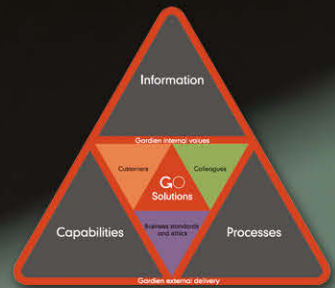
Co-founder Gary Griffin said, "One large benefit of coming to Fast Interconnect is the fact that we can design your product in your existing CAD software package. Many companies that ask for design updates find it hard to find a company to assist them that can use the software they have established as their core software design suite."

DuPont Microcircuit Materials Intros New Inks for Printed Electronics

DuPont Microcircuit Materials is launching electronic inks that cure quickly at low temperatures, expanding the possibility of printing electronics onto a new group of plastic films. The technology is expected to enable electronic components such as sensors, heaters and antennas to be printed on more versatile and less expensive substrates.

Alismalibar Ramps up Production of Bond Sheet Prepreg and Thin Lam Cores

Alismalibar has increased production of their HTC Bond Sheet Prepreg and Thin Lam Cores. Customers have been using HTC Bond Sheets to connect cutting edge high-power LEDs mounted on MPCBs to heat sinks to allow for superior heat dissipation.



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Breaking the Bottleneck: Electrical Test Cycle Time Reduction

by Todd Kolmodin

GARDIEN SERVICES USA

As with many manufacturing theatres there is a stream of additive processes that combine to create the finished product. The manufacture of printed circuits is no different. From the conception of the design and issuance of the procurement document, dozens of processes must take place before the PCB is shipped for assembly. Each of these processes takes time and the additive result of all these steps results in the manufacturing cycle, or lead time. Almost always, the customer just wants to know the lead time, or “When do I get my boards?”

However, in the manufacturing process steps leading to the final shipped product, there are individual cycle times within each process. From imaging all the way through final packaging, each process is allotted a predetermined amount of time to complete a given piece or full production order. In a perfect world, all individual process steps or cycle times will be completed early or on-time with the result being on-time delivery (OTD).

But, let’s face it, many times Murphy makes an appearance and cycle times may increase. If this happens early in the manufacturing cycle,

then the predetermined, gauged cycle time for subsequent processes is out the window. The time for those processes is now compressed or disregarded entirely and the order becomes ASAP. Did the time it took to effectively process that part miraculously compress as well? No, it did not. Now this order is competing with other orders in the same process step that were originally on-time, causing them to delay and WIP (work in process) to climb, thus resulting in the dreaded bottleneck! This is a term that sends chills through production managers and sales forces alike.

With that said, how do we combat this scenario? We streamline the process step by fine-tuning the attributes within that process. The result is reduced or optimized cycle time. This can result in the process step having “sprint capacity” to combat Mr. Murphy when he decides to make a visit. (However, in reality, once production planning finds out the process has reduced its cycle time...well you know what happens.)

Since I’m focused on quality assurance and electrical testing (ET), we will look at this scenario in the electrical test theatre.





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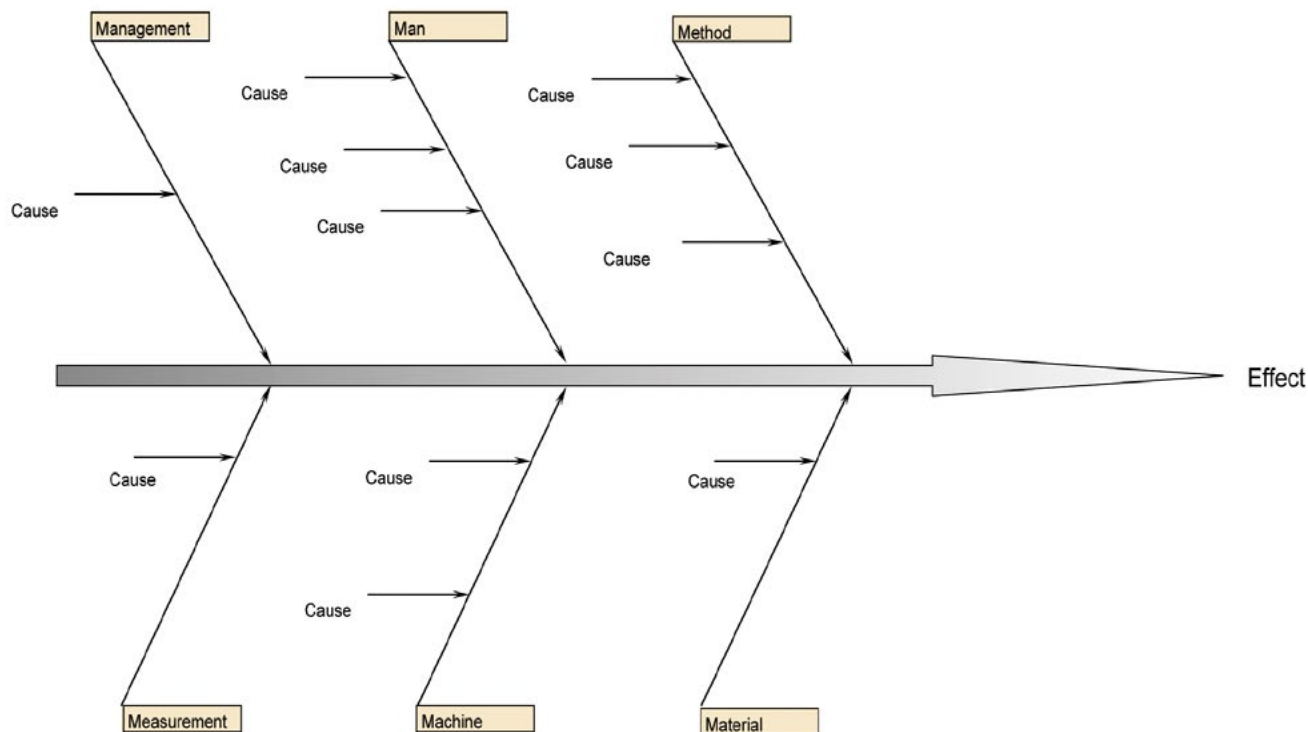


Figure 1: Ishikawa's Fishbone diagram.

Reducing Cycle Time in Electrical Test

In most manufacturing plants the back-end struggles with the additive cycle time violations of all previous processes. Everything is “hot” and cycle time is of the utmost importance. Extreme pressure is put on these late stage processes to make up lost time and attempt to ship the product on-time or as close as possible. Unfortunately, many of these latter processes are the most important. In final inspection and test, all of the prior processes are inspected and validated against the customer requirements and industry specifications.

Many tools and disciplines are used to help analyze a process to gauge its effectiveness and identify areas of concern or targets for improvement. Some examples are Kaizen and 5 Ys. Kaoru Ishikawa, a Japanese quality pioneer, introduced a highly visual diagram to illustrate cause and effect attributes that result in the undesirable outcome. It is known as the Fishbone. In general terms, with regard to ET, the basic diagram is outlined in Figure 1.

Now, using the diagram in Figure 1, we must identify the attributes affecting cycle time in ET. Some immediate items come to mind:

- Yield
- Production issues
- Excessive rework
- Misleading or confusing fabrication drawings/requirements
- Incorrect ET tooling
- Missing information
- Machine downtime
- Human error
- Load balancing

Using the above diagram, we can extrapolate these items into the Fishbone. Figure 2 summarizes our list.

From that diagram, we can now see the causes that can affect cycle time in electrical test. Let's first look at the cause attributes in manufacturing. As I stated earlier, planning and scheduling are extremely important. We see it is one of the attributes listed. In many cases production planners put a fixed time allotment for electrical test. However, this can be a problem. Dependent on whether the job is tested on a flying probe or a grid test machine may influence the time it would take the same

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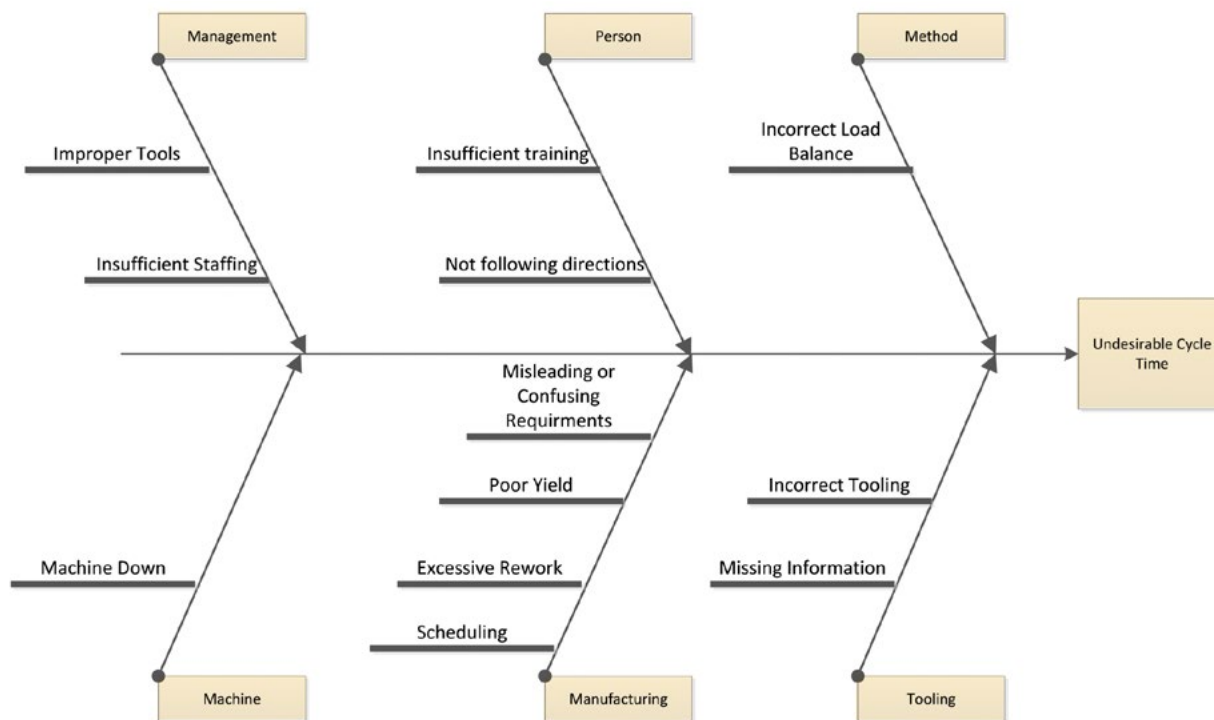


Figure 2: Populated Fishbone diagram.

job to test on either machine. Today it still remains that the most expedient way to test a PCB is using a well manufactured fixture on a grid test machine. However, there are increased costs with fixtures. There is the actual fixture cost, maintenance of the fixture itself and also the storage. Poor yield and excessive rework are two of the other main attributes that increase cycle time in ET. Although these are causes on the diagram they are not specifics that can be solved in ET.

As briefly stated earlier, load balancing is a large contributor to cycle time. We see this listed in Figure 2 under Method. Both flying probes with automation and grid test machines can be used. However, with flying probes there can be an indirect or direct method to the test. Using the indirect method does provide a faster test but some customer/industry standards do not allow this on some product. Direct method testing, albeit favored by some customers, is a slower test. These variables can cause a wide range in cycle time for specific product.

Drawing some conclusions for the above exercise, we can see that manufacturing and

methodology are the two largest “bones” that have the highest impact on cycle time in ET. While in manufacturing, ET cannot influence the yield and rework attributes but the other two, scheduling and requirement, it can. This goes along with the attribute in methodology. The solution here is...communication! Communication of requirements, expected volume, layout, and requirements for TDR/HiPot all come in to play when going through ET. Knowing well in advance can influence whether grid test fixturing should be used or flying probe. Also, should manual HiPot testing be used or a multi-channel fixture? Here alone, significant time can be saved if this is known in advance. Many times a first time build is only a few panels with no visibility for the future. Generally, flying probe is used. It is now tooled and forgotten. Two months down the road volume is manufactured and arrives with only flying probe tooled as the solution. Cycle time skyrockets as the test solution is no longer correct.

Scanner/flying probe combinations can also significantly reduce cycle time on flying probe

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orders. Favorable selections are most double-sided product, LED product and multitude of multilayer builds.

With correct scheduling, load balancing the management attribute solves itself. With proper future foresight, staffing can be adjusted to process varying loading cycles. Strong maintenance/PM programs attack the machine attribute while a strong training/cross-training program attacks the “person” attribute.

Communication, scheduling and proper loading in our exercise are the main influences

in ET cycle time. Keeping these variables under control can reduce ET cycle time measurably while also providing the needed sprint when Mr. Murphy makes a visit upstream. **PCB**



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

4-D Technology Allows Self-folding of Complex Objects

Using components made from smart shape-memory materials with slightly different responses to heat, researchers have demonstrated a four-dimensional printing technology that allowed creation of complex self-folding structures.

The technology, developed by researchers at the Georgia Institute of Technology and the Singapore University of Technology and Design (SUTD), could be used to create 3-D structures that sequentially fold themselves from components that had been flat or rolled into a tube for shipment. The components could respond to stimuli such as temperature, moisture or light in a way that is precisely timed to create space structures, deployable medical devices, robots, toys and range of other structures.

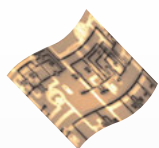
The researchers used smart shape memory polymers (SMPs) with the ability to remember one shape and change to another programmed shape when uniform heat is applied. The ability to create objects that change shape in a controlled sequence over time is enabled by printing multiple materials with different dynamic mechanical properties in prescribed patterns throughout the 3-D object. When these components are then heated, each SMP responds at a different rate to change its shape,

depending on its own internal clock. By carefully timing these changes, 3-D objects can be programmed to self-assemble.

The research creates self-folding structures from 3-D printed patterns containing varying amounts of different smart shape-memory polymers. The patterning, done with a 3-D printer, allows the resulting flat components to have varying temporal response to the same stimuli. Earlier methods required application of differential heating at specific locations in the flat structure to stimulate the shape changes.

The research was reported September 8 in the journal *Scientific Reports*, which is published by Nature Publishing. The work is funded by the U.S. Air Force Office of Scientific Research, the U.S. National Science Foundation and the Singapore National Research Foundation through the SUTD DManD Centre.





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MacDermid: Redefining Global Strategy

by Barry Matties
I-CONNECT007

There's excitement brewing at MacDermid. I recently sat down with Don Cullen, global marketing director, and Steve Kenney, business director, at the company's headquarters in Waterbury, Connecticut, to discuss how they've tackled cycle time reduction for their North American customers, and how these requirements differ from their global customers. The growing excitement comes from two new acquisitions coming over the horizon that should redefine MacDermid and their place in the industry.

Barry Matties: *Let's start with a little bit about what you guys are doing here at MacDermid—I know you're making some acquisitions and things are moving forward.*

Don Cullen: MacDermid feels very strongly about supporting the electronics industry in general, and we are excited about how things are going and the future of our company. There is definitely excitement in the technology and the interconnect spaces. Looking at the global picture, we derive a lot of our revenue from

Asia, and China is underperforming right now. In this brief downturn, we're investing in resources where other companies might not.

Matties: *In China, are there two fronts that you're battling? One is the economy, but is there a local supply base that is also emerging over there?*

Cullen: I wouldn't say it is emerging; it has already emerged. We're pretty aware of the local suppliers. I wouldn't say that there's really much change in the dynamic of the local supply base over there.

Steve Kenney: Not in the last few years.

Matties: *It just seems that there's more of a nationalistic attitude over there of late, to buy local.*

Cullen: In electronic systems, it's been really big news. China is proposing to regulate the specification of systems, which is favoring domestic manufacturers such as Huawei instead of Cisco, with policies like this. With chemicals, there's been a little bit of a regulatory change, where they're trying to tap into the formulations of



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Don Cullen, global marketing director, MacDermid.

chemistry. That would obviously affect our investing over there, but they've scaled back from that and from some of the mandates on formulation disclosure. I'd say the net effect has really been small recently. The local supply is known, and we continue to stay in the newest innovation space. We don't see that the local guys are innovating any better or trying to move into our space that successfully. Our thoughts about innovating for China are still in relation to our traditional competition with a lot of the Western suppliers, really.

Matties: *Interesting. What acquisitions have you made recently?*

Cullen: Alent and OM Group's electronic chemicals and photomask businesses are two acquisitions we have signed, and we expect to close those in the next few months. Until we do, we're operating completely as we have been in the past. Again, it's a very exciting time for MacDermid. Platform is a good parent company for us, and they understand that investment

in specialty chemicals is a great business, and the customers really win in this. Our customers partner with companies that value innovation and service, and that's been our mantra for many years now. If we innovate in the front end by listening to what our customers need, make those products, and then service them really well once they're developed, the customer does great. We're looking at companies in our space that do that well, too.

Kenney: We talked earlier about the electronics business as a whole. Platform has made a really big step forward with these possible acquisitions. Most of the businesses will go into MacDermid's vertical, so they'll be part of us. Globally, it will change our scale but it will never change our strategy. So Don talked about making sure we're customer-focused and innovation first—what we call 'high touch,' which is customer service—and that won't change. Whether it's the Asian business that gets much bigger or the Europe or North American businesses, the strategy is going to be the same.

Matties: *Is the strategy to brand them all under MacDermid, or to leave them as their existing brands?*

Kenney: If and when the acquisitions are complete, we would likely maintain a lot of the brand names, as they both have very well-known product groups. There's not going to be any effort on our part to dissolve well established brands, or do anything that would be detrimental to the customer base. I can tell you, in every meeting that we've been in, maintaining that customer perspective is the number one goal for us. We may have internal synergies that become available to us, and we'll take advantage of those, as long as they don't impact the customer in a negative way.

Matties: *For the customer, it should be neutral or positive, with the goal being positive.*

Kenney: The goal is, if we execute well, that we should be able to take those three companies and come out of this with a much stronger innovation group and certainly a much stronger

CYCLE TIME REDUCTION FOR DOMESTIC AND GLOBAL CUSTOMERS

field group. That's really what we base our whole business on. If we can do it well, together we'll be much stronger than any one of us would have been individually. We have a lot of respect for these businesses today; they have technologies in their innovation group where they're patented and we can't go near them. Likewise, with some MacDermid products. The thought is that we could combine some of these technologies and make an even better third product, for instance. That's what's exciting to the innovation guys.

Cullen: From the perspective of our innovation team, for example, we need to draw on the experience from our people. It's a great experience, but it's not all the experience in the industry. Once we bring in other really great innovators from OM and Alent, it builds on all those experiences to deliver a better product faster and with higher yield for our customers. The same could be said for the service people. Service is all about experience. If you have more people with a broader breadth of experiences, it's going to be a much better experience for the customer at the end of the day.

Kenney: On the service side, experience is one piece, and the other side that we struggle with all the time is speed. Getting our service solutions quickly to a customer is super important. Now that you combine all three of these groups together, we will virtually have someone in every customer's backyard. None of us had that individually. No one has a person in every customer's backyard, but together we just might. We talked about experience being very important to success, but speed and cycle time reduction is equally important, which means these fabricators really rely on us to be there to help them with the job that's due tomorrow. We're going to be able to get to places faster than we ever could have in the past. That's exciting for us as well.

Matties: *When you talk cycle time reduction, is it more about the service and not necessarily the process?*

Kenney: I worked at a PC fabricator for a long time. Back then, it wasn't always about one-day,



MacDermid headquarters in Waterbury, CT USA.

two-day, three-day turns, but whenever you run into an issue, whether it's chemical-, mechanical-, or process-related, that creates some kind of a lag in your production delivery. Now, if there's basically an engineer from a supplier, who is on-site the same day within a few hours, we can take that eight- or nine-hour delay to maybe two hours. This is how we will continue to grow our value.

The value proposition we bring to an owner is, "Now we're in your backyard, so when there is a process problem, what you want is a supplier who's knowledgeable, with the experience, and who can get there the quickest." We're going to get them back up and running with that prototype job today, not the day after tomorrow. For them, that's real money. We have customers that tell us all the time, "If I don't ship on time, there's either a huge discount or we ship it for free." That's their pledge to their customer base, so how important is it to have a supplier that understands that, and takes part in that process? That's another way we bring value to our customers.

Matties: *That's interesting, because there was a point where a lot of the American suppliers really just left America and joined the race to China.*

CYCLE TIME REDUCTION FOR DOMESTIC AND GLOBAL CUSTOMERS



Steve Kenney, business director, MacDermid.

Kenney: MacDermid included, Barry. Two years ago, three years ago, we were in that same boat. We did not spend a lot of time in North America.

Matties: *The technical services were really left up to the distributors who were handling multiple lines with limited knowledge about each of them.*

Cullen: It's interesting, if you think about the big picture, because the suppliers went to Asia in a largely a proportionate way. Asia became most of the opportunity, and we brought most of our resources over there. Did we leave a proportionate amount in North America? Maybe. But did we leave critical mass? Since that time, we realized that we needed to bring that critical mass back to North America. That's really been a focused effort of ours.

Matties: *How's that process working?*

Cullen: It's working. In MacDermid's view in North America, I don't think that we really did rely on distribution as much as a lot of our competitors. The ability to bring that back gives better value to our customers in North America especially. We've been seeing benefits having done that.

Kenney: Two years ago, when we went through the transition of being a private company to being acquired by Platform, it really stimulated the change. We knew that there were changes coming, and we knew that there were likely to be acquisitions made in that space, so we made a conscious decision to say, "How do we sell and service all geographies?"—with North America being one of those. We went back to a traditional MacDermid model, where we had dedicated sales and service people calling on the PCB marketplace, where we hadn't done that in five or six years. Our electronics resources were kind of blended with our general metal-finishing business, and we tried to service the industry that way.

We made a line-in-the-sand change two years ago, and said we would have a dedicated team, and we would have dedicated sales and service and strategic people handling the large accounts. We had a concerted effort on the marketing side to make sure the customers knew what the changes were that were taking place. It has made a big difference. We had not had great sales success in the previous four or five years in North America until we made this kind of line-in-the-sand change. We've seen a real turnaround.

Matties: *What sort of percentage are you talking about, in the increase?*

Kenney: We had stagnant revenue for a five-to-six-year period. We stopped the slide last year; this year we're projected to be up significantly over last year, and most of it's not with a fast-growing market. Most of it is through our added value we bring to customers, where we're winning competitive battles.

Matties: *When you're with a customer today, what sort of demands do they ask you to address?*

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Kenney: The demands that they ask us for today, quite frankly, are no different than they were a few years ago. They asked for good new products, and one of the things that we hadn't done well in the North American space is talk about and bring to light the new innovations that MacDermid did have. We were just highlighting them in other geographies around the world. As an illustration, we had lots of new via-fill products and acid copper products selling very well in Asia, but no customers in North America even knew we had them. We went through this reinvention or re-education of the customer base here, saying, "Even though you haven't seen MacDermid doesn't mean we haven't been doing anything." We started this year-long process of, "Let me re-educate you on what our product line looks like today."

The second half, getting the business, was addressing this customer view: "Well, we haven't seen a MacDermid service guy in two or three years. Your product might be good, but we need someone who's going to be there." We worked really hard on making sure we had at least the right kind of people close by. Not someone in every backyard like we wanted to have, but someone close enough that was an

expert, where we could get someone in within a one-day response time. Quite frankly, the Waterbury team has been excellent in lending resources, where in the past our North America team couldn't have gotten much access to them. But now, if we had a big opportunity in North America, it was proportionate around the world. Most of these guys will spend 85% of their time in Asia, but at least there was some time available for us in North America, and it's made a big difference. Customers have told me personally that they've seen a shift in MacDermid's strategic approach to their business in North America in the last two years, and that's tangible.

Cullen: It's a North American question. You asked, "What are the customers asking for?" They want to have access to the really successful products that we've deployed elsewhere around the world. It's really important in North America to bring them tried and true, excellent products. In North America it's different than in Asia, where it's all about volume, up-time, yield, and constant service. In North America, we're able to provide a lot more benefit for the fabricators who need to have that circuit board delivered in eight hours, or they have to be able to bring up a dormant chemistry immediately with 100% assured quality. That's certainly different from the rest of the world. This is where Steve has done a great job to recognize that need, communicate it back to our global innovation and service people, and bring to the customer exactly that response.

Matties: *When you go out on a technical call, what sort of issues are you dealing with?*

Kenney: Most times when our technical group goes in to troubleshoot a problem, it's typically a PCB fabricator who's trying to build something they haven't built before. There are only ~300 board shops left here. Most of them are fairly sophisticated; they know how to build a fairly complicated circuit board. Quite frankly, they do a good job self-servicing. We get involved when all of a sudden they're getting that first job where they've got blind or buried vias, or they've got stacked vias somewhere, or



Entrance to MacDermid's research center in Waterbury.

CYCLE TIME REDUCTION FOR DOMESTIC AND GLOBAL CUSTOMERS

they've got tighter line and space than they've ever had before, so they need some help figuring out how to build stuff for the first time.

They lean on us like an extension of their engineering team. Like Don alluded to earlier, we have the right level of experience. It's a matter of putting it in the right spot, getting a high-level meeting with a large fabricator and the right people from MacDermid. I've been here 17 years, so I know who the right people are to pull from, and how to get the right people in front of the right person at the customer—and we make things happen for them. When you do that, the customers immediately recognizes that value. We've had circumstances in the last two years where customers have all but given up on certain jobs they couldn't build. The yields were too bad, they just couldn't take the revenue. We've installed processes where they can now accept jobs they couldn't have taken last year.

Matties: *You're helping them add capability to their line card.*

Kenney: That is our goal. If we can do that, imagine the power of a supplier that can help you actually grow revenue, and do things you couldn't do last month. That makes us as valuable as anyone else could possibly be in that process. That's our goal, and that will never change. If any one of my guys were here today, they'd tell you I preach to them all the time that our goal is to be as valuable as possible in the customers' supply chain. We have tech service engineers who are at the board shop so frequently, the employees think the MacDermid engineer is a member of their own company. They think they're like some high-level engineer from corporate that comes in when there's a problem. That's who they believe the MacDermid folks are, which is fine for me. At the fabricator level, I want our team to be part of that process.

Matties: *Part of their team.*

Kenney: Our goal, which was different than it was two or three years ago, is to be on the process improvement teams, part of them, on the team, collaborating on all processes, whether



they're MacDermid, or it might be a competitive process, it doesn't matter.

Matties: *Because your value goes up.*

Kenney: It does, and eventually that always comes back to us. If we're in this for the long term, which we are, opportunities will come to us and they always have.

Matties: *It's interesting that you use the value analogy. In our business, PCB007, I always say that we need to be like electricity. You never consider living life without electricity, you never question the value. When the bill comes in, you don't say, "This is crap, turn it off." You just pay it, because the value is so high. It sounds like that's what you're trying to become—electricity.*

Kenney: Yeah, and it's interesting, because I try to be a student of business, and running a business in that model at our scale is difficult. We didn't have as many people, and we didn't have as many resources, but if you think about it, with the potential acquisitions that will take place, we're going to have significant scale and a lot more resources. It makes it easier for me to keep my promise. My promise to the customer base is, "We're going to be that influential to your process. Just give me time to make this work." The excitement around these new acquisitions is that we will now have the scale to deliver on those promises. We'll have more ex-

CYCLE TIME REDUCTION FOR DOMESTIC AND GLOBAL CUSTOMERS

pertise under the MacDermid name brand than any other company in the world, period. We're so excited about what's possible.

Matties: *You will have a knowledge base to pull from, because of all this knowledge from around the world.*

Kenney: It's really going to be powerful, so it comes down to most of our conversations internally now being about how we execute properly. There are ways you could take these three companies and screw it all up.

Matties: *We've seen it done.*

Kenney: Right! Over the years, there has been a lot of business cases about how to just go spend money and watch it all disappear. Our focus is on how do we maintain customer preference? That, for us, is the number one thing. How to make sure the customers sees this as, "Wow, this is much better for us, because we get faster service, potentially more knowledgeable service." The new products that come out of innovation now will be a hybrid of exactly what Don said: The smartest guys at these companies got together and there's a step change in technology available to the market space. If we do it well, that's where we'll end up.

Cullen: It's the products, the service, and also the global reach—it's all important. A lot of our most important customers are multinational, and they mainly interact with our regional people around the world. Now, increasingly, we're going to be able to communicate with our Asian people at their Asian location, our North American people at their North American location, along with our global resources, all together on the same phone call.

Kenney: We do this today, we'll talk with the big PCB fab, and they'll have literally the same part number they're trying to make here, and they're also going to make it in some other plant in Asia or one of their other plants. We'll have an internal call and say, "Hey, this is how we run the process here." We've got our strategic sales guys and our technical guys here, and the



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same ones in Asia, and we'll talk exactly about how we run the process, because that same part number is being moved from one plant to the other. That, again, is all about the value to that fabricator. We do that today, on what I would consider a small scale. With the potential acquisitions coming, we think that scale is going to change dramatically. Again, we don't want to be just an outside third-party supplier to the industry. We want to embed ourselves in that whole fabrication process.

Matties: *It's interesting, I recently did an interview with EchoStar^[1] and it's a lot like what you're doing, but in reverse. EchoStar is part of the Dish Network, and they manufacture all the satellite set-top boxes. They're taking the total integration strategy that you're talking about with their EMS. Their quality has never been higher in terms of their finished product. For the EMS, they are getting their Diamond Award, an incredibly difficult award to earn. In fact, when they first came out with the standard to achieve this, people were saying, "You're crazy; it's impossible."*

Kenney: Not possible to get it.

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CYCLE TIME REDUCTION FOR DOMESTIC AND GLOBAL CUSTOMERS

Matties: *Tiger, an EMS company in Shanghai, achieved it. Unbelievable, but it's all through integration, exactly what you're talking about.*

Cullen: Just like you said, we're approaching it from the other end of the supply chain. They're doing it from top-down, where they're taking control of integrating their providers. We're doing it from the bottom-up. We're trying to make sure that we're providing a value to our customers that's really transparent—they don't have to take on the extra employees, they don't have to invest in extra expertise. We give it to them through our regional service staff, paid for through chemical sales, as long-term partners. We can communicate with the OEMs and the EMS companies to make sure that we're really saying the same thing throughout the supply chain. That's always brought the most quality to the end customer.

Matties: *Because you're now at the table with your fabricator while they're sitting there with their customers, the OEMs.*

.....



Kenney: We do have a global OEM team, which Don was talking about, and we also have an electronics OEM piece on a smaller scale here in my North American team. We have a global position but also a North American position with OEMs. You can imagine, globally speaking, our OEM manager calls on the big guys at Intel, Apple and Samsung, but those aren't the folks that buy most of the circuit boards in North America, so we have a North American focused OEM. We are regularly going with our customer base to some of these smaller, more regional OEMs. Our goal really is to educate these OEMs on how to specify a chemical product a couple steps away from them down the supply chain.

We talk about ENIG versus ENEPIG, we talk about finishes, or we talk about what a spec should be for a dimple on a via. We're really trying to educate, because it helps our fabricator. Most times, our fabricator comes to us and says, "We cannot convince this OEM to write a specification that makes sense," and we go as back-up for them.

We sit with the board manufacturer, and we explain to them exactly the difference between silver and ENEPIG, or the dimple sizes, etc., whatever the case might be. We do an education process. A lot of times what ends up coming out of that is we now become the OEM's go-to expert: "Hey, we're thinking about a new design. We're not really sure what to put on this, can you guys come in and talk to us?" We foresee this going forward as a really big part of how we manage our electronics group. We want to be all the way upstream as far as we can, to that design phase.

Like in the old days when they used to think about final finish, they'd call Don and say, "Tell me about this sterling silver," and Don would help them specify it into their customers' spec. We're going to be the same way, so no matter who the OEM is, whether it's Samsung or Huawei that we handle globally, or whether it's John Deere and some of these other regional OEMs, we're going to have the same value proposition: Be part of the design phase, be part of the education process, and be the supplier they call.

Matties: *It's a smart strategy. It's the only strategy that you can really be successful with these*

CYCLE TIME REDUCTION FOR DOMESTIC AND GLOBAL CUSTOMERS

days. You mentioned process engineering. Aside from capabilities, are the fabricators looking at reducing their process cycle time? Do you see that as something that's on their minds?

Kenney: The best way I can get a meeting in North America is to tell someone I can help them shorten the cycle time, at any level.

Matties: We recently did a survey on this very topic for our cycle time reduction issue that's coming up. We asked people how important it is. Surprisingly, I thought it would be number one, and it really wasn't.

Kenney: Really?

Matties: Some said, "Yes, it's very important." Others said, "Other things are more important." Then we asked, "How do they do it? Do they have a dedicated team?" Most of them don't. Then we asked, "What sort of title leads this effort?" Many didn't have a dedicated person.

Cullen: Most of your responses were fabricators?

Matties: Yeah, fabricator responses.

Cullen: Some of the fabricators said it was important, but even those who did didn't have a good plan in place or a dedicated person?

Matties: A lot of them struggle to do it—to reduce cycle time. Some of them were saying, "We leave it up to the operators." The truth of the matter is you can't leave it up to the operators. This has to be a top-down, really, that, we're going to reduce cycle time by X percent, let's go make this happen; that's where we're going to bring in the suppliers. Because to me, there's so much waste in the processes. If you just look at one simple loader and unloader, which could be two people, but the amount of time that you can save just in yield and performance.

It seems to me that you're also in the great position not just to help them increase capability, but to help them understand that cycle time is a big issue all the way through. If you're in the process engineering arena with them, I would think that these guys would be really looking for



Research laboratory.

that. I'm surprised that there are people who just don't realize how valuable reducing cycle time is. Maybe it is lack of knowledge.

Kenney: Absolutely, it is part of the problem with this North American space. I don't think there is a very good understanding of the direct correlation that one hour of production time is worth X dollars. Depending on who you talk to, that answer is vastly different. One of the strange things about this marketplace, which is good, is there are only 300 customers. You can get an intimate knowledge of everyone's really important needs, so we do as good a job as we can in understanding the differences between all of them. We don't lump them all together and say, "Everyone has the same needs for this." We just don't do it. It's almost a luxury where we can separate and say, "Okay, here's the 100 customer projects that we want to go after this year. What are the common needs there? Is there a common value proposition?"

Whatever that is, you can start to dig into some detail with a smaller customer set, and get really specific. There may be a hundred of those that are very worried about cycle time. Half of them will have a whole different idea of how they want to go after it. Some are all into the automation space. The other half will say, "All I care about is plating time. If there's a reduction of plating time, that's my number one priority this year." Other people have different ways they think they're going to get the

CYCLE TIME REDUCTION FOR DOMESTIC AND GLOBAL CUSTOMERS



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cycle time reduction, so we customize it. It's not up to us to tell them; we'll educate them and say, "Look, you have to also look at automation, at people, and cycle time." Everything's included. We'll customize a solution, that's where we'll lead them. It's not magic, we create customized solutions for every customer, but that's how we earn new business. It's custom for them.

Some people love the ACA-4 chemistry controller that does everything for them. Another customer says, "No, I just want your local guy to show up every morning, do my titration and I'm good. What's better than that?"

Cullen: When we think about what is the best possible cycle time, we take the innovation team and design products that plate at a faster speed and with less downtime, the analyses are more optimized. We also need to think about cycle time in real production, meaning how do we respond to customer demands? What happens if they have a problem? That's the service aspect, so again, it is innovation and service.

The innovators try to design things that work best in full capacity production. The service team tries to keep our customers at their targeted capacity, and this gives them the ability to turn around that part quickly, so that's what we try to do when we design the chemistry in our labs.

For a lot of our global customers, when we're trying to show the value proposition of our products, we include the cost of, for example, a piece of plating equipment that produces some nominal number of boards per hour, and we amortize that cost in our calculators to show what the cost contribution should be, but in North America, with the lower capacity utilization, it's different. How many parts get through the plating line depends on the quality of the plater, the ability to service it, and the ability to make it work in the most efficient manner. The more our process engineers make the North American fabricators more efficient will depend, in part, on how well we can innovate and service.

Matties: *It's an exciting time for you guys and the industry.*

Kenney: I think so. For us, it's going to be exciting. It's going to be a lot of work. We started today by saying we were busy. We haven't done much yet. But Platform has made some acquisitions and then the work will really start for us.

Matties: *The other challenge, of course, will be the cultural integration between these groups.*

Kenney: It's always the biggest challenge.

Matties: *How do you overcome that?*

Kenney: I'm not 100% sure. I can tell you one thing, at MacDermid we do have a tangible culture. I told you, I'm the newest guy here at 17 years. Our culture is pretty ingrained. I flourished in it and I love it. Today we talked a lot today about business; we didn't talk a lot about people. My #1 job next year, if these acquisitions go through, will be managing people. How do I get all of the employees as motivated as our existing MacDermid people?

CYCLE TIME REDUCTION FOR DOMESTIC AND GLOBAL CUSTOMERS

Matties: *I would think that's your greatest challenge actually, in this deal.*

Kenney: It is. This is what will happen. We have really good sales guys and really good technical people, and great products. I don't want to say they will take care of themselves, but the right thing will come up. The hard work is going to be how we manage all the people to keep them motivated, to keep them excited about the change. Theoretically, we've been competitors for years, so that builds with it a little bit of cultural differences. Trying to bring everyone into one culture is difficult, but that will be my focus next year—trying to make sure all of the really good employees understand what the culture is like and they end up enjoying it as much as I do.

That's really the challenge for me. Quite honestly, the preparations from here are all about making sure the business stuff is in place, and the structure is right. Then I'm going to become an HR person all next year in making sure everyone gets out of this what they want. MacDermid is committed. We understand it's not just in our mission statement. We talked about service a lot; that comes from our direct employees. We want to make sure everyone likes it here as much as the existing employees.

Matties: *I was just reading on your website, in the 'corporate philosophy,' how they value the people here at MacDermid. It was impressive.*

Cullen: I wanted to chime in on that, because people have their own strengths. The way that they bring the most value to MacDermid is they apply their strengths in what they do most beneficially to us and to our customer. Barry, you probably looked at the part of our philosophy about the "supreme worth of the individual", and that's a big part of what our philosophy is. If people are strong in their convictions and do what they know is best, it makes for the best customer experience. That's going to be the best way for integration of people into MacDermid, just to recognize that everybody has their own strengths.

Matties: *Yeah, get them in the right seat on the bus.*



Kenney: From Jim Collins, right? The right seat on the bus.

Cullen: Steve will be happy by having happy employees, and then the happy employees do a better job for our customers, and the customer are happy to have those people serving them.

Matties: *Great, well it will be fun to watch you guys do all of this.*

Cullen: It'll be exciting for sure. **PCB**

References

1. [EchoStar: The Future of Supply Chain Management Done Right](#), SMT Magazine, July 2015.

ELCOSINT - The Future of High Temperature Interconnect

The increasing need for electronic assemblies to endure high-temperature operating conditions in aerospace, automotive, oil and gas drilling, power management and renewable energy applications, whether those conditions involve high ambient temperatures, high cycle temperatures or high junction temperatures, is driving the development of high-temperature interconnection technologies.

Fortifying Computer Chips for Space Travel

Space is cold, dark, and lonely. Deadly, too, if any one of a million things goes wrong on your spaceship. It's certainly no place for a computer chip to fail, which can happen due to the abundance of radiation bombarding a craft. Worse, ever-shrinking components on microprocessors make computers more prone to damage from high-energy radiation like protons from the sun or cosmic rays from beyond our galaxy.

Sensor Data Fusion Offers Countermeasures against Small Drones

Airbus Defence and Space has developed a counter-UAV system which detects illicit intrusions of Unmanned Aerial Vehicles (UAVs) over critical areas at long ranges and offers electronic countermeasures, minimizing the risk of collateral damage.

NASA is Laser-focused on Deep Space Communication

Today's technology has all but eliminated time delays in telecommunication on Earth, but when they do occur they can be frustrating, especially when trying to communicate complex or time-sensitive information. The same type of delay could happen when communicating with spacecraft and crew members in deep space on the journey to Mars.

China Now Third Largest Importer of Defence Equipment

China's defence budget is expected to almost double by the close of this decade, according to a new analysis released today by IHS Inc., the leading global source of critical information and insight.

Self-healing Material Could Plug Life-Threatening Holes in Spacecraft

For astronauts living in space with objects zooming around them at 22,000 miles per hour like rogue super-bullets, it's good to have a backup plan. Although shields and fancy maneuvers could help protect space structures, scientists have to prepare for the possibility that debris could pierce a vessel.

The Drones Report 2015

The fast-growing global drone industry has not sat back waiting for government policy to be hammered out before pouring investment and effort into opening up this all-new hardware and computing market.

Advancing Bio-inspired Micro-robotics Technology

BAE Systems will have a significant role working with the MAST Alliance's team of scientists from the U.S. Army, academia, and industry as it advances bio-inspired micro-robotics technology to extend the remote sensing capability of U.S. ground forces. "The technologies being developed under MAST will support products that extend soldiers' capabilities while keeping them out of harm's way," said Bill Devine, MAST's strategic development manager for BAE Systems.

Construction to Begin on World's Largest Camera

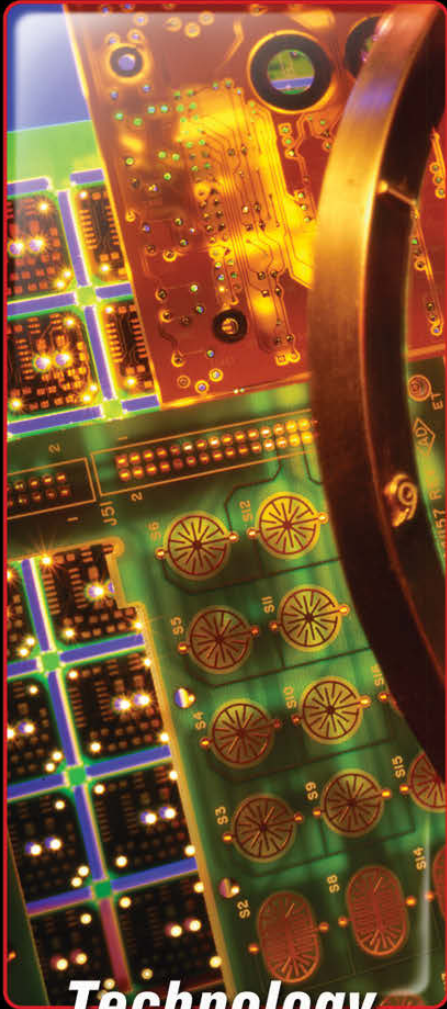
The Department of Energy has approved the start of construction for a 3.2-gigapixel digital camera—the world's largest—for the Large Synoptic Survey Telescope.

Teeny Tiny Guardians of Our Chips

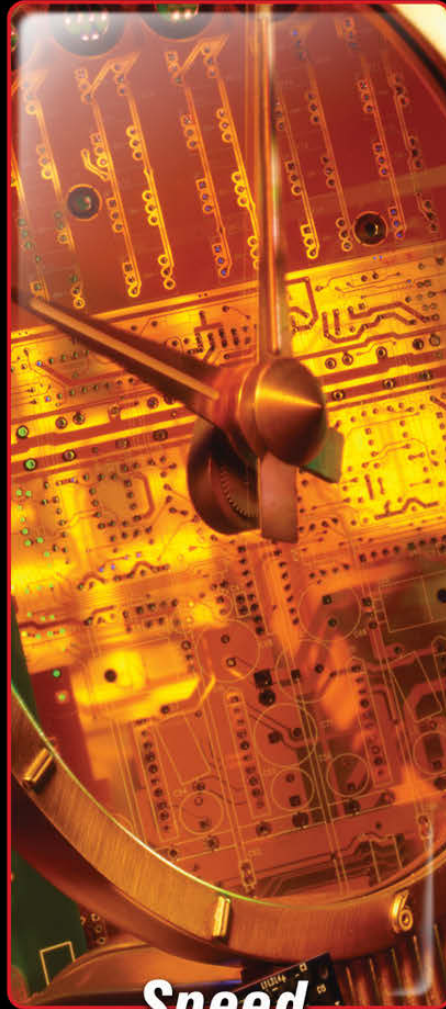
Counterfeit, cloned, and otherwise doctored electronic chips already are circulating in markets and the problem is only likely to grow in the coming years. Shown here are dummy "dielets" that DARPA-supported researchers have produced to help them learn how to dice, sort, pick, place and otherwise handle such teensy components, which would affix to individual chips with a footprint the size of a dust speck.

We Take the Time to do it Right

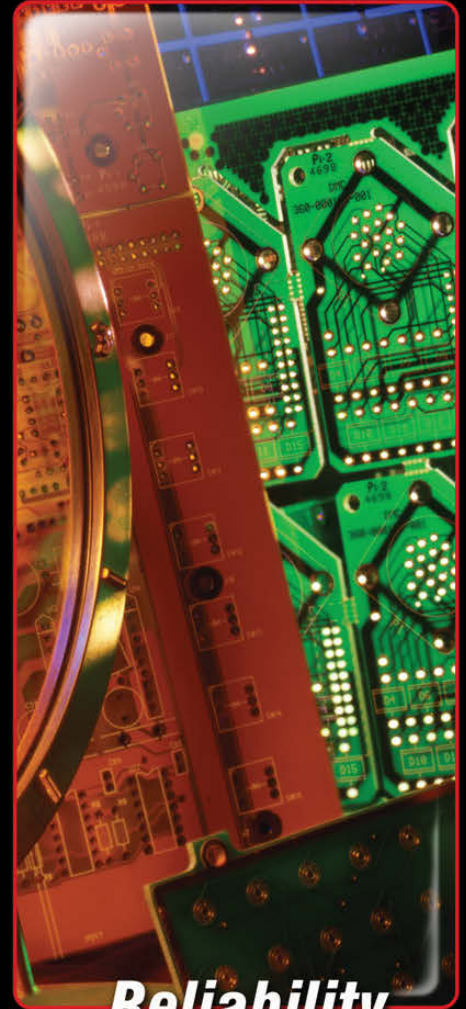
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Tips for Time-Critical PCBs

by Tara Dunn

OMNI PCB

Can you relate to this common scenario? A quotation is received for the fabrication of three different PCB part numbers and a purchase order is placed for delivery in five days, on a time-critical project. A few hours later, the dreaded e-mail is received. Questions regarding the design are putting the project on hold. It takes a day, or possibly two, to coordinate the resolution of the questions between your customer, the PCB designer and the fabricator. Next, you are informed that the delivery date for the PCBs is pushed out for the two-day delay in answering questions. Ugh! Now the schedule has to be adjusted, the components you paid a premium for will be sitting there waiting for the boards, and your customer is not happy.

This scenario occurs time and time again. Approximately 90% of designs that go through CAD/CAM at a PCB fabricator have questions that must be answered before the fabricator can start manufacturing the board. Some questions are minor and can be answered quickly; others can require a partial or complete redesign of the PCB.

Elizabeth Foradori and I sat down to discuss our ideas about how to best work with PCB fabricators to reduce the likelihood of any delays during time-critical development of a new product. Chapters could be written on this topic, but our hope is that these ideas provide a basis to encourage discussion early in the design process.

Prior to Placing a Purchase Order

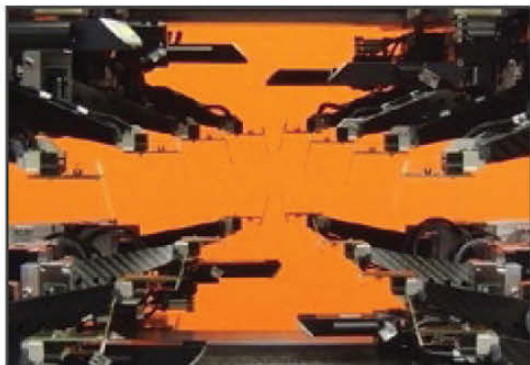
1. Research and select your PCB fabricator early in the process. If the design is going to be a standard design, on common material and fit neatly into any manufacturer's "standard capabilities," that makes things much easier. But if the new design is going to be pushing the limits of standard technology in any way—microvias, fine line, tight pitch or tight tolerance, selective surface finish, exotic materials, rigid-flex—selecting a supplier early in the process, whose capabilities match the technology needed, will ensure that the design can be manufactured quickly once you are ready to release the files.



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TIPS FOR TIME-CRITICAL PCBs

2. Involve the fabricator early in the design process. Ask questions. Talk to your supplier frequently during the design of the PCB. They should encourage questions and be happy to make recommendations. Once the fabricator understands what you are trying to accomplish, they can make recommendations that will ensure that the design is manufacturable. As a final step, or even an intermediate step during the design process, ask your fabricator to run a design rule check based on your files. This may not catch every issue and eliminate all engineering questions at the CAD/CAM stage, but it will catch the major issues that would require lengthy redesign once a project is released.

3. Verify that material is available and will be in stock when the design is complete. Fabricators try to stock the common materials and even small quantities of the less common materials to avoid delays. Unfortunately, they cannot stock all materials. Once the stack-up is finalized, ask the fabricator if this is material that will be in stock. If not, work with your supplier to pre-order the material to have in-house when you are ready to release the design. Some fabricators will secure material based on a simple email authorization; others will require a purchase order. Either way, planning for material to be in stock when the design is complete can save anywhere from five days to six weeks.

After a Purchase Order is Placed

1. Send complete files. Review the files being submitted with the purchase order to ensure they are complete. Is the net list included? Are the fab notes complete, confirming any quality requirements, material specifications, and surface finish requirements? Do the fab notes match the Gerber data? These are all very common reasons that files are placed on engineering hold.

2. When you receive questions from the CAD/CAM tooling group, ask if this includes all questions associated with the design. Sometimes two different engineers may be working on the same design to

meet an expedited delivery and both may have questions in their portion of the process. Other times, when the initial issues are encountered, the job is set aside only to find additional issues when work is resumed. The process can be streamlined by taking all questions to your designer or your end customer at one time.

3. If necessary, schedule a conference call between your fabricator, your designer or end customer and yourself to resolve the issue as quickly as possible. Email offers a great documentation trail for any changes, but can drag the process out longer than necessary. If communicating via conference call, ensure that someone is responsible for documenting the discussion and sending that to all parties involved.

4. Follow up with your supplier to confirm that the questions involved in the tooling process have not impacted your delivery schedule. Delays of a few hours are usually absorbed into the initial lead-time. Longer delays can impact delivery. PCB fabricators are typically very good about notifying customers of any changes in delivery date due to engineering questions, but it is always a good practice to ask. You don't want to be surprised on the day you are expecting your printed circuit boards.

In summary, communication with your supplier is the best way to reduce the cycle time needed for fabrication of time-critical, new PCB designs. Ask for recommendations during the design phase to ensure the design is manufacturable, verify that material will be available when the design is released, and if there are engineering questions, communicate quickly to have those resolved. Take advantage of the fabricator's expertise and ask questions! **PCB**



Tara Dunn is the president of Omni PCB. To contact the author, [click here](#).

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Plant Culture: a Direct Contributor to Quality, Output and Predictable Manufacturing

by Andy Thomson
ECHOSTAR

The culture of any organization influences the net output of any product or service it produces. That being said, the manufacturing of products brings complexity with an order of magnitude that can affect the net output at any given point along the build cycle, starting with the sub-component supply chain to final pack. Manifestations of breakdowns along this chain are failure to make schedule, poor quality, scrap, excess labor (rework) and field returns. External ramifications are loss of revenue, loss of customers and inability to win new customers. In this article, I will try to show the interrelationship between a plant's culture and its final product, which are not only the shippable goods, but also customer service, revenue and profit.

The four cornerstones to a manufacturing plant's culture are discipline, training/tools, motivation (plant citizenship), and self-worth.

These four cornerstones need to be set in that order, and they are constructed by elements that make them weaker or stronger in supporting a culture that functions optimally. Each one mutually supports the other, which can create a self-reinforcing effect.

Discipline

By far the most important, discipline, when properly implemented and maintained, starts the process. Discipline must be all-encompassing to be employed properly. Management must be fair and consistent across the board, with no distinction between salaried and hourly employees. The implementation, or changes as to how accountability in the factory will change, needs to be clearly communicated. A date of implementation should also be set and a grace period of no more than a week, where employees are verbally warned for infractions that had in the past been ignored by management. After that grace period, normal disciplinary proce-



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dures is followed to the letter. This approach will soon foster and motivate the good employees who like a level playing field in which all employees pull a fair load.

In a non-disciplined environment, the good employees do their job with contempt for management that allows rogue employees to constantly break the rules. These employees are the same ones who care little for the work they do and subsequently, quality and productivity suffer. Discipline cannot be personal. Discipline must be approached as

“Trained people are assets and replacing them is costly in training time, tenure to reach quality, and efficiency levels. If the employee cannot be turned, by following the company policy, the problem will remove itself from the factory environment.”

business, and contractual between company and employee. It must be impersonal in the dispensing, wayward employees must not be browbeaten, but rather encouraged to rehabilitate with special attention from supervisors to come into the fold. In order for this to happen, supervisors need to care. Trained people are assets and replacing them is costly in training time, tenure to reach quality, and efficiency levels. If the employee cannot be turned, by following the company policy, the problem will remove itself from the factory environment.

Training

In its proper format, training is critical to the employee and company equally. Without proper and consistent training, employees can-

not perform their required duties to exacting standards. The employee left to on-the-job training or given haphazard instructions will not feel very good about himself or herself, or the company. In many cases, employees fail and are terminated because no one ever trained them properly. Training is part of the equation. Employees need to have the proper tools and equipment in order to feel self-worth and do the expected job to the best of their ability. This would include making work areas bright and clean and an environment someone would not mind working in 10 hours a day. Lavish and fancy are not required, but painted, clean and well-maintained are. This tells the employees they are important to the company and in turn, for most employees, that fact will reflect in their work. Employees building complex products, even at the bottom of the rung, can still be treated and respected professionally. This in turn builds self-worth and pride that begins to take form in doing their work. That pride and feeling of being a valued part of the process translates into productivity and quality! In turn, camaraderie is bred and the next thing you know, you have a team! Training needs to be continuous and tools need to be audited and replaced. Employees need to be consulted on tool application and always be the ones approving the tools they may be forced to use. This allows for buy-in and might yield valuable information that could improve the process.

Motivation

Motivation is an elusive state, but once captured and turned loose, it can do amazing things in any work environment. Motivation starts at the top. Employees need to know their leaders are working as hard as they are. Leaders need to set the example. Leaders need to coach, praise, teach, and be humble when they're wrong, which includes apologizing. If they call an employee on the carpet in public, then the apology must take place in the same public arena and with the same witnesses. The best policy is to do a proper investigation and bring the employee off the floor and into a closed office. Employees need to know their leaders are honest, fair and trustworthy. They need to know



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that if they have a crisis in their life they can come to their supervisor and expect compassion and help within the guidelines of the company rules. They need to know that honest mistakes are treated as such and no one is crucified for making one, because all humans make them and ideally, learn from them. The benefit of this is employees who are willing to 'fess up and not hide a problem that would be harder to fix if discovered in a later stage of manufacturing. Employees need to be told often that they are doing a good job and not just by their immediate supervisor. These practices tell the employees that they are valued and a part of the factory family—not just mere employees. This will bring loyalty and respect for the leadership because leadership respects them.

Self-worth

Self-worth for your employees is easy, and a natural result, if you follow the above guidelines. Once employees feel like they're part of something, they begin to care. They have pride in their work. They know who they are and they boast about whom they work for because they feel a part of something that is good.

Put the four cornerstones in place and you have a factory that is unstoppable; you have a team that is unbeatable. **PCB**



Andy Thomson is VP of operations at EchoStar.

Disappearing Carbon Circuits on Graphene Could Have Security, Biomedical Uses

In the television drama "Mission Impossible," instructions for the mission were delivered on an audio tape that destroyed itself immediately after being played. Should that series ever be revived, its producers might want to talk with Georgia Institute of Technology professor Andrei Fedorov about using his "disappearing circuits" to deliver the instructions.

Using carbon atoms deposited on graphene with a focused electron beam process, Fedorov and collaborators have demonstrated a technique for creating dynamic patterns on graphene surfaces. The patterns could be used to make reconfigurable electronic circuits, which evolve over a period of hours before ultimately disappearing into a new electronic state of the graphene. Graphene is also

made up of carbon atoms, but in a highly-ordered form.

Beyond allowing fabrication of disappearing circuits, the technology could be used as a form of timed release in which the dissipation of the carbon patterns could control other processes, such as the release of biomolecules.

"We will now be able to draw electronic circuits that evolve over time," said Andrei Fedorov, a professor in the George W. Woodruff School of Mechanical Engineering at Georgia Tech. "You could design a circuit that operates one way now, but after waiting a day for the carbon to diffuse over the graphene surface, you would no longer have an electronic device. Today the device would do one thing; tomorrow it would do something entirely different."

Reported in the journal *Nanoscale*, the research was primarily supported by the U.S. Department of Energy Office of Science, and involved collaboration with researchers from the Air Force Research Laboratory (AFRL), supported by the Air Force Office of Scientific Research.





2015 Programs

October 13

IPC Conference on Government Regulation

Essen, Germany

Discussion with international experts on regulatory issues

October 13–15

IPC Europe Forum: Innovation for Reliability

Essen, Germany

Practical applications for meeting reliability challenges like tin whiskers, with special focus on military aerospace and automotive sectors

October 26–27

IPC Technical Education

Minneapolis, MN, USA

Professional development courses for engineering staff and managers:

- DFX-Design For Excellence (DFM, DFA, DFR and more)
- Best Practices in Assembly
- Advanced PCB Troubleshooting
- SMT Problem Solving

October 28–30

IPC Flexible Circuits-HDI Conference

Minneapolis, MN, USA

Presentations will address Flex and HDI challenges in methodology, materials, and technology.

November 2–6

IPC EMS Program Management Training and Certification

Chicago, IL, USA

November 4

PCB Carolina 2015

Raleigh, NC, USA

November 10–13

productronica

Munich, Germany

December 2–3

IPC Technical Education

Raleigh, NC, USA

Professional development courses for engineering staff and managers:

- DFX-Design For Excellence (DFM, DFA, DFR and more)
- Best Practices in Assembly
- Advanced PCB Troubleshooting
- SMT Problem Solving

December 2–4

International Printed Circuit and APEX South China Fair (HKPCA & IPC Show)

Shenzhen, China

December 7–11

IPC EMS Program Management Training & Certification

San Jose, CA, USA



IPC Flexible Circuits – HDI Forum

October 28–30, 2015 • Minneapolis, Minnesota

ADDRESS challenges associated with flexible circuits and HDI technology

To help you make optimal choices for meeting customer reliability requirements, IPC has gathered leading subject matter experts to share their knowledge and experiences with you in an exciting three-day forum.

- | | | | |
|------------|-----------------------|---------------------------|--------------------|
| • Battelle | • Flextronics | • Multek-Flextronics | • SAIC |
| • DuPont | • Insulectro | • Orbotech | • TTM Technologies |
| • eSurface | • Intrinsiq Materials | • RBP Chemical Technology | |

For more information, visit www.ipc.org/flex-hdi

QUESTIONS? Contact IPC Director of Education at AnneMarieMulvihill@ipc.org

Visit www.ipc.org/events for IPC Calendar

TOP TEN



Recent Highlights from PCB007

1 **Characterization of PCB Material & Manufacturing Technology for High-Frequency**

Concepts like Industry 4.0, Internet of Things, M2M communication, smart homes and communication in, or to cars are maturing. All these applications are based on the same demanding requirement—a considerable amount of data and increased data transfer rate. These arguments present major challenges to PCB design and manufacturing.

2 **Flex Market Evolution**

Flex circuits are designed to solve electronic packaging and assembly problems, solve interconnection issues, assist in miniaturization, and provide a dynamic electro-mechanical solution. They are configured with repeatable conductors that foolproof assembly errors. Flex is used in designs where standard PCBs, connectors and cable assemblies just don't provide the right electrical or mechanical solution.

3 **Automotive Technology: The Next Driving Force in Electronic Manufacturing**

The devices we have come to expect in luxury and high-end vehicles are now becoming available and even common in lower priced ones. While that significantly increases automotive electronic device manufacture volume, the next wave will dwarf what we have experienced to date.

4 **Detroit vs. Silicon Valley: What's Driving the Proliferation of Automotive Electronics?**

For the past several decades, modern cars have not changed much. They have four wheels, an engine, a radio (possibly even an 8-track) and seatbelts. Over time, however, cars' electronics parts have evolved faster than any other part of a car with enhancements like power windows, power mirrors, seat heaters and GPS navigation.

5 Georgia Tech Joins Manufacturing Innovation Institute for Flexible Hybrid Electronics

The Georgia Institute of Technology has become a founding member of the new Flexible Hybrid Electronics Manufacturing Innovation Institute (FHE-MII) established by the U.S. Department of Defense.

6 IPC Releases White Paper on Conflict Minerals Due Diligence

The Dodd-Frank Act continues to be burdensome for companies required to report on the usage of conflict minerals. In order to address industry concerns, IPC—Association Connecting Electronics Industries has released IPC-1081, Conflict Minerals Due Diligence White Paper (IPC WP-1081), a document designed to help with some reporting woes.

7 Conflict Minerals Study: Only 25% of Filers Fully Met Dodd-Frank Section 1502 Requirements in 2014

A recent, independent evaluation of the public company “conflict mineral” filings submitted to the SEC for reporting year 2014 under Dodd-Frank Section 1502 found that of the 1,262 companies evaluated, 312 scored a perfect 100% and 245 scored below 75% in meeting the requirements of the SEC rule.

8 Lone Star Circuits Adds Lance Riley as VP of Sales

Lone Star Circuits, a high-reliability technology driven printed circuit board manufacturer, is pleased to announce that Lance Riley has joined the company as Vice President of Sales.

9 Integrating with Gardien Group’s Roland Valentini

Gardien Group is one of those companies that are always looking out for their customers. The company is, without a doubt, the last word when it comes to bare board quality assurance, focused on helping customers deliver the most electrically sound boards in the business. Gardien’s technologists are experts at testing and other quality assurance disciplines.

10 IPC Lauds Launch of Flexible Hybrid Electronics Institute

On behalf of IPC—Association Connecting Electronics Industries® and an estimated 800,000 people employed in our 2,200 U.S. member facilities, we applaud the launch of the new public-private institute on flexible hybrid electronics in Mountain View, CA. This new facility, which will contribute to America’s global competitiveness in manufacturing, is part of the new National Network for Manufacturing Innovation (NNMI), which IPC has strongly supported.

For the latest PCB news and information, visit: PCB007.com



EVENTS



For the IPC Calendar of Events, [click here](#).

For the SMTA Calendar of Events, [click here](#).

For the iNEMI Calendar of Events, [click here](#).

For the complete PCB007 Calendar of Events, [click here](#).

IPC Conference on Government Regulation

October 13, 2015
Essen, Germany

IPC Europe Forum: Innovation for Reliability

October 13–15, 2015
Essen, Germany

14th International Symposium on Microelectronics Packaging (ISMP 2015)

October 13–15, 2015
Seoul, South Korea

International Wafer-Level Packaging Conference

October 13–15, 2015
San Jose, California, USA

Long Island SMTA Expo and Technical Forum

October 14, 2015
Islandia, New York, USA

TPCA Show 2015

October 21–23, 2015
Taipei, Taiwan

LED Assembly, Reliability & Testing Symposium

November 17–19, 2015
Atlanta, Georgia, USA

Rapid Oven Setup & PCB Profiling—Seminar

November 24, 2015
Warwickshire, UK

2015 International Printed Circuit & APEX South China Fair

December 2–4, 2015
Shenzhen, China

IPC APEX EXPO Conference & Exhibition 2016

March 15–17, 2016
Las Vegas, Nevada, USA



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ADVERTISER INDEX

atg Luther & Maelzer GmbH.....	93	Mutrax.....	13
Burkle North America.....	21	Nano System.....	9
Camtek.....	27	OMG Electronic Chemicals.....	61
Dibble Leaders.....	3	Orbotech.....	31
DIS.....	25	Os-tech.....	71
Electra Polymers.....	67	Panasonic.....	63
ESI.....	5	Plasma Etch.....	53
First EIE.....	47	Prototron.....	91
Gardien.....	69	Rogers.....	23
I-Connect007.....	106	Schmid.....	43
ID Tech Ex.....	75	Shengyi Technology.....	11
Insulectro.....	49	Taiyo America.....	45
IPC.....	81, 101	Technica.....	77
IPS.....	17	The PCB List.....	2, 85
Isola.....	7	The Right Approach Consulting...	99
Matrix USA.....	41	Ucamco.....	65
Mentor.....	97	Uyemura.....	37
Meptec.....	95	Ventec.....	59
Mortech.....	57		

Coming Soon to *The PCB Magazine:*

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November:
The Data
Factor(y):
Looking at
the Industrial
Internet

December:
Associations and
2016 Events

January:
Medical
Electronics

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