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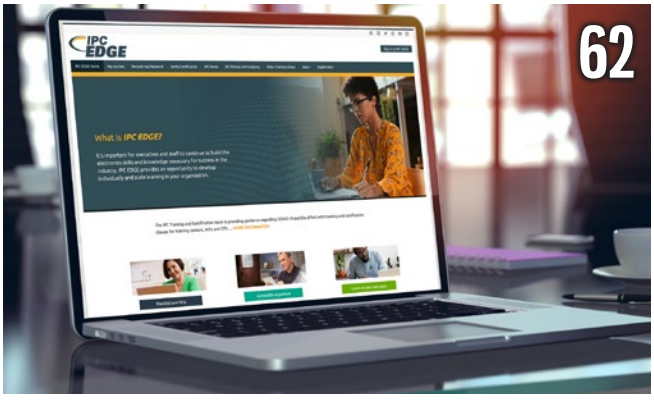

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Inventory Management

Nolan's Notes

by Nolan Johnson, I-CONNECT007

Years ago, when HDMI was a brand-new audio-visual connector type, and 1080p was the cutting edge of screen resolution, I worked at a company, designing and manufacturing large video display walls and digital signage. Some of the products were based on LCD flat panels, but many were built on some highly sophisticated rear-projection technology. By this time in my career, I'd been around a fair bit, but mostly in software. Thus, when we were informed that a factory in Asia that manufactured projector lamp bulbs had been destroyed in a fire, I was interested but not impressed—until it was pointed out that there were only two factories on the planet making these lamps, and one of them was now a smoldering pile of rubble.

Coming from mostly a software background, this was my first real exposure to supply chain bottlenecks and interruptions. Procurement, engineering, and customer service all dove into developing a response plan to ensure we had the kind of supply we needed to support our manufacturing and customer maintenance contracts. Next in priority were spares and parts sales. Ultimately, the disruption was minimal, as inventories were well-stocked all along the chain. To my knowledge, we never experienced any issues in delivering lamps for our customers. That doesn't mean, however, that this was no big deal. During the time that there was just one bulb factory on the planet, global supply was very much at risk; thankfully, the supply chain maintained a steady demand in the face of it all.

Jump to current events in 2020, and we've all learned about supply chain—more than we care to, in some cases. We've seen the supply chain fall apart due to demand and hoarding, and we've seen shutdown-related shortages ripple down like a row of falling dominoes, as well as failures from the supply side and the demand side. This can have a financial impact. While putting together this issue, I turned to IBM's Quentin Samelson for some insights (I also interviewed his colleagues Michelle Lam and

Christophe Begue). In one of his recent articles on inventory management [1], Quentin wrote:

> "Electronics is an industry where some companies seem to have ample cash, and others have constant issues maintaining sufficient cash flow. The problem can be especially noticeable in the electronics manufacturing services (EMS) industry, where a kind of double jeopardy exists: first, they are often paid by their customers on 90-day terms but must pay semiconductor suppliers in 30 days. Secondly, their customers' forecasts are often relatively inaccurate, forcing the EMS companies to hold inventory for weeks to months. Bottom line: they often are forced to pay for components long before they get paid for the assemblies containing those components."

What we learned from building our August issue was that good inventory management not only helps smooth out your inbound supply chain and cash flow, but that there is ongoing development work to improve inventory management within the walls of your factory that can cut down on labor hours (increasing staff availability for decision-making tasks), increase pick-and-place line efficiencies, improve management of consignment parts, and more.

In our previous reporting on smart factories, we've tried to determine how an EMS firm can get started on moving toward Industry 4.0. Perhaps, for some, inventory management is a great place to start. We're interested to hear what you think. **SMT007**

Reference

1. Quentin Samelson, "Five new blockchain use cases for electronics," Medium, June 5, 2018.

Nolan Johnson is managing editor of *SMT007 Magazine.* Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing. To contact Johnson, click here.

Lean Digital Thread: Driving Productivity Excellence—Lean PCB Manufacturing

by Sagi Reuven, SIEMENS DIGITAL INDUSTRIES

If you follow the financial reports in electronics manufacturing, you know that the average cost of materials can easily represent around 90% of the cost of the product. In addition, we can all agree that during the last decade, the number of products manufactured and their complexity is skyrocketing. If you pour into this mix the demand to lower the cost and shorten the time-to-market, the only way to thrive is to master how to get the most out of your resources. (To read the full column, click here.)

Sagi Reuven is a business development manager for the electronics industry, Siemens Digital Industries. Download your free copy of the book *The Printed Circuit Assembler's Guide to… Advanced Manufacturing in the Digital Age* from Mentor, a Siemens Business, and visit I-007eBooks.com for other free, educational titles.

IBM: Supply Chain Blockchain

Feature Interview by Nolan Johnson
I-CONNECT007

IBM's Michelle Lam and Christophe Begue, along with Nolan Johnson, discuss the basics of blockchain, and how it enables a more secure and traceable supply chain. They also address some of the applications for this technology and what the future holds.

Nolan Johnson: Maybe we could start with an introduction from each of you, your background, and your title?

Michelle Lam: I'm a senior technical staff member in IBM's System Supply Chain Engineering organization. Among many roles I have, counterfeit prevention program manager is one that got me into working on blockchain.

Christophe Begue: I'm the director of solution strategy in the industry team for the electronics industry at IBM. My job is to bring the various things that IBM does, and solutions from our partners, and package them together to specifically address the various needs of our clients—which spans from semiconductor to consumer electronics.

Johnson: That's exactly the space that we're hoping to talk about—the electronics supply. For those of us who don't really know, what is blockchain? What does it do, and why is it good for this sort of application?

Begue: Blockchain is, at its core, a shared ledger. It's a way to record a transaction that involves multiple parties in a ledger, which is shared by these parties. Instead of recording your accounting transaction with another partner—which is recorded when completed in two separate ledgers—here is a ledger that accounts for the transaction that brings you two together. In the life of doing business, you and this other party do business with many other parties.

If you design the blockchain to include all these different parties, there would be this ledger which records the set of transactions that brings two or multiple parties together as they relate to each other. It's novel because of the way it reaches across multiple organizations

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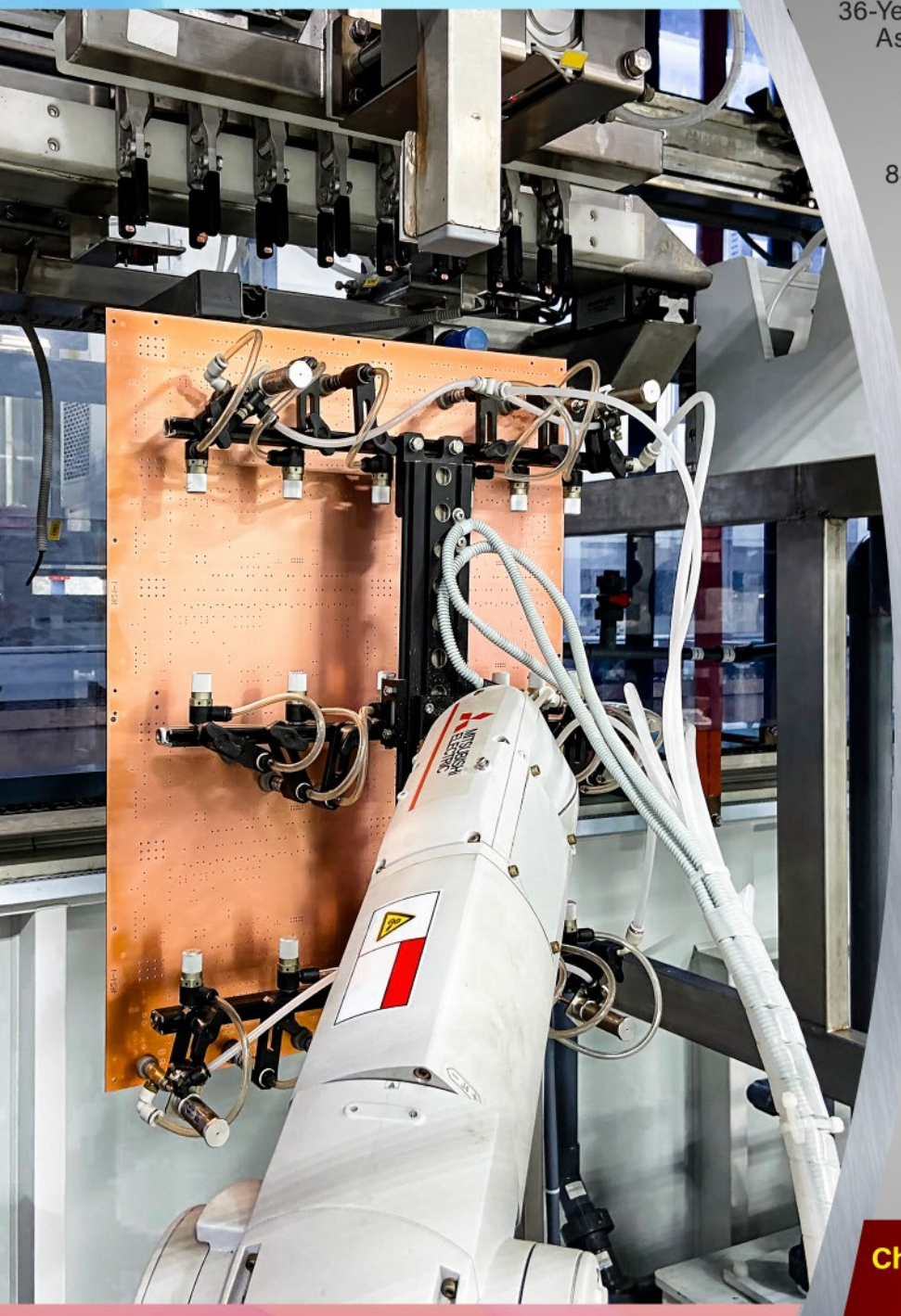

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and manages the information, security, and immutability. Its record of history cannot be changed, so it's a new way of looking at multi-party processes and transactions.

Lam: Christophe summarized it very well, but I want to add that there are so many different types of blockchains. The one we're talking about is the permissioned blockchain, instead of the permissionless, anonymous blockchain where anyone—even if they don't know each other—can join.

Begue: That's a very important point. Here, we're discussing the use of blockchain in the context of business processes and enterprises, which are dealing with each other. They have names, locations, and reasons for doing business. We're not talking about cryptocurrencies and anonymous participants.

Michelle Lam

Johnson: Wouldn't anonymity be a problem when you're dealing with provenance in the supply chain?

Begue: Correct. You'd like to buy stuff from people who exist, and you know their name. Quite often, it's a legal requirement.

Johnson: Where is the blockchain, and where does the transaction ledger reside?

Begue: Think about a ledger or database that would either be hosted by one of the participants, or by your solution provider, and the participant agrees to jointly write a set of data that represents this transaction to that ledger. That ledger certainly accounts for the history of these transactions across these different parties as it evolves over time. It's the equivalent in that case of a software-as-a-service (SaaS) solution where different participants contribute their own transactions.

Johnson: And there isn't anything more in the ledger than tracking the transactions?

Begue: Yes. It's more than a transaction. Very often, while I'm issuing a purchase order, there is a lot of information associated with the purchase order, the product description, and maybe some legal documentation. You may not want to put all of that onto the blockchain, but you can link to it, which means the blockchain is just the record that the transaction exists. You can point to associated documents that describe the content of a transaction, and there is a fairly complex security layer, which is going to manage the accessibility of all this data to the different parties. Because it's one thing to have you, your client, and your client's client sharing transactions, but it doesn't mean that everybody should see everything. There is a lot of control you may want to provide about who can see what and when.

Johnson: That makes sense because not everybody needs to know everything.

Begue: Definitely. And everybody shouldn't see everything.

Johnson: When we talk about supply chain management, there are two different applications: there's supply chain management, and then there's the identification of potential counterfeits in the supply chain. Looking at supply chain management for the moment, how does blockchain move us forward? Why isn't the current method sufficient?

Begue: I always use the same example, but I think it's a decent one. If I'm in the electronics industry, and I'm shipping one box of components or sub-assemblies from someplace in China to the port of Long Beach, California, who is involved in that transaction? The obvi-

ous answer is that I have a supplier organization and a buying organization, but there are probably four or five other institutions or organizations involved. I would have the supplier freight forwarder, a transportation agency—maybe FedEx or an airline—and maybe a customs agency in China. I would have another customs agency in the U.S., possibly another freight forwarder in the U.S., and then one or two more logistic companies. They all see part of that simple supply chain transaction. You could reconstruct the life of that transaction for all the different parties.

There is an electronic or paper-based set of transactions, but there is not a single system where, if you wanted to see the history of a simple supply buy transaction, you could see all these different parties coming together. If you look at the extended supply chain—with all the outsourcing, contract manufacturing, complex subassemblies, and so on—the electronics industry is full of these very complex multi-party processes. There is no SAP system for that. Each one has its own set of transaction systems, but it doesn't amount to the entire end-to-end solution. With blockchain, we're trying to build that cross-participant, multi-party view of every connection in the transaction.

Christophe Begue

Johnson: What happens if the blockchain continuity through the supply chain is interrupted?

Begue: The blockchain is going to be the record; it's not necessarily where you're going to initiate the transaction. If a freight forwarder is contacting FedEx or is working with a customs agency in Shenzhen, China, they will continue to use their existing ERP or other logistics system to initiate that transaction, but it would be recorded on the blockchain. If you are in the U.S. and want to see where my stuff is, for example, or the status of those different events, you would go to the blockchain to reconstruct the history of what happened. We are not replacing the existing business systems; we are adding a layer of connectivity through the way they relate to each other from the point of view of a single transaction.

Johnson: Does blockchain in the supply chain require head-to-tail use, all at once, to be effective?

Begue: No. For most of our cases, we focus on one particular aspect, such as international shipping or data exchange. You focus where it makes more sense to you. The starting point is there are multiple parties, and they work together in some ways; there is some sort of inefficiency in that process. Another assumption is that if I could view these set of transactions as they relate to each other, it would help me either simplify or go faster, and remove inefficiency. Where do I want to focus? Maybe it's invoice reconciliation, international shipping or customs declaration. You start there.

Lam: I don't view blockchain differently from any other emerging technology. It's almost like all other data-related projects or analytical data projects; they all need to have data input into a certain platform and layer, and that depends on the pain point you want to solve in your business. You further figure out how to utilize the data that you put into that platform and monetize it, or apply it to solve your problem. The only one that's additionally important is the specific need to have more than one party input the data. Otherwise, you really don't need that technology because the point of it is to improve security and then increase trust between the entities that are part of the stakeholder of that problem you're trying to solve.

Johnson: This is going to need collaboration. If you can't get collaboration in front of you and behind you in the supply chain, that leaves you effectively standalone. Your supply chain isn't ready for something like this yet.

Begue: Correct.

Johnson: Are there any portion of the electronics supply chain that seems to be driving the adoption of this technology?

Begue: We see a couple of big buckets. There's one big bucket around international shipping. We do a lot of work with ocean freight—not that relevant for electronics, but inside our supply chain, there is a fair amount of work around air shipment. Freight forwarding, air shipment, customs declaration, all of that is one big bucket. The other big bucket is more around what Michelle is driving regarding the provenance or validation of origination of the components and being able to go back for a computer system that has been in use for a period of time. Where was that sub-assembly coming from? Is it valid? Is it being owned by a customer who should own it? It's reconciliation between the product and the client.

Lam: In our internal supply chain for our hardware system, we focus on these two areas: supply chain in terms of logistics and supply chain for electronics in terms of traceability of provenance.

Johnson: And these two areas—logistics and traceability—come together to provide some protection against counterfeits?

Lam: They kind of solve their own problem. A logistics-type of supply chain helps a great deal in terms of the process of moving products from one place to another globally. Different from the TradeLens focus on ocean carriers, internally, we also move things through air and land, and there are a lot of processes—such as customs declaration processes—that we need to handle manually. With blockchain, we will be able to reduce cycle time and costs in terms of that, and that solves a logistics problem. For traceability of provenance, it solves other problems like quality recall issues, authentication of product traceability, or whether it's really coming from a certain supplier, that type of thing. In various areas, we solve different things when you apply blocking into each case. It depends on the use case you have.

Begue: Invoices in logistic processes may look trivial, but there are inefficiencies associated with the manual aspect which create disputes. For example, if you have 10% of your transportation invoices being disputed, it could represent a fair amount of payment being disputed. Now, when you have a record of what happened, and which all parties trust, you can resolve these disputes much faster.

Johnson: Are there some examples that we might be able to talk about for the electronics supply chain where this has made a difference?

Begue: We use it because we're service providers for our clients' IT needs. The invoice that the client receives at the end of the month is not one or 10 lines; it's hundreds of lines for different types of services—reset that server, do this, do that. If even a relatively small percentage was an object of dispute, or the parties could not recognize the service, it would


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limit the payment of the entire invoice. Now, when the client calls on a service to be provided by IBM, we can write that request onto the blockchain and deliver that service with a reference to that request.

This creates an undisputed record of a request, and that is the basis for self-billing; the client bills itself for the service and the level of disputes is dramatically reduced. We get paid much earlier, and the client doesn't waste its time disputing invoices. It makes for better customer service.

Johnson: What about reverse supply chain issues? One of the challenges for electronics manufacturing is when there is a manufacturing issue that takes some time before it's identified, and manufacturing could have been running in a bad state for quite some time before they find out. One common example of this is field failures. How does blockchain help with traceability in that case?

Lam: Telemetry data would be useful in this case. Depending on our customer's choice, telemetry data might be available to us to understand machine health out in the field. It doesn't collect any data, like client-related information, but it's more about the machine. How is it being operated? What is the heartbeat of that system?

Depending on our customer's choice, telemetry data might be available to us to understand machine health out in the field.

A potential use case will be to apply blockchain to capture the space between the telemetry collection point and the forward-supply chain portion. If anything goes wrong, we can easily tap into that, along with the forward supply chain provenance data, and then contact our customer to say, "There is something wrong with this machine." One scenario might be to initiate a recall. It's very applicable in other industries, such as automotive, where they have a similar infrastructure.

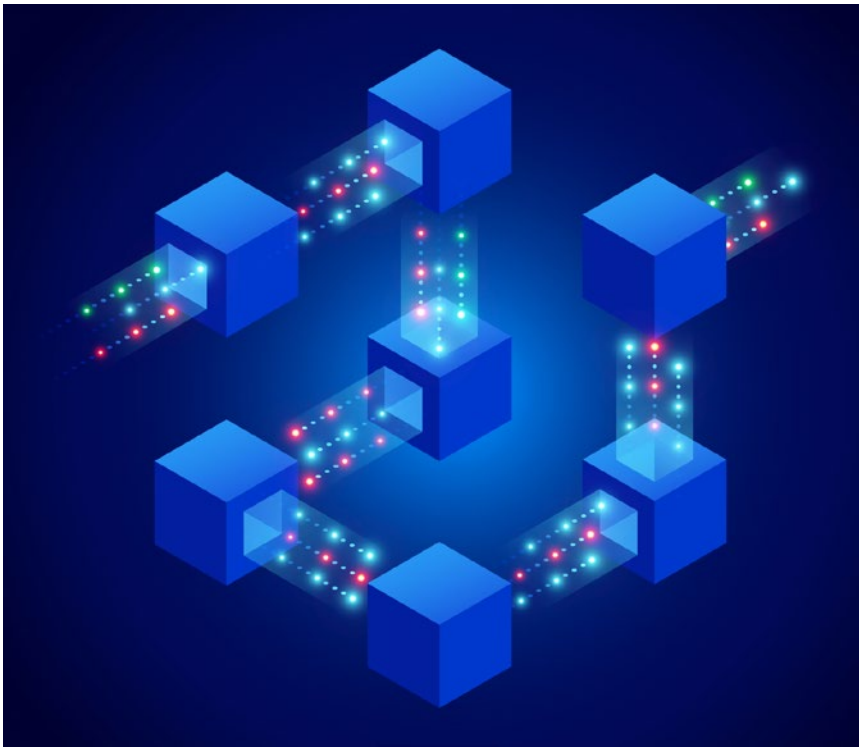
Johnson: This sounds like there's some potential to include machine data from the manufacturing process. For example, was this particular machine in or out of spec? There are plenty of situations where manufacturing tolerances can cascade, and a manufacturing process was within the process window on the edge. And that's fine unless you run into some other later processing step that pushes the whole subassembly out of spec. Could that sort of detail also be tracked along with the overall history of the product?

Lam: That's one potential use for a blockchain, as Christophe mentioned earlier. You put all the information on the ledger in terms of the transaction, but you could always have off-chain information, like the parametric data during manufacturing.

Johnson: It allows you to trace back and find the root causes of field failures and recalls. That could cause the manufacturing supply chain to recognize the need to modify process windows to maintain specifications at all times. Is there some ongoing optimization that can happen here as well?

Begue: Exactly. And one thing I wanted to mention earlier that may be emerging is that we are seeing several clients in electronics have a large part of their bill of material (BOM) made of embedded software that is delivered with the hardware. For example, think about a communication system of some kind, such as a base station. There is a lot of software on the hardware of the base station. Some of it is open-source, and others are proprietary software, but there's a lot of entitlement that needs to be managed. In many cases, the configuration for that complex system is somewhat specific or may be specific to that order.

In many cases, the build of the software is not necessarily unique, but it's somewhat specific to that order. Keeping track of which software we have built into that product—and then reporting the set of entitlement and renewals associated with that particular build—is a good way to use blockchain because you can use it to manage your relationship with these different software providers.



Johnson: That is an interesting point. When you have software and firmware that goes along with a particular piece of hardware, it isn't just about the components. That's a factor, but so is the overall configuration of what gets shipped.

Begue: Yes. And you may have to renew that license or pay some royalty; otherwise, there may be some update to that configuration you need to take into account.

Johnson: I have a hypothetical example in my mind. I have a Wi-Fi router that periodically gets firmware updates from the manufacturer. My router is now running on a different version of the firmware code than when I took it out of the box. Is that something that also would be tracked by the provider?

Begue: It could be, but imagine you have firmware, with two or three open source components, and then an embedded database. When the firmware gets updated, maybe it updates the database, and then it renews your entitlement for that entire stack for another six months. But if one of the open-source components was not updated, it may be interesting information to know that you haven't updated all of the components at the same time. It may trigger a different form of software entitlement compared to your providers.

Johnson: Where do you see this technology taking us with respect to making the supply chain more secure, more resilient, or more robust? What's the future for us in electronic manufacturing?

Begue: The supply chain—particularly in electronics—is going through pretty big changes. You have a different evolution of demand and supply in different parts of the world. You have tariff issues and relationships between different countries, COVID-19, and the transformation of a product as a service. It's becoming more complicated. Blockchain is not going to make that go away, but it's going to allow different participants to this complex supply chain to make their work a little bit easier in terms of visibility, trust, and maybe enter into relationships faster, onboard suppliers faster, and provide that level of organization and trust across this complex and changing physical process.

Lam: From a practitioner perspective, the key to the supply chain is collaboration. Whenever you talk about collaboration, it's really more human than technology. I see blockchain technology, and there's no problem there. If we want to do it, we can achieve it in terms of data science and computer engineering. We're able to handle all kinds of features and platform requirements. Right now, we're at the

stage of still trying to get together to be able to go through that minimum energy barrier. If you could get through the specific minimum level of energy you need to achieve and overcome, then people will really come together and grow the blockchain into the ecosystem level of usage. Right now, a lot of things that we're doing are still between just a few participants, from the electronic supply chain perspective, and the next phase will be about getting a bigger number of participants into one blockchain to slowly grow and connect.

Johnson: In technology, new solutions tend not to make systems simpler. Instead, they tend to allow complex systems to become even more complex yet more manageable. That's probably key as the industry is taking stock of the fact that the global supply chain is a throttled-down channel in some key places. Supply chain solutions using blockchain would allow a more network nodal, mesh-type supply chain without losing control of the provenance of your product.

Begue: At least in building the necessary level of trust, it's faster. One solution we are promoting, called "trust your supplier," aims to bring together all the necessary information that describes a supplier. Who are they? What are their reasons for business? Where are they located? What are their capabilities, human rights records, environmental certification, banking information, etc.?

Of course, when you enter in a conversation with a supplier, you ask for this data, and they provide it to you, but how do you know when it gets updated, and is there any change? How do you know when it's accurate? It's a fair amount of work for the supplier to maintain that data set and constantly update that data. What if you had a blockchain where that data would be uploaded, kept updated, certified by a certifying agency, and accessible to people who are interested in doing business with you? You would reach that level of trust faster.

Johnson: That would be the payoff. In answer to the question, "Is this going to grow for us over time?" the short answer would be, "It looks like it will."

Begue: This is a network-based solution. In the beginning, you need to have people willing to get started, trying to bring their business partners onto it, and then after that, the network effects work in your favor. Once you have a number of your suppliers onboard, these same suppliers are supplying to other people, and it would be easier for the next person to connect and get onboarded.

Johnson: How should interested companies get involved in the collaboration?

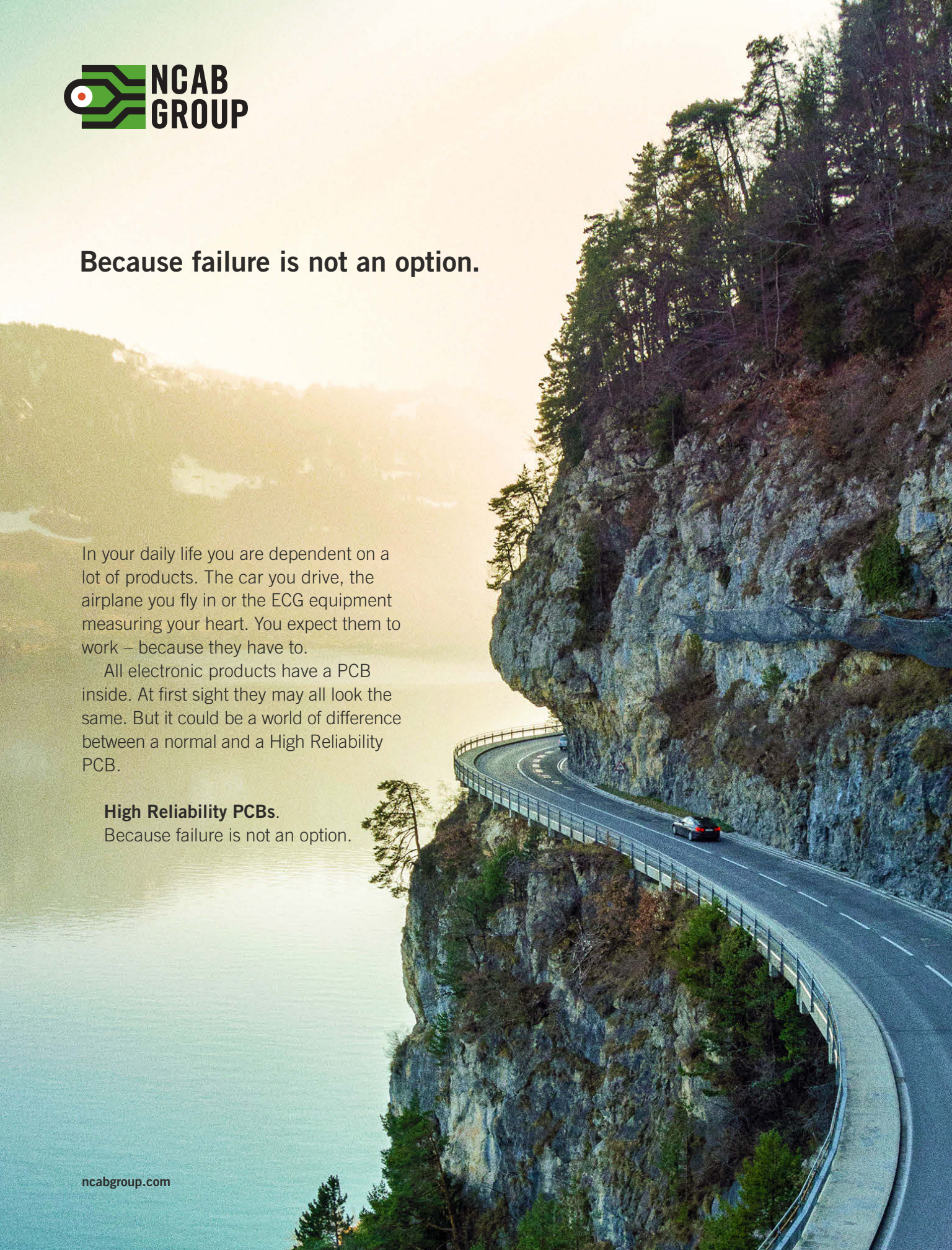
Begue: There are industry associations and industry groups interested in trying to define good ways of using blockchain across the electronic supply chain from a data representation or maybe the choreography associated with the exchange of that data. Michelle and I—and Michelle, in particular—are actively involved in these, and our position is that it values more shared and open standardization. It makes the life of everybody easier. We try to help in that direction.

Lam: With so many different organizations starting to define how they should use blockchain in their world, it's evidence that it is our future. We're going to use it as a very common underlining, underpinning all the technology.

Johnson: This was terrific information. Thanks for your time.

Beguec: Absolutely.

Lam: Thank you. SMT007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Increase Traceability, Prevent Counterfeiting

Feature Interview by the I-Connect007 Editorial Team

Michael Ford, senior director of emerging industry strategy for Aegis Software and I-Connect007 columnist, speaks about the increasing importance of traceability in manufacturing and throughout the supply chain, including how it affects such areas as counterfeit components and inventory management.

Nolan Johnson: What are the current concerns regarding the handling of counterfeits and component tracing through the supply chain, and how is IPC tackling them?

Michael Ford: At the time IPC started the standard for traceability, about five years ago, traceability had a very bad reputation in the industry, as it is something that operationally costs a lot of money, and many people will disagree on what data to collect and how to store it. We wanted to improve things so that traceability would become an everyday net benefit, in addition to the headline ability to discover the scope of any defects that might happen in the field and be able to narrow down the scope of rework or product recall, for example. We also wanted to use traceability for advanced quality purposes so that if, for example, we made 1,000 products, and one had a defect, we could discover the unique set of circumstances that caused the defect such that processes and parameters could be modified to avoid that condition—effectively a closed-loop quality feedback loop.

Those were the initial requirements. What we did not realize was how many counterfeit materials were out there in the market, and how much of a requirement there was by these parties to use traceability to combat that. When we look at counterfeits, they can take many forms and are basically any material that is not as intended or presented. Examples range from areas where distributors have substituted or used alternate vendors, all the way to cases where dummy parts have been specifically manufactured. Sometimes, we find materials that were filtered into good and poor quality, where rejected parts had found their way back into the supply chain.

When companies are desperate to get components to complete production, opportunities for counterfeit materials increase. For example,

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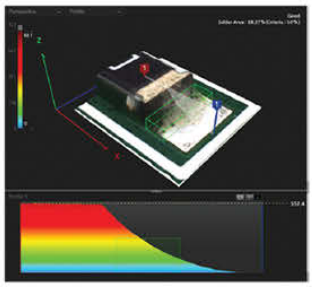

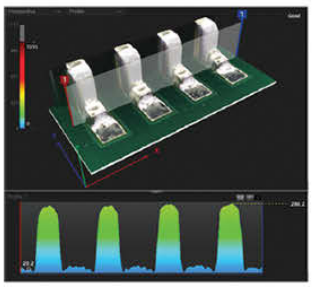

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Michael Ford

if you are making a laptop with 2,000 components and there is just one tiny passive component missing, it's game over in manufacturing to make that work order. In that situation, people will do almost anything to get that product made and out the door, including buying materials from the gray market, which simply means they don't know the true source of those materials. There are bad actors who use these opportunities to try to make money through the substitution of counterfeit parts of some kind for genuine parts. We've seen many cases where people have found cloned chips—some that seem to work but not very well, and others that are little more than a plastic box with legs on it.

We've also seen one really concerning case where there was a reel of 1,000 components; the first 100 were genuine, but every seventh part after was counterfeit. That's clearly been created to specifically defeat the inspection process—which involves only the initial materials, and then the subsequent distribution. Including the counterfeits create seemingly random chaos and confusion within manufacturing, as they cannot pinpoint issues back to the incoming source. These people are clever, and though they make very little amounts of money, for them, it's significant, and they don't care about the consequences. You can buy plenty of secondhand machines on the market now to re-label or re-make materials back onto reels.

We have seen a huge rise in this. Talking to the typical manufacturing company in Europe, they see instances of counterfeits every few months. In areas such as military applications, there is likely to be a much wider problem because they typically use higher-value materials. In one presentation, I saw that there is concern that 15% of the entire supply chain of the military is suspected to be counterfeit. There was even a case where programmable devices were stolen from a warehouse and replaced with fake parts, which looked and behaved exactly the same as the originals except that there was suspicion that a degree of additional programming had been incorporated, which could be spyware or a back door, with all of the associated risks. It is a serious problem.

You would expect, then, that there would be a serious plan in place to take care of the ingress of counterfeit, but actually, we found that there's none at all. You can read a great deal about various standards, procedures, requirements, and other information related to counterfeit materials. There are many standards that provide information about how to do the documentation and record the fact that you have a counterfeit, talk to your supplier about the counterfeit, test for counterfeit materials, or visually identify counterfeits, but there has been nothing about how to prevent counterfeiting from happening in the first place.

It's ridiculous that you have these technologies and procedures, adding a significant cost to the industry in terms of incoming inspection and testing, without delivering a benefit. Of course, you could argue that the filtering out of bad components is a benefit, but that's not only what standards should do. What was missing—and how we approached this from the IPC standard perspective—was

to address the actual root issue of counterfeit ingress potential using traceability in two different ways.

Within an organization, such as a manufacturing house, you need an internal control of materials in a trusted environment, which we call internal traceability. For sure, bad actors may exist internally, and they could deliberately misplace something, but if that happens, you have a much bigger problem. Internal traceability must be able to document the provenance of materials in an outgoing product to the specific internal material responsibility. This was covered in the first release of the IPC-1782 traceability standard, such that you could take any component by reference designator within a manufactured product and track its provenance all the way back to the incoming material and associated responsibility—for example, the box and reel in which it came from the supplier. Such traceability implemented within the IIoT-based MES solution gives you absolute proof, which can be used in a court of law—if required—that the specific instance of material came from this package from this supplier.

Johnson: Now, you know what's happening inside your facility, at your location, in the supply chain.

Ford: Exactly. IPC-1782 is the standard for traceability within electronics assembly manufacturing, and there are other sources of traceability that apply to niche areas of component manufacturing, for example, the semiconductor industry. The challenge is that you also need traceability for logistics to link the different elements of manufacturing operations together for material flow, as well as the flow of sub-assemblies between sites. Materials will be shipped outside of the trusted environment. Every container or carrier of materials has a label, which—if using simple barcodes and text—becomes the identification of a target for a potential counterfeit. The next stage of IPC-1782, revision A, then set about additionally to define the rules for external traceability. The question was, "How do you prevent packages from being targeted, and also ensure that associated data remains intact?"

This is how it works. For a start, each container should not be labeled in such a way that anyone unauthorized is able to identify the contents—so-called "anonymous packaging." In fact, it is safer not to have a label on it at all, as any man-made label can be copied or replicated by someone else. 1D and 2D barcodes, and even holographic images, can all be copied. It is better to employ some intrinsic feature of the packaging itself to create a unique identity. There are a number of technologies to do this. There are two great examples of this. One is a company called Alitheon, where they can individually identify seemingly identical objects simply using surface features. After an initial picture is taken, the object can be identified even after they've been in service, used, abused, and even damaged. The other example is a technology called fiber-code, created by a company in Scotland called Septillion, which features randomly embedded UV sensitive fibers within the packaging material, making each instance unique.

Using just a mobile phone and a UV light, each package gives a unique immutable identification. These technologies can both easily be integrated into systems on top of existing logistics operations. The digital side, linked to each physical identifier, is then a record made with data from each key logistics event, for example, the initial statement of content, the evidence of packaging, moving, splitting and combining packages, etc. which all has to be very securely recorded, and assured tamper resistance in the

data through the use of distributed technology, such as blockchain.

Though this may indicate a small additional cost in the supply chain, there are potentially significant cost savings. Take the case of a U.S. military consumer. They are typically facing restrictions related to Defense Federal Acquisition Regulations (DFARs), which effectively means they can only buy directly from an original source, not a distributor. Such restriction is quite costly and also not as effective as they would like it to be. These materials still go onto a van, owned and operated by a third party. And what they don't realize is that the van may not be secure. They're paying a premium for material that can and is being targeted for counterfeiting. Such materials also cannot be resold into the market, as the secondhand nature of them would violate the DFAR rules—hence the smaller lot sizes being ordered—which contributes to the higher pricing.

Though this may indicate a small additional cost in the supply chain, there are potentially significant cost savings.

With IPC-1782A, we set about creating a set of rules for how you should utilize and handle tamper-evident packaging with tamper-evident labeling, along with storing the transactional and other information in an immutable way, using a distributed storage mechanism such as blockchain. Using this method, you can establish the exact chain of provenance for the material that you receive into the factory, and you can know for sure who is responsible for the content of that box.

Putting the internal and external traceability together, a product such as a military drone can be made using this traceability. You can take any individual component, even if it is not uniquely identified—such as a simple ceramic capacitor—and the internal traceability identifies, without doubt, the incoming package of that material. The external traceability takes over to show exactly where and who in the supply chain had responsibility over the package contents.

Since it is known that such responsibility will be tracked, each party will be seriously motivated to ensure that nothing was compromised under their control. Driving responsibility up the supply chain means that it's increasingly difficult to counterfeit components. The effort to identify packages—forensically opening, replacing content, and closing the package without evidence of tampering—the inability to alter logistics records to divert suspicion and the knowledge that the responsible entity will be identified all go together to eliminate the ingress of counterfeit materials in the supply chain.

Distributors could open and process the contents of packages, as they have the assurance of provenance to that point, and take responsibility for the content. Whether they are splitting materials out for distribution, performing test or inspection, and then they create new secure packages. This can include materials that would have been classed as being "gray market," if the provenance showed that the materials had been owned only by a responsible party, who is also now part of the responsibility. Trusted material consumers can now resell unused materials to another customer because the responsibility in the provenance is tracked and preserved. Therefore, the DFAR rules could potentially be altered and, at the same time, enhanced with the use of the secure supply chain, greatly reducing the cost of materials.

There is a strong financial driver behind all of this. The additional cost is a cent on the dollar or less because this technology is already established, including the packaging, unique identification, and tamper-evidence and blockchain solutions. All that is necessary is to follow the simple procedures outlined in the standard. In theory, there is a lot to look forward to as we see the complete elimination of counterfeit.

The semiconductor industry could go one step further again. There is a mechanism

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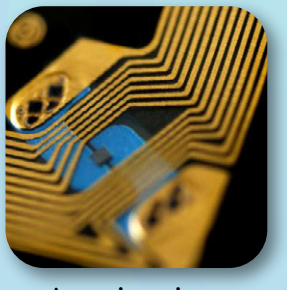

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whereby there is a circuit that, on initial power-up, creates a unique fingerprint identifier within the chip. Enrolling the ID into the secure database ensures that any device that requires absolute authentication of key semiconductors can be done by linking back to the secure database, confirming the chip ID, and making sure that the chip has gone through all of the official procedures of manufacture and distribution. All stages of manufacture through semiconductor and assembly have links into the secure environment.

Johnson: Essentially, you can do an authenticity check on all the activities in the system.

Ford: Exactly. The problem that leaves, of course, is the continued rise in counterfeits, which has been traditionally in the semiconductor side but has moved to passive components, and so there is the need for the secure supply chain for all. One of the biggest issues recently was the counterfeiting of millions of ceramic condensers. A system on an aircraft failed when up in the air. After landing, all the tests on the system passed, but when it went up in the air again, it failed. The immediate thought was of a failure of the key semiconductor, but they were perfect. They eventually discovered that a key signal to the device was routed through a ceramic condenser, in which the dielectric was not of the right specification. It did not have the right properties; it was counterfeit.

There were millions of these counterfeit components all over the world—most of them never to be discovered, we hope! It's very interesting to think of even the lowliest components being a risk to life. We need a solution that supports every material. There could be devices like that right now in driverless cars. The counterfeiter doesn't think about consequences. This is why it is so important for the industry to realize that investment in the secure supply chain is strategic, that we have to be able to trust what we build. Today, almost everything we own or use has an electronic device in it. The industry has choices. We can embrace this reality and make the necessary upfront investment, and then start saving money, as we reduce once again the need for testing, the amount of rework and recalls. It pays off in the long run. Or we can put our head in the sand and wait for an event which will force us to do that, which likely will not be pleasant.

Johnson: As you walked us through the first phases, I was struck by how little database management is required. You're describing a lot of very local inside-the-packaging work. It wasn't until you started talking about the semiconductor actives that a large database to track the individual serial numbers came up in conversation. It doesn't sound like this has to be a massive cloud-based database project to provide supply-chain traceability, at least not for a majority of the parts.

Ford: There are three elements to this. Internal traceability collects a multitude of "big data" from across the operation, usually now through IIoT, following the requirements of

IPC-1782. With our Aegis FactoryLogix software, we do all of that within the four walls of the secure operation. External traceability is not a huge amount of data, as we're talking about event transaction record-keeping, including knowledge and relationship of the hierarchical package and material IDs, package contents, process and asset owners, and details of significant events. It is too much data to put on a blockchain, so much of it will be stored in various secure cloud storage databases.

People talk about blockchain as if it's the savior of everything secure, and it really isn't. Blockchain only prevents alteration to data that has been written already, through the process of duplication of the data across many unconnected systems, which—statistically—cannot be all hacked at the same time. The volume of data is an order of magnitude or greater than the original data itself, bringing massively increased costs, access times, etc. Only a relatively tiny amount of data can practically exist in a blockchain, usually only the "digital fingerprint" ID of the physical object, the electronic fingerprint of the associated data and transaction codes. Writing data to, and reporting data after reading data from the blockchain, can still be compromised with a simple hack of an application. Security remains critical as we use this data going forward.

The quality of the data traceability itself is another key question. Manufacturers often claim that they have traceability from the machine vendors on the shop floor, which is usually correct, but then you find compatibility issues and "gaps" in the data. There's also box build assembly traceability, which, again, is not likely to be compatible. Companies collectively have been spending millions—if not billions—of dollars in an attempt to get internal traceability to the levels needed for regulatory compliance, but few have put everything together under a single IIoT-based platform solution that standardizes traceability data following IPC-1782 and is effective from end to end in manufacturing, covering all automated and manual operations. We see major companies—especially in automotive—that have established their own traceability rules. If you're an EMS company and have 10 different customers, then you have 10 traceability specifications; thus, you have 10 different ways of operation and 10 more opportunities to forget to do something, as well as zero chance of doing it efficiently.

Johnson: This starts to sound like the early days of Industry 4.0.

Ford: Precisely. Lucky for us, the data that's collected for traceability has a broad overlap with that used for Industry 4.0. Whether talking about traceability, dashboards, reporting, analytics, AI, Lean materials, active quality management, etc., the secret in the software world is that it is all the same data. This is why it is important to have a single IIoT-based platform for MES, as you can get multiple values from one set of data, as opposed to many sets of cost for a contradictory result. This was where the IPC's Connected Factory Exchange (CFX) is so important for the industry, as it defines the exact information that is needed, which includes the requirements for exact internal traceability. Implementation of Industry 4.0 values pretty much enables traceability without the additional cost of ownership. This is the original messaging that we've been putting out with traceability.

Johnson: That makes sense because contract manufacturers have so many components running. Traceability helps make a point for the bare board fabricators as well. They need to provide traceability for their boards as a part of the supply chain. That's critical.

Ford: Traceability within PCB assembly must treat PCB fabrication as a key component—more of a sub-assembly—as the fabrication process is quite complex, and can introduce significant variation in terms of yield within assembly. I've seen real use cases where a company has made a thousand products, and one of them became defective in the market. What was the difference? They made it on the same production line with the same materials

at the same time, but there were micro-variances in processes and key materials. And if there was a big variance, it would have been caught as a defect in the factory. But a combination of several influences put together can create a critical weakness, such as a joint failing after a certain time.

With traceability, you can pinpoint exactly the unique circumstances that contributed to the failure, and then with software, monitor and ensure that the same condition is avoided, including poka-yoke machine control where we can command a machine to stop because what it is doing is likely to create a defect. And that's the way to use traceability as a closed-loop system, in a positive way such that you can learn from even the most complex and rare defects.

Johnson: I'm reminded of the nursery rhyme, "For want of a nail, a horseshoe was lost," which is essentially a supply-chain story.

Ford: We all depend on our suppliers, and we are all links in the chain. We need to trust that what we're getting is what we think it is. We see the loop closing now, where the product goes out into the market, where maintenance and repair work is done in association with the original manufacturing data, such that we have feedback about product reliability and performance back to design such that comparison can be made against expectation.

Johnson: In a previous job, I wrote software for integrated circuit design. Back annotation information, even 20 years ago, was the weakest link. How can you determine how rev B performed in the field so that you know what to change on rev C?

Ford: As a designer, you think, "I did everything possible. I did all my design rule checks, and everything was perfect." And then you have the product made most likely in a distant place where they use an alternative material that you didn't take into account. You should run all the DFM again, but it's too late from the design perspective since the board is already produced, you have to live with it. Until now, there hasn't been a mechanism to say, "For rev C, let's learn from what we did for revs A and B and look at the performance, the production compromises, the material variances, and the equipment capabilities that we know is going to be used to make this product, and let's use the feedback to influence design improvement." This logic can boil down to a design feature, as opposed to a product, such that you can have the same benefit when making new designs.

Johnson: Is there a responsibility on the part of an individual company to do their part within their small loop in the cycle? Can we talk a little bit about what the benefits are, and why those individual players should get involved in providing more information for traceability?

Ford: From the traceability aspect, it is important that everyone works together. Internal traceability benefits manufacturing in terms of quality. Externally, each entity in the chain will benefit from having incorrect responsibilities perceived, and also increased business opportunity in that the gray market becomes secure, and DFAR processes opened up. The way of working together, however, has to be defined in that data from all of the different parties must be made somehow compatible. In this way, a greater benefit from the whole can be enjoyed.

Within IPC, another standard that has taken shape recently is the IPC-2551 digital twin. The approach that has been taken is quite unlike solutions for digital twin that have been appearing recently in the market. We have created a framework—an architecture—that defines the interoperability of how information from all aspects of the overall manufactured product lifecycle should flow. As with traceability, there needs to be a benefit for each part involved for it to be sustainable. Nobody wants to have to do something for somebody else's benefit without getting a benefit themselves. You may be a contract manufacturer that needs to get a quote done very quickly. You may be designing a manufacturing line, and you need to understand the capability, throughput, risk,

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and speed. You might be in purchasing, wanting to understand whether it is okay to substitute this material for that because there's a shortage, or need for a dual supplier.

Instead of existing islands working in isolation, we want them to do what they're doing today, but within a framework in which the different parties share information. A company doing a simulation of a production line or robot cell using a production-orientated digital twin would find it easier if there were a standard form of digital twin related to the product. Even easier if there was a standard form in which to represent the digital twin of each piece of equipment that's being used. Instead of having to spend millions of dollars to create bespoke digital twins related to any particular application, why not use standards-based digital twins that have been created as part of other processes?

There is practical information that helps people to understand the context in which they are working.

Each of these individual contributors within a structure is able to exchange and share information with others creating interoperability of digital twins created for different purposes. This interoperability concept was already proven with IPC-CFX. Originally, machine data was a default kept private to the vendor, available to customers and others at a significant cost. Every machine vendor who now supports CFX sends their data outside and has access to the data from every other machine, line and factory operation so that they can see the line condition, the schedule, and the materials, providing them with the opportunity to optimize their own machines in real-time as production is happening.

This is the same as the way in which the IPC digital twin works, all the way from initial material design, product design, manufacturing layout, and execution, including traceability within manufacturing, extending out all the way into the market, including rework, recycling, etc. We've created the infrastructure, such that existing proprietary solutions need not change dramatically to be able to take advantage of digital twins from other parties. There is practical information that helps people to understand the context in which they are working. For everybody who's taking part, they have an extra benefit, and that's the ultimate principle.

Johnson: As this rolls together—and one can follow a particular active component through manufacturing, packaging, distribution, and application, all the way through the process—you'll also be able to see the critical manufacturing data that went along with the machines and the steps all the way into the finished product that goes onto the shelf for sale.

Ford: Correct. The challenge is how to contextualize the data for each particular use case.

Johnson: How do you put that into a usable form?

Ford: Many detailed elements within the IPC digital twin are to be defined; however, for the product side, it's already defined, by utilizing existing IPC standards, such as IPC-2581 design format. You can break the design elements down into individual features against which, for example, aspects of production or usage performance can be measured.

Barry Matties: This becomes more along the lines of predictive engineering.

Ford: You could say that, yes, it is actually all about prediction, engineering, materials, quality, throughput, capabilities, market returns cost, and everything that the business and engineering planners need to know.

Matties: With that knowledge of the digital twin, and what you're describing, what impact does this have on inventory management?

Ford: The whole process of the gathering of traceability data accounts for material usage and spoilage, essential for the creation of the "pull" signal that enables Lean materials, which, when used correctly, significantly reduces the cost of inventory. You are able to account for every individual piece of material, so there are no unexpected "internal" material shortages, and you avoid the need for bloated material stocks.

These days, with Industry 4.0, we're changing models and products more often, doing smaller quantities. The inaccuracy of material inventory becomes a far higher risk. Being in control of what is to be made has a direct dependency on what materials are available physically. Any errors that accumulate through spoilage and attrition threaten the ability to complete what needs to done.

Matties: And all that information is right at your fingertips.

Ford: With COVID-19, many manufacturers do not want to be dependent on long-distance supply chains. We want to have supply chains that are more local. But how do we make those local supply chains make money? The only way is to get rid of the investment in stock. This trend has been going on in manufacturing for 20–30 years. Having accurate and timely information available means that the just-in-time regime can be extended outside the factory to local suppliers or distributors. Working locally in such a way, there is a significant increase in the number of turns of material, as well as a decrease of stock in the distribution chain. Direct shipping to the customer becomes quite practical. Orders will be satisfied very quickly and very flexibly, such that we have almost zero stock in the supply chain.

We need to create whole new supply-chain networks locally within the U.S., as well as within Europe, such that we can make the products we want without the burden of excess material stock. Taking out these costs, we have investment potential for more production automation, including people using Augmented Reality technology, and we achieve the winning business case for manufacturing locally.

Matties: What you're talking about requires a lot of visibility and sharing up and down the supply chain. A lot of people still think there are all these secrets in manufacturing, and what you're talking about in terms of even sharing the information about the geometry of one component being vertical or horizontal, you have to be careful not to give away any detail. You're just talking about characteristics, but the same would apply to the supply chain as well.

Ford: It would. We started talking about the secure supply chain, where we have anonymous packaging, with just an immutable ID to identity materials. Information about materials, demand, supply, etc., is all held digitally and securely. We can then control the information on a "need to know basis." Sanitized information can then be shared further and wider without risk of exposure of intent or IP. The order of a set of materials does not indicate what we will be making, especially where only the computers know the big picture; each entity only sees that which it needs to see.

Matties: The security side is one point, but it's the digital interface between the supplier and customer that has to be established as well, or at least the communication methodology. That might be a struggle in itself.

Ford: We have defined the processes that we need to go through and what communication we need at each of those processes. The challenge is that everybody has their own solutions right now, which we don't want to replace or reinvent. When we wanted to do machine communication, we didn't replace the machine or software. Instead, we simply added the CFX component that enabled the machine to communicate in a certain way. We simply extended this same principle.

Matties: Michael, thanks for all of your insights today. It's greatly appreciated.

Ford: Thank you. Nice to speak to you. **SMT007**

Automating Inventory Control

ISM3900 UltraFlex
(behind ISM3600 silhouette)

Feature Interview by the I-Connect007 Editorial Team

JUKI's Bill Astle and Bob Black discuss inventory storage and management, and the important role it plays in SMT manufacturing. They also detail JUKI's newest storage offering, stemming from the company's partnership with Essegi Automation.

Barry Matties: First of all, the equipment we're talking about is inventory control. Can you please give us a quick overview of that system and its capabilities?

Bill Astle: Our bread and butter is our ISM UltraFlex 3600 storage cabinet, which has the capability to automate picking complete kits, 27 cases at a time. Or if you have two reels in there, that doubles the output. The system is under full humidity control which gives the added benefit of not having them in desiccant bags when you put them back in. Also, when they go to the floor, they're fully tracked. The MSD software is built-in.

Primarily in these units, the users see a tremendous increase in the pick-and-place line's productivity. How that happens is in the setup time. It has been reduced drastically by pulling complete kits and having them ready to go for the setup crew or the pit crew. In addition, if there is replenishment needed in one of the machines, that can happen automatically through the software. It's line utilization, pick-and-place setup time, operator time set up, and space savings because we can fit 3,600 8-millimeter reels in a fairly small floor footprint.

Matties: Certainly, you have done the financial analysis and ROI. What case are you making in terms of the economics behind this piece of equipment?

Bob Black: We have two major classes of customers: EMS companies, both large and small. For example, there are several areas of savings. The first area is labor costs. If you go to an average customer and ask them how long it takes them to pull a 100-piece kit, they'll probably

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say around 100 minutes, a minute apart. It involves somebody going into the warehouse stacks, finding the appropriate reel, adding it to a cart, and moving on to the next one. A company with fantastic efficiency could do one in 40 seconds. A company that is not so efficient can be upward of 1.5–2 minutes apart.


Bob Black

If you have a group of 2–3 towers, you'll pull that 100-part kit in about 20 minutes. If you have 4–5 towers, you'll pull it in less than 10, and no operator has to be present while the machines are pulling the kits. It's one of the big advantages Essegi Automation has in the tower construction, and one of their first patents was pull stacks. They pull a stack of cases, full of reels, without an operator needing to be present. When they're finished, the operator just opens the door of each unit, takes the stack out, and takes them to the feeder setup area.

If I'm pulling a 100-part kit, operator time would probably be around 40 seconds to go to the towers, open the doors, take the stack out, and move on to the next one. You've saved them from 100 minutes down to less than a minute, and that's considerable savings; it's the same for putting kits away. On production floors, you usually see a few bin boxes full of reels, waiting to be put back into inventory. Usually, there's somebody running around, going through those boxes and looking for a reel that's needed for another job but hasn't been returned to stock yet. All of that is eliminated with storage towers.

You simply put the stack of reels back into the tower, push a button, and the machine puts the parts away. The biggest savings is in labor costs. Other savings include the floor space savings, especially if a company is feeling crowded in tight quarters. We save about 70% of floor space versus a six-high, double-sided shelf. One company is pulling a lot of kits per day because they're doing prototype and short runs mostly based on their design business. Adding the towers enabled them to pull and put away several more kits per day. It increased the number of SKUs they could run on their five wides.

As Bill mentioned earlier, one of the things big EMS companies saw was they justified it on labor costs. Since this location was in Mexico, they looked at about a 1.7-year ROI just based on labor cost savings in pulling the kits and putting them away. But one of the features of the machines and software is that they have Fuji lines. Fuji, like many other placement companies, can give a low reel warning if a reel is about to run out. The reel warning is given automatically to the tower. The tower interrupts what it's doing, pulls that reel in a separate drawer, sounds an alarm, and the operator says, "This is urgently needed on line two, machine five, feeder 20." The reel can be there and be replenished before the previous reel runs out.

In this example, company management were shocked at the end of the first quarter of production to find that their line efficiency had improved by 8.5%, and on the 250,000 CPH line, 8.5% is a lot of placements. Also, the ROI went down from about 1.7 years down to about 7.5 months because you have all those lines that are expensive. If it's been idle waiting for somebody to go over to the warehouse, get another part, and bring it back, that's not efficient. They weren't even aware that that was that big of a problem until this happened. Naturally, they've now added towers to every line in that factory in Guadalajara. That's another area where you can save.

Matties: That's a great example of how the smart factory or digital factory can benefit an assembler or EMS company. What about inventory management? Because it seems to me that, with a system like this, you can now preserve some cash flow by better control of inventory with this system.

Astle: There is a video of a company in Japan that runs JUKI lines for SMT, but then they invested in eight towers. They are experiencing almost a 30% reduction in inventory costs because of the efficiencies of knowing where the parts are, where they are on the floor at all times, and the quantity. Another ROI is the ability to lower your inventory goods. Additionally, there are human mistakes. The part numbers nowadays are 30 characters long, and it's challenging for a human to pull that, get it correct, go back and forth, and make sure it's exactly the right part. It happens once a week that a human will pull the wrong part. The towers are fully barcode-capable and read barcodes in and out. They don't make those types of mistakes. That's not something that we put in the ROI, but the towers eliminate those type of mistakes.

Black: We're doing a project you might be interested in with an OEM customer that wanted to reduce the amount of inventory they were carrying themselves. They made agreements with three of the big components houses. We're doing software for them that when a reel goes out of the tower to the line, since they're producing high volumes of the same products, the reel doesn't come back, so it's used until it's empty. But it reports that by email directly to the vendor, who then supplies that part with a copy to purchasing. At the end of the day, that vendor puts all those in a box. They keep a reserve stock for the customer and FedEx them overnight.

The receiving department takes them, puts them in the cases, and stacks them in the tower. The tower does the receiving and notifies purchasing and accounting that the part has been received. This company was able to reduce its overall inventory from $10 million to $4.5 million without losing efficiency. Industry 4.0 is a buzzword that everybody talks about, but there are some very interesting things you can do with it that result in financial benefits.

Matties: You are selling an inventory management system, not just a piece of equipment.

Black: Exactly.

Matties: Where's the tipping point for getting somebody to look at a system like this, or is it universal, and all companies should look at this?

Black: Eventually, all companies will look at it because one thing screwing the U.S., especially in states like California and Washington, is that wages are going up, particularly minimum-wage or lower-wage hourly workers. A lot of states are setting the benchmark at $15 an hour, which means once you add loaded social costs, it's probably $22–24 an hour, depending on the state. As those increase, companies are going to look for more ways to save on labor. One big driver of automating inventory management is the cost savings on labor.

I have a few white papers on different subjects, including ones about integrating the storage towers into the company's ERP and MES system. We see companies saying, "This was a novelty 4–5 years ago. Why do I need that?" But today, it's an established product, and people are seriously looking at it, both from the EMS side and the OEM side.

Dan Feinberg: In those lines, what is the average time to get payback on the investment in your system or a similar system?

ISM3600 UltraFlex Intelligent Storage System.

Black: It's about one year. If you're efficient, it can be 8–9 months. If it's less of an impact, it can be 1.5 years.

Feinberg: At this point, what percentage of the industry do you think is using your inventory system or a similar inventory system?


Bill Astle

Astle: It's still in the early growth period. I would say 10–15% with all of the competitors and towers being installed. This was invented by Essegi, which is a small contract house as well. The necessity is the mother of all invention; their customers said, "Where did you get that?" They responded, "We made it." Their customers would want one because it fits in small contract houses and the motherships like Sanmina and Flextronics.

Black: Essegi Automation spun off the automation division into a separate company, and JUKI Corporation invested and bought 49%. The original shareholders of Essegi owned 51%, and JUKI Corporation in Japan probably owns 49%. JUKI saw this as an important area, and that's when they invested money in it.

Feinberg: I think you are in a great position.

Matties: You're making a strong case that the smallest of EMS companies with limited resources can become much more efficient with this system. Their labor force could keep the lines running consistently rather than having to stop to pull parts. With such a quick ROI, it seems like this would be a priority purchase for the smallest of EMS companies. Do they see it that way, or do they see it differently?

Black: Some do, but others don't, as always. One company has only 20 employees, but they have three towers, which they bought very early. One of the things that has made us successful is we decided at the beginning that instead of just selling this tower to JUKI customers, we would integrate it into anybody's placement machine. Well over 60% are at the customers of other people's placement machines. We've made an effort to integrate our software so that we can talk to any placement machine and give the same productivity. That has been a big factor in our success as well.

Matties: That's an important strategy to be part of the 4.0 or digital factory solution because if you isolate to oppose the environment, you close off a lot of the market. Smart move.

Nolan Johnson: It would seem like this inventory management application would be a rather obvious first step into factory automation for manufacturing.

Black: Yes, we've enhanced that in the last year. We've added the product we call IMS or incoming materials station, and it's basically a table with a big glass window in the middle and a 13-megapixel camera looking up with a lighting system. When you receive the parts from the vendor, you put it barcode-side down on the window, and it confirms all of the data; it also prints out a unique ID label, communicates to the ERP system that the part has been received and is the correct part, and prepares it to go into inventory. That can be used whether you have towers or whether you're still just stocking in a warehouse on shelves. It speeds up receiving considerably and prevents errors of reading the wrong barcode. We probably all see reels with 3–4 different barcode labels, depending on how many hands it's been through, from the manufacturer to distributors to the costumer.

When you read barcodes by hand with a scanner, which one do you read? Being able to use this camera, read all the barcodes, extract the data, formulate them to a standard format, and then print out a unique ID label for that particular reel can be made in about five seconds. We sell a lot of those stations, even to people who

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– Felix Valenzuela, Director of Engineering, Molex

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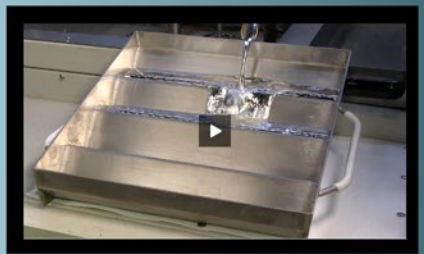

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have not yet done towers, to improve the efficiency of their receiving process.

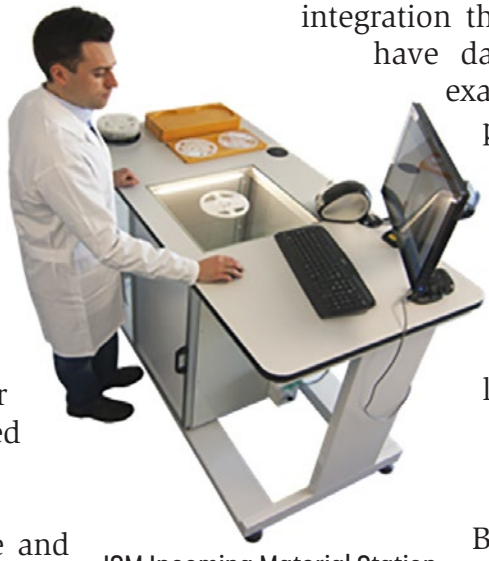
Matties: With the tower, there's another benefit, which is the integrity of the component as it lives through storage and moves into the assembly line. Do you find that there's less handling, which is another advantage?

Astle: The cases protect the components, but early on, if smaller CMs had a mix of consignment and turnkey parts—meaning the consignment was from their customer—they tended to just leave them in a box by the line. But when their customer found out they had a storage cabinet under lock and key, they said, "We want our parts in that storage as well—not just your turnkey parts, but our consigned parts." It's also a security thing, especially for consigned parts from companies; they don't want other people seeing or taking parts.

Matties: This would give them real-time access to their inventory and be able to see what's there and what's being moved because I'm assuming that there would be some remote access into the cabinet as well.

Astle: Correct, and they have segregation software now, too.

Black: If you have one tower, but you have a couple of customers who want their parts only used on their jobs, the segregation software reserves that part only for that user's jobs. If somebody tries to pull that reel for somebody else's job, that machine won't do it. It will reject it and send an error message, saying, "This part is reserved for this customer only. That hasn't been added just in the last year."



ISM Incoming Material Station.

Astle: Essegi is very flexible and quick on innovating and developing. I enjoyed working with them over the past few years.

Matties: What's been the shift in attitude toward the digital factory? Do you see more and more requirements or requests around that?

Black: Yes. People are not sure what form it's going to take or how deep they're going to plunge in, especially the smaller companies. But now everybody wants to make sure that their machines and systems communicate with each other, and they're open to any improvements that can be done in the future. That is becoming more and more prevalent. You can see it in advertising in all forms. You rarely see an ad that doesn't say "Industry 4.0 ready" or "Industry 4.0 compliant."

Matties: There's a lot of talk about the benefits of 4.0, but I'm not sure that there's a clear path forward for talent, skill set or experts to be in these factories to implement them. They rely more on you, the suppliers, for advice and guidance. Do you see that as the case as well?

Black: A lot of the sales process with the automated storage towers centers on education. A lot of customers are not aware of all the possibilities and what it can do. When you sit down with a customer and start to go through things, many are surprised at what type of integration they can have and how they can have data at their fingertips. A good example is inventory counts. Most placement machines have the ability to count down as they use the parts on a reel. At the end of a run, if a reel is pulled off the machine and returned to the tower, we can ask the machine to ask the placement line, "How many did you use?" It will give us two numbers: the number of parts placed, and the number of parts mispicked. By adding those two together, the customer can even enter a contin-

gency factor. How many parts do you lose on average when you strip back the cover tape to load a feeder when the reel is new? It could be 7–10. It will add those three together and subtract it from a former total, then update the total of the inventory as the part comes back into stock. It's practical.

The newest thing that's hot in the market is these X-ray component counters. We've already integrated software-wise with the four biggest manufacturers, where if it's a free-standing unit—any reel or tray that's counted in the counter—we can query when the part comes back into the tower. We can ask the counting unit, "How many does this reel have?" and update the inventory that way. We just showed it at productronica. We integrated one of the units physically to the machine so that we can deliver parts still in the case, into the counter, have them counted, and pull them back into the tower. This gives you the ability to do automated cycle counting. While the tower isn't in use at night, you can say, "Please count these 300 parts tonight." When you come back in the morning, you'll have the result.

Johnson: All of this technology gets close to providing some sort of incoming inventory counterfeit detection. Is that on the roadmap?

Astle: We're looking at it internally. The imaging group is a $10 billion problem, and 10% of the reels have fake components in them. I was shocked when I found that out. It can be done with optical character recognition when they unsolder the boards and don't know what the date and lock code are, so they mark the top with a logo that's not original and/or some date and lock code that doesn't match up with the actual vendor's part. You can catch it that way or through X-ray. It's a huge problem.

Johnson: I heard an example not so long ago about a reel that came through with counterfeit parts in which the first 100 on the reel were legitimate, and then after that, every seventh one was counterfeit.

ISM500 Intelligent Storage System.

Astle: Right. That's what they do.

Black: They're sneaky.

Matties: It's big business.

Astle: It's unbelievable, especially with the ICs. We are looking at expanding the capability of the storage tower, and we installed one in Hong Kong that stores diamonds. Each individual pocket in the tray has its own barcode. We're looking at maybe collaborating with a large company, like an auto parts store. Toyota has a big storage solution, as well. Now that JUKI invested 49%, it's looking at other industries for the towers. It is a good fit for anything that's small and valuable, especially with the trays.

Black: We did a special software for a large defense OEM. They had components that cost $27,000 each. They didn't want these to be just generally accessed. We'd have software that required three supervisors to enter their codes before that part can be withdrawn from the tower.

ISM material incoming station configured with two monitors for picking list and delivery note checking. (Source: storagesolutions.it)

Matties: That's a lot of security protocol capability. When it comes to the towers, what's a typical installation? What do people have to prepare for? How did their systems change?

Astle: The number one thing is that the unique identifier needs to be on the reel, and some companies don't have that. They must prepare for the fact that each reel needs to have its own license plate so that we can track it on the machines and back into the towers. A typical setup is a couple of weeks. They also need to prepare their materials to have unique IDs on all of the reels. Then, it's a job to analyze the process flow and understand exactly how many reels of which sizes they have and the appropriate proposal to put in front of the customer in terms of towers.

That's where it's an education for the customer, and it's a learning curve for the salesperson to propose the right set of software, hardware, whether it's a combination of automated or semi-automated cabinets, and what software they want to use. Do they want to talk to the MES? Do they want to talk to the mounter? All of this is like a project, to go over a full list and identify the customer's aim and goal.

Black: The unique ID requirement is something that's very important and necessary if you're going to do Industry 4.0. We've made that easier for the customer with their incoming material station. If their ERP system doesn't use unique IDs, we will generate a unique ID and tell the ERP it now exists. We'll generate a label for the reel and also link it to the part number in that. This makes it easier for the customer to move to a unique ID situation without having to do a lot of work themselves if they don't use unique IDs now.

Matties: Is there any special employee training that goes on, or is this a graphic user interface that's pretty self-intuitive?

Black: We usually tell people to give us any good, conscientious employee that pays attention to details, and we'll make them an excellent operator.

Holden: Does this system have CFX plug and play?

Black: Yes, it does. Essegi, being European, started on the Hermes track, which has now merged with CFX.

Matties: Bob and Bill, thank you both. As Nolan's pointed out, this is a great starting point for anybody who's serious about a digital factory.

Astle: Absolutely.

Black: Thank you. SMT007

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Electronics Industry News and Market Highlights

Qualcomm and Infinite Collaborate to Facilitate Powerful Digital Transformation in Smart Cities ▶

Qualcomm Technologies Inc. and Infinite Computer Solutions, a global technology company and provider of products and platforms for digital transformation, announced a strategic collaboration to promote the widespread adoption of smart cities solutions and deliver internet of things as a service (IoTaaS) for plug-and-play deployment.

NVIDIA Provides More Tools for Working Remotely ▶

For many organizations, the coronavirus pandemic has created a permanent shift in how their employees work. From now on, they'll have the option to collaborate at home or in the office.

RSL10 Mesh Platform Enables Smart Building and Industrial IoT Bluetooth Low-Energy Mesh Applications ▶

ON Semiconductor, driving energy efficient innovations, introduced a new Bluetooth® low-energy mesh networking solution based on its ultra-low-power RSL10 system-in-package (RSL10 SIP). Using the RSL10 mesh platform, engineers can easily implement ultra-low-power mesh networking, using Bluetooth low-energy technology, and move quickly toward full deployment.

China Everbright Limited, Terminus Technologies Launch a 10-Billion AI Economy Fund ▶

China Everbright Limited and Terminus Technologies recently announced the joint launch of "CEL AI Economy Fund," aiming to raise RMB 10 billion and operate in both Renminbi and U.S. dollars.

Quanergy Secures First AI-Powered 3D LiDAR Integration With Security Center Platform ▶

Quanergy Systems Inc., a provider of light detection and ranging (LiDAR) sensors and smart perception solutions, announced the first commercial integration of 3D AI-powered LiDAR solutions with the Genetec Inc. Security Center unified security platform. The integrated solutions will provide advanced people flow and occupancy management in smart spaces as well as enhanced threat detection and surveillance in high-security environments.

Apple Reimagines the iPhone Experience With iOS 14 ▶

Apple® previewed iOS 14, introducing the biggest update ever to Home Screen pages with beautifully redesigned widgets and the App Library, a new way to tap into the App Store® with App Clips, powerful updates to Messages, and more.

Former Dyson CEO and COO Jim Rowan to Appear on MADE IN ▶

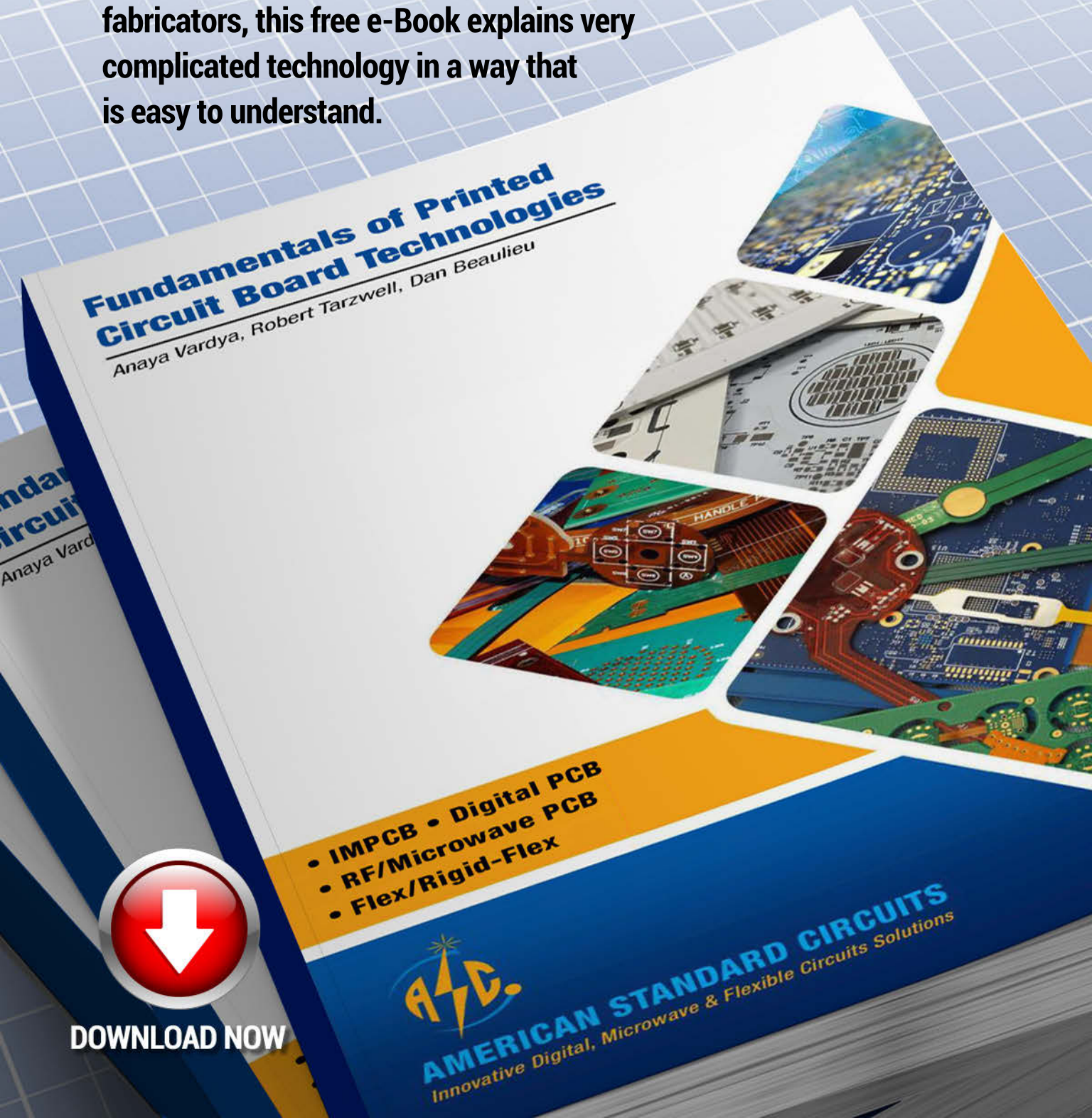
Following stellar guests including Jabil CEO Mark Mondello and former Flex CEO Mike McNamara, the team at MADE IN have announced that Jim Rowan, Dyson's former CEO and COO, will be their guest in their next show, set to broadcast on July 2 at 2:00 p.m. (Pacific).

MixComm Names James Martin Vice President of Business Development ▶

MixComm announced the appointment of James "Jay" Martin as vice president of business development. Martin will drive growth in 5G and related markets for the millimeter-wave startup.

Everyone in the industry should get their hands on this book.

A "must-have" for PCB designers, OEMs and fabricators, this free e-Book explains very complicated technology in a way that is easy to understand.



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Foad Ghalili

An EMS Perspective on Inventory Management

Feature Interview by the I-Connect007 Editorial Team

Foad Ghalili of Epoch International discusses the inventory management practices the company has in place between its two facilities in Fremont, California, and Dalian, China; and how upgrading to an electronic management system made maintaining a much larger inventory possible.

Barry Matties: We're looking at inventory management on the EMS side. Foad, please share with us how Epoch manages inventory. It must be interesting because you have multiple locations. Is it computerized, manual, or a combination?

Foad Ghalili: Sure. Let me give you just the overall view of what we do. We use the Oracle E-Business Suite, which we purchased in 2008. All our ERP and MRP systems are done through that, and we generate a unique ID code for every item that we purchase everywhere, both in Fremont and in China. Every item comes with a barcode, which is identified there. And many of our material suppliers are also putting our barcodes on their label as it comes through. The system catches the barcodes as it comes through; then, it goes through the IQC system, and we transfer the material to our cabinet through our barcode system.

The cabinet is linked to our ERP system and controls everything that comes in and out of the cabinets. By the way, we have developed the interface modules in-house for the barcode system and all the software for the cabinet. We have done a lot of in-house software development to feed into the Oracle ERP system. Our feeders are also linked to the Oracle system. We know which component is fed where, so we have a fully integrated system.

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In Fremont, we also have a cabinet. Of course, it's not as sophisticated as what we have in China, but the two inventories are transparent to both facilities. We can look into their system, and they're able to look at ours. Fremont is not on an Oracle system yet. We plan to move it into Oracle by the end of this year. We're moving rapidly. We were having the team come here and set up, and then we got clogged up with COVID-19. In the future, both facilities will have visibility to each other's operation.

Matties: With the barcode system, are you counting every component individually, or are you counting them in bulk?

Ghalili: It depends. Each fab will have a different barcode. But components will have a barcode per lot, and all of them are entered into the system with the quantity at the time of receiving. The fab's unique barcodes, traced from screen printing on, are linked to all the barcodes of the components that the fab uses. All reels are barcoded, linking it to a different purchased lot. The idea is for us to be able to trace it back to purchasing and manufacturer lot items. We also have linked it to our manufacturing worker order lot number.

The fab's unique barcodes, traced from a screen printing on, are linked to all the barcodes of the components that the fab uses.

Matties: When you take a job, and it comes in, you have to kit it up and get it ready for assembly. How do you manage that?

Ghalili: The BOM is fed into the cabinets. The person puts in the work order, and it feeds into the cabinet. The cabinet automatically shows which item needs to be picked up. A person picks it up, reads the barcode, reads the barcode on the feeder, and then drops it into that feeder.

Matties: It gives you an exact count of inventory that's being utilized, as well as inventory that remains in stock.

Ghalili: Exactly. When it goes back, the remaining components are counted, and then fed back into the cabinets. Say they took a reel for 5,000 capacitors—it goes through the process, and it comes out with 1,000–2,000 used. They recount what is left on the reel, and then feed it back into the cabinet.

Matties: And when you say recount, do the computers recount it?

Ghalili: We have two lines running. One line has a software system we just bought from Europlacer. It tells us how many components have been used, and therefore, how much is left on the reel. For ICs and expensive parts, we may do a manual check as well. But for passives, we use the number from the system.

Matties: You have been in business for several years, and your inventory management has most likely evolved over time to become more and more efficient. What would you say the result of good inventory management has been regarding quality, cash flow, etc.?

Ghalili: We started manual in China; they used books that they were physically writing into it. We didn't even have an Excel spreadsheet at one point. It started with little accounting books, and then we moved to Excel sheets and then a very small software that we bought out of the U.K. to keep inventory.

In 2008, we moved into Oracle and had a long implementation process. When we purchased Oracle, it took us three years before we were able to implement the system and make it work. We initially had a large company that did the implementation. It didn't work out, and then we hired a single consul-

Epoch International's inventory storage and management equipment saves both labor and inventory cost.

tant, which did not work out either. Finally, we hired our own people who understood Oracle, and now we have a team of four people running our Oracle system. They're the ones who upgrade and run the Oracle system. It was a huge task, but it has paid off. Today, if the ERP system is shut down, our factories shut down entirely.

Matties: When you say it has paid off, going from the manual to this new system, you recouped a lot of human hours.

Ghalili: Yes. The reality is also we would not be able to manually run what we are running today. We have close to 4,500 different components. Because we are mid-volume, large mix, and quick turn, there is no way that a human being could sit and manage all of that. It was more a function of survival that we had to go to an electronic system, not so much a function of cost. Without that, we were not able to do it.

Matties: That being said, there was a financial result in cash flow because now your inventory is much more balanced to what the forecast of workload is.

Ghalili: The inventory is much more balanced. It's challenging with customers who have high expectations with almost zero forecasts. We deal with customers who give us a 4-week lead time, while some of the raw materials are 8–12 weeks. There's a lot of playing around and juggling the ball, as they say. How much do we buy at risk? Inventory is a major challenge because of not having a clear forecast. But if we did not have an electronic system, I don't think we could survive or maintain an inventory. Right now, we're running about $2.5 million in inventory. If I had to run this order manually, we would have to maintain about $10 million in inventory just to be able to feed exactly what we're doing today. It's a major differential.

Matties: In your inventory management, with a very short window of visibility, how critical or how engaged are your component suppliers in your system?

Ghalili: With critical component suppliers, we are very engaged because we do a lot of forecasts, and we constantly work with them. The way we operate on that is our sales order manager forms a team. The team sits together, makes forecasts and demands, and puts that into the ERP system. Once that happens, based on the MRP, purchasing works with the suppliers to pull or push the material shipment. There's a lot of discussion that goes back and forth between the buyers and the suppliers daily.

There's a lot of discussion that goes back and forth between the buyers and the suppliers daily.

Matties: I would think that your team must be in almost constant communication with your suppliers.

Ghalili: Yes.

Matties: What other challenges do you find in inventory management?

Ghalili: My major challenge for inventory has always been visibility. Again, we had customers in the previous life that would give us one-year projections, and that was good. Our advantage now is that we're able to attract customers since we are able to manage the complexity of inventory. Our daily challenge is still what it was before: How do we balance customer requirements and our inventory? This is a constant battle. I don't think that has gone away with just making it an electronic system.

Matties: But with the electronic system, you've been able to at least preserve more cash and not have it tied up in inventory.

Ghalili: Definitely. Again, without an electronic system, we would not be able to be in this business. It would be a $10–12-million inventory you have to maintain to just feed these customers. And then the team of people involved—right now, we have 8–10 people in purchasing—we would have to maintain at least 20–25 buyers to go through that system. I don't know if it would be possible without an electronic system.

Matties: When you look at your jobs being released onto the floor and your daily work schedule, is that done through your computer system, or are you manually loading your shop up with the day's work?

Ghalili: We have a planner who goes into the ERP system and pulls out a dashboard that gives them all the materials that are ready, as well as the customer requirements for that part. That planner also works with the buyers to see when the components are coming in, and they plan and lay the production schedule based on that.

Matties: It's done with a human touch.

Ghalili: Absolutely. It's the same thing with the forecasting. People make projections and forecasts, and then put that forecast or demand into the system. Then, MRP runs it and says what you need to buy and when.

Matties: Do you see a time where you would use a computerized AI system to balance the workload on a daily basis, releasing the jobs in the right order to optimize your capacity?

Ghalili: Yes. I imagine that at one point, we would look at an AI system for job releases. At present, we have an SPI, screen printer, and then AOI. We are trying to integrate those systems so that our inspection system SPI and AOI gives a signal to the printer how to adjust

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its setting. Our first goal is implementing AI in our SMT line first to ensure quality.

Matties: Do you have one inventory control manager that oversees all of that, or is it a collaborative effort?

Ghalili: We have an inventory control manager who oversees our inventory. But in reality, there is a whole team of people: the inventory manager, the sales order processing manager, the program manager, and the purchasing manager all monitor the inventory. They have daily meetings, and collectively, they decide what needs to be purchased at what time. It's a team effort.

We have an inventory control manager who oversees our inventory. But in reality, there is a whole team of people.

Matties: You have to have every component to release a job. You can't let a 50-cent resistor stop your production.

Ghalili: Exactly. To be honest, it does happen once in a while. A resistor can stop a $1-million production.

Matties: It's costly when you make inventory control mistakes.

Nolan Johnson: Do you run into any issues with counterfeit components? How are you able to prevent that from happening in your production through the system you use?

Ghalili: Everything that we buy is through a certified manufacturer and designated distributor. We don't buy anything outside of that. We've been very regimented about that. It's interesting that, for example, right now, we are looking for an ST micro-component. Their facilities in the Philippines, Malaysia, and Mexico were down due to COVID-19, so there is a shortage. We found this one component with an unrecognized distributor and decided not to use it since we could not trust this distributor, even though it impacted production. We can't afford that. We have stayed away from that as much as possible. It's very costly.

Johnson: That puts you in a situation where you have to weigh the trade-offs of being even later with your customer or take the risk of being on time with components that could be sketchy, costing you money and reputation later. That's a difficult trade-off to make.

Ghalili: Right. A few years ago, we had one instance where we asked the supplier to take pictures of the components, and we sent it back to the manufacturer for verification and the lot numbers. Again, having one of the largest companies as our customer, we can't afford that. We have to make sure that those are going to work. It's a challenge in China, but we have been able to avoid it so far. And we communicate with the customers about it: "This is what it is, we don't trust it. What do you think?" And 90% of the time, they say don't do it.

Johnson: Getting your customer involved in reaching a consensus makes sense.

Ghalili: Key components are all identified by the customer as to who the manufacturer is and what components we buy. They're very much involved.

Johnson: What are the advantages to your organization by having this inventory management system in multiple facilities? How does that help you be more responsive or more competitive?

Ghalili: The Fremont operation is a new one. We just started it, and it has built some level of inventory. For example, right now for the orders that we produce, we have a U.S. Satellite Office Support Team in our China office, that looks inside the inventory and sees what

we have here in the U.S. They also look at the inventory in China and see what components they have and whether they're dedicated to any other projects. They can feed this facility here with components. It makes sense for us to have this interconnection going between the two.

Johnson: In some cases, you're doing global intra-company shipment of components?

Ghalili: Correct. We have also designed our own electronic Kanban system. It gets the information out of the SPI and AOI and puts it right up onto the production floor to help quality. And for the MSD, the cabinet has been a huge help because the cabinets are environmentally controlled. And when the product is out of the cabinet and comes back, we know how long it has been outside of the environmental control. That also has helped us resolve some of our other issues. Those are the two areas where we've had problems previously. We continue to have problems, but we are trying to address them by designing internal systems.

Matties: The cabinet is a big help in inventory management, as well as in protecting stock.

Ghalili: Exactly. And again, this is a cabinet that's designed by us. We have patents on it, and, in a way, we're marketing it under our PTC, which is another division that's fully owned by Epoch. But it has been a major asset since we've been working on it, and it has been in development for 6–7 years. We have version four or five right now that we're using in our factory.

Matties: What would you recommend customers do to help their job go through your factory more efficiently?

Ghalili: If they could get us a good forecast, that would be a big help to get us through much faster.

Matties: What advice would you give to another EMS for inventory management?

Ghalili: That also depends on the complexity. With factories like us doing quick turns of small volumes, large mix, I don't know how it can be done anymore without an electronic system unless you work on a very limited number of products. We have a very large number of products that we put out, and the volumes are not necessarily that high. Without an electronic system, I don't think you could manage it.

Without an electronic system, I don't think you could manage it.

Matties: You bring up a good point because my understanding is that some EMS companies make a living off a couple of dozen customers, and they don't have to go beyond that.

Ghalili: Yes. Manual is fine. And they don't have to invest because it is a heavy investment. The software is more than $500,000. Then, you have to implement that, and it will cost $500,000–$1 million just to get it up and running. It's not a small investment for a company.

Matties: What do you expect the timing to be for ROI on that sort of investment?

Ghalili: It takes 5–6 years minimum to get that back.

Johnson: It's not necessarily a competitive advantage, but it's mission-critical for your business.

Ghalili: Exactly.

Matties: This has been very helpful, and I greatly appreciate your time and insights.

Ghalili: Thanks, Barry. It's always a pleasure. **SMT007**

MilAero007 Highlights

IPC: Shawn DuBravac and Chris Mitchell on USMCA ▶

On July 1, 2020, the USMCA trade act (United States-Mexico-Canada Act) phased in as a trade agreement guiding economic trade and growth in North America. Nolan Johnson spoke with both Shawn DuBravac, IPC's chief economist, and Chris Mitchell, IPC's vice president of global government affairs and an I-Connect007 columnist, about the impact of USMCA on North American electronics manufacturing.

Understanding MIL-PRF-31032, Part 1 ▶

Over the course of this series, Anaya Vardya will discuss topics such as MIL-PRF-31032 requirements, the quality plan, responsibilities of the Technical Review Board (TRB), and the testing and reporting requirements for the certified shop into the DLA.

This Month in *Design007 Magazine*: When Working Remotely, Cybersecurity Is a Necessity ▶

When we started planning this issue on working remotely, we knew we'd have to speak with Stephen V. Chavez, chairman of the Printed Circuit Engineering Association (PCEA). We recently asked Steph to discuss some of the security measures that his company employs and what his experience has been like since he began working out of his Arizona home office full-time several months ago.

Defense Speak Interpreted: DMEA ▶

A June 17 article announced a supply chain award of $10.7 billion to eight defense companies for semiconductors. Dennis Fritz explains how the Defense Microelectronics Agency (DMEA) administers this contract and keeps the technology secure.

Cyberattack! Think It Couldn't Happen to You? Think Again! ▶

Eric Cormier and Dave Ryder of Prototron address the ransomware attack that locked them out of their system last December, bringing business to a screeching halt and forcing them into the arduous process of a full rebuild. With things finally starting to normalize, Eric and Dave now offer precautionary advice they've accumulated over the past six months.

Murrietta Circuits Appoints Alliam LLC to Cover Sales in South-Central U.S. ▶

Andrew Murrietta, CEO and co- owner of Murrietta Circuits, announced that his company appointed the sales firm Alliam LLC to handle Murrietta's sales in the South-Central United States.

Northrop Grumman Awards Contracts to Kitron ▶

Northrop Grumman Corporation has awarded Kitron a contract for the production of Integrated Communications, Navigation, and Identification (ICNI) modules for the F-35 Lightning II program. Deliveries will secure a backlog into 2021 and have a total value of more than USD 18 million.

NEOTech Partners with Numerica Corporation for the Air Defense Market ▶

NEOTech—a provider of manufacturing technology and supply chain solutions for brand-name OEMs in the industrial, medical, and mil/aero markets—is thrilled to announce a new partnership with Numerica Corporation—a company that continues building on two decades of experience developing and deploying sophisticated algorithms and software for some of the nation's most critical air and missile defense programs.

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Trust in Time

Smart Factory Insights

Feature Column by Michael Ford, AEGIS SOFTWARE

We've all heard of "just in time" as applied to the supply chain, but with ongoing disruption due to COVID-19, increasing risk motivates us to return to the bad habit of hoarding excess inventory. Based on the public's initial response to COVID-19—namely hoarding toilet paper—we can only imagine what is filling our manufacturing warehouses right now. Such practices usually just make matters worse. Knowing is everything, yet what we see in ERP in terms of material quantities cannot be trusted. If you fundamentally cannot trust that you have all materials available when you need them, manufacturing will fail. This is happening right now.

Trust in Time

This is simply the knowledge that you physically have, or will have, all of the required materials available to complete an intended production job at the planned time. Don't bother Googling this phrase; you are hearing it here for the first time. Trust, in this case, is based on knowledge and control. Knowledge includes information about exactly what materials are on site, in what quantities, the supply forms, locations, as well as full accountability of actual consumption, spoilage, and any other dispersion. Control extends through warehouse storage, logistics, as well as the management of part-used materials that are on

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a carrier, such as on a reel, in a box or carton, etc. The difficulty is that during manufacturing, all of these aspects of knowledge and control are fluid, changing several times every second as materials are allocated, moved, and used. Keeping track manually or by ERP has, in the past, proven to be nearly impossible and certainly impractical.

The Stock Check

Symptoms of the lack of trust in material inventory are easily and commonly found. The periodic stock check entails going through the whole factory and warehouses, counting up the quantities of physical materials. This process can take a couple of days, even with a massive focus of manpower. The factory will be stopped for most of this time to enable an un-fluid snapshot to be taken, which costs the operation around 1% in annual lost productivity each time the stock check is performed. The result is usually much more painful, as significant discrepancies between the physical stock, and what ERP has as inventory levels, are revealed and have to be financially written off. In medium-sized electronics manufacturing sites, around $1 million in write-offs of "lost" materials per year, is not unheard of. In terms of cost savings, in this aspect of material management alone there is a great deal of potential justification for a solution that can eliminate these discrepancies.

Where Did It All Go Wrong?

Immediate culprits are easy to identify. In the electronics sector, and in common with other areas of automation, SMT machines throw away materials during their operation that they cannot pick up and recognize in exactly the way they need. The setup of feeders and variations in material dimensions can have quite an effect on the rate of this form of spoilage. A feeder set to the incorrect pitch can create 50% spoilage without anyone noticing until later, when an unexpected internal material shortage happens because materials that ERP identifies as available no longer exist.

Materials are also lost due to repeated handling, especially part-used materials in SMT that need to be put on and taken off from feeders and other carriers. All materials, however, can be lost or damaged whenever they need to be "touched," including becoming contaminated. In addition, materials become too old to use or obsolete after the relayed product's end of life.

The symptom of the need to perform a stock check is the occurrence of unexpected material shortages. Having to stop or delay production is bad, but in many cases, it's not even the worst issue. The immediate response in such cases is the mandate to maintain higher levels of buffer stock, which leads to holding excessive inventory on the balance sheet. ERP will not order materials unless it can see the requirement, so the required buffer levels in the system have to be increased. It is not the fault of ERP that it is mind-numbingly difficult to manually count and update the attrition of every lost part; it just doesn't get done.

ERP also has additional challenges when the consumption of materials is not registered until the product is completed. Materials may be in the factory, many of which are already on a partially assembled product. If the completion of that product is delayed, perhaps due, ironically, to lack of a material, the problem compounds. The knee-jerk reaction, going back decades, is to bloat the stock levels, even though it is expensive, risky, and not good for the bottom line of the business. In the vast majority of manufacturing operations today, we find bloated inventories, with (hopefully) enough materials to carry the operation from one stock check to the next. And then COVID-19 comes along.

What Do We Do Now?

As humans facing COVID-19, we bought toilet paper, bread, and wine. I'm not sure what the connection is between these items, but what food items should we stock up on? For too long, people in manufacturing have been concerned with the supply of critical materials, forgetting that the absence of any part, no matter how insignificant, will mean the product cannot be completed. As humans, we can go without chickpeas or avocados for a couple of weeks, but in manufacturing, the full set


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of ingredients in the recipe for each product is always required.

Unexpected material shortages cause havoc, especially mid-way through a production run. Before any production commitment, availability of materials to complete the order must be checked, though with this being a fluid concept, it is not easy unless cages are set up to surround kits of materials that have been created. ERP, the tool purchased to manage this situation that we trust to keep our factory moving, cannot help us because we are in between stock checks, with many unknowns in terms of actual physical inventory quantities.

Software technology in manufacturing has radically advanced recently, specifically related to IIoT data exchange and associated digital MES functionality. This is a clear step up from the capabilities of ERP or incumbent MES systems, though modern IIoT-based MES solutions are designed to directly complement ERP, as well as many aspects of PLM. With production processes linked up as part of the IIoT-based MES platform, every individual component that exists in the factory is accounted for, almost all without the need for human intervention—whether individually identified or supplied in bulk. The IIoT-based MES platform supports decision-making for immediate production changes, safe in the knowledge that the exact materials are definitely available for use without the indulgence of bloated stock levels.

As the physical stock levels are so closely aligned with the system, the stock check process becomes virtual, continuous, without nasty surprises. ERP performs its work more seamlessly, optimizing the incoming supply-chain in terms of cost, risk, and quality. With such technology, we typically see up to a 75% reduction of materials on the shop floor. Short-term schedule changes are handled seamlessly without additional concerns. Warehouse sizes have been known to reduce by a factor of four when all the unnecessary bloated stock is removed.

The overall effect on the bottom line of the business of the "trust in time" Lean supply chain within the factory is seen by many as being the most significant cost saving that can be made. "Trust in time" lean materials is a very simple concept and far simpler to computerize than the push-kit system that it replaces. It is a real differentiator that any operation, regardless of size or location, can utilize today. **SMT007**

Michael Ford is the senior director of emerging industry strategy for Aegis Software. To read past columns or contact Ford, click here.

New Model Aims to Give Robots Human-Like Perception of Their Physical Environments

MIT engineers are envisioning robots more like home helpers, able to follow high-level, Alexa-type commands. To carry out such high-level tasks, researchers believe robots will have to be able to perceive their physical environment as humans do.

"To make any decision in the world, you need to have a mental model of the environment around you," says Luca Carlone, assistant professor of aeronautics and astronautics at MIT. "For robots, it's a hard problem, where it's about transforming pixel values they see through a camera into an understanding of the world."

Carlone and his students developed a representation of spatial perception for robots that is modeled after the way humans perceive and navigate the world. The new model, 3D Dynamic Scene Graphs, enables a robot to quickly generate a 3D map of its surroundings that also includes objects and their semantic labels, as well as people, rooms, walls, and other structures that the robot is likely seeing in its environment. The model allows the robot to extract relevant information from the 3D map and query the location of objects and rooms, or the movement of people in its path.

(Source: MIT News)

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

Supplier Highlights

Electrolube Provides Conformal Coating Solution for IoT Customer ▶

Electrolube has many protection solutions for sensors used in IoT and would like to share a real-life case study focusing on the protection of a door sensor manufactured by IoT-based smart home products.

VIRTEX Partners With MIRTEC to Guarantee Stringent Quality Standards ▶

MIRTEC is pleased to announce that VIRTEX has selected MIRTEC as its AOI business partner. MIRTEC's award-winning MV-6 OMNI is the ideal 3D inspection solution to meet the stringent quality requirements of VIRTEX's high-reliability customers.

David Hamel Joins VJ Electronix as Director of Global Sales and Marketing ▶

VJ Electronix Inc., the leader in rework technologies and global provider of advanced X-ray inspection and component counting systems, is pleased to announce the appointment of David Hamel to director of global sales and marketing.

Jaroslav Neuhauser Promoted to General Manager of Saki Europe ▶

Saki Corporation, an innovator in the field of automated optical and X-ray inspection equipment, announced the promotion of Jaroslav Neuhauser to general manager of Saki Europe GmbH (Saki EU).

Indium Corporation Introduces Ultra-Thin Precision AuSn Preform ▶

Indium Corporation has expanded its portfolio of precision preforms with an ultra-thin AuSn preform designed for semiconductor laser applications, where thermal management has become a challenge.

KYZEN Launches Global Tech 2 Tech Sessions ▶

KYZEN, the global leader in environmentally friendly cleaning chemistries, introduced all-new Tech 2 Tech cleaning sessions. These innovative, high-tech, high-value sessions are the exclusive, no-nonsense way to get answers to your cleaning questions in minutes. Casual, informative sessions are facilitated by leading cleaning experts and are being offered around the world.

Datest to Increase Capacity, Throughput, Flexibility With Acquisition of Second SPEA 4060 ▶

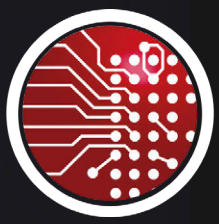
Datest—a leading provider of advanced, efficient, and mission-critical in-circuit testing, test engineering, X-ray inspection, and CT scanning solutions—is acquiring a second SPEA 4060 to increase capacity and throughput. The new machine features the Leonardo OS2 operating system.

Mycronic U.S. Operations Combined in New State-of-the-Art Facility Near Boston ▶

Mycronic U.S. is pleased to announce that all of its operations have been successfully integrated into a new state-of-the-art, 102,000 square-foot facility in Tewksbury, near Boston, Massachusetts. This brings together under one roof the Global Technologies division comprising of MRSI Systems and AEi and the U.S. operations of Mycronic's High Flex Division.

EPE Corporation's Investment in Mycronic Doubles Manufacturing Capacity ▶

EPE Corporation, an industry expert in high-reliability electronics manufacturing services since 1965, recently invested in its surface mount assembly line capacity with the purchase of two new Mycronic MY300DX-17 pick-and-place machines, feeder systems, and other line software upgrades.



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IPC's Certified Electronics Program Manager Course Goes Digital

Interview by the I-Connect007 Editorial Team

Susan Mucha, president of Powell-Mucha Consulting, and Carlos Plaza, IPC's director of education development, outline IPC's Certified Electronics Program Manager (CEPM) Training and Certification Program, which was converted to an entirely online platform in 2017. They also discuss what it means to be a successful leader. Read more about this program here.

Nolan Johnson: Why don't we start off with each of you giving a quick background on what you're bringing to IPC's CEPM Training and Certification Program and how you're involved. Let's start with you, Susan.

Susan Mucha: In the EMS world, there is a function called program management. This particular course has been designed to be broad enough to be of interest to the entire program team. This can include the program manager, the EMS provider's support team members, and the OEM's supply chain management person or members of their team. But it is specifically related to the concept of program management of outsourced contract manufacturing.

It helps the individuals charged with managing outsourced contract manufacturing to do a better job. The premise is that people who go into program management and join program teams are often lopsided in their foundations. Either they're very strong in business skills, or they're very strong in technical and engineering skills. But they are very rarely strong on both sides. This six-week program is designed to give them a common foundation across anything that would impact their job, from the basics and sales aspects of program management to contracts and contract negotiation, accounting and finance principles, manufacturing, and materials management.

In week six, we look at the whole concept of leadership because the real challenge for program managers is that, in most cases, they have a dotted-line relationship with their team, and they have two charges. On one side, they are the customer's champion within their organization. And on the other side, their business must make money. Sometimes, they have to

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tell the customer, "This isn't quite working. We're going to have to raise prices." Or they might say, "You can't get the delivery on the day you want because we can't pull in the schedule that much." In other words, they sometimes have to be the bad guy. Other times, they are telling their manufacturing team, "You have to find time for this customer because this is critical." These are skill sets that relate to leadership.

Susan Mucha

In terms of my qualifications to teach the course, I started in the EMS industry in 1981. I have worked at six contract manufacturers, and since 2001, I've been a consultant. I've managed marketing and sales functions throughout my career, and in many cases, had an influence on program management. For my last corporate assignment, I was a vice president and corporate officer of a NASDAQ-traded, Mexican-based contract manufacturer called Elamex. In that role, I was involved with program management training and very closely integrated into program management, along with my sales and marketing-related duties. I was also that company's lead contract negotiator. From those standpoints, I have a lot of real-world industry experience. As a consultant, I've been doing management and marketing-related assignments in the industry for roughly 19 years. I've worked for companies all over the world, and I can work with small regional companies to ones that are multi-national.

My CEPM classes have been diverse—I've had students from Thailand, the EU, and Mexico—so it's relatively easy for me to customize the lectures to the needs of that particular class. This is important because there's no set way to manage programs in this industry, yet there are industry practices that are more common than others. One of the benefits of the course is that students get to understand the very big differences in various organizations, how others do things, pull out best practices, and improve their programs.

Barry Matties: Thank you for that. Carlos, do you have some additional thoughts?

Carlos Plaza: Let me touch on why we provide certification and some of the feedback we've received from past participants. One of the most important aspects of this course is that these program managers receive a broad overview, like the ones Susan was delineating. She can immediately frame each one of those concepts and relate it to an application that she has lived herself, what was good or bad, and the steps needed not to make those same mistakes she's encountered. She knows about those issues because they're prevalent, and she's been there and done that—repeatedly. We hear back from the students that it's one of the most important aspects of the class because they can go back to their jobs the next day and apply it in a very practical way. It's because of the way Susan frames it, and that's key to this. Susan, would you agree with that?

Mucha: I would. People get bored fast, and they often don't remember concepts. Whether it's me or the attorney we bring in who teaches the contracts section and also has a ton of EMS experience, we try to use examples they'll remember.

When we announced it was online, I expected most students would ditch class and speed through the recorded sessions versus staying in a live session. But after a year and a half doing this, I have students apologizing if they're not in a live class. The only time I see students missing a live class is when they're traveling. I'm amazed they feel it's important to be part of our discussions and be interactive in class because that was one of my big fears with an online course, and it's turned out so well.

Johnson: That's intriguing that the students feel there really is a need to be in the live class. And that's interesting in a long-distance learning situation. Can you attribute that to anything in particular?

Carlos Plaza

Mucha: There are two things. One, we have class discussions. Sometimes, because of the material, I have to be a talking head, but we try to break into a class discussion whenever possible. Students say it's one reason they show up to class. Two, they like seeing what's on a slide and then being able to interact. They show up because they want to hear the stories.

Matties: Do these people come in with leadership skills, or do they develop through this program?

Mucha: It's all over the map. Some of them have very good leadership skills and are senior in their career, while some are brand new to program management. In some cases, they've been in a technical or manufacturing role where they've had some basic supervisory or leadership training. In other cases, they have good business skills but haven't had any leadership training. I have a master's degree in management, and I've taught in both MBA programs and in undergraduate business classes, so I'm able to lead them through a basic overview of management theory. I talk about the difference between managing and leading, so our first week is like a basic management 101 class in a master's degree program.

We deal with the topics of difficult people, ethics, stress management, and how to build a team. It's very abbreviated compared to a college-level management program, but we hit the high points in terms of giving our students the skillset and knowledge to motivate their team to achieve high performance and deal with interpersonal skills issues that may arise. Another interesting aspect of the class is the weekly case study where we break our students up into teams, and they get together outside of class in Zoom meetings. It's interesting to them because they're from different companies, and when they get together and analyze a case study, they learn about the different ways their companies may approach these issues. In the leadership program, those studies involve employee conflict situations, which is good.

They also have "branched" learning exercises that involve what-if scenarios. Students view a series of conversations and then decide what the person in the conversation is going to say next in each scenario. It could be a program manager talking with an employee or it might be a customer. If they select one answer, it sends them down one branch. If they pick a different answer, it sends them down a different branch, so they can see how choosing different answers impacts the flow of conversation and the ultimate outcome of that conversation.

We do that twice in the leadership section of the class and once in program management skills, and then we administer some multiple-choice tests on the material to check their retention and understanding. We try to provide several different learning modalities to help them retain the information, then test whether they correctly understand the information.

Matties: Leadership is a skillset in itself. You're teaching this. Is there a disconnect? With some people coming in as strong leaders and some who are 101, how do you bridge that range to satisfy each segment so one doesn't get bored because they already know everything and another feels they don't know anything?

Mucha: Particularly in the leadership section of the course, we're heavy on class discussion. I've found the majority of people really enjoy discussing the situations they've been in. The more experienced people outline some of their previous situations and how they dealt with it. Sometimes, those who are less experienced will say, "I'm having this experience, and I don't know how to do it." Because it's a class discussion, we can all talk about our own experiences, rather than me just saying, "This is how you do it."

For the most part, class members have never had a broad-based introduction to leadership like this. Maybe they had a first-line supervisor class, but we go a little deeper into the material, so even folks who have a fair amount of managerial or supervisory experience are learning new information.

Plaza: I can add a little bit to that. IPC serves the whole electronics industry, and we are always looking at the skills that employers need from their people. When we look at studies—like those in the World Economic Forum, other publications, and research houses that put out publications—we see that the skills employers want most change over time. The World Economic Forum makes a list every year, and right now, the top 10 needed skills are complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision making, service orientation, negotiation, and cognitive flexibility.

Matties: You just outlined most of what someone needs to be a successful leader.

Plaza: Leadership can be broken up into these different types of aptitudes, abilities, and even intelligences. Someone might come to the table with strong people management and creativity but may not be as strong in emotional intelligence. Because Susan covers a lot of ground in the content and experience, it helps class members shore up some of their deficiencies. You might not overtly say, "Today, we're going to talk about creativity, or today we're going to talk about critical thinking." But you're essentially doing those things in a case study or a discussion.

IPC tries to be responsive with its certification programs to provide the skills employers need. This happens to be a certification program rather than a training program. With certification programs, participants can say, "I took this course, and a test at the end saying that, 'As my employer, you can be sure, based on IPC's reputation, that I have these skills and I am a qualified or certified electronics program manager.'"

Matties: How many people have you had go through this course?

Mucha: We've had close to 50 in the online class and several hundred on-site. The online course is a redo of an IPC program, and I've taught part of the on-site program since 2003. With that, they've had several hundred people go through the total course. The bottom line is the body of certified program managers out there is fairly significant.

I did some CEO interviews related to articles I was writing on the on-site course, and they told me that they really noticed a difference with those who had gone through the certification program. They tended to be more proactive in how they analyzed program or facility challenges, and they were doing more to address issues before they became issues.

Matties: There's a direct ROI for each individual.

Mucha: Right. Essentially, people were putting things together better. During the course, we point out that much of the material we present they probably already know, but by presenting it in a very focused program over a six-week period, they'll be reminded of things they had probably forgotten about. We ask them to write down a personal improvement plan based either on what they're learning or things they already knew that they want to reinstitute when doing their jobs.

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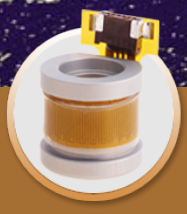

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We don't ask them to turn in their plan, but we allow them to voluntarily discuss it as part of our last session. From what I've seen, most of the personal improvement generally is related to interpersonal skills we teach in the leadership curriculum. It might include being more proactive in identifying problems; a lot of times, they think more about how they interact with people and how it may influence the conversations they have.

They also look more at their negotiating skills, thinking about the importance of building business cases for the things they either ask their employer or their customers to do. Those come out in our class discussions, and it helps them be more organized in the way they interact in their jobs.

From what I've seen, most of the personal improvement generally is related to interpersonal skills we teach in the leadership curriculum.

Matties: That's great because you talk about one phase of this course being focused on leadership, but the truth is that every aspect of the course all relates back to your leadership. Whether it's the contract negotiation or problem solving, you have to take those leadership skills and apply them in the right circumstances.

Mucha: Exactly. Essentially, a program manager can make or break the company they work in. In a large company, you can't kill a company with a single program manager. But in a small- to medium-sized company or a small or regional contract manufacturer, one program manager making one bad mistake can kill a company's profit for an entire year. It's a pretty important position in most companies. A good program manager also helps a company become more profitable because they eliminate a lot of things that cost money.

A good program manager benefits the OEM side of the equation as well because they eliminate wasted activity that costs money. And when we look at the pricing in contract manufacturing, we say, "We want to pay attention to the price." But there are a lot of hidden costs on both sides of the equation. If the contract manufacturer is efficient, and the OEM team is efficient, they eliminate items that would otherwise cost their respective organizations money on factors that nobody ever measures. This can include wasted activity, such as having to do three transactions instead of one because they're not thinking through how many ECOs they need in a week. Or it's somebody who is expediting stuff because they weren't paying enough attention to forecasting.

That's what we talk about in this program. We help people focus on how to prevent bad things from happening in a business, which benefits both OEM representatives and contract manufacturing or EMS people who attend the class. It helps them think things through, which makes them better leaders in the parts of the programs they're managing.

Matties: It's not what we pay; it's how much it costs. That's true in all aspects. With the shift of world circumstances, what sort of shifts are happening in leadership training with the large shift to remote work?

Mucha: In the companies that I've talked to, I've seen two things. One is people have to take more personal responsibility for making sure their work—and the work of their team—gets done. But from what I've seen in most companies, a lot of the people on the program team still have to work inside the facility. It's people in sales who typically work out of their homes.

Depending on the company and its system capabilities, program managers might be doing more work from home, but most of the time, they have to go back into the factory. We talk about ethics and personal responsibility because that's part of it, too.

The biggest thing is controlling the chaos that happens in somebody's house when they work

because the people they live with aren't used to having an office environment in the house. We talk about managing the stress that comes along with it. It hasn't been a huge issue relative to what we do, and I don't see it changing our training program.

Plaza: The current crisis has changed a lot of minds about online training and even testing. Many of us had reservations—especially my generation and prior—because we mostly went to school in a classroom. We were not exposed to online training or online education, for the most part. We saw it as a shortcut that was possibly not as effective and too open to chaos because there wasn't that direct connection with the instructor.

But people taking our online courses have seen that it's not the case. You can get the same—or, in some cases, even more—out of an online course. You can focus more—assuming that you can control your dog and maybe keep the kids out of the room for a little bit—because you don't have to drive anywhere and you're in your home. You get to easily schedule your time to do your work and focus on the content at hand.

They also have access to that instructor. With Susan, they can talk to her two hours a week as well as email her. Depending on the instructor, you can call them. Look at the modalities over the years—radio, TV, and then computers—each one was heralded as a better technology for education. There were radio distance courses in the '30s and '40s. Then, we had TV, and we all thought this would revolutionize education—think of "Sesame Street" and shows like that. Computers came along, and we thought, "This is definitely it."

However, we've seen—over and over again—that it's not the technology; it's the instructor, the motivation of the students, and the content. In head-to-head studies of the same content delivered through various modalities—such as computer vs. classroom—there is no difference. The actual difference comes in the content, the strategy the instructor uses, and the motivation of the instructor; it doesn't have to do with the technology. That's what we see in Susan's class. Someone could teach the same content live, and we would have less satisfaction because it's not Susan and her strategies.

Matties: It reinforces the idea that they see it online, as well as replay the entire session. If you miss a live classroom, it's gone, and you wind up with a "Swiss cheese education."

Plaza: That's right. It's as fast as you can write and take shorthand or whatever.

Matties: One of things that we've been talking about is the resurgence of total quality management (TQM) with the environment of continuous improvement. You're looking at not just teaching these people how to do a job but how to continuously improve their job performance. What do you see around TQM or management styles these days?

Mucha: Believe it or not, we talk about TQM in the manufacturing section of the course material, as well as Lean manufacturing. But again, the whole thrust of the course is that if you really sit down and study quality management theory over time, you'll find there have been 3–4 original ideas that everybody has built upon. Continuous improvement has been embedded in every quality methodology since the '50s, and it applies in leadership and manufacturing all across the board.

Most companies have a goal of continuous improvement. Getting into the whole nature of certification programs, this is an important theme as well. I've been pursuing certification programs throughout my career—even though I have two degrees related to my job—and we learn a lot as we do our jobs. The difference in a degree program is that you have a platform and can look at a body of knowledge in a very systemic way. You build core skills, and then you look at the whole body of knowledge and say, "I understand how all this interacts together."

The same can be said of certification programs. You take a body of knowledge, present it in an organized fashion, and give everyone the same core foundation to build off. Going back to your question about TQM, revving up

leadership skills, and bringing together the knowledge they already have with new concepts into one core platform. That's the benefit of any certification program. It gives you a core foundation where you can see how everything interrelates. That's why you get certified.

It's not because it's better or worse than a degree. It's because you stop what you're doing, take a gut check, and make sure that you organize all your learning into one foundation that says, "This is how all this comes together to better focus on the critical skills I need for my job."

Plaza: I wanted to pick that up because the point you just made circles us back to when we were talking about why students get involved in the live training rather than just watching the recorded sessions. It's because they can work on a larger sample size of experience in order to learn how to generalize what you're teaching.

Mucha: Exactly. Another piece that makes this particular program a little bit different than others is the people who work in the same industry—they might be competitors—are all getting together. It's cool when they discover there's more than one way to do their job and that they all have the same challenges. It's important to bring out because this is a stressful position for many EMS companies. Whether folks have been in the industry a long time, or they've only worked at one company, sometimes, they start to think their company is the only one that has these problems.

When they discover that everybody else in class deals with the same issues, it helps and gives them more self-confidence in how they do their jobs. It also gives them a better feeling about the company they're working in because with the customers they see as "problem customers," they start to realize that it's not just their particular problem, but it happens throughout the industry.

Johnson: It's the danger of being a program manager. You are very accountable for the success of a program. Usually, you have no direct reports. You're a dotted line influencer through your customer and your organization to make all this happen—very little authority but a whole lot of accountability. It takes a lot of charm to do this job.

Plaza: TQM is really more relevant today, and the belt system that kind of systematizes them and markets them. What you're talking about is the ability to learn something new and apply it. You have to look at something, take into account new technology—which is more prevalent today even than the '70s and '80s when this started—be able to capitalize on it, or look for the potential problems down the road. What you're telling people is that the number one ability needed in the 21st century is to learn and apply new things.

Matties: It's what I've called just-in-time (JIT) training because you can come in, learn something, and apply it the next day to what you're doing. It has a real benefit.

Mucha: Exactly. And in that particular role, the ROI is pretty significant if a program manager changes their performance even a little bit.

Matties: Exactly. Now, one of the things that we talked a lot about is alignment, meaning the ability to get people to move into a common direction. One of the greatest alignment moments in history is when JFK said we're going to go to the moon. That aligned everybody. You could ask someone working on computers, "What are you doing?" and they would say, "We're going to the moon." So would someone, say, sweeping the floors. The power of that alignment is the key to success. How do you deal with alignment in your training, and how does it translate back into the companies that your students are in?

Mucha: We don't call it alignment in our training. We call it team building and motivation, but it's the same concept as we talk about goal setting and how important it is that everybody has input into that goal. In the leadership portion of the course, there is a focus on alignment, but we don't label it as such.

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Matties: Are these students coming to the course based on requests from their leadership, or do they decide to take this course and bring it back to their company?

Mucha: All the above. I've had students come because they lost a job, and they pay for the course on their own because they feel being a certified program manager will give them more ability to get a job. There are some whose bosses told them to go. And then there are others who want to go just because they feel it will improve their skillset. I had one student in the last class who worked for a client company, and I recommended that she consider it, but it was her choice. She was over the moon that she was approved to go. Because she'd recently come into that industry, I felt that it would be the next step in her skillset.

Matties: How would you summarize what a great leader is?

Plaza: Number one is the ability to listen as accurately as possible to what's happening, which could be anything—from the factory, equipment, and computer systems, to the way people are interacting with those systems and with each other. It goes back to the list I gave earlier, which would include emotional intelligence, people management, and critical thinking. These are aptitudes that you have to cultivate.

One of the mistakes that we often make in business is assuming people either have these things, or they don't—the "born leader" example. I'm not sure that it really exists. Sometimes, you have people with the right aptitudes for a particular problem, and in the old days, those problems were pretty static and repetitious because technology and systems moved so slowly. But today, because they move so quickly, you need to have someone who's able to apply those aptitudes—be creative, have complex problem-solving skills, and emotional intelligence—constantly to different situations. That all starts with listening and being able to accurately take in the world around you without letting your ego get in the way. Checking your ego is one of the top things a leader needs as well.

Matties: Susan, what do you think makes a great leader?

Mucha: Talking about what makes a great leader is a big class discussion. We probably spend 15–20 minutes on it, and in a two-hour session, that's a fairly big chunk. But the key points are, like Carlos said, that they listen and carefully assess what's happening. They are collaborative rather than dictatorial. They understand negotiation skills. They're organized. We end up with a list of probably nine or 10 things. The bottom line is there's not one thing that makes a great leader, but a combination of really being able to know when it's time to lead and manage and being able to inspire a team rather than have to order them to do it.

Talking about what makes a great leader is a big class discussion.

Johnson: Do you have any specific plans to expand how leadership skills are delivered to the industry through IPC?

Plaza: We are in the process of looking into a wider program that addresses soft skills—one of which is leadership for people in entry-level positions. It's on our radar.

Johnson: Thank you both for participating in this conversation.

Plaza: Thank you.

Mucha: Thanks a lot. SMT007

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Real Stories of Applied Advanced Analytics in the Electronics Manufacturing Smart Factory

Article by Derek Ong, BscEE
KEYSIGHT TECHNOLOGIES

Abstract

The smart factory is starting to become a reality, as part of the overarching Industry 4.0 paradigm. With the technology enablers, such as industrial IoT (IIoT) and cloud computing, electronics manufacturing operational technology (OT) are on a converging course with traditional information technology (IT). Beyond the challenges of data acquisition and transformation, the true "proof in the pudding" is in the quick ROI from advanced analytics. This is where domain knowledge application into data science is paramount. We will share examples of successful, profitable implementation of applied machine learning (ML) in the electronics manufacturing line, where measurement science meets data science.

Introduction

Industry 4.0 is becoming a hot topic in the world today. The first industrial revolution saw mechanization through water and steam power. The second industrial revolution introduced the ability to mass produce products using electricity.

It was almost a century before the third industrial revolution where computers became cost-effective and powerful enough to be adopted in the factories. Through the unprecedented processing and computational speed available then, the factory could automate more processes and provide better feedback on their processes.

Data has started to become the currency of productivity. Supply chain, commodity, customer relationships, quality, and production management could be harmonized on an enterprise-wide platform that empowered companies to optimize costs of manufacturing, reduce inventory, ship quicker, and improve quality.

Fast forward to today and the internet of things (IoT), believed by many industry experts to be the key driver of the next industrial revolution. The concept simply implies that machines will be intelligent enough to communicate and automate processes between themselves with minimal human intervention, creating a self-monitoring and self-sustaining internet of machines, for machines.

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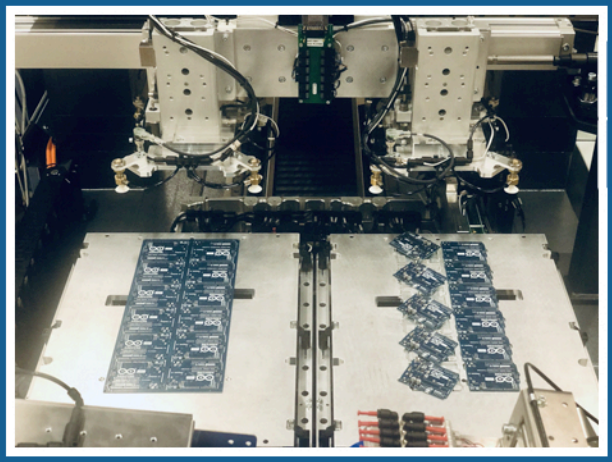

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The Hype of Smart Factory

Industry 4.0 is a very wide paradigm that consists of many seemingly technological miracles. A lot of excitement and marketing have been made on big data, artificial intelligence (AI), augmented reality, additive manufacturing, robotics, and autonomous machines. However, one needs to appreciate that many of the core fundamentals for these technologies were developed decades ago. For example, AI goes as far back as 1956 [1] and has been refined over the years. Nevertheless, it is believed that the implementation phase of these technology enablers truly begins now, as we have achieved the beginning of the right performance and cost of electrical, electronics, and wireless components that makes it all feasible and practical.

An application of Industry 4.0 will have to be the factory, and the endgame is to make the latter "smart." In the never-ending quest to improve productivity and efficiency—which hallmarks every industrial revolution since and, ultimately, advances humankind in terms of quality of life—the decisions of what makes a smart factory in fact, smart, and the pragmatic approach to realizing ROI will define just how far and quickly we reach the plateau of productivity (Figure 1) [2].

As we have seen in many of the discussions with customers and their smart factory initiatives, simply jumping on the Industry 4.0 bandwagon may often be a recipe for disaster.

It Starts With a Vision

We have consulted and analyzed many use cases and datasets of more than 50 plants worldwide and more than 1 TB of manufacturing test data in our quest to provide the right set of value differentiators with the goal that customers will choose us as their key solution partner. Thus, it is imperative that we define—at least in our perspective—what the "smart" in "smart factory" means.

The "smart" begins with a strategy, and this is paramount. Often, what we see in many of

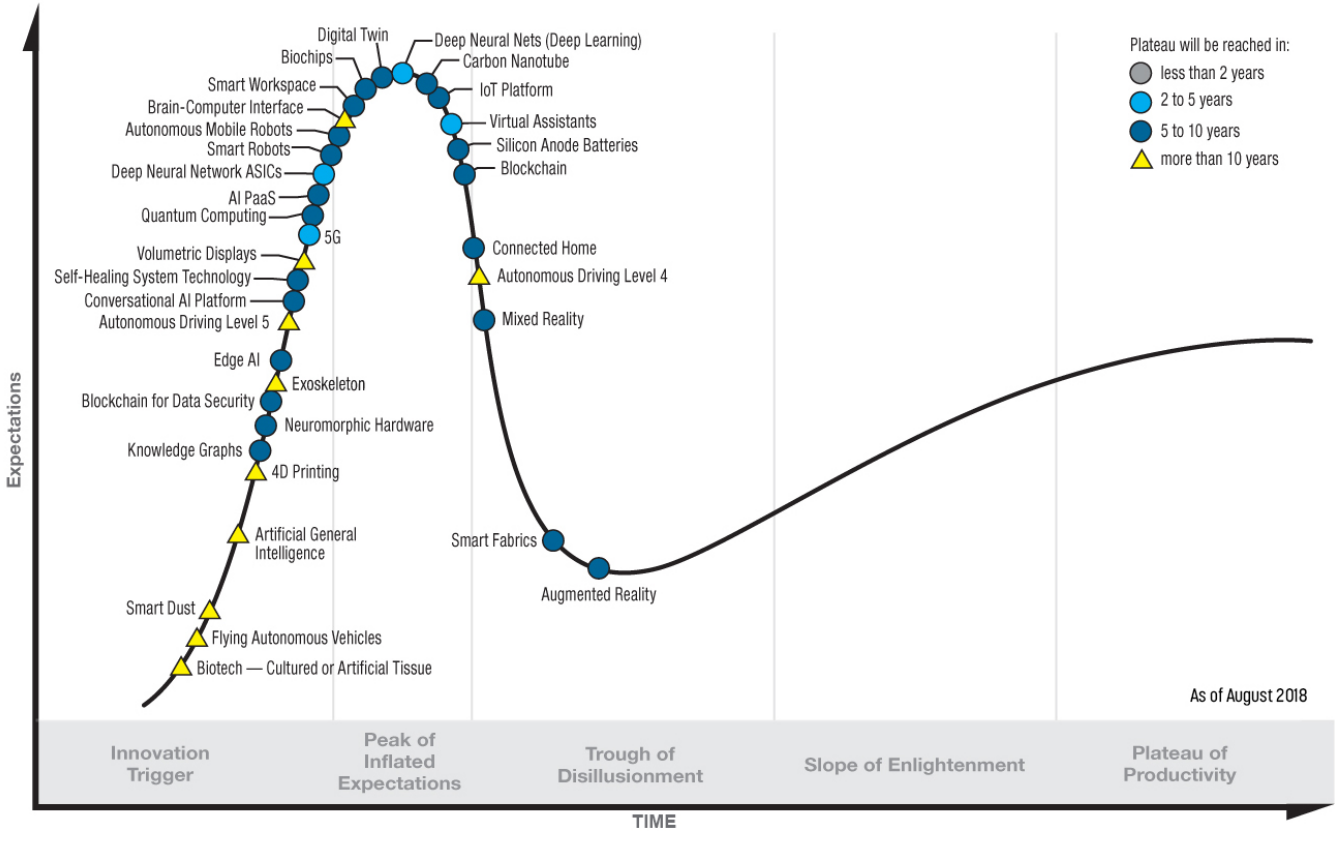

Figure 1: Inflated expectations lead to disaster.

the factories we have had the opportunity to consult with, Industry 4.0 implementations fail and perish rather quickly because of the lack of vision and clarity from the highest levels of the organization. Without clear directions—and these tend to be plural—from the leaders on the factory's digital transformation strategy, many plants and their corresponding management will have their own interpretation and ideas on implementing Industry 4.0 technology enablers.

This creates major issues that they may not be expecting, such as:

1. Inability to leverage core infrastructure and platforms across the company to keep it cost-effective.

a. When we approached single satellite plants on the smart factory journey, discussions were mostly delegated to engineering and operations managers. One of the key Industry 4.0 technology enablers would be big data analytics for operations. However, this requires the involvement of the companies' IT stakeholders as typical IT concerns about security, the cloud, and bandwidth need to be resolved. Moreover, IT capital expenditure (capex) such as server hardware and data centers is not under the purview of the operation teams or OT.

b. The industry is just beginning to realize the importance of OT/IT convergence. However, this is often not reflected in the organization as the digital transformation (or lack of) has yet to take shape in the company. What we also realized was how siloed IT and OT teams are and how little they work together. The disciplines, budgets, management, cultures, objectives, expertise, or even just the technical language of both IT and OT are worlds apart.

c. What eventually happened was that the OT teams were reluctant to get the global IT team involved as they see it as an obstacle rather than a necessity or value. Thus, instead of having the big data manufacturing analytics solution in a central corporate server or cloud where other plants can start to leverage the same infrastructure without adding scaling up costs, the customers opted to buy their own server hardware and install it inside that plant. This will never be cost-effective for scaling up across the company, and it would be an expensive lesson to learn. Without IT's blessing, this solution will be short-lived anyway.

2. Silo resource investments that only focus on one plant objective without alignment to the corporate strategy and objectives.

a. For example, one plant may have workforce inefficiencies and competencies that motivate them to implement robotics to replace workers, augmented reality to deliver higher-quality training, and deep learning in cameras to monitor worker non-compliance. However, this may not serve to fix the root cause, and that is that the plant may not be adhering to the best practices that the corporate had outlined or that it is simply a poorly run operation.

b. We found that often when we were faced with such situations, we were not surprised when we consulted with upper management and corporate executives that the company has more pressing key performance indices such as reducing quality issues and return merchandise authorization (RMA) or reducing scrap costs that are increasing exponentially due to yield and handling issues.

3. Corporate Industry 4.0 strategy does not align with the plant operation's true needs and challenges.

a. Many times, for companies that are forward-thinking enough to put in place a corporate strategy with digital transformation, the strategy and programs are owned by IT.

b. We had found that often there is not enough engagement and collaboration with OT teams on the issues and chal-

lenges they would like the strategy to address. Part of the problem here is that it is difficult for an IT expert to truly comprehend the intricacies of an operation and its processes. This creates a major disconnect between what the corporate strategy objectives are and the actual value it brings to the operations.

c. For example, an IT-driven private cloud-based Business Intelligence platform may be able to acquire huge sets of data from the manufacturing floor. This is very aligned with the ideas of Industry 4.0. However, the insights from the platform are too far away from the action on the floor. It is usually used as a reporting tool or an alarm system for machine and yield issues. The operators or technicians fighting fire on the floor are not able to use this platform to take quick, immediate, simple actions that may mitigate the resulting wastage.

These are just some of the things we had to research and understand that led us to conclude that as much as the technology enabler readiness and employee competency is important, the "smart" in smart factory starts with a corporate crystal-clear digital transformation vision that addresses the OI/IT convergence challenges.

Real, Applied ML in Electronics Board Manufacturing

In one of our customer successful implementations of advanced analytics, we started with a proof of concept (PoC) upon their subscription to the service for their test systems in production. Figure 2 shows a typical electronics board manufacturing line that the customer implements in the factory.

The cloud-based advanced analytics software as a service platform (Figure 3) was developed to provide almost real-time data acquisition, transformation, and analytics of the test sys-

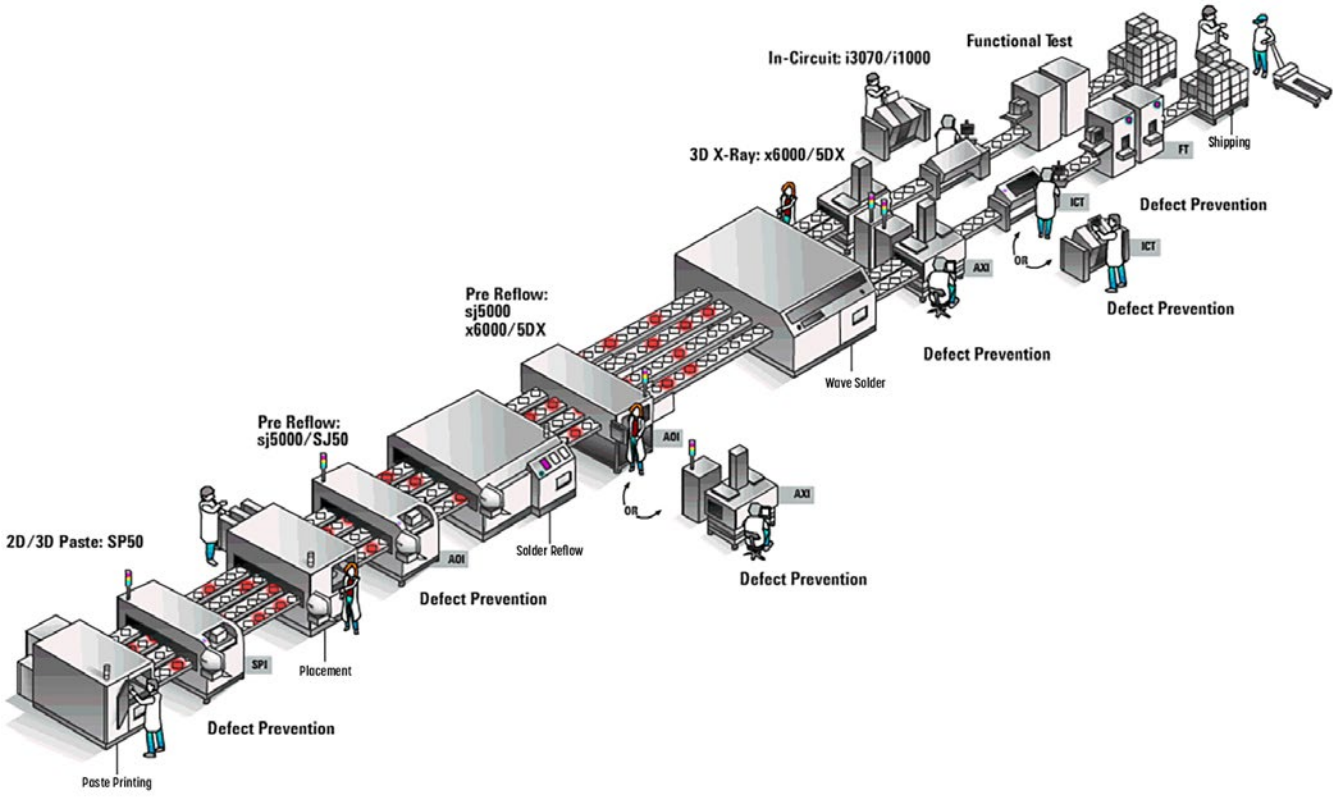

Figure 2: Example of a typical electronics board manufacturing line.

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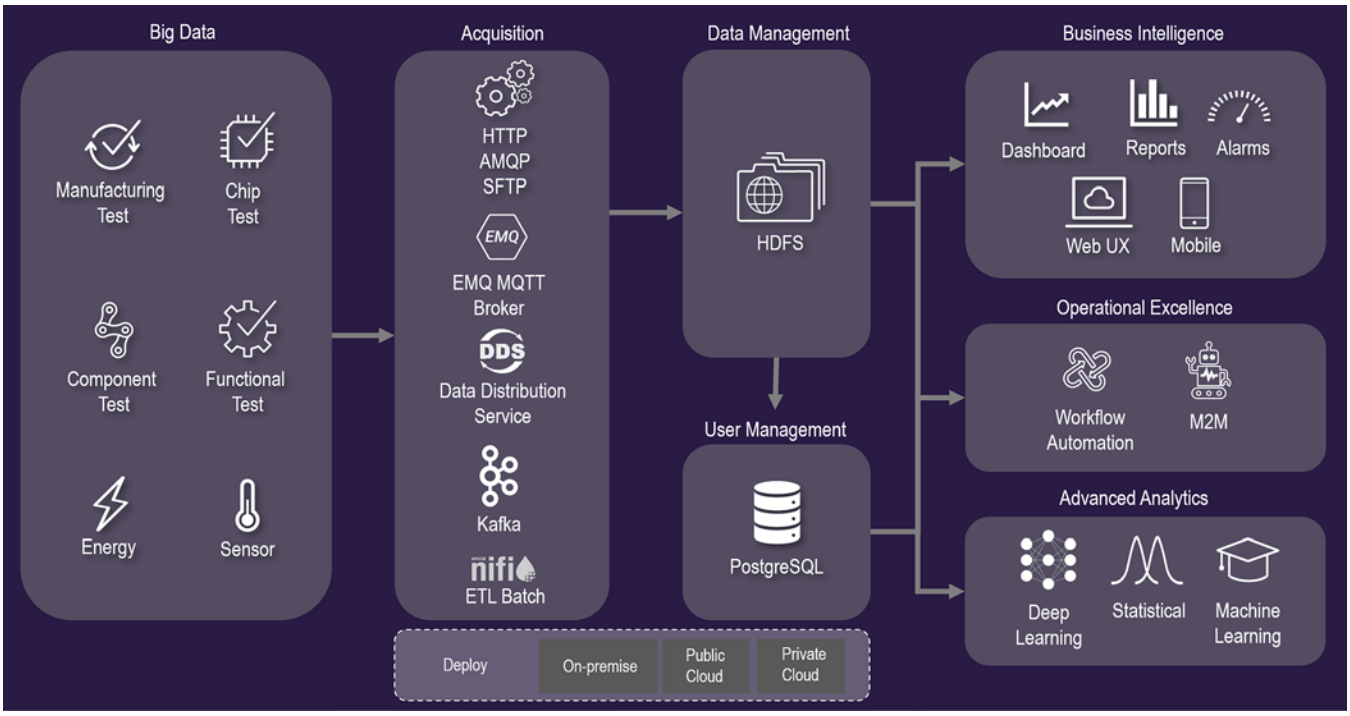

Figure 3: Cloud-based real-time advanced analytics architecture.

tems and measurements that define the quality of the products.

The solution had to address use cases where workflow automation and yield loss predictions were due to failures caused by fixtures, test program settings, and other factors that are not due to the actual parts used in the product. These were false negatives that increased production costs.

At the core of the solution, a fundamental prediction it makes involves almost real-time anomaly detection for every test in production. At any one product test, there are hundreds to thousands of such measurements and tests. On a typical day, a few hundred products go through this mandatory process. Some of these anomalies will be classified as degradation patterns that relate directly to specific parts of the fixtures.

Simply put, anomalies are atypical to what is normal. This presents the first challenge for manufacturing and test. Current factories may capture and store high value and critical data such as failures. It was never imperative to capture good measurements, especially down to a single test. Therefore, to predict anomalies, the factory must be able to capture all measurements that are performed—regardless of the nature of the result associated with that measurement.

Figure 4 shows a screen capture of an actual anomaly that was predicted by the system. The component is an expected 10K Ohm resistor on a complicated electronic board. The green dots are measurements within the test limits or specifications, which are the dots in white. The anomaly is the pink dot and is measured at 9.429K Ohm. In production, this will not trigger any concern as the test "passes" and there is no capability of current processes to detect such a situation.

However, it is evident that the manufacturing process is very capable of producing such stable measurements. The mean and median are standard deviations from the test limits. In such situations, it should be alarming that such a drastic anomaly happens in production regardless of whether it is within the test limits.

Measurements such as these may shift suddenly or over time, depending on many factors. The anomaly detection algorithm must have the ability to learn the "norm" as fast as possible to avoid too many false calls. Detecting anomalies is the first step in the process of applying ML in manufacturing test.

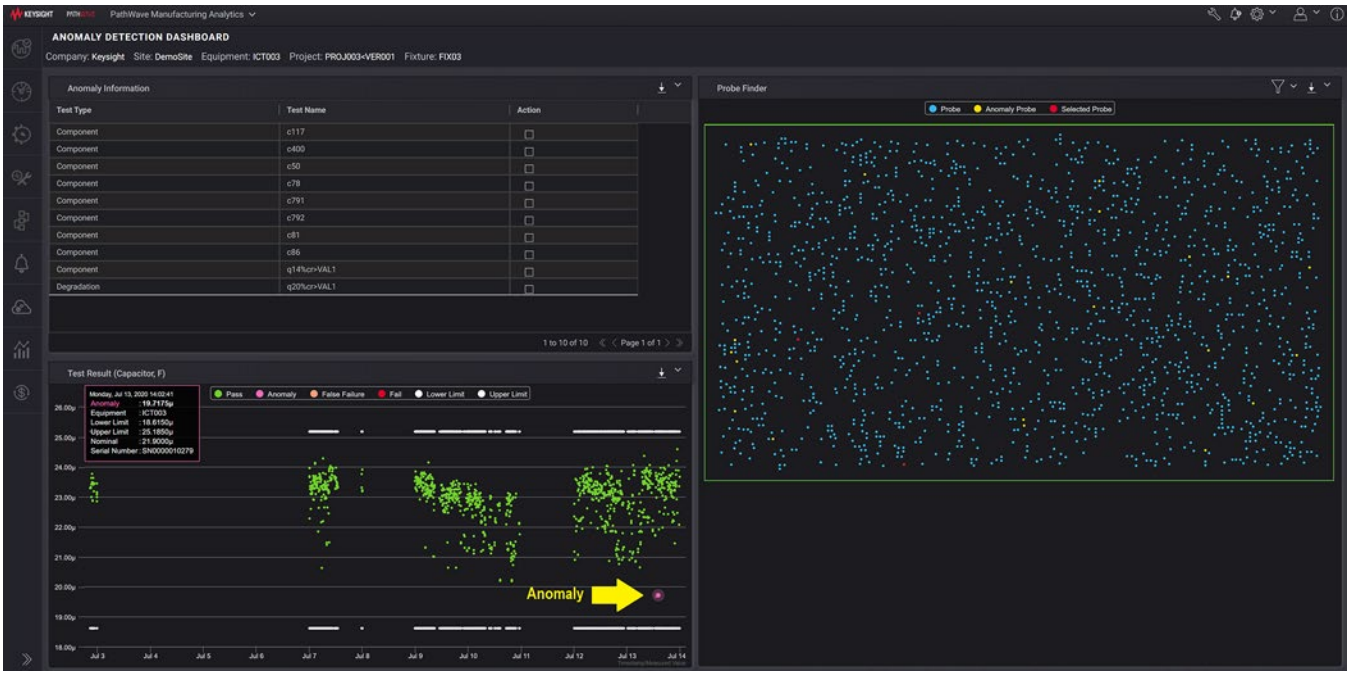

Figure 4: Example of a measurement anomaly.

In an over-simplified ML model development process, datasets called training data are fed into the model to help the machine "learn" the patterns and trends. Then, the model is tested with real-life data and measured by a variety of methods, such as:

- F1 score [3]
- Mathews correlation coefficient [4]
- Weighted average precision [5]
- Weighted average recall [6]

One important factor that may not be obvious was that the predictive confidence of the ML algorithms is highly dependent on:

- The amount of training data available (the bigger, the better)
- How focused the data is relevant to the ML output expectations
- The fusion of different ML and statistical techniques based on application expertise and experience

During the algorithm testing process, we had to make significant changes to the fundamental anomaly detection algorithm to achieve the scores we needed to give confidence to our customers that the anomalies were relevant and important. This customized algorithm is now a trade secret and cannot be shared here. However, you can use popular open-source algorithms, such as local outlier factor (LOF) [7] or autoencoder neural network (ANN) [8], and start there.

Now that we established a fundamental core prediction, which is the anomaly detection, we then had to correlate and classify these anomalies with potential causes and manufacturing process issues. This is the only way for operators and technicians to take the appropriate action to avoid costly downtime or bad product escapees.

Figure 5 shows how we had grouped the different types of anomalies by the same patterns and characteristics. Each of these patterns indicates a different potential cause and effect from the manufacturing process. For example, when a degradation anomaly (Figure 6) is predicted, the customer may investigate the particular test probe associated with that anomaly. Through our comprehensive testing, we have discovered that a degradation pattern is highly correlated with wear and tear of test probes in a manufacturing test process.

Other anomalies that are not correlated to the wear and tear of test probes do not usually degrade over time, but rather occur suddenly in steps or shifts (Figure 7).

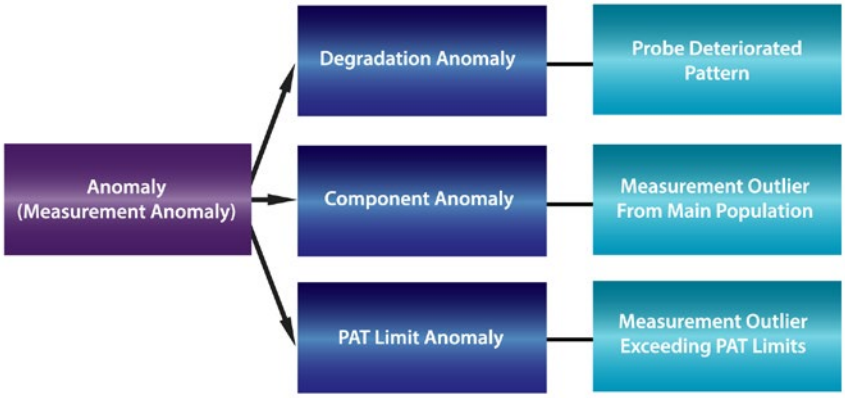

Figure 5: Multiple classifications of anomaly types.

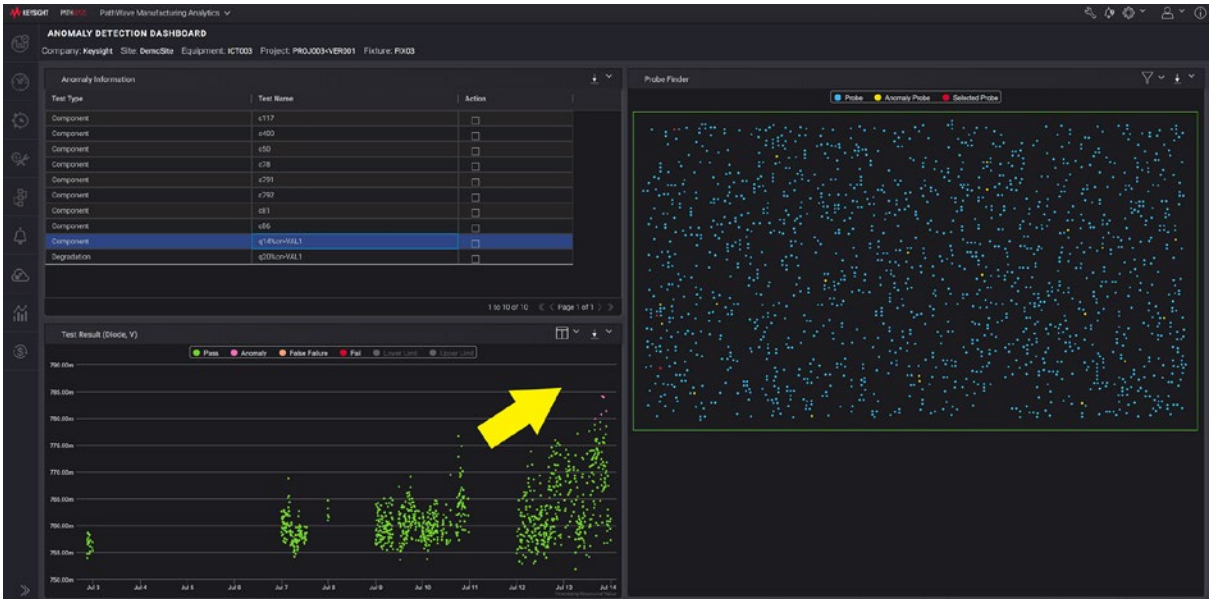

Figure 6: Example of a degradation anomaly.

Figure 7: Example of non-degradation anomalies.

There are also anomalies that show bimodality (Figure 8). This may indicate a component source issue, perhaps from dual vendor sources. An action to verify if the correct component has been mounted or an incoming sample measurement before component consumption could point the customer to the root cause.

To summarize the cause and effect associated with the component anomalies predicted using this method, refer to Figure 9.

As these anomalies are in real-time and alerts are sent to the production teams, quick action can be taken to resolve performance and quality issues that couldn't be predicted or detected until a much later time. Figure 10 shows the interface that maps the degradation anomaly to the actual test probe location for immediate action.

Calculating the ROI

To provide tangible ROI and savings to the factory, we decided on a 12-month period for the calculation and metric tracking. The first important metric would be the first-pass yield (FPY), which is the quantity of boards that pass test the first time it is tested over the total number of boards tested the first time. This is important as it indicates the robustness of the manu-

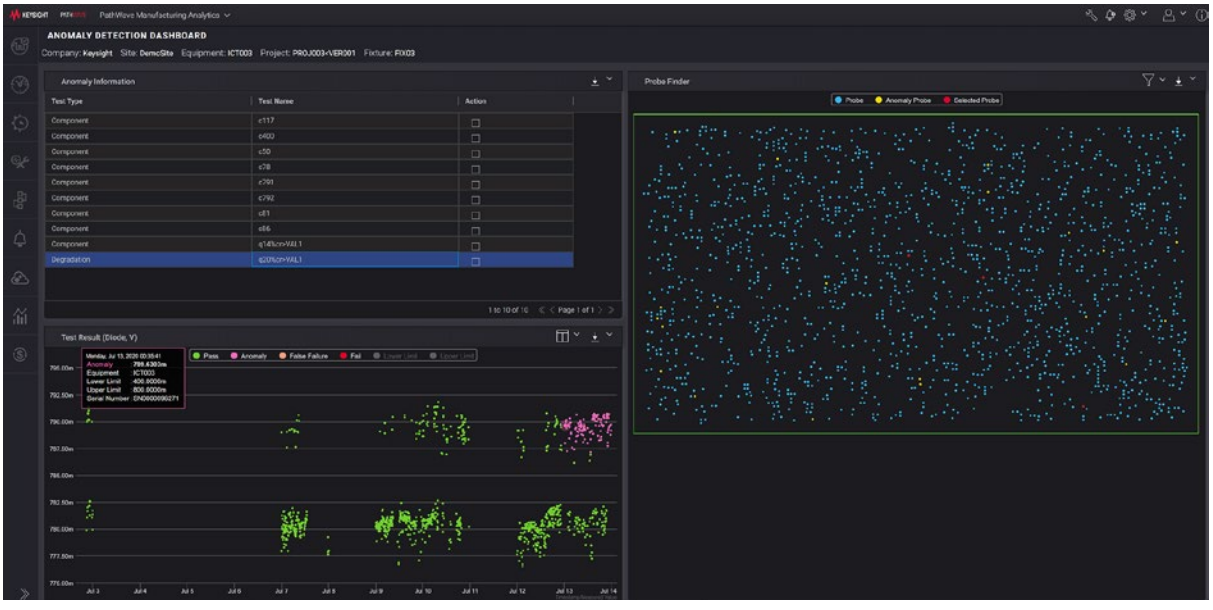

Figure 8: Example of bimodal anomalies.

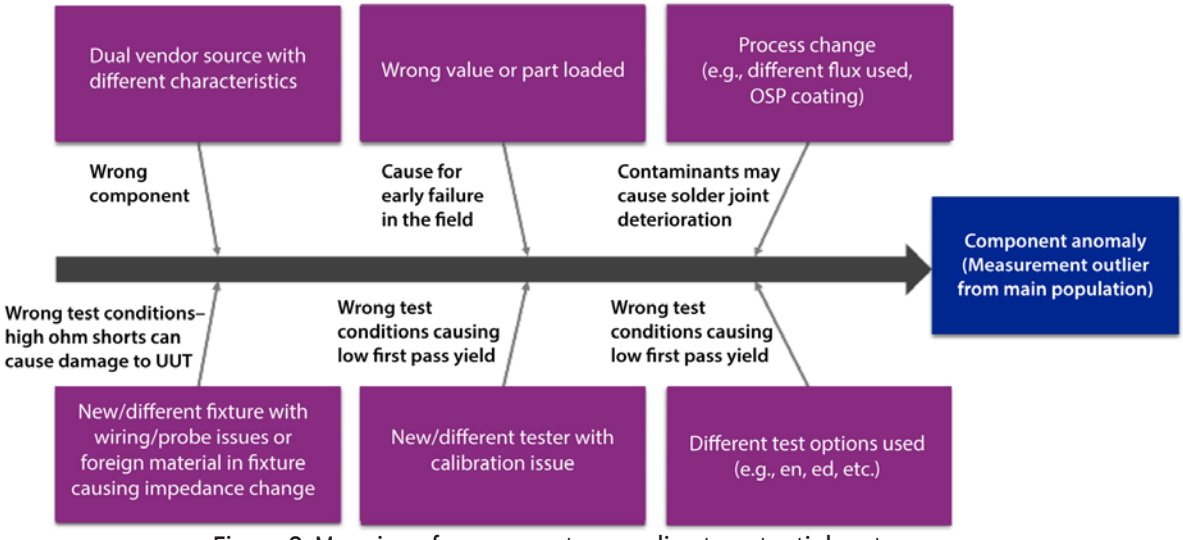

Figure 9: Mapping of component anomalies to potential root causes.

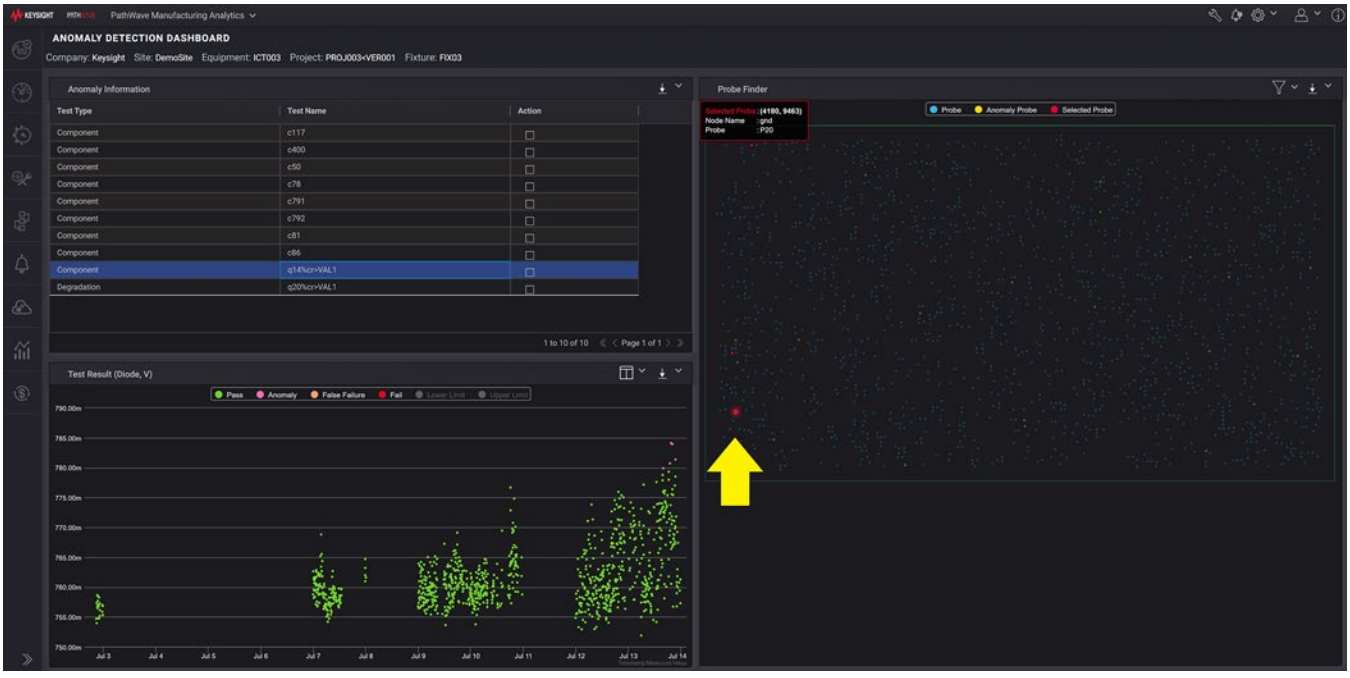

Figure 10: Screenshot of degradation pattern anomaly prediction mapped to a location.

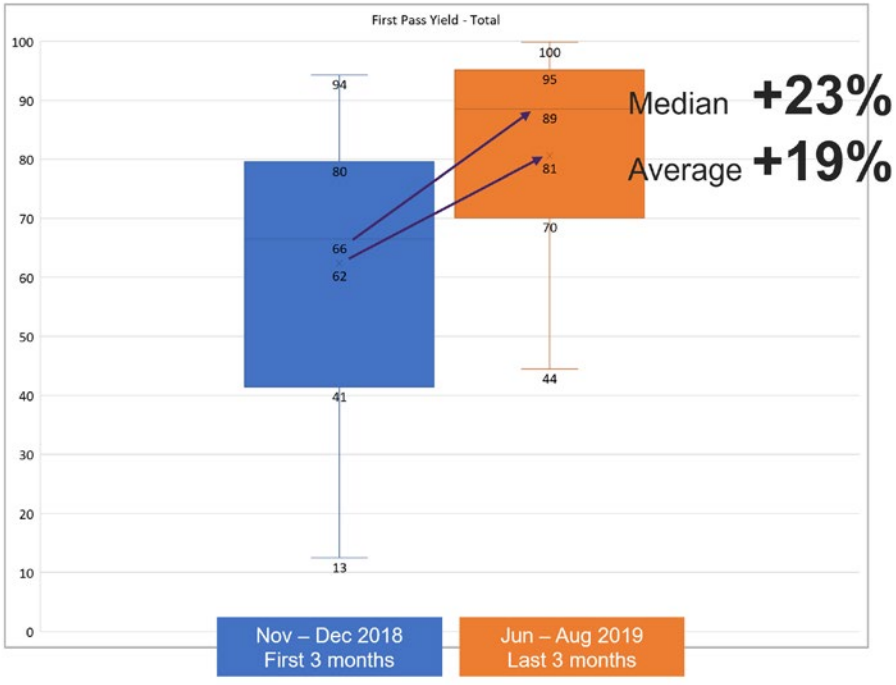

Figure 11: FPY tracking results.

facturing test. A higher FPY would mean higher throughput, which maximizes machine utilization. It also means less handling of boards due to retest that may damage or deteriorate the condition of the board. This would shorten the expected life of the product out in the field.

The average and median FPY has improved significantly by 19% and 23%, respectively (Figure 11). This is comparing the first three months before anomaly detection was introduced in production to results after. That would mean for a 40,000 boards per month typical run rate, more than 8,000 extra boards would be gained in terms of pure output, which directly translates to better capacity in the factory.

In addition to the pure output gain from FPY,

IPC E-Textiles 2020 Virtual Summit is a technical education event you won't want to miss!

- Collaborate and connect with industry leaders
- Learn about the latest innovations, designs and manufacturing concepts for e-textiles
- Enjoy a tour of the **Wearable Technology Lab | College of Design University of Minnesota**

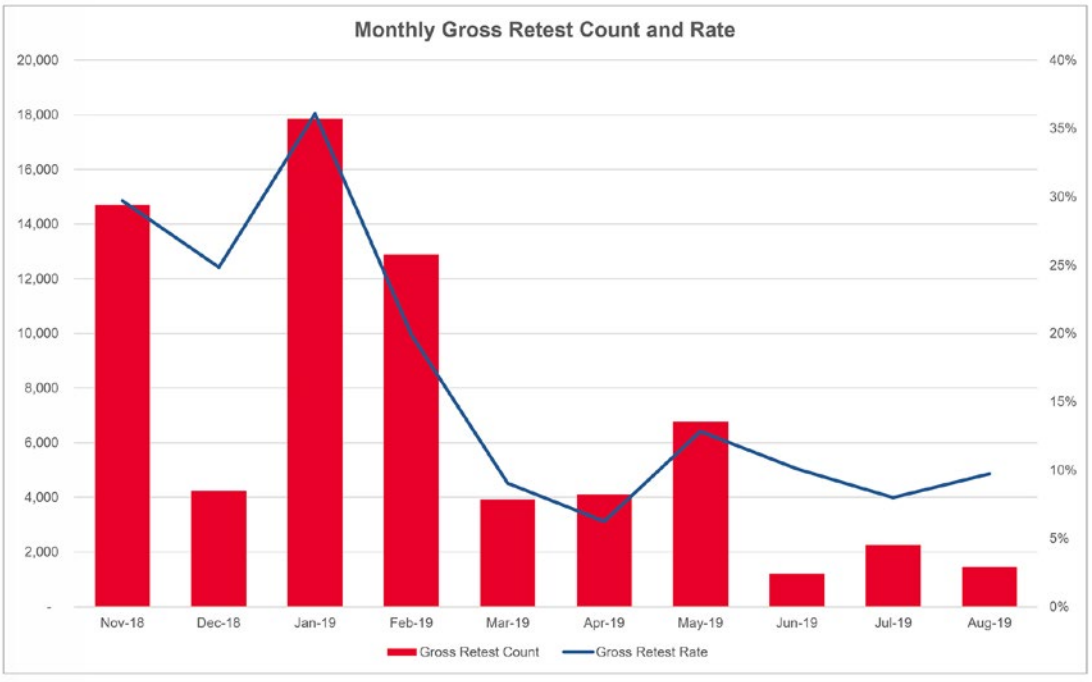

Figure 12: Tracking gross retest count.

the other important measure of productivity is on the gross retest count. This is simply a total of how many times any board is retested.

For every retest, an operator must perform physical manual tasks that would take a few minutes. A percentage (typically between 10–30%) of these total retests would require an engineer to investigate further, which will take another 5–10 minutes of manual task. Every factory would assign a fixed cost per minute for these wastages. As such, it is tangible to calculate the savings in terms of cost per month due to retest. Figure 12 shows the actual monthly total retest count tracking. It is evident and reassuring that since applied ML of anomaly detection was implemented, the gross monthly total retest count has improved by as much as 19%. This directly translates to more than 300 hours of additional productivity per month.

Conclusions

Advanced analytics techniques, such as anomaly detection, combined with a big data infrastructure for real-time data acquisition and ingestion—along with a clear vision and digital transformation strategy from management—can be significantly beneficial to most high-value factories. These techniques require complicated measurements, and a vast amount of them, to define the product quality and quantity. The key to a profitable ROI is successfully mapping the predictive outcomes to potential tangible root causes for the production team to take decisive action before the problem escalates. **SMT007**

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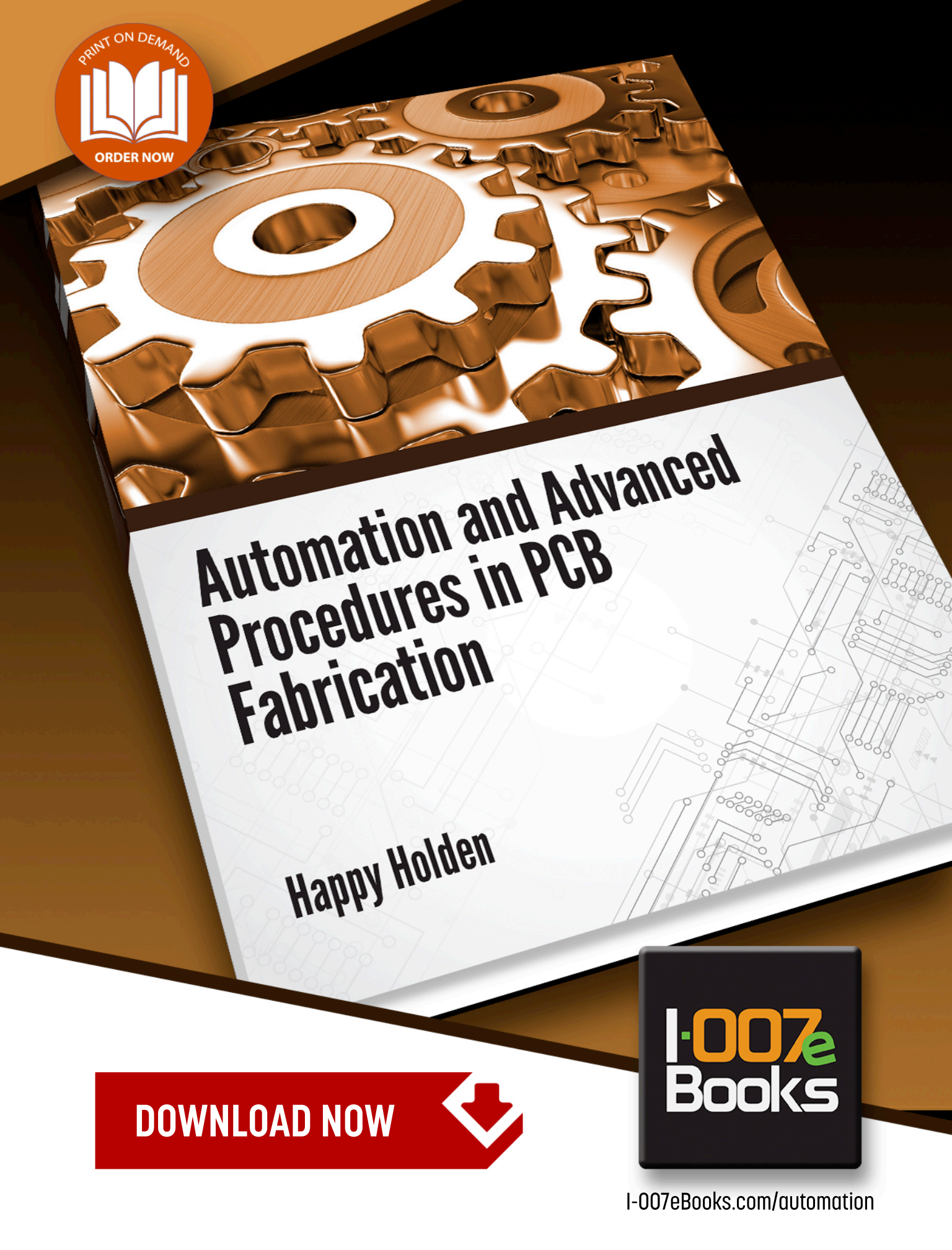
Derek Ong, BscEE, is a manufacturing technology and software solutions planning manager for Keysight Technologies.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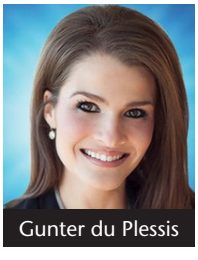
1 Zulki's PCB Nuggets: Soft Electronics Pose PCB Microelectronics Assembly Challenges ▶


Zulki Khan

Zulki Khan explains how PCBs have moved from traditional large rigid boards to considerably smaller rigid and combinations of rigid and flex circuit boards, even to the point that bare chips and wire bonding are used during the PCB microelectronics assembly of these tiny boards.

2 Foundations of the Future: Student Representative on IPC Board of Directors ▶


Gunter du Plessis

Charlene Gunter du Plessis describes how IPC's Board of Directors recently added a full voting board seat to an IPC student member, including introducing the student liaison and sharing an interview with Dr. John Mitchell and Shane Whiteside.

3 Catching Up With Fane Friberg: Supply Chain Management Expert ▶


Fane Friberg

Dan Beaulieu recently spoke with Fane Friberg, principal at CEPHAS and a supply chain management expert, about how he started his company, as well as current market challenges he sees and what he thinks the future holds for companies—especially post-pandemic.

4 The Government Circuit: Renewed Focus on Worldwide Supply Chain Amid COVID-19 ▶


Chris Mitchell

One of the key takeaways from the coronavirus pandemic is that in times of crisis, sophisticated global supply chains can break down. Chris Mitchell explains how as the pandemic continues to play out, IPC is actively engaged in promoting global trade and the regionalization of supply chains.

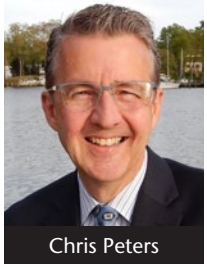
5 SMTA International Conference and Expo Goes Virtual ▶

The Surface Mount Technology Association announced that its annual conference and exhibition, SMTA International, will proceed for 2020 as a completely virtual event starting September 28, 2020. The decision has been made in light of the COVID-19 pandemic to ensure the health and safety of all those who attend.

6 Sparton Corporation Sells its Manufacturing and Design Services Business to One Equity Partners ▶

Sparton Corporation, a provider of engineered products for the defense industry, entered into a definitive agreement to sell its contract manufacturing unit, Manufacturing and Design Services, to One Equity Partners, a middle-market private equity firm.

7 This Month in *SMT007 Magazine:* Electronics Manufacturing—A Critical Industry and Supply Chain ▶



Chris Peters

Chris Peters represents the U.S. Partnership for Assured Electronics, where he advocates for electronics manufacturing as a critical industry. Here, he describes the current status, the supply chain, and what he sees in Washington, D.C.

8 TT Electronics Adds Advanced Industrial Electronics Manufacturing Facility in Malaysia ▶

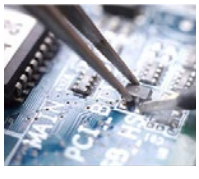
TT Electronics, a global provider of engineered electronics for performance-critical applications, announced that its Global Manufacturing Solutions Division is expanding its footprint by opening operations in Kuantan, Malaysia, in response to overwhelming customer demand for an additional manufacturing center in Asia.

9 ViTrox Expanding Into Mexico With SMTo Engineering ▶

Santoyo and Sanchez

ViTrox Technologies—a machine vision inspection solution provider of innovative, advanced and cost-effective automated 3D machine vision inspection solutions for the semiconductor and electronics packaging industries—announced its current business expansion of SMT inspection solutions in Mexico.

10 Big Move Creates New Opportunity for U.S. Electronics Manufacturer American Fibertek ▶



Recently acquired American Fibertek had been based out of New Jersey for over 30 years but recently moved to St. Petersburg, Florida. The move allows the leading American-manufactured electronics company to utilize and be a part of the continually growing electronics manufacturing scene in St. Petersburg area.

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Looking for the purrrrfect applicant?

Find industry-experienced candidates at I-Connect007.

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

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MivaTek Global: We Are Growing!

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

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

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

Contact **HR@MivaTek.Global** for additional information.

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ROYAL FLEX CIRCUITS

Director of Business Development

Royal Flex Circuits is looking for an experienced Director of Business Development to increase company revenue by identifying and nurturing profitable business opportunities and developing long-term sales strategies. The successful candidate will have experience contacting potential clients, establishing lasting relationships, and converting leads to sales.

Responsibilities include but not limited to:

- Consistently meet or exceed monthly sales objectives with profitable sales revenues for a specific territory
- Develop new customers and maintain business relationships through active and personal communications
- Work with internal departments to efficiently handle customer data and order needs
- Provide ongoing account management by holding regular discussions with customers
- Understand the customer's general business needs, and be able to effectively communicate Royal Circuits' unique approach to provide quick-turn PCB fabrication
- Develop and maintain technical knowledge of the various aspects of circuit board fabrication

PCB sales experience strongly preferred.

The successful candidate will demonstrate excellent communication and leadership skills as well as strong business acumen.

Please send resumes to victor@royalcircuits.com

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Career Opportunities

LENTHOR ENGINEERING
MAKING THINGS FLEXIBLE IN A RIGID WORLD®

Sales Account Manager

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

Responsibilities

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

Qualifications

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

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

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

Contact Oscar Akbar at: hr@lenthor.com

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LENTHOR ENGINEERING
MAKING THINGS FLEXIBLE IN A RIGID WORLD®

Senior Process Engineer

Job Description

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

Position Duties

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

Qualifications

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

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

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

Contact Oscar Akbar at: hr@lenthor.com

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Career Opportunities

Chief Technology Officer

SOMACIS Inc. is a well-established (over 45 years in business), advanced technology, high-reliability PCB manufacturer, located in Poway, California.

The CTO will be our first technology go-to expert and play an integral role in setting the company's strategic direction, development and future growth.

CTO will:

- Be responsible for the implementation, maintenance, and improvement of all processes and procedures
- Review current and future technologies and make recommendations as to the most suitable direction for the future technical development of the company
- Ensure company is in compliance with legislative and regulatory requirements
- Supply technical support in all areas throughout the company in accordance with instructions of the operations director
- Collaborate with both quality and production departments to ensure the quality of the product
- Plan and manage the evaluation, introduction and acceptance trials of new equipment and processes
- CTO will manage the operational and fiscal activities of PCB engineering processes, procedures, technology, and the Somacis Process Engineering Team

Required skills:

- B.S. degree in chemical, electronic, mechanical or manufacturing engineering technology or 10 years of progressively responsible experience as an engineer in the PCB industry
- Minimum ten years' engineering experience in related manufacturing industry
- Ten years' progressively complex technical experience in PCB manufacturing processes involving the latest state-of-the-art applications and techniques

Excellent benefits and relocation reimbursement.
Salary negotiable and dependent on experience.

Send resume to:
Cindy Brown, cindyb@us.somacis.com

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Quality Engineer

SUMMARY

Quality engineer with supervisory responsibilities, reporting to operations manager at Indium Corporation, European Operations. Candidate should be based within one-hour travel distance of Milton Keynes, U.K. M-F, 40 hours per week. Open until filled.

RESPONSIBILITIES

- Preventive/predictive maintenance, servicing, calibrations of equipment and facility in the work area
- Overseeing document control
- Approval of departmentally controlled docs
- SOP updates
- Full involvement in external audits, supported by the rest of the supervisor team and operations manager
- Internal and supplier auditing
- Product audits
- Sign off on TEOs and MRBs
- Reporting KPI performance to operations manager
- PPAP
- FMEA, control plan
- Customer complaints, RMAs investigation and reporting
- Project lead
- MSA design and implementation
- Maintenance of approved supplier list (ASL) and approved parts list (APL)
- Supplier risk assessments
- CAPAs, including SCARs
- Product qualifications
- Maintenance of equipment list
- Control of non-conforming product
- Sign off on change management (minor)

REQUIREMENTS

- IT literate
- Excellent written and verbal communication skills
- Strong interpersonal skills
- Numerate
- Six Sigma green belt
- Core Tools trained and certificate held
- Experienced auditor to IATF standard
- VDA trained auditor
- Several years' experience in a quality department within the automotive industry, including experience of IATF16949
- A recognised degree-level qualification in science
- Member of a certified industry organisation (CQI) or equivalent

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Career Opportunities

Image Department Operator

Alpha Circuit Corporation is a manufacturer of printed circuit boards located in Elmhurst, IL. We are currently seeking an operator in our Image department.

- All safety gear will be provided
- No experience required but a plus
- Full paid training provided
- Benefits: Health Insurance, 401(k), paid time off

Responsibilities:

- Expose dry film and liquid photo imageable ink
- Develop exposed photo imageable ink
- Develop exposed dry film
- Laminate dry film resist on inner layer and outer layer printed circuit panels
- Learn, understand, apply, and accept responsibility for in-process quality standards
- Be able to lift up to 15 lbs. shoulder high

If you are interested in this position, please contact Nita Buccino.
Email: nvb@alphacircuit.com,
cell: +1-847-489-2341.

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Service Engineer
Schmoll Laser Drilling and Direct Imaging

Burkle North America seeks a full-time service engineer in the Northeastern U.S. This position will provide expert-level service on multiple laser drilling and direct imaging product lines. Install, commission, and maintain Schmoll products at multiple customer sites across the Northeast. The candidate will perform modifications and retrofits as needed. Maintain complete and detailed knowledge of Schmoll products and applications and handle a wide variety of problems, issues, and inquiries to provide the highest level of customer satisfaction. Assist customers with the potential optimization of their machine functions and work with clients on application improvements.

Qualifications

Required: Bachelor's degree from a technical college/university in an associated field. Three years directly related experience, or equivalent combination of education and experience. Must possess a valid driver's license and have a clean driving record.

Preferred: Experience in control systems and electronic troubleshooting, as well as in general electrical and mechanical service tasks. Experience and knowledge in the PCB manufacturing process, with a focus on laser drilling and/or direct imaging.

Send resume to hr@burkleamerica.com.

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Career Opportunities

WHELEN®
TRUSTED TO PERFORM™

Process Engineering Director

Whelen Engineering Co., Inc. seeks full-time process engineering director in Concord, NH, to develop, plan and execute GreenSource Fabrication, LLC Div.'s process technology business strategy; manage process engineering activities, staff and compliance; improve process design, cost, quality and resource utilization; interact w/ customers and incorporate feedback; develop financial capital and labor projections; travel internationally for conferences, supplier and customer visits (15-25% worktime); write white papers, IP applications and give talks re. Division's products/processes.

Min. req.: U.S. Bachelor's or foreign equivalency in environmental science or engineering; min. 10 yrs. work exp. in: PCB fabrication process engineering; comprehensive and current experience in PCB fabrication/substrate markets w/ SAP tech; developing chemical and mechanical processes, chemistries and equipment for PCB manufacturing demonstrated by international experience implementing complex processes; ability to direct and troubleshoot PCB manufacturing problems; min. 5 years exp. leading, managing and training process engineering teams, developing and executing process technology business strategies and plans in worldwide PCB markets, including Japan, Taiwan, China, Europe; min. 3 years exp. giving talks, writing and presenting white papers; ability to travel internationally (15-25% worktime).

Send CVs to: Corinne Tuthill,
ctuthill@greensourcefab.com
or GreenSource Fabrication, LLC,
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Qualifications and skills

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

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

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

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

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

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Development Chemist
Carson City, NV

Develop new products and modify existing products as identified by the sales staff and company management. Conduct laboratory evaluations and tests of the industry's products and processes. Prepare detailed written reports regarding chemical characteristics. The development chemist will also have supervisory responsibility for R&D technicians.

Essential Duties:

- Prepare design of experiments (DOE) to aid in the development of new products related to the solar energy industry, printed electronics, inkjet technologies, specialty coatings and additives, and nanotechnologies and applications
- Compile feasibility studies for bringing new products and emerging technologies through manufacturing to the marketplace
- Provide product and manufacturing support
- Provide product quality control and support
- Must comply with all OSHA and company workplace safety requirements at all times
- Participate in multifunctional teams

Required Education/Experience:

- Minimum 4-year college degree in engineering or chemistry
- Preferred: 5-10 years of work experience in designing 3D and inkjet materials, radiation cured chemical technologies, and polymer science
- Knowledge of advanced materials and emerging technologies, including nanotechnologies

Working Conditions:

- Chemical laboratory environment
- Occasional weekend or overtime work
- Travel may be required

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Career Opportunities

Manncorp™

SMT Field Technician
Huntingdon Valley, PA

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

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

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

We Offer:
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- Retirement fund matching
- Continuing training as the industry develops

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U.S. CIRCUIT

Sales Representatives (Specific Territories)

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

- Florida
- Denver
- Washington
- Los Angeles

Experience:
- Candidates must have previous PCB sales experience.

Compensation:
- 7% commission

Contact Mike Fariba for more information.

mfariba@uscircuit.com

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This position is responsible for IPC and skill-based instruction and certification at the training center as well as training events as assigned by company's sales/operations VP. This position may be part-time, full-time, and/or an independent contractor, depending upon the demand and the individual's situation. Must have the ability to work with little or no supervision and make appropriate and professional decisions. Candidate must have the ability to collaborate with the client managers to continually enhance the training program. Position is responsible for validating the program value and its overall success. Candidate will be trained/certified and recognized by IPC as a Master Instructor. Position requires the input and management of the training records. Will require some travel to client's facilities and other training centers.

For more information, click below.

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For information, please contact:
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General Manager PCB and PCBA
Senior manager with experience in operations and sales. He has overseen a number of successful operations in Canada. Very strong candidate and has experience in all aspects of PCB operations. He is looking for a new full-time position in Canada.

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Strong relationship management skills. Sales experience focused on defense-aerospace, medical, high-tech PCB sales. Specializes in technical sales. Also has experience in quality, engineering, and manufacturing of PCBs. He is looking for a fulltime position in the Southeastern U.S.

Field Application Engineer (FAE)
Has worked as a respected FAE in the U.S. for global companies. Specializes in working alongside sales teams. Large experience base within the interconnect industry. He is looking for a full-time position.

Business Development Manager
Understands all aspects of interconnect technical sales from PCB design and fabrication to assembly and all technologies from HDI microvias to flex and rigid-flex. Has also sold high-tech laminates and equipment. Proven record of sales success. He is looking for a full-time position.

CEO/President
Specializes in running multi-million dollar companies offering engineering, design, and manufacturing services. Proven leader. Supply chain manager. Expert at developing and implementing company strategy. Looking to lead a company into the future. He is looking for a full-time position.

PCB General Manager
Forty years of experience serving in all capacities, from GM to engineering manager to quality manager. Worked with both domestic and global companies. Available for turn-around or special engineering projects. He is looking for long-term project work.

Process Engineering Specialist
Strong history of new product introduction (NPI) manufacturing engineering experience: PCB/PCBA. Held numerous senior engineering management positions. Leads the industry in DFM/DFA and DFX (test) disciplines. He is looking for either a full-time position or project work.

VP Sales Global Printed Circuits
Worked with a very large, global company for a number of years. Built and managed international sales teams. Created sales strategies and communicated them to the team. One of the best sales leaders in our industry. He is looking for a full-time position.

Plant Manager
This professional has years of experience running PCBA companies. Led his companies with creative and innovative leaderships skills. Is a collaborative, hands-on leader. He is looking for a full-time position.

National Sales Manager
Seasoned professional has spent the past 20 years building and growing American sales teams for both global and domestic companies. Specializes in building and managing rep networks. He is looking for a full-time position.

Global Engineering Manager/Quality Manager
Has experience working with large, global PCB companies managing both engineering and quality staff. Very experienced in chemical controls. She is interested in working on a project-by-project basis.

CAM Operators and Front-end Engineers
These candidates want to work remotely from their home offices and are willing to do full-time or part-time projects.

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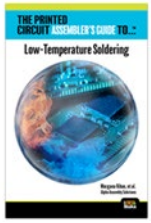
Process Validation, by Graham K. Naisbitt, Chairman and CEO, Gen3
This book explores how establishing acceptable electrochemical reliability can be achieved by using both CAF and SIR testing. This is a must-read for those in the industry who are concerned about ECM and want to adopt a better and more rigorous approach to ensuring electrochemical reliability.

Advanced Manufacturing in the Digital Age, by Oren Manor, Director of Business Development, Valor Division for Mentor a Siemens Business
A must-read for anyone looking for a holistic, systematic approach to leverage new and emerging technologies. The benefits are clear: fewer machine failures, reduced scrap and downtime issues, and improved throughput and productivity.



Low-Temperature Soldering, by Morgana Ribas, Ph.D., et al., Alpha Assembly Solutions
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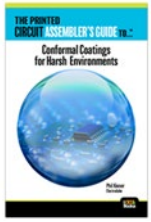

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MANAGING EDITOR: **NOLAN JOHNSON**
(503) 597-8037; nolan@iconnect007.com

PUBLISHER: **BARRY MATTIES**
barry@iconnect007.com

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

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

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

TECHNICAL EDITOR: **PATTY GOLDMAN**

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

ASSOCIATE EDITOR: **KIERSTEN ROHDE**
kiersten@iconnect007.com

ASSOCIATE EDITOR: **MICHELLE TE**
michelle@iconnect007.com

PRODUCTION MANAGER: **SHELLY STEIN**
shelly@iconnect007.com

MAGAZINE LAYOUT: **RON MEOGROSSI**

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

CREATIVE TECHNOLOGIST: **BRYSON MATTIES**

COVER: **SHELLY STEIN**

COVER IMAGE: **ADOBE STOCK © DANMORGAN12**

SMT007 MAGAZINE

SMT007 MAGAZINE®
is published by BR Publishing, Inc.,
942 Windemere Dr. NW, Salem, OR 97304

August 2020, Volume 35, Number 8
SMT007 MAGAZINE is published monthly,
by BR Publishing, Inc.

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EDITORIAL CONTACT

Nolan Johnson
nolan@iconnect007.com
+1 503.597-8037 GMT-7

SALES CONTACT

Barb Hockaday
barb@iconnect007.com
+1 916 365-1727 GMT-7

www.iconnect007.com