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I-Connect007

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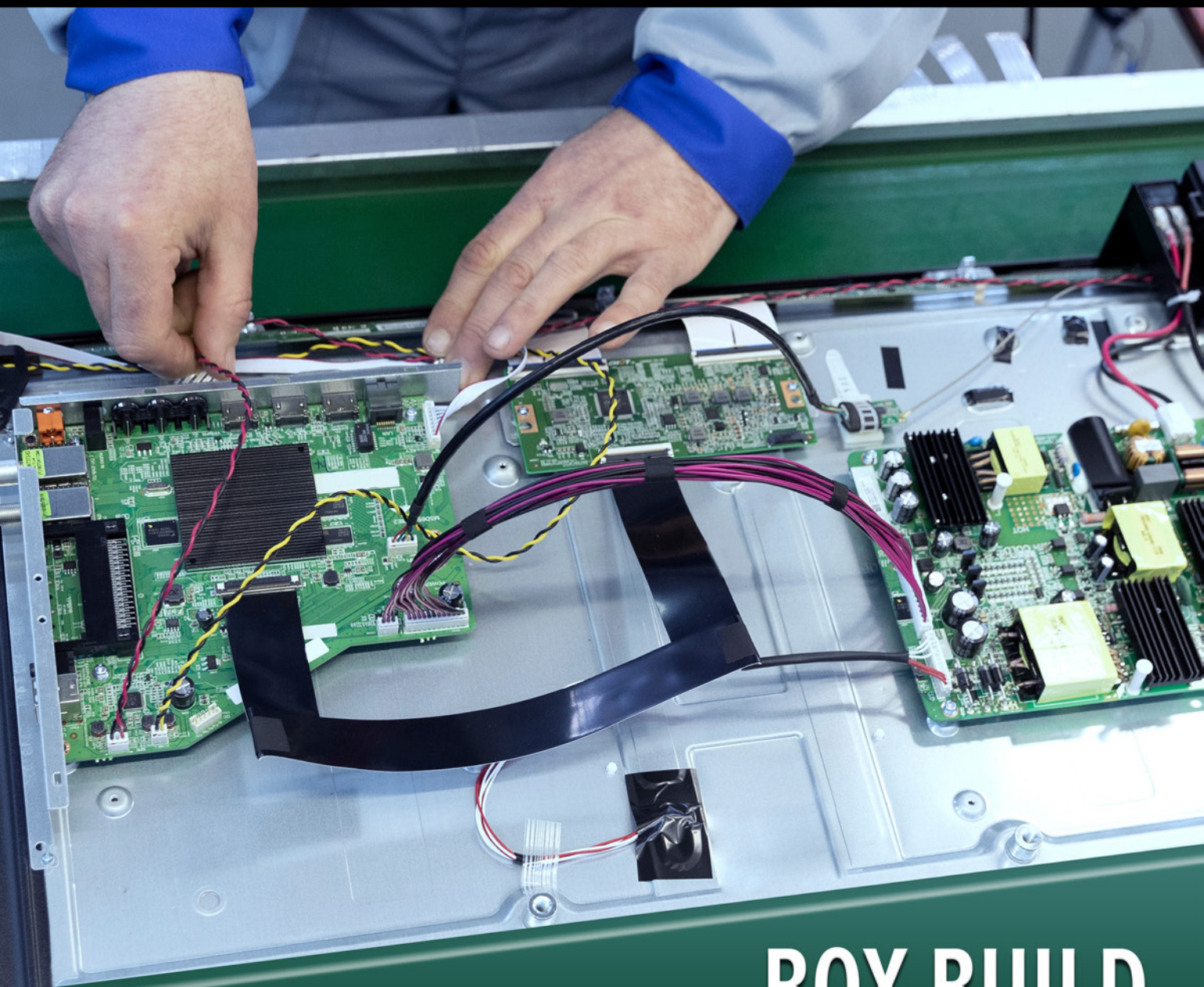

BOX BUILD

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Box Build

Keeping an existing customer is much easier than finding and winning a new one. But what do we do when our customers are looking for ways to localize or simplify their manufacturing chain? One trend is to add box build and final assembly to your product offering. In this issue, we explore the opportunities and risks of adding system assembly to your service portfolio.

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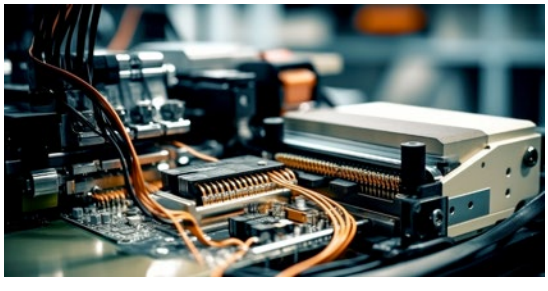

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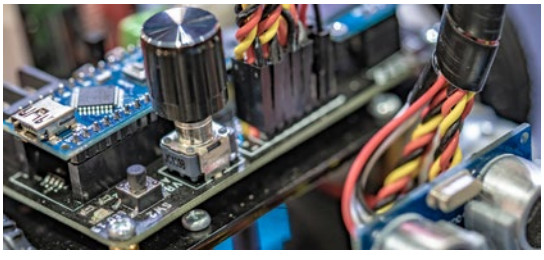

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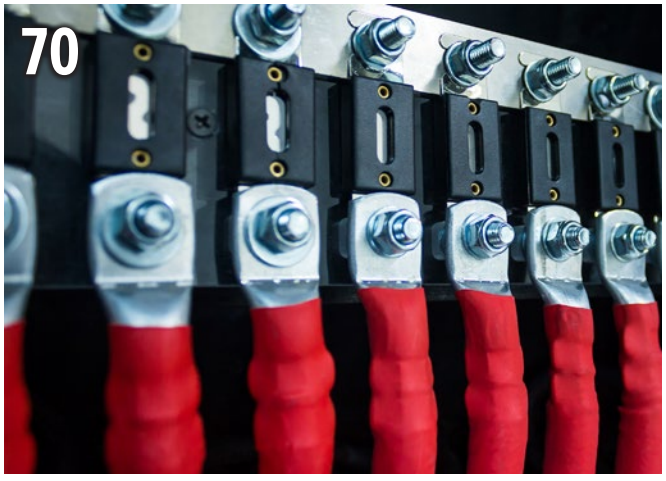

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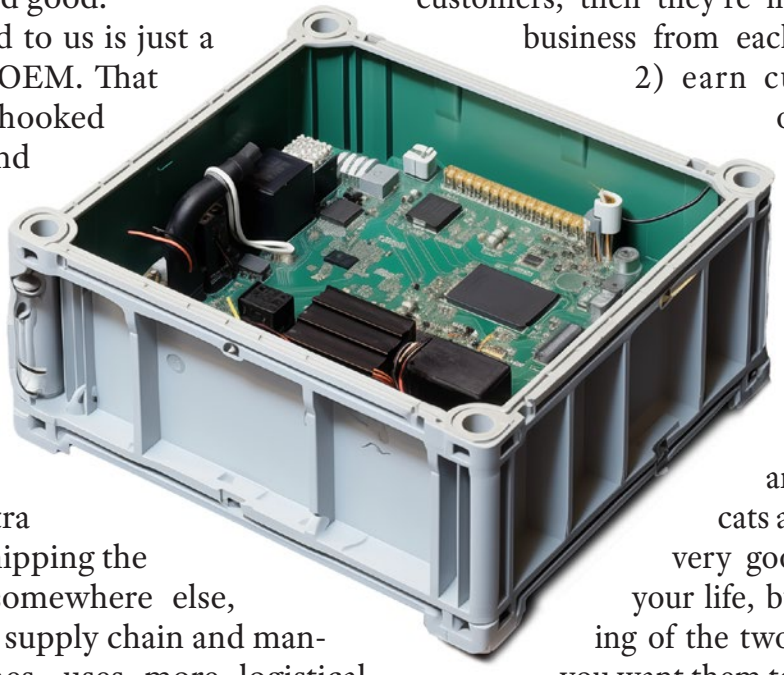
Do More, Get More

Nolan's Notes

by Nolan Johnson, I-CONNECT007

This month we're investigating box build, a manufacturing sector so closely adjacent to board assembly that some OEM customers think they're the same thing. To those of us doing this work, we know they're very different. Traditional electronic assembly work is typically concerned only with attaching the components to the circuit board. That's our idea of a "finished good."

But what's finished to us is just a subassembly to the OEM. That board still must be hooked up to other bits and bobs—maybe a power supply and a set of buttons, or perhaps an enclosure. There might be other boards to connect either directly or via wiring. Those extra steps mean you're shipping the populated boards somewhere else, which lengthens the supply chain and manufacturing lead times, uses more logistical resources, and more. So, what to do?



Well, for many OEMs, co-locating board assembly and box-build services make sense under these circumstances. Instead of a long line of vendors, each doing just one step of the assembly process, what if one vendor could do all the steps? This can make the OEM's life a lot easier. (I know, there are a lot of steps in assembly, but from an OEM product manager's point of view, board assembly is a single box on their supply chain flow chart.)

For many EMS suppliers, adding box-build services makes sense, too. In essence, an EMS provider's value-add is project-based specialized labor. If they can add even more specialized labor services, which are of value to their OEM customers, then they're likely to 1) get more business from each job in the queue; 2) earn customer loyalty by owning more of the customer's manufacturing process; and 3) attract new customers who need those expanded services as well. It's tempting. But board assembly and box build are like cats and dogs: Both can be very good for the quality of your life, but the care and feeding of the two are very different if you want them to thrive.

When I started researching this topic, I expected we would publish content on technical and practical box-build topics: workstations, tools, training, hiring, and such. But I soon realized this is a business planning story. What's different are the manufacturing philosophy and skill set; hiring criteria are similar, but also different. The supply chain, standards,

and functional test requirements are not the same. In other words, some unique investment is required when committing to box build, especially if you aspire to build the OEM's finished product and drop-ship their orders.

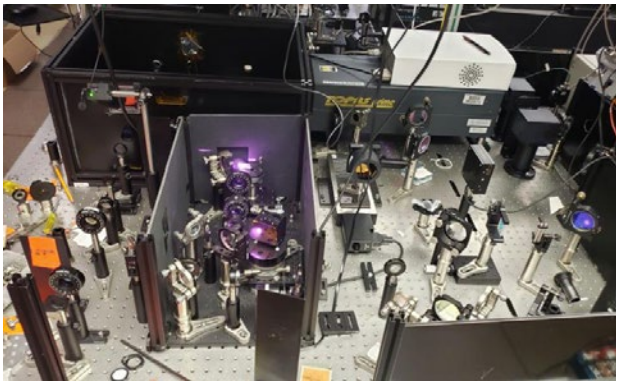
In this issue, Joe O'Neil gives a business-level tutorial on how box build is its own animal. Jon Schmitz, business development head at RiverSide Integrated Solutions, provides a day in the life of a company specializing in both assembly and box build. Columnist Mike Konrad brings a second practical perspective to his interview with two assembly experts doing box build. Since it's wiring that connects the boards to the box, we also talked in-depth with Christina Rutherford, a materials engineer specializing in aviation wiring harnesses, about the role of wire harness manufacturing and standards developed by both WHMA and IPC.

In addition to the feature content, we bring you a case study on the contribution of inspection equipment at ADCO, and an article by Susan Kayesar on how cloud-based services are contributing to improved design for manufacture throughout the manufacturing chain—including assembly. Dr. Jennie Hwang starts her column series on artificial intelligence, and we round out the issue with a box-build/wire harness related paper from the IPC APEX EXPO 2023 Technical Program on testing pull force on crimped connectors. (I guess there was some practical information on this issue, after all.)

If you aspire to grow your business, increase your margins, generate "more sticky" customer relationships, or do any combination of the three, you will find information on in this issue that will further your understanding and perhaps even help you avoid pitfalls. **SMT007**

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.

A Battery's Hopping Ions Remember Where They've Been



Solid-state batteries store and release charge by nudging ions back and forth between two electrodes. From our usual point of view, the ions flow through the battery's solid electrolyte like a gentle stream.

But when seen on an atomic scale, that smooth flow is an illusion: Individual ions hop erratically from one open space to another within the electrolyte's roomy atomic lattice, nudged in the direction of an electrode by a steady voltage. Those hops are hard to predict and a challenge to trigger and detect.

Now, in the first study of its kind, researchers gave the hopping ions a jolt of voltage by hitting them with a pulse of laser light. To their surprise, most of the ions briefly reversed direction and returned to their previous positions before resuming their usual, more random travels. It was the first indication that the ions remembered, in a sense, where they had just been.

The research team from the Department of Energy's SLAC National Accelerator Laboratory, Stanford University, Oxford University and Newcastle University described what they found in the Jan. 24 issue of Nature.

"You can think of the ions as behaving like a mixture of cornstarch and water," said Andrey D. Poletayev, a postdoctoral researcher at Oxford who helped lead the experiment when he was a postdoc at SLAC. "If we gently push this cornstarch mixture, it yields like a liquid; but if we punch it, it turns solid. Ions in a battery are like electronic cornstarch. They resist a hard shake from a jolt of laser light by moving backwards."

(Source: SLAC)

AI Opportunities, Challenges, and Possibilities, Part 1

SMT Perspectives and Prospects

by Dr. Jennie S. Hwang, CEO, H-TECHNOLOGIES GROUP

In this installment of my artificial intelligence (AI) series, I will touch on the key foundational technologies that propel and drive the development and deployment of AI, with special consideration of electronics packaging and assembly.

The objectives of the series:

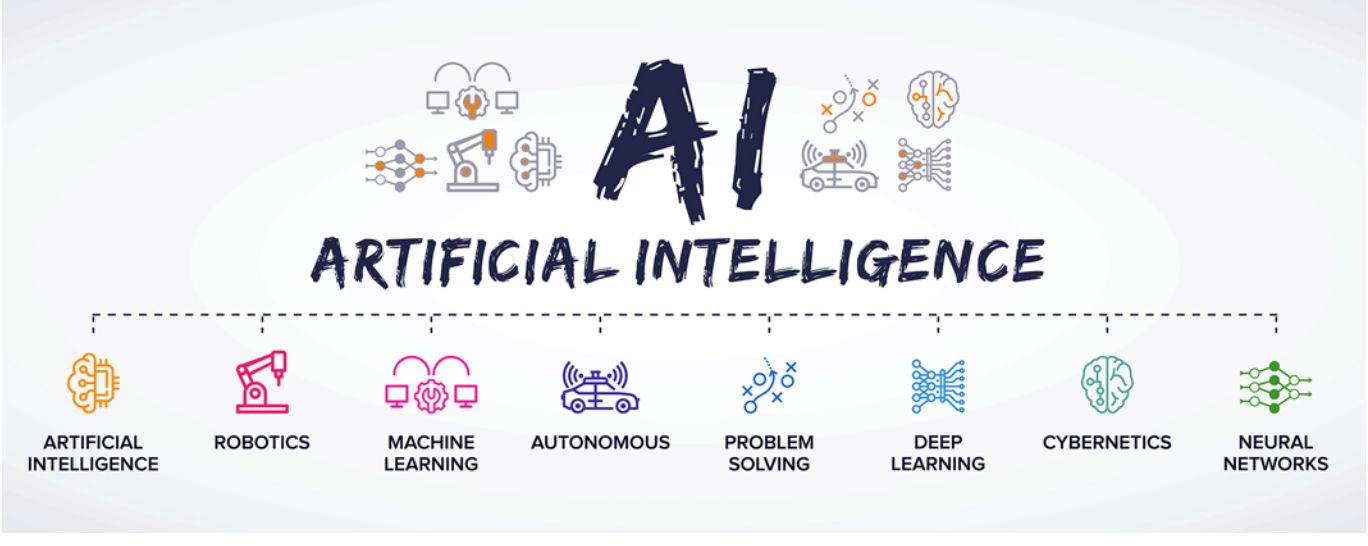
- Build and stay in the knowledge zone
- Spur innovative ideas and inspire new vistas for new opportunities
- Highlight what it takes to achieve AI with justified confidence and trust
- Achieve a balance between AI's omnipotent power and its potential downsides
- Leverage AI as a virtual tool to facilitate an individual's job efficiency and effectiveness and future job prospects, as well as the enterprise business growth

Breakthroughs and Transformational Technologies

Since the discovery of the electron in 1897 by Joseph John Thomson, striking breakthroughs of the 20th and 21st centuries include:

- Invention of the transistor in 1947
- Introduction of the microprocessor in 1972
- Official birth of the internet in 1983
- Internet-enabled hardware and applications during the decade of 1990s
- AI development in the decade of 2010s
- Introduction of AI ChatGPT-4 by OpenAI in 2023

Based on these breakthrough technologies, many products and services have been developed that improve the quality of human life and spur global prosperity—and it all came from the discovery of that tiny unit called an electron.



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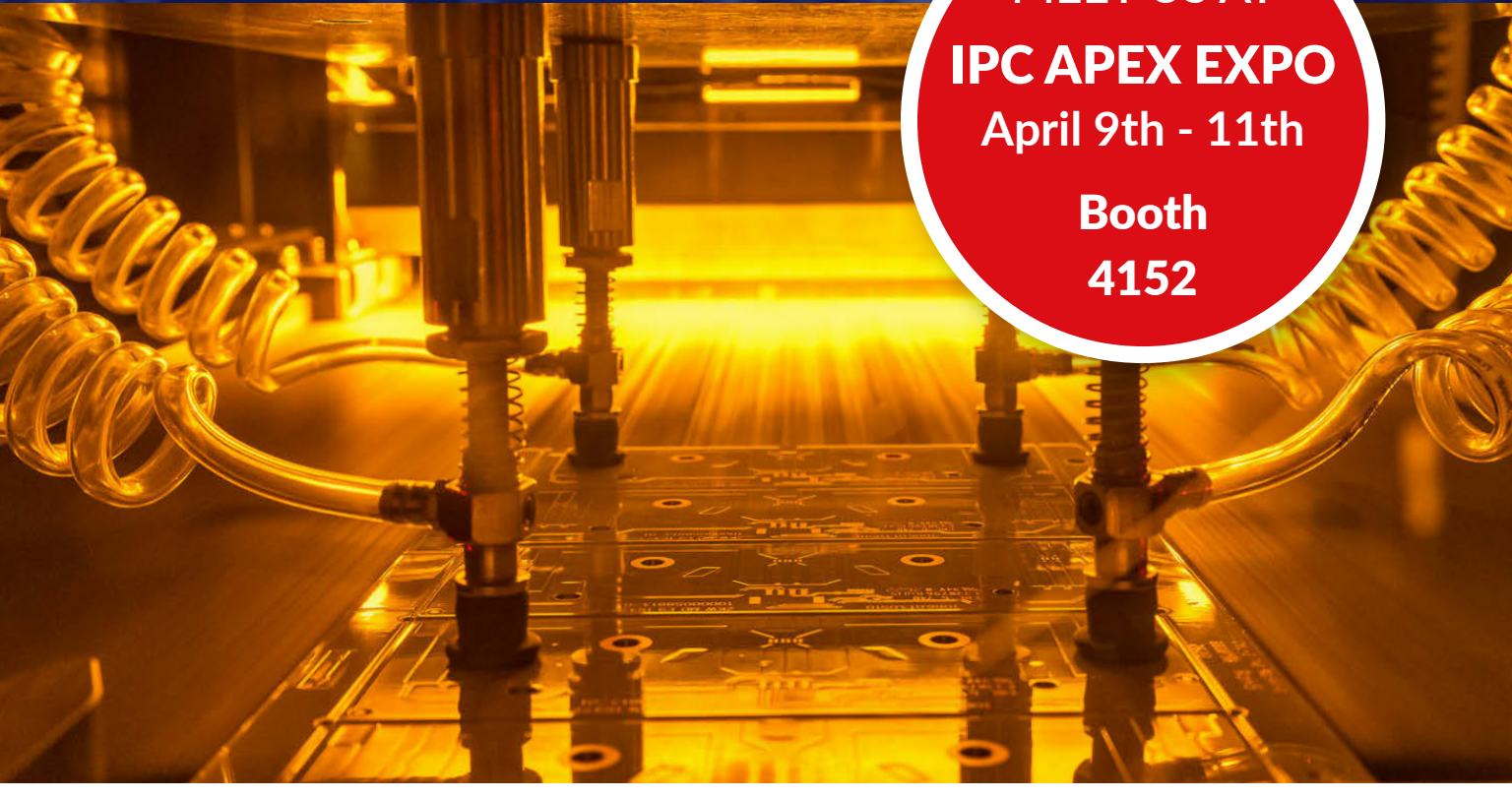

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Operating AI demands the use of heavy-load hardware that processes algorithms, runs the models, and keeps data flowing. These bandwidth-hungry applications necessitate higher-speed data transfer, which opens a crucial role for photons by taking advantage of the speed of light to deliver greater bandwidth and lower latency and power. Hardware components typically will connect via copper interconnects, while the connections between the racks in data centers often use optical fiber. CPUs and GPUs also use optical interconnects for optical signals.

Both electrons and photons will play an increased role. AI will drive the need for near-packaged optics with high-performance PCB substrates (or an interposer) on the host board. Co-packaged optics, a single-package integration of electronic and photonic dies, or photonic integrated circuits (PICs) are expected to play a pivotal role.

AI Market and Hardware

To AI, high performance hardware is indispensable, particularly with computing chips. As AI becomes embedded in all sectors of industry and all aspects of daily life and business, the biggest winners so far are hardware manufacturers: 80% of AI servers use GPUs and it's expected to grow to 90%. In addition to GPU, the required pairing memory puts high demand for high bandwidth memory (HBM). The advent of generative AI further thrusts accelerated computing, which uses GPUs along with CPUs to meet augmented performances.

Although the estimated forecast of the future AI market varies, according to PwC[1], AI could contribute more than $15 trillion to the global economy by 2030. Most agree that the impact of AI adoption could be greater than the inventions of the internet, mobile broadband, and the smartphone combined.

AI Historical Milestones

AI is not a new term. John McCarthy coined "artificial intelligence" and held the first AI conference in 1956. "Shakey the Robot," the first general-purpose mobile robot, was built in 1969.

In the succeeding decades, AI went through a roller coaster ride of successes and setbacks until the 2010s, when key events, including the introduction of big data and machine learning (ML), created an age in which machines have the capacity to collect and process huge sums of information too cumbersome for a person to process. Other pace-setting technologies—deep learning and neural network—were introduced in 2010, with GAN in 2014, and transformer in 2017.

The 2020s have been when AI "finally" gained traction, especially with the introduction of generative AI, the release of ChatGPT on Nov. 30, 2022, and the phenomenal ChatGPT-4 on March 14, 2023. It feels like AI has suddenly become a global phenomenon. The rest is history.

AI Bedrock Technologies

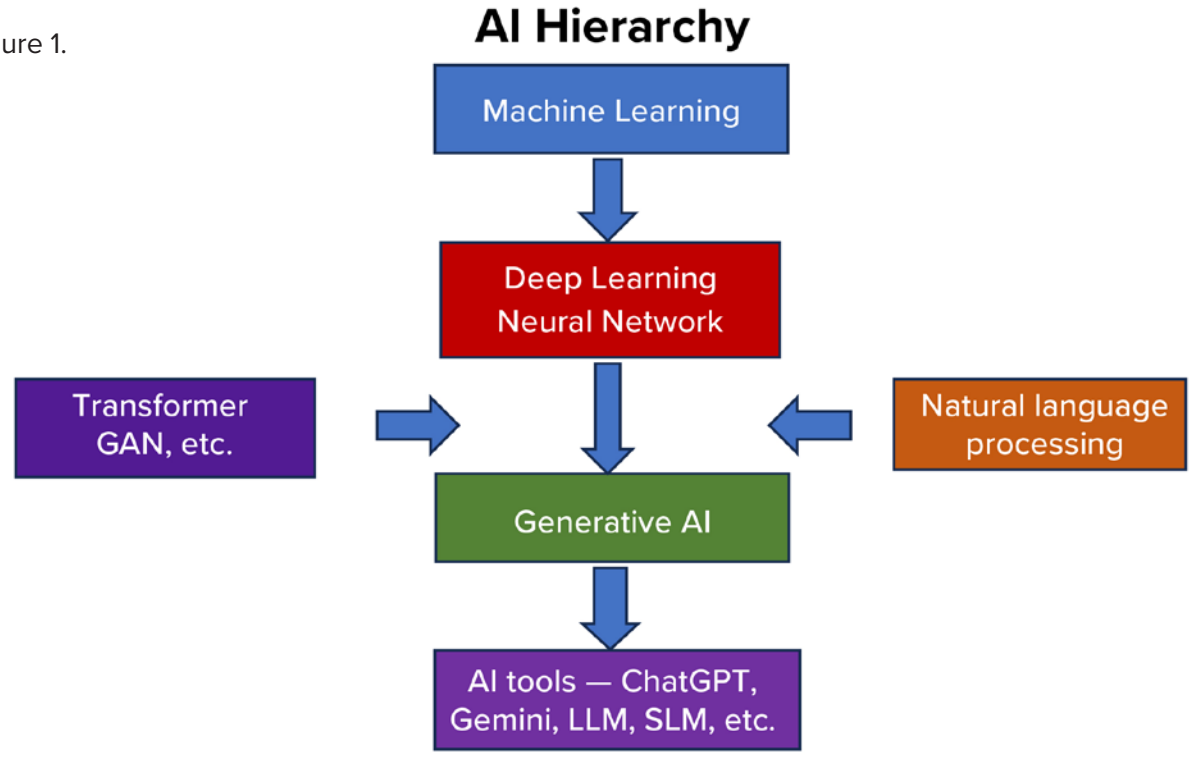
Generally speaking, AI is a digital technology that mimics the intellectual, analytical, and creative ability of humans, largely by absorbing and finding patterns in an enormous amount of information and data. AI covers a multitude of technologies, including machine learning (ML), deep learning (DL), neural network (NN), natural language processing (NLP), and their closely-aligned technologies. In one way, AI hierarchy can be shown in Figure 1, exhibiting the interrelations and evolution of these underpinning technologies.

Now I'd like to briefly highlight each technology:

Machine Learning

Machine learning is a technique that collects and analyzes data, looks for patterns, and adjusts its actions accordingly to develop statistical mathematical models. The resulting algorithms allow software applications to pre-

Figure 1.



dict outcomes without explicit programming and incorporate intelligence into a machine by automatically learning from the data. A learning algorithm then trains a model to generate a prediction for the response to new data or the test datasets.

There are three types of ML: supervised, unsupervised, and reinforcement.

- Supervised ML is task-driven and requires a data analyst to provide input and a desired output, then determine which variables the model should analyze
- Unsupervised ML is data-driven and does not have labeled data. Its focus is learning more about the data by inferring patterns in the dataset without reference to the known outputs.
- Reinforcement learning uses algorithms that learn from outcomes and decide which action to take next. In reinforcement learning, there is no data input, or desired output but the reinforcement agent decides what to do to perform the given task by learning from its experience with a trial-and-error method to achieve the maximum reward in an environment. An agent learns to make decisions by interacting with an environment and receives feedback in the form of rewards or penalties based on the actions it takes.

In addition to these basic ML techniques, more advanced ML approaches continue to emerge.

ML understands patterns and can instantly see anomalies that fall outside those patterns, making it a valuable tool in myriad applications, ranging from fraud detection and cyber threat detection to manufacturing and supply chain operation.

Deep Learning

Deep learning is a subset of machine learning based on multi-layered neural networks that learn from vast amounts of data. It comprises a series of algorithms trained and run on deep neural networks that mimic the human brain to incorporate intelligence into a machine. Most deep learning methods use neural network architectures, so they are often referred to as deep neural networks. Software architecture (type, number, and organization of the layers) is built empirically following an intu-

ition-based optimization process, with training data in the loop to tune DL model parameters. Training for DL software occurs "atomically" and with strong coupling across all layers of the DL software.

The increased accuracy of DL software requires more complex implementations in which the number of layers, their size (number of neurons), and the amount of data used for training increase enormously.

Generative AI

I tried ChatGPT to see how the bot explains generative AI:

"Generative AI refers to a category of artificial intelligence (AI) that focuses on creating new and original content. It uses models and algorithms to generate data, such as text, images, audios, or even videos, that resemble human-created content. Generative AI models are trained on large datasets and can generate creative and coherent outputs based on the patterns and information that have been learned. They have applications in various fields, including art, language, music, and more."

A generative AI model, in a mathematical representation implemented as an algorithm, can create something that didn't previously exist by processing a large amount of visual or textual data and then determining what things are most likely to appear near other things using deep learning or neural networks. Programming work goes into creating algorithms that can recognize texts or prompts. It creates output by assessing an enormous corpus of data, responding to prompts with something that falls within the realm of probability as determined by that corpus of data.

Generative AI tools offer the ability to create essays, images, and music in response to simple prompts.

My next column will highlight the foundational technologies behind AI, including the large language model (LLM) and foundation model. **SMT007**

References

1. PwC's Global Artificial Intelligence Study: Exploiting the AI Revolution, pwc.com.

Appearances

Dr. Jennie Hwang will teach a Professional Development Course, "Artificial Intelligence – Opportunities, Challenges & Possibilities," on Monday, April 8, at IPC APEX 2024. She will also teach a course titled, "High Reliability Electronics for Harsh Environments" on April 7.

Dr. Jennie S. Hwang, an international businesswoman, international speaker, and a business and technology advisor, is a pioneer and long-standing leader in SMT manufacturing since its inception, and in developing and implementing lead-free electronics technology and manufacturing.

She has served as chair of Artificial Intelligence-Justified Confidence for DoD Command and Control study, chair of AI Committee of the National Academies, and Review Panels of NSF National AI Institutes. An International Hall of Famer (Women in Technology), she has been inducted into the National Academy of Engineering, named an R&D-Stars-to-Watch, and received the YWCA Achievement Award. She has held senior executive positions with Lockheed Martin Corp., and was CEO of International Electronic Materials Corp. She is currently CEO of H-Technologies Group, providing business, technology, and manufacturing solutions.

She has served as chair of the Laboratory Assessment Board, the DoD Army Research Laboratory Assessment Board, and the Assessment Board of Army Engineering Centers. She is on the board of Fortune-500 NYSE companies and civic and university boards, Commerce Department's Export Council, National Materials and Manufacturing Board, NIST Assessment Board, various national panels/committees, and international leadership positions.

She is the author of 10 books (four as co-author) and 700+ technical/editorial publications. She is a speaker and author on trade, business, and education issues. Her formal education includes four academic degrees (Ph.D., M.S., M.A., B.S.), as well as Harvard Business School Executive Program and Columbia University Corporate Governance Program. To read previous columns, click here.

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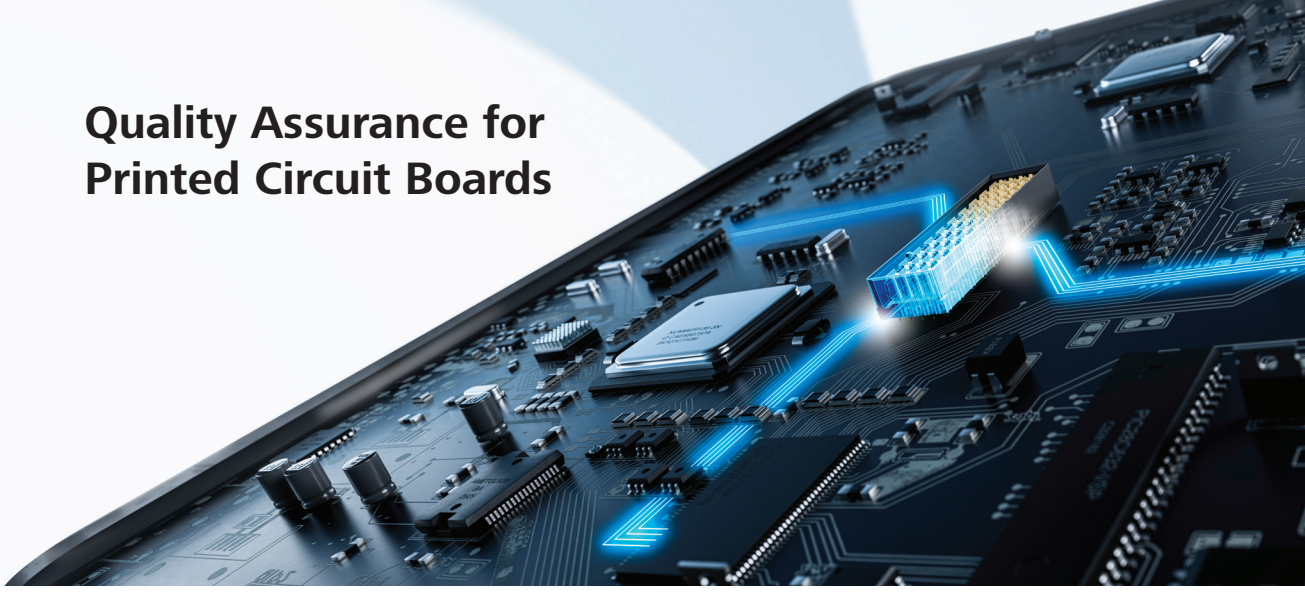

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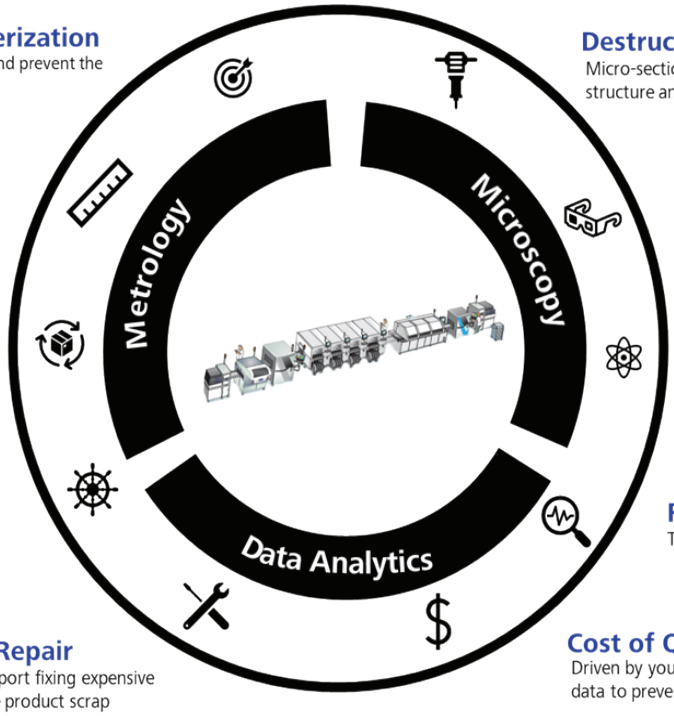

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Thinking Inside the Box for a Change

Feature Interview by the I-Connect007 Editorial Team

In this interview, Joe O'Neil, who leads the IPC Education Foundation, discusses the growing importance of box build from an EMS provider perspective. Supply chain disruptions and the desire to offer more value to customers have fueled interest in box build. Additionally, mass customization is emerging as a trend, allowing for personalized product variations. While Tier 1 companies have mastered this approach, Tier 2 and 3 players hold significant opportunities in the industrial space.

Nolan Johnson: Joe, from an EMS perspective, is box build growing?

Joe O'Neil: Yes, and the global events of the past four years may have led to an acceleration of a natural progression wherein EMS players continue to expand, moving further upstream—or downstream—as they figure out their niche in the EMS provider space.

In terms of customer retention, box build was very sticky for us over the years. The supply chain disruption and getting your hands on the later stages of the product as it went through the transformation process increased in importance. Providing more value to the customer through box build is a good reason to get into it. There can be some factors you can put into your in-region vs. low-cost-region calculator to determine where it makes sense for OEMs to have their product built.

Another driver on a macro level is mass customization. This is the ability to build in-region and provide options for the "31 flavors" of your

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Joe O'Neil

product. Now, customers can decide what configurations they want today and get them tomorrow. It is a major differentiator for the OEM, and also an opportunity for the EMS suppliers to capitalize on proximity.

Johnson: How much is that style of built-to-order business growing in electronics manufacturing?

It's surprising in the industrial space. Think of the maturity of the Dell model. You can configure your laptop, and it shows up the next morning. That's pretty impressive. The Tier 1 companies have been executing quite well in this space. My perspective is shaped more by the sub-$100 million EMS supplier folks.

Johnson: Tiers 2 and 3 are probably where the most interesting stuff is happening.

That's where the opportunities lie. Certainly, the U.S. is where the largest pool of players is. While there are new service opportunities, in-region fulfillment presents some challenges, or at minimum, some things to consider before you jump into a very capital- and facility-space-intensive sector of the business.

Johnson: Is it labor intensive?

Yes, but it's no harder than staffing SMT lines, or finding skilled, qualified engineers for that role. This is one of those areas where you can find talent in adjacent industries and pull them in. So, it's one of the easier areas to find talent vs. the usual dynamic of EMS guys stealing labor from each other. While the labor pool is a little bit broader, the cost of quality is certainly higher.

Barry Matties: Isn't box build more employee-dependent, or is automation really a factor there?

Box build comes in a lot of different flavors. There are places for automation, especially in the high customization piece. The ability is there, for example, to have a robotic arm turning screws. But the lower quantity, higher customization, just-in-time type of service better lends itself to labor.

Johnson: U.S. companies might be looking at box build to increase their revenue, but does it improve their margin?

You may lose a point or two in your percentage of margin, but in terms of hard dollars, it can be quite profitable. You can stack your margins a bit. Keep the traditional board-level business where overheads and everything are already calculated. Then, perhaps, add more overhead allocation as you go upstream, delivering higher levels of subassemblies and even final assemblies. But it cuts both ways: Your top line is growing, but your time-to-revenue, inventory, carry, and cash-to-cash cycle will be extended.

Many EMS companies operate on a purchase order-to-purchase order model. When you get into this higher level of engagement with an OEM, master service agreements become increasingly important.

We all know the example of the $10,000 screw or the $10,000 resistor. You have 99.9% of the bill of materials, and that's great, but you can't build it until you have 100%. With box build,

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that sub-penny part isn't holding up a couple hundred dollars on a board; now it might be holding up tens of thousands of dollars of a system. Put a couple hundred of those stuck jobs together, and it can get real dark really quickly.

You'll need to have your inventory controls really tight, and you'll have systems visibility on multi-level BOMs, and what-if scenarios. It's a different level of system and maturity when you go from 100 boards to 100 boxes. Are you building out 19-inch racks for a customer? If you're doing 100 racks a day, and you bring in two weeks' worth, suddenly you might have just filled a quarter of your facility with pallets. Then you have ESD, foam boxes, packaging pallets, the loading dock—it's a major impact on a facility and not something you can go into overnight.

If you want to make box build part of your core value proposition, then you must understand your cash-to-cash cycle—your supply base. As we went through the supply chain ripples, people got gun shy about just-in-time deliveries and quickly pivoted to adding more safety stock and increasing inventory levels. Everyone relaxed in terms of inventory efficiencies. However, when you manage these higher-level assemblies, you may need to consider returning to just-in-time delivery practices. You need a good vendor-supplier management program.

"You need a good vendor-supplier management program."

With an in-region supplier, those challenging parts can be fed upstream into your supplier base. Now you don't need to bring in two weeks' worth of those racks. You can agree to 100 a day, transform them, and ship them out. The next day, another 100 show up, but it requires that you have vendor management in place and some reliable local partners.

Matties: You're describing a sizable investment just to get started. Do most EMS companies offer box-build services?

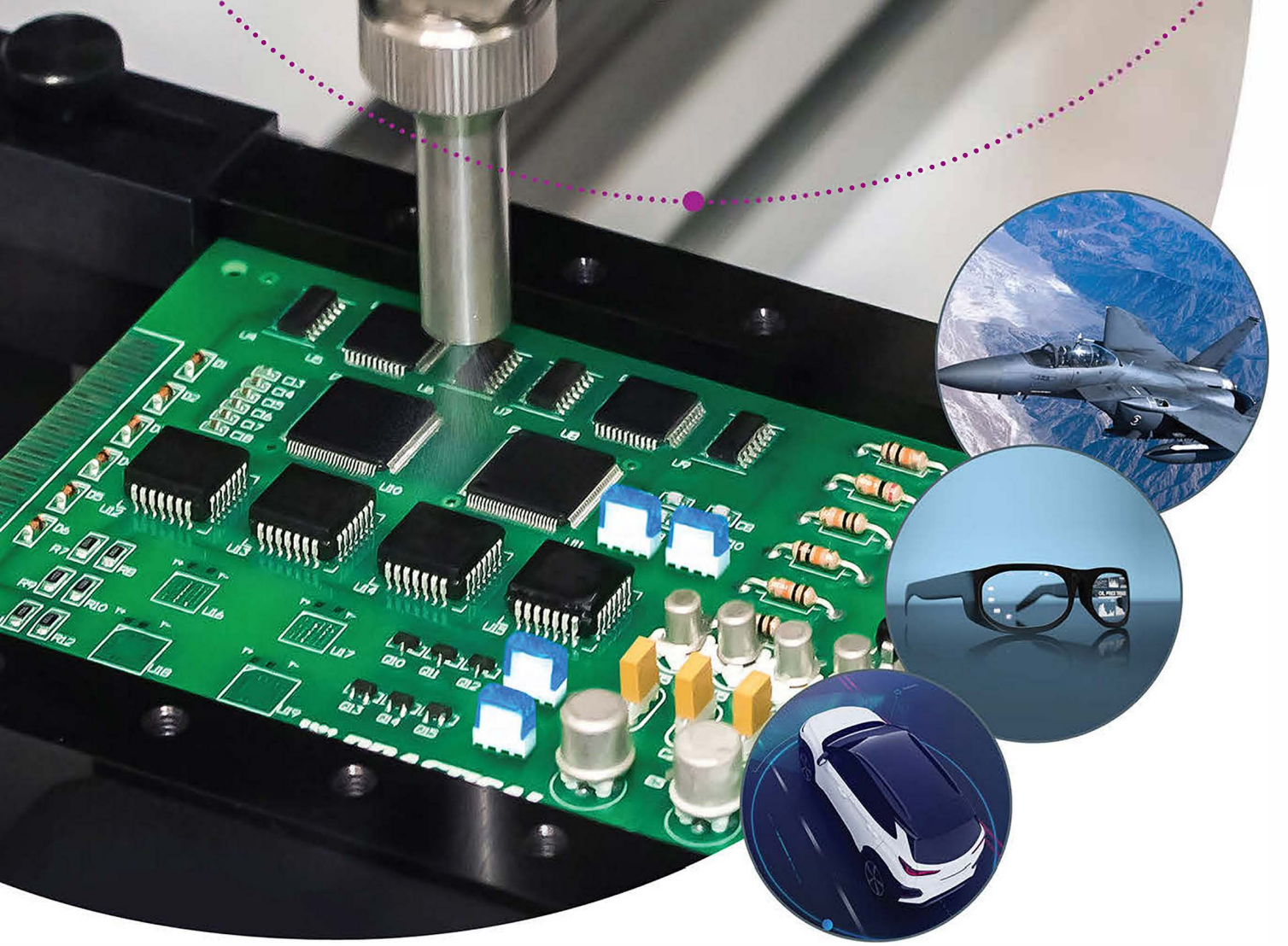
There are some ways to mitigate the amount of that capital requirement. But this has been the Tier 1 "secret sauce" for years: They deliver the speed and customization that the OEMs use to differentiate.

It's an up-and-coming area in the Tier 3 space. When you've got an OEM customer who regularly wants to pull or push something on the schedule, it's a good opportunity to understand their business. What's causing them to move schedules? Maybe they're having staffing problems, or their systems aren't as robust as yours. Ask your customers if they've thought about outsourcing at a higher BOM level. Maybe they're at that tough spot where they either take on another 100,000 square feet or outsource. If they're struggling with their sourcing model, it's an opportunity to take on larger pieces of business.

If you can work out a partnership agreement, where you're not carrying a ton of capital, then maybe you're still invoicing at the board level and holding consigned stock, and you charge for value-add as you keep going upstream. That could take pressure off the capital requirement. But it requires that you have really good systems; you can control who owns what, the delivery details, and compliance, as well as work with everyone's accounting practices and system requirements. It's all doable, but you can't afford to make a lot of mistakes at these higher levels.

Marcy LaRont: Is cash management the biggest barrier for Tier 3 companies?

It's a combination of cash and systems. You'll need multi-layer capability with tight traceability, and with that comes additional opportunities for back-end services, like repair and refurb services. But, if somebody cuts in an ECO today, three levels down on your BOM, you'll have to manage that efficiently. Many Tier 3 companies' existing tools may have those



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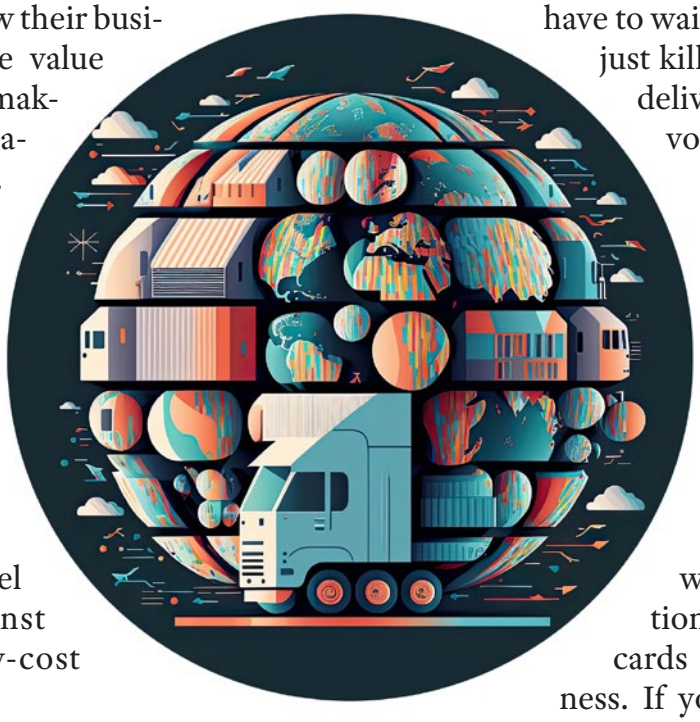
capabilities, but they're not used to working deeper than a single- or two-level indentation.

Johnson: It sounds like this will make their supply chain management skills an order of magnitude more complex.

The supply chains in the EMS world are the real challenge, but we have methods in place to recover in 24 hours from just about any event. However, you don't have that type of recovery window for these custom-made mechanical parts. It's a different puzzle.

That said, I think most of the industry is looking for ways to grow their business by bringing more value to the customer and making those customer relationships more sticky. Higher-level assemblies and box build is an achievable next step, perhaps even a logical step. We've talked about regional manufacturing, and building close to your customers gives you an advantage. It helps level the playing field against the high-volume, low-cost regional play.



Johnson: Joe, how should an EMS company get into box build? Where do they start?

It's a logical series of events. It often makes sense to start with your existing customer base. Have an open discussion with them about the direction your company is heading, what it can unlock for them, where you are in the process, and how you'd like to explore options with them. Those options could be cutting in as a second source to their current solution, an internal or external supplier. Make sure you can repeatedly and reliably meet their needs. You must de-risk it before changing the current supply chain. You'll have very short customer relationships if you pull them into trouble as they're searching for solutions.

If you're transparent about where you're at, where you're going, and the milestones, then they'll be more comfortable showing their cards. There's a reason they're having trouble, and sometimes they hope that changing suppliers will fix their problems. But often, there are underlying challenges—it could be with their processes, or maybe their marketing and sales department says something like, "It's great that we offer 31 flavors, but if they want anything other than vanilla, they have to wait eight weeks, and that's just killing us." This is a way to deliver some additional flavors tomorrow.

It's important to get that on the table. It all starts with candor and a dialogue of trust. It's tough because these conversations tend to happen in a competitive bid situation. At the end of the day, the customer you want is willing to have that relationship. So, showing your cards isn't a point of weakness. If you don't win that one, you're much more prepared for the next one. But don't try to fake it.

Within several months, you can be pretty well down the path of having people, processes, and systems in place to pivot with the opportunities that come along.

Matties: In some cases, you could find yourself controlling everything about that customer's production. Do you feel like the relationship has to be stronger between a box build and their customer than with a fabricator?

Yes, but also the reverse. Expect your customer to do a deeper dive on you as well. That's where that candor brings value. The conversa-

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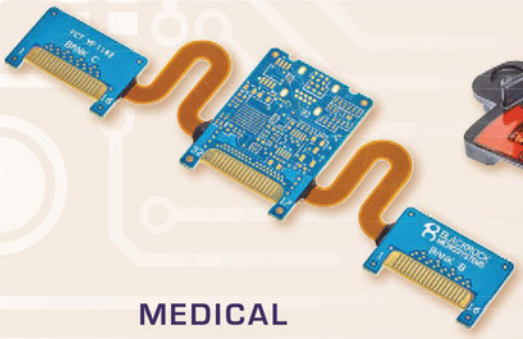

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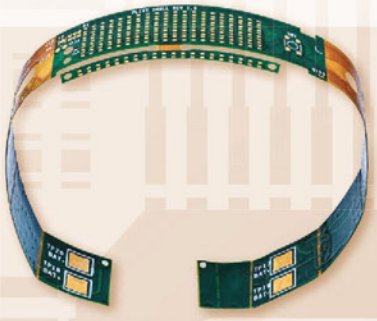

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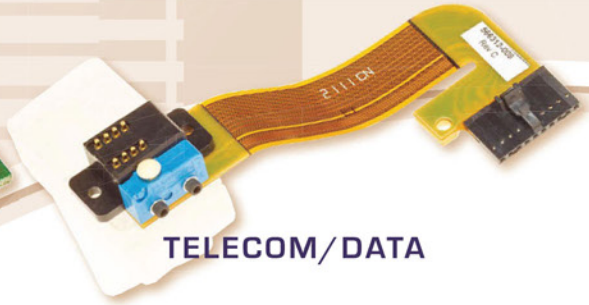

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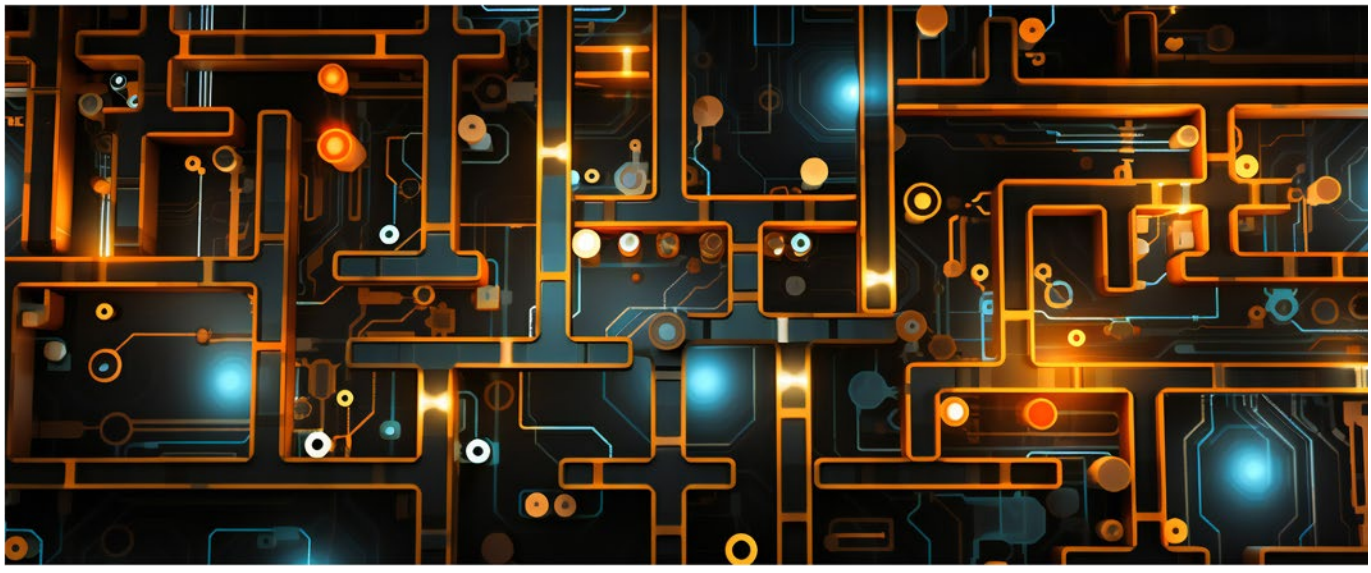

tion might be something like, "We modeled this, and it will have a $3 million impact on our cash flow. That's not an acceptable risk for my company at this moment. But if we approach it this other way, we can cut that risk in half." You'll still get all these other benefits; the customer is getting invoiced, and the cash-to-cash cycle gets the benefit. You want a customer who understands the value of healthy supplier partners.

LaRont: Do you see any big shifts coming in supply chain? Is there something we should be on the lookout for?

I look at the margins through the value stream, and I look at distribution. I still try to wrap my head around someone in the value stream who doesn't touch or transform a part, driving the highest margins of the value stream. Maybe that's just jealousy. I can't figure it out.

The mass customization piece still has a way to go, and it's really hard to do that unless you're in-region. That's a big opportunity.

Johnson: From your perspective as an EMS supplier, does wiring harness require the same skill set as box build? How does that fit?

If you're getting into higher-level boxes, you will most likely need a great supplier there. There are very simple commodity types, such as wires, interconnected harnesses, and things like that. Then there are defense and aerospace, which is a whole different market, and automotive is yet another market.

Johnson: Final thoughts, Joe?

Most EMS companies already have some level of capability for box build. They have a great chain of component level suppliers for assembly; it's almost the same with your mechanicals. Look for commonality. If you have eight customers all using 19-inch racks, there may be some benefit to doing some of that yourself versus outsourcing it.

The wire harness business is going through the transition to automation and machine learning, including tools, visual aids, and inspection. It's transforming that industry. Historically, wire harness has been 100% customized: just a big piece of wood with some nails in it and a wire diagram. I would ask customers, "Is there anything else we can do for you? What headaches are you having?" They will invariably mention that they would appreciate an introduction to a solid wire harnesses supplier. It's a tough business, so go into it with your eyes wide open.

Johnson: Joe, thank you for your time and insight.

Absolutely. **SMT007**

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A CM's Perspective on Box-build Practices

The Knowledge Base

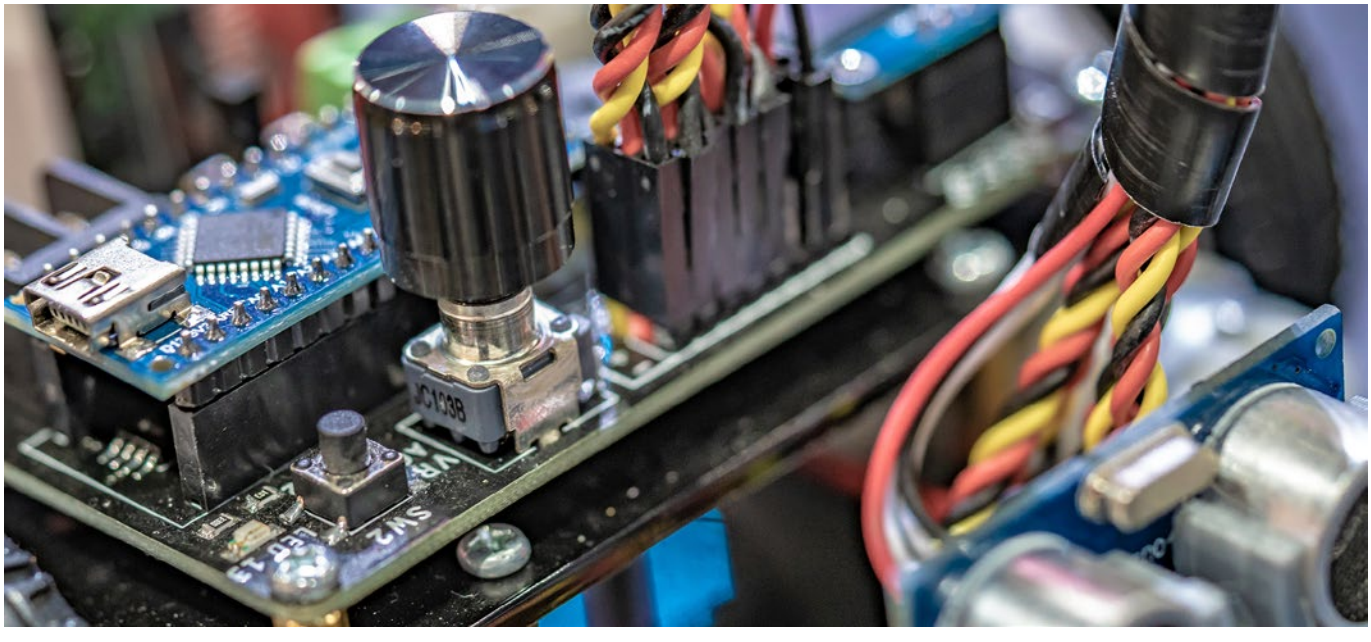
Feature Column by Mike Konrad, SMTA

In the ever-evolving landscape of electronics manufacturing, the box-build process stands out as a critical phase that bridges the gap between individual component manufacturing and the delivery of a fully functional electronic system. This intricate procedure, encompassing the assembly of everything from PCBs to wire harnesses and mechanical enclosures, demands a high level of precision, efficiency, and innovation. As the electronics assembly industry expands and diversifies, understanding the best practices within box-build assembly has become paramount for manufacturers aiming to stay ahead in a competitive market.

In this column, I will delve into the subject of box-build best practices within the electronics assembly space. These conversations will explore the nuances of systems integration, focusing on the strategies industry leaders employ to navigate challenges such as supply chain management, quality control, and technological advancements.

To discuss box-build best practices, I invited Allison Budvarson, COO of Out of the Box Manufacturing (OBMFG), a contract manufacturer in Renton, Washington, and Chris Denney, CTO of Worthington Assembly, a contract manufacturer in South Deerfield, Massachusetts, to provide insight on box-build best practices based upon their experience and company protocols.

Through this interview, we aim to shed light on the methodologies that have proven successful in ensuring that electronic assemblies



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Can you walk us through a complex box-build project your company worked on? Specifically, detail how your company addressed any technical challenges that arose, including any innovative solutions you implemented to overcome them.

Allison Budvarson: OBMFG recently went through an NPI build for a new and very complex box-build assembly, which included several densely populated PCBAs, wire assemblies, mechanical assembly, and test requirements. This is a project we have been working on with our customer over several months, which started with building the PCBAs and then moving to box-build.

We're unique in that we offer a dedicated work cell for our customers to utilize during an NPI, so that we can work side by side with them on our shop floor during product realization. In this case, when it came time to assemble the box-build, the customer spent a week in our facility with us, assembling the first articles and working through test while we created assembly documentation and set up a 5S work cell to accommodate production qualities in the future. One of the challenges in a project with this many subassemblies and assembly steps was how and where to insert inspection and test points to accomplish the most efficient and high-quality assembly process.

Chris Denney: We don't really get involved in anything I would call a "complex" box-build. Most of the box-build we do is small enough to sit on a workbench, nothing larger than a VCR. (Does anybody even know what those are anymore?)

I recall working on this one particular box build that involved two circuit boards sandwiched together and then crammed inside a small plastic case about the size of an iPhone. All the components on this board were through-hole components and included a

Chris Denney

large serial port that the end user would interface with. Because of the thinness of the plastic case and the fact that two circuit boards were being sandwiched together, it required us to cut all the through-hole pins flush to the PCB and fold other devices flat to the board to keep it compact enough to fit into the case. The design was so old that the customer was forced to ship serial-to-USB adapters with each order they sent to customers. It also used rectangular LEDs to provide feedback to the user, but these rectangular LEDs were very difficult to align with the plastic case's overlay.

Being that it was all through-hole, it was already time-consuming and expensive for us to assemble. We asked the customer if they would be interested in changing the design to use surface mount devices, but all their engineers had either left for other jobs or retired. We decided to take on the task ourselves instead. We redesigned it with all surface mount devices (except for the LEDs), got everything to fit onto a single PCB, and changed the serial port to a USB port.

The last thing we tackled was getting the LEDs to align to the overlay properly without

fussing around with them. These LEDs needed to be through-hole as they had to stand off the PCB and push through the plastic enclosure's cutouts to align properly with the overlay and provide feedback to the end user. To make this easier, we created a "poka-yoke" device that held the LEDs in place while we soldered them. It made it impossible to get their height or their alignment incorrect. So, by the time we put the PCB into the enclosure, they fit perfectly without having to adjust their alignment first.

Explain the steps from receiving a box-build project's specifications to the final assembly and testing phase. How do you ensure that all components, such as PCBs, wiring harnesses, and mechanical enclosures, integrate seamlessly?

Budvarson: We always start with the relationship. Our business development and technical sales teams begin by meeting with the customer to gain a well-rounded understanding of the assembly as well as the customer's goals and timelines. From there, we gather documentation, build a quote and assembly docs, create necessary fixtures, and plan the work according to the customer's delivery needs. We generally batch the various subassemblies and ensure they all meet quality requirements prior to beginning the box-build. As in the previous example, a customer can visit us to see how things are working as we begin assembly and spend time close to the project.

Denney: Box-build is a journey, not a destination. Your initial look at the project will result in dozens of questions. Those will then lead to more and more questions until, finally, your customer goes away and finds somebody else who will do it for them. We don't bother with any of that nonsense. We look at what the customer is trying to accomplish and discuss building a small quantity of units first; it's typically no more than 50 pieces.

We are upfront with them that there will almost certainly need to be changes made to the design based on this initial build, and we make sure the customer is open to working together with us on this. We give our customers a maximum price we'll charge them for the box-build, with an agreement that we'll learn from this to provide a more accurate quote. If it takes us longer than expected, we eat that cost. But if it takes us less time, we'll offer them credit on a future order for that value.

Once we sit down to actually perform the build, we note down what does and doesn't work, and what needs to change. We may have to do this for a couple of revisions, depending on how close the engineers got in their initial design until we can finally provide a fully accurate quote from a process that we're happy with.

Describe your experience with quality control in box-build assembly. What testing protocols do you implement to ensure the final product meets both the industry standards and customer expectations?

Budvarson: First articles always receive 100% inspection to validate workmanship prior to shipment. For in-process inspection, we build appropriate inspection points according to each manufactured assembly. Assembly personnel generally work in a cell formation, so each person inspects the work done by the prior person before moving on. We also look back at captured quality data regularly to identify areas for improvement and training. Test is customer-directed and usually requires working with the customer to create the fixture, program, and procedure to meet their individual needs.

Denney: IPC has standards for circuit boards and wiring harnesses, and we train and certify our staff to follow these standards. We inspect all the subassemblies to make sure they meet the standards before installing them into the final assembly. Oftentimes, the final product itself will have a built-in diagnostic mode where we can test all the product's functions before delivering it to our customer.

In your experience, how have you managed or collaborated with suppliers to ensure the timely and cost-effective procurement of components necessary for box-builds? Can you give an example of a supply chain challenge you faced and how you resolved it?

Budvarson: Metals can present a challenge. In one instance, we had a box-build customer that was ordering sets of parts, with 23 pieces making one set. If one piece is non-conforming, you obviously have a problem. Lead times for sheet metal and fab shops can also drag out assembly delivery, especially when it includes paint or other special coatings. Usually, box-build jobs will push us to a customer-directed source as well, so we're managing a new product and qualifying a new vendor simultaneously. It's a challenge but something we've done many times over the years, so we've got a good base of knowledge from which to work.

Another challenge with this type of situation is that customers may want to consign these metal pieces. In this case, we end up with drop-shipped components. We still need a vendor relationship with the fab shop, but a relationship with the customer is critically important to ensure that we receive what we need in a timely manner and keep them informed on both on-time delivery and quality of drop-shipped materials.

Denney: We're constantly managing this. It never ends. Time is your friend here, so the earlier you work with suppliers to give them dates and quantities, the better. One supply chain challenge we had, as it specifically relates to box-build, was working with an injection molder who regularly had challenges delivering product on time to us. We had a conference call with them and learned that there was basically just one person in the company who could set up the injection molding machine and run the first few samples before they could proceed with production. We calmly but firmly insisted that they train and/or hire additional staff to help with this. They agreed and committed to making the change and have since turned into one of our most reliable suppliers.

Allison Budvarson

Discuss how you approach project management within the context of a box-build assembly. How do you coordinate between different teams, such as design, procurement, and assembly, to ensure the project is completed on time and within budget? Can you share an instance where your company's leadership directly contributed to the success of a project?

Budvarson: OBMFG has always been successful because of the expertise and teamwork of our incredibly talented personnel. Generally, management team members from purchasing, manufacturing, quality, engineering and technical sales come together during the NPI phase of a complex box-build project. We also have an immensely talented lead in the box-build cell that is an integral part of the process. We utilize our planning and assembly processes to ensure things get done. When something doesn't work, we utilize our CAPA process to

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Denney: That's just called "doing business." We use our MRP software to manage the supply chain and drive the assembly process to deliver to our customers. The harder part was managing demand expectations. How much of what was needed and when? This is largely in our customer's hands, and most people would stop there. But last-minute orders that take weeks to prepare for aren't rare, and nobody's happy about it. Not us, and certainly not our customers.

We invited one customer to visit us and showed them our process for assembling their products. We were able to show them how long each product takes to prepare, and all the various steps involved in getting the subassemblies ready for the final assembly. We then proposed using a shared online spreadsheet so that we could track their in-stock inventory, along with our "ready-to-ship" inventory. This provided much greater visibility into each other's shops. We could easily see their demand, and they could easily see our supply. If we notice a sharp drop in their stock of any one product, we should make sure we're building more of that product. If they notice our ready-to-ship inventory is low, they can give us a heads-up that they will soon need more and that we should get ready. This smoothed out the whole process. No more surprises. No more overbuilding and holding inventory longer than we need to. We're happy, our customers are happy, and our suppliers are happy. I think Michael Scott would call that a win-win-win. **SMT007**

Mike Konrad is founder and CEO of Aqueous Technologies, and vice president of communications for SMTA. To read past columns, click here.

Researchers Capture Strange Behavior of Laser-excited Gold

New research, conducted at the Department of Energy's SLAC National Accelerator Laboratory, illuminates the strange behavior of gold when zapped with high-energy laser pulses.

When certain materials, such as silicon, are subjected to intense laser excitation, they quickly fall apart. But gold does the opposite: it gets tougher and more resilient. This is because the way the gold atoms vibrate together—their phonon behavior—changes.

"Our findings challenge previous understandings by showing that, under certain conditions, metals like gold can become stronger rather than melting when subjected to intense laser pulses," said Adrien Descamps, a researcher at Queen's University Belfast who led the research while he was a graduate student at Stanford and SLAC. "This contrasts with semiconductors, which become unstable and melt."

For decades, simulations hinted at the possibility of this phenomenon, known as phonon hardening. Now, using SLAC's Linac Coherent Light Source (LCLS), the researchers have finally brought this phonon hardening to light. The team published their results on Friday in Science Advances.

In their experiment, the team targeted thin gold films with optical laser pulses at the Matter in Extreme Conditions experimental hutch, then used super-fast X-ray pulses from LCLS to take atomic-level snapshots of how the material responded. This high-resolution glimpse into the atomic world of gold allowed researchers to observe subtle changes and capture the moment when its phonon energies increased, providing concrete evidence of phonon hardening.

They used X-ray diffraction at LCLS to measure the structural response of gold to laser excitation. This revealed insights into the atomic arrangements and stability under extreme conditions.

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Determining the Value-add of Box Build

Feature Interview by Nolan Johnson
I-CONNECT007

At a strategic level, adding box-building services makes sense for customer loyalty. But is it really that simple? Jon Schmitz, who manages customer engagement at RiverSide Integrated Solutions, talks about what it really takes to be successful in offering EMS and final assembly services under the same company banner.

Nolan Johnson: Jon, "box build" could mean anything from taking the next step into a larger subassembly to delivering a finished good or even drop shipping from the EMS house. Where does RiverSide Integrated Solutions fit?

Jon Schmitz: In our arena, we do it all. We started with printed circuit board assembly; all our standard EMS provider business is printed circuit board assembly. Then we moved up to product assembly work, and that's where box build comes in. It may mean putting a circuit board assembly into a housing, like you described, which is a subassembly for our end customer. We send those completed subassemblies to an end customer, which turns it into the finished product. We also have many cases of completing the entire product and shipping it directly into the field. It could be straight to a dealer, or an end consumer.

What are some examples of compelling events, trigger events, or crises for a customer that might cause them to go deeper into box-build services with you?

We start with a customer's need, and ultimately, we offer three main solutions to their needs. First, we have certain customers that want to be virtual. They are not interested in doing any manufacturing themselves and want a manufacturer to do everything for them. That is one of the main reasons we started doing

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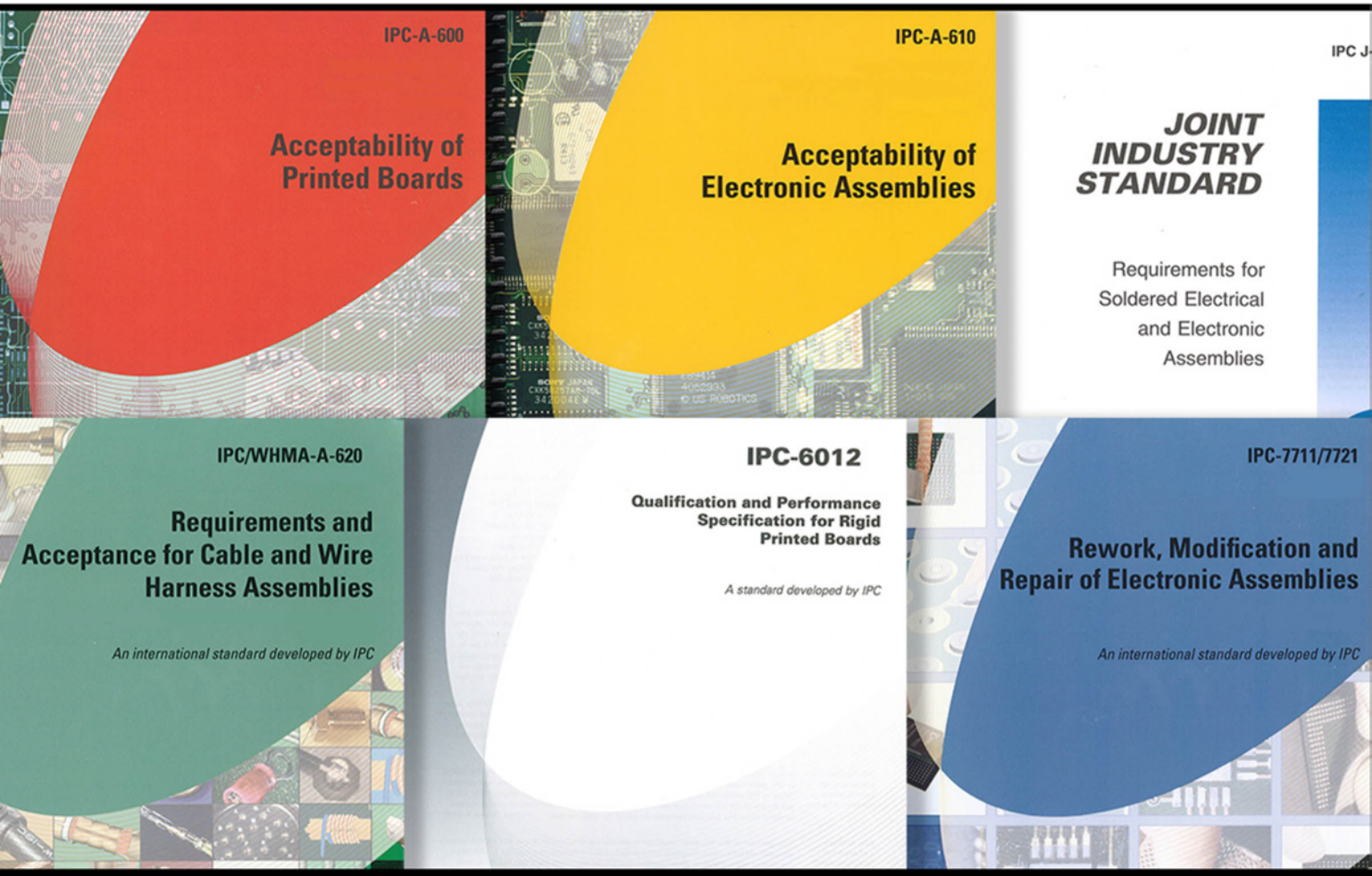

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box build and product assembly. Second, we have customers that don't have the internal resources to do this. They may have a labor shortage, or a certain constraint on their business that motivates them to outsource. Third, it may be a core competency issue. We have customers specializing in the final finished product, but they don't want to do any subassembly work outside their core competency. In that case, they may need a contract manufacturer or EMS provider to do that portion for them.

Jon Schmitz

From our standpoint, the more value-add we can create, the better it is for our business. But we have to determine whether the need is within our core competency and whether we can take the risk of the additional service. Our core competency is in skills like soldering and assembly. There may be other required skills outside our core competency, such as wire harnesses and cabling.

We recently took on a product assembly that involved copper brazing, so we're now doing that type of work. We had to decide whether that should be in our core competency. It's different than soldering. In this case, we said we should. But why? Because we decided that if we expanded our core competencies, we could expand our skill set. We could use qualified operators who have those skills, just in a slightly different way.

That makes a lot of sense. Part of that decision-making process, I suppose, is asking how generalizable that new skill set is.

Yes. Is it truly just for this one customer, or can we offer it on a larger scale? If it's something we can replicate, we're more likely to add it to our business. We really have to think about whether it's in the best interest of our business.

Can you share an example of deciding to pursue a new skill set for box build?

I'll tell you more about the copper brazing project. It was an opportunity for product assembly work, a box build that went above and beyond our core competency at the time. The customer found us because we do both box builds and product assembly. In their case, their definition of box build included copper brazing refrigeration tubing.

We asked them to explain everything involved with the product. When we looked through the product requirements, specifications, and schematics on the products, we discovered that there was refrigeration work. We knew we didn't have the skill set, so where and how could we add it? We partnered with local refrigeration experts with HVAC and refrigeration expertise, including our local community and technical schools. We asked them to teach us the skill set; after all, it's not all that different from soldering.

We trained a team that became skilled in that core competency and expanded our work into that arena with that customer. Just adding that one skill led to future business.

How is that relationship going?

In fact, we've taken on even more box builds from that customer. The customer had a labor shortage and couldn't get qualified applicants, so they were looking to outsource. Now, it didn't come without roadblocks and barriers. We weren't experts overnight. It took six to 12 months for us to develop the necessary skill sets. We had to work through that timeline with our customer.

What other challenges did you have outside of training?

Typically, an EMS provider receives a standard doc package from its customer. You also must build to IPC standards. In the case of a finished product, you must add and meet safety

agency documentation. When shipping a finished product out into the field, you have to meet all the safety standards that go along with that product. With electronics, almost every single product has some sort of safety protection. In that case, we had to make sure we were in full compliance with safety agency specifications.

The other major requirement is cosmetics. If your end product is going directly into the field, you have to make it look pretty. If it's a subassembly going inside something else, it doesn't need to be pretty every time. Solder joints don't need to look picture-perfect; at the end of the day, they just need to function. But when you ship that final finished product, it must be pristine. For a typical EMS supplier, the difference between box builds for a circuit board assembly and a final assembly is that you have to understand the final cosmetic specification. What are the visual specification processes and criteria for you to be successful? It's not as simple as it looks.

When it came to understanding these new criteria, how much help was your customer?

They pointed us to experts they've used, and certain standards. It's great when the drawing says, "Build to this standard." In this case, we took on a whole portfolio of products. Some were designed within the last two or three years, and the documentation was great. Other doc sets are for products designed 20 or 30 years ago. Well, standards change over time. Even design requirements change. So, what looked good as a design package 30 years ago doesn't look so good as a design package today.

What are the cautionary points? What's your advice for catching pitfalls?

Make sure you understand all the product and safety agency requirements. Know the industry-wide specifications for everything you're building, whether it's a printed circuit board assembly or a wire harness. That skill needs to be a core competency. Everything is built on industry standards; you build this subassembly to this standard, and you're good. When you get into product assembly and box build, you encounter unique product requirements for every single product built by every single OEM. Make sure you understand the individual product requirements for that OEM. It's critical.

When we talk to the typical EMS provider, they say managing unique product requirements is just a normal part of doing business. But you're saying that box build is even more so.

Yes. Circuit board assemblies, wire harnesses, cables, etc. Each product comes with its own files: Gerber, CAD, and all those types of things. Each one is custom, so there are individual requirements. But it's on a different level when it's a product assembly because now you're building more than customer files. You're truly building to industry standards and specifications, safety agency requirements, and governmental regulations. Every EMS provider would say every standard is unique, but with box builds and product assembly, it is more. There is a different level of requirement.

I'm getting a sense that this requires additional skill sets on the manufacturing floor as well as more admin and project management.

Yes, specifically in engineering and technical resources. For example, every EMS provider has an SMT line, and when you get a new circuit board assembly, all you're doing is putting that new board on your standard SMT line, which already exists.

With box build, you are now creating an individual work cell around that individual product. So, there's the design of the cell and the design of the manufacturing space. The testing requirements associated with approving that specific product are unique, so it will need its own functional test, not to mention jigs, test procedures, and unique assembly instructions. That all comes along with the individual box builds and tooling.

We needed extra test technicians devoted to the project and supply chain staff to manage the part procurement. In this environment, you don't just go to your typical component distributors to buy standard off-the-shelf parts. Almost everything is custom.

You need more commodity experts. When you're doing circuit board assemblies, you don't always need a sheet metal expert. But in box build and product assembly work, you definitely do.

After such a significant investment in floor space, equipment, new expertise on staff, planning engineering, admin, etc., how does this improve your margin?

At the end of the day, it's a higher margin than a printed circuit board assembly. You're ultimately gaining a larger piece of the value stream. Rather than just providing labor or supporting a portion of the OEM's bill of materials, you're building the entire BOM. For us, it's about getting more of the larger value stream, which ultimately allows us to be more successful as a business.

The OEM in this partnership can focus on what they do well, which is designing and innovating because you have the realization of their product under control.

Exactly. We can both focus on what we're good at. Another value for the OEM is that they don't have to carry inventory and the overheads associated with doing this as a business internally. They can outsource that to us. There's a huge value in that to the OEM as well.

Jon, this has been quite enlightening. Thank you.

Thank you, Nolan. **SMT007**

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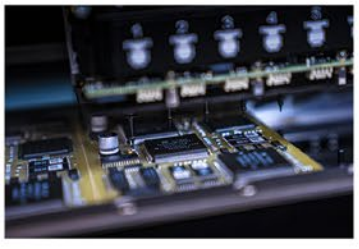

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The Top Five Things You Need to Know About

MANUFACTURING TRAINING

by Blackfox Training

Electronics manufacturing companies need skilled and certified workers to perform the intricate and important tasks required to build modern electronic equipment. Here, we explain five ways to gain these workers:

1 **Train and Certify Manufacturing Employees and Support Staff to the IPC Standards**

2 **Fill Training Gaps with Customized Courses that Focus on Basic Knowledge and Skills**

3 **Access Tools and Resources to Assess Your Workforce and Maintain Skill Levels**

4 **Stay Up to Date with Constant Changes in the Electronics Manufacturing Industry**

5 **Hire U.S. Military Veterans Who Have Already Completed Immense Training**

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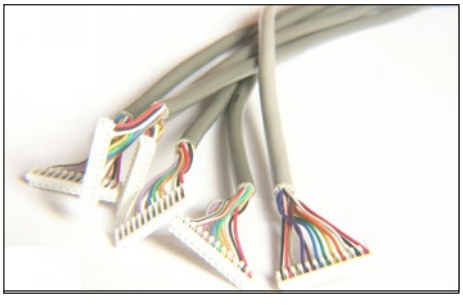

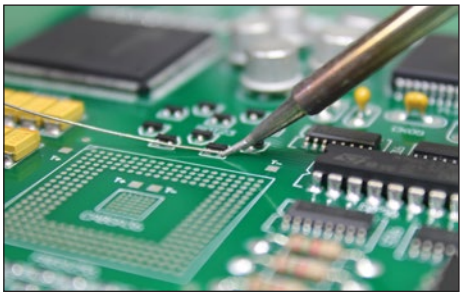

1 Train and Certify Manufacturing Employees and Support Staff to the IPC Standards

IPC certification is an internationally recognized credential that proves an employee's knowledge and skill level. IPC training and certification is industry developed and covers electronic manufacturing quality concerns, including PCB assembly and soldering, rework and repair, wire and cable harness production, and bare PCB fabrication. Having an IPC-certified workforce demonstrates an attention to detail and commitment to quality.

2 Fill Training Gaps with Customized Courses that Focus on Basic Knowledge and Skills

IPC training and other standardized courses don't cover every aspect of electronics manufacturing. Therefore, it is important to have customized courses that fill those missed gaps. Basic soldering, ESD, and electronic component identification are just a few examples of the many courses that complement IPC certification and ensure that your workforce is prepared for any challenges that may come their way.

3 Access Tools and Resources to Assess Your Workforce and Maintain Skill Levels

Assessing your workforce before and after training is an essential part of a proper manufacturing training program. The effectiveness of training and the retention of knowledge gained can be gauged through assessments that are computer-based, interview-based, or audit-based. In addition to assessments, both students and trainers need to have complete access to resource documents and training materials after training has been completed.

4 Stay Up to Date with Constant Changes in the Electronics Manufacturing Industry

Technological advances and new discoveries are occurring constantly that greatly impact how we manufacture electronic products and evaluate them for quality. This makes maintaining your IPC Certifications through renewal and recertification critically important. In addition, attending industry meetings and participating in IPC committees will ensure access to the latest information.

5 Hire U.S. Military Veterans Who Have Already Completed Immense Training

Now more than ever, highly skilled and efficient employees are needed in manufacturing. The U.S. military invests an enormous amount of training in our soldiers. They are equipped with a framework of skills and attributes such as loyalty, integrity, leadership, and excellent work ethic. They know how to learn new skills quickly and adapt to changing environments, which are highly desirable qualities for manufacturing.

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The Top Five Things You Need to Know About

DRILLING AUTOMATION SOLUTIONS

by Burkle North America and Schmoll Maschinen

Living in this era of rapid technological progress, PCB production is making a noticeable shift toward automation. What was once manufactured manually with human hands and low production numbers has transitioned to high-volume production using precise and efficient machines. Today, Industry 4.0 and artificial intelligence are further expanding the boundaries of automated production.

1 Automation in PCB Production

2 Registration, Alignment, Accuracy

3 Maximum Productivity with the Right Application

4 Automation Possibilities

5 Features for Automation to Increase Utilization

1 Automation in PCB Production

PCB manufacturers worldwide are investing in new equipment to improve technology and production, especially in the field of automation. In Europe, the automation of drilling machines is already standard to increase producivity and achieve a higher degree of utilization. The current talent shortage in the U.S. and Canada is accelerating the demand for automation as well. Drill and rout machines with shuttle system and loaders; direct imaging machines with robot arms; and X-ray capabilities with drill and inline automation already allow the automatic loading and unloading of PCBs and ensure contact-free panel handling in the factory, which results in both labor cost savings and quality assurance in the PCB.

2 Registration, Alignment, Accuracy

Highly technologized devices such as spindles, lighting heads, laser sources, cameras, code readers, and sensors are built-up on solid granite and then connected to the machine controller to deliver perfect results and ensure highly accurate PCB processing. For high-end panels, machines with CCD are an option, as any inaccuracies of the panel will be corrected. A two-pin system on panels is mandatory for automated drilling and a well-proven process to support the needed accuracy.

3 Maximum Productivity with the Right Application

Track and trace technology is also being adopted in the handling of PCBs. With a barcode or 2D code, panels can be uniquely identified and processed according to the specific CAD/CAM program. Integrated CCDs and scanner systems in the machines handle the reading of specific part programs.

Automated calibration procedures ensure machine accuracies at the highest level to ensure quality of drilled, routed, and imaged products. Automated spindle maintenance reduces machine down-time and increases productivity.

4 Automation Possibilities

The engineering industry has recently advanced with Industry 4.0 and the building up of several new standards. Drill, rout, and laser machines can be equipped with a loader to feed the panels automatically—one of the new simplified solutions. X-ray and direct imaging machines can now be put into a production line with belt conveyors and run at a constant speed, resulting in increased output. Panels are then handled with robot arms. More robotics have also been introduced to the market, including automated guided vehicles, automated line systems, and shuttle systems.

5 Features for Automation to Increase Utilization

Standard SW interfaces to the MES allow bi-directional communication between machines and high-level production controls, which allows for real-time status information. An operator can have remote access to all machines from the control room, allowing them to monitor automated PCB production, run statistics, and react quickly to any error message or breakdowns.

Visit Burkle North America online.

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The Top Five Things You Need to Know About

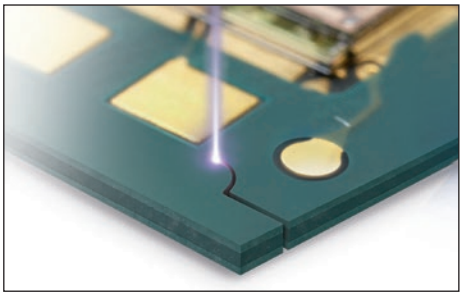
LASER DEPANELING

by LPKF

As high-tech manufacturing takes center stage across the globe, laser depaneling is more critical than ever. What was once an advanced technology focused on niche applications, is now fully scalable to the modern production environment. Laser depaneling is changing the SMT landscape with higher power, cleaner cuts, and more affordable equipment.

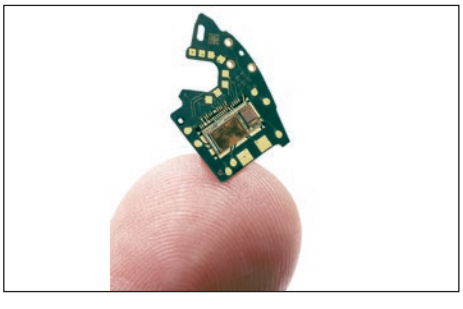
1 **Technical Cleanliness: Nothing Beats Laser...Period**

2 **Zero Consumables**



3 **High-volume Production**

4 **Unparalleled Accuracy and Zero Stress**



5 **Flexibility**

1 Technical Cleanliness: Nothing Beats Laser…Period

Completely eliminate post-processing steps/stations. No more Q-Tips and isopropyl alcohol to clean up after pizza cutters, routers, and inferior laser systems. Advanced software and laser technology allow the operator to fine-tune settings to match your exact quality and cycle time requirements. Depaneling parts for a key military component? Laser can set for perfect edge quality. Processing 30 million PCBs per year? Laser can be set for maximum throughput.

2 Zero Consumables

No more monthly router bit or blade reorders. Despite a slightly higher cost of entry, newer machines require an air filter change just once or twice a year and typically costs less than $5 an hour to operate.

3 High-volume Production

With hundreds of lasers running full-time and three shifts/day worldwide, implementing laser depaneling can scale to your production needs. With full inline configurations and a modular approach, today's systems offer a number of in-house automation and board-handling solutions, and can also be integrated with almost any third-party automation.

4 Unparalleled Accuracy and Zero Stress

We provide ±20 µm accuracy, which means unlimited contours, components populated within 200 µm of the PCB edge. No mechanical or thermal stress on your PCB = near zero failure rates.

5 Flexibility

Full contour cuts, V-score, mouse bites, tabs—we can cut it all, whether it's FR-4, flex circuits, ceramics, or thin metals. Laser depanelling offers the latest in factory integration and traceability features for laser marking, barcode reading/writing, bad board recognition, and full MES factory integration.

About LPKF

Thirty years ago, LPKF pioneered the industry-wide transition from chem-etch SMT stencils to precision laser processing. Today, LPKF is again leading the way with laser depaneling. After 15+ years honing laser technology, techniques, and software, LPKF depaneling lasers are faster, more accurate, and less costly than ever before. Contact sales.usa@lpkf.com to discuss your application with an expert.

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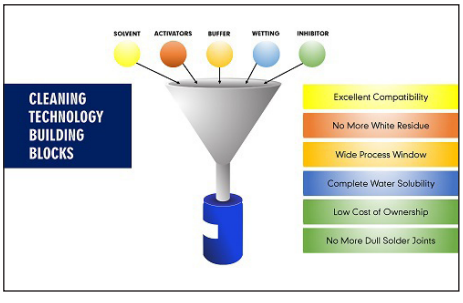
The Top Five Things You Need to Know About CLEANING

by KYZEN

An optimized cleaning process will provide reliable and dependable electronic assemblies. KYZEN's team of cleaning experts work with you to develop the most effective cleaning process for your needs. You can quickly increase productivity and yields by considering these Five Forces of Cleaning and implementing them in your process:

1 The Cleaning Agent: Choosing Wisely Will Save You Money in the Long Run



2 Concentration: More is Not Always Better

3 Time: Determine the Most Effective Wash Cycle Time

4 Temperature: Too High or Too Low Can Cost You More Than Money

5 Mechanical Energy: Adjusting Nozzles Can Make All the Difference

1 The Cleaning Agent: Choosing Wisely Will Save You Money in the Long Run

Consider the material of the substrate and the soil, and test to make sure your cleaning chemistry is effective on the soil sets you are using and compatible with all materials of construction in your assembly and your cleaning machine.

2 Concentration: More is Not Always Better

No two cleaning chemistries are created equal. The concentration at which they are effective will differ, and most often, the chemical supplier will supply a range for use. Start at the high side of the range and lower the concentration in small increments until you reach the optimal concentration for your unique process parameters.

3 Time: Determine the Most Effective Wash Cycle Time

A few factors will determine how long your assemblies will need to be exposed to the wash solution before they are completely residue-free. Is your soil easily removed? If not, can other process parameters be adjusted or optimized to shorten your wash cycle time?

4 Temperature: Too High or Too Low Can Cost You More Than Money

If your operating temperature is too high, you could harden the flux residue, making it harder to remove. High heat can also damage delicate substrates, not to mention the wear and tear to your machine. Running at a lower temperature may not take advantage of your chemistry's solvency, which will result in poor soil removal. Optimizing your process with thorough testing will help you find just the right temperature to bring success.

5 Mechanical Energy: Adjusting Nozzles Can Make All the Difference

Spray-in-air is the most common choice when it comes to PCB cleaning. Whether you choose a batch or inline washer is often determined by your throughput and floor space. There are a variety of adjustments you can make in each process to maximize the mechanical energy needed to completely clean and rinse your assemblies. Bonus tip: You are only as clean as your last rinse.

About KYZEN

KYZEN is the leading global cleaning chemistry supplier offering a wide range of products for electronics assembly cleaning processes. For expert cleaning advice, visit us at KYZEN.com.

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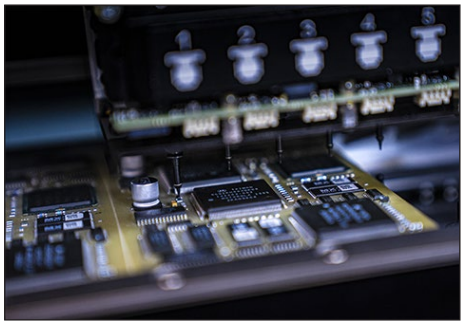
The Top Five Things You Need to Know About

PLACEMENT

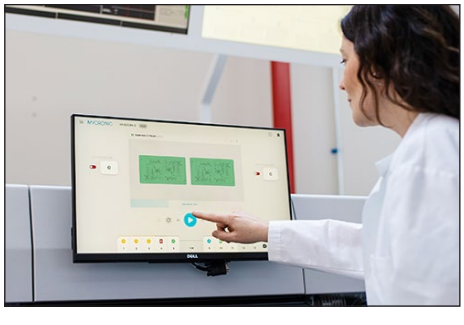
by Mycronic

Today's high-mix electronics manufacturers need to adapt to a rapidly changing environment. To meet customer expectations and maintain competitiveness and profitability, their component placement process must meet several conditions. Here are the top five things to consider:

1 **Combine High Placement Productivity With Consistent Reliability for Growing Batch Sizes**

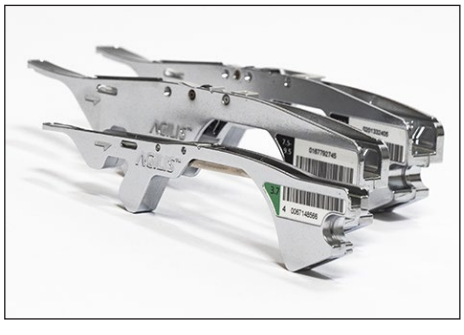


2 **Have the Versatility to Cope With an Expanding Diversity of Components**



3 **Create a User-friendly Graphical Interface for Efficient Operation and Faster Training**

4 **Have Extreme Flexibility With the Shortest Changeover Time**



5 **Utilize Live Process Control for Optimized Performance**

1 Combine High Placement Productivity with Consistent Reliability for Growing Production Volumes

To handle the demands of more complex products, diversified production, and shorter delivery times, high-mix producers need to significantly raise their placement productivity while maintaining the highest precision and quality. Boosted by the new MX7 mounthead, the MYPro A40 placement machine delivers an outstanding 59,000 CPH throughput, giving high-mix manufacturers the productivity and peak speed they need to meet aggressive production schedules.

2 Have the Versatility to Cope With the ExpandingDiversity of Components

The wider the range of components your placement system can handle, the faster, more versatile, and more cost-effective your production process will be. This is why each nozzle of the MX7 individually picks, rotates, and places, allowing the high-speed mounthead to place the widest range of components in the industry. In fact, the MX7 mounthead mounts chip components as small as 01005 (0.4 × 0.2 mm), large BGAs, and components as large as 150 × 40 × 15 mm.

3 Create a User-friendly Graphical Interface for Efficient Operation and Faster Training

A high-mix platform is only as efficient as its operator. When human-machine interaction is clear and straightforward, with uncomplicated, step-by-step touchscreen guidance, the most relevant process data becomes more visible and actionable. The MYPro A40 is equipped with a new graphical user interface (GUI) for more natural, fluid interaction with the operator. This intuitive GUI makes both training operators and running the pick-and-place smoother—and more error-proof—than ever before.

4 Have Extreme Flexibility With the Shortest Changeover Time

The performance and responsiveness of a high-mix electronics manufacturer depends on its ability to switch from one production run to another as quickly and efficiently as possible. Today, changeovers should be completed in minutes, from feeder and program loading to production start-up. Mycronic's unique Agilis™ feeders with no moving parts are easier and quicker to load than any alternative and enable the shortest changeover time on the market.

5 Live Process Control for Optimized Performance

Pick-and-place production data is extremely valuable if used properly. Live KPIs enable production engineers to quickly spot any performance drift. An advanced dashboard gives them the actionable information they need to increase utilization, reduce reject rates, and improve line balancing in real-time. With live component misspick and reject analysis, MYCenter Analysis makes it possible to diagnose root causes before the problems multiply.

MYCRONIC

Mycronic is a global high-tech company that develops, manufactures, and markets production equipment that meets the electronics industry's highest expectations for precision, flexibility, and efficiency. www.mycronic.com

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The Top Five Things You Need to Know About

IMPLEMENTING SMART AUTOMATION SOLUTIONS

by Technica, U.S.A.

There are limited production hours available each year, so make them count. It starts by integrating reliable hardware and software automation solutions. But it doesn't end there; reassessment of your automation needs will be ongoing.

1 **Choose an experienced partner**

2 **Clearly define your short-term and long-term visions**

3 **Align Your Goals With Your Budget to Execute an Automation Solution**

4 **Evaluate the structure of your IT landscape**

5 **Position yourself for the journey of benefitting from big data**

1 Choose an experienced partner

To ensure the journey is rewarding, it's important to have an automation partner experienced in analyzing and examining your current processes to help you choose the best robotic and cell layout solutions. Working with a company that has actually implemented full-scale automation and smart factory status into similar companies is key in designing the solution that you desire.

2 Clearly define your short-term and long-term visions

Are you considering automation for certain purposes, such as lower operating costs, improved work safety, reduced factory lead times, increased production output, improved quality, or achieving a smart factory environment? Understanding your short- and long-term goals will determine the level of hardware and software tools that will be required to meet your goals and achieve a desired outcome.

3 Align Your Goals With Your Budget to Execute an Automation Solution

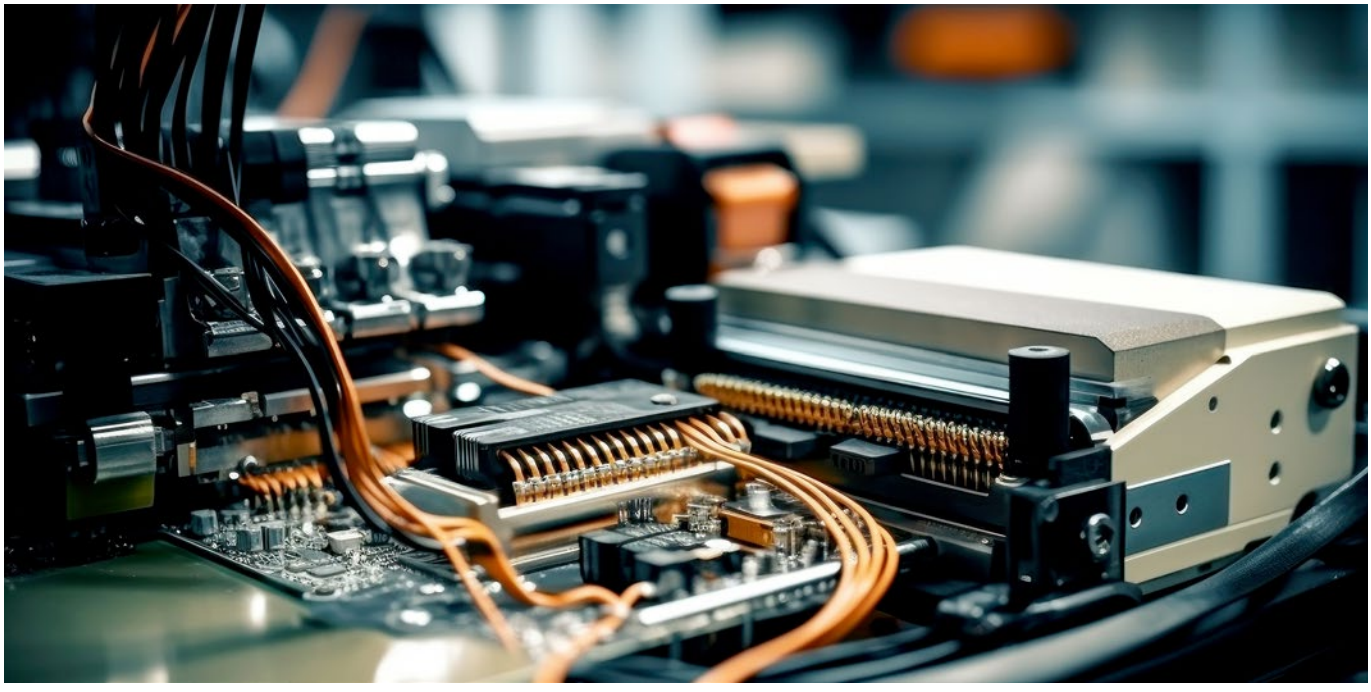
It takes a certain level of commitment as it relates to the investment of time and capital to implement a smart factory solution. How fast you begin to recognize your ROI will be based on a sound understanding of how to plan, create, and define the implementation.

4 Evaluate the structure of your IT landscape

Connectivity, tracking, controlling, and analyzing are major parts of implementing a smart factory concept. Having an IT structure that can support the data journey is also important in achieving smart factory data management, factory intelligence, and material process control. Implementation of tools on the shop floor, such as factory dashboards, advanced planning, and scheduling, are outcomes of your data journey.

5 Position yourself for the journey of benefitting from big data

Gathering data is a benefit of adding automation and connecting it to other equipment in the manufacturing process. Seamlessly sharing the collected data with enterprise software (ERP, MRP, PLM, MES, MOM) is where meaningful data will be gained to better control your processes and improve productivity. Having the personnel and software resources is important in recognizing the benefit of big data.



The Connection Between Wire Harness and Box Build

Feature Interview by Nolan Johnson
I-CONNECT007

Christina Rutherford is a technical lead and expert in materials engineering at Honeywell, where her specialty is the design, specification, and manufacture of cables and wire harnesses. Rutherford also sits on the committee for IPC/WHMA-A-620. In this conversation, we explore the changing dynamics in wire harnesses and how they relate to box build. Christina's standards work allows her to draw insightful parallels between wire harness and box build.

Nolan Johnson: Christina, we're here to talk about wiring harnesses and how they play into assembly and box build at the end of the supply chain. First, tell me about your speaking engagement at the upcoming wire show in Milwaukee.

Christina Rutherford: I will be giving the keynote address at EWPTE on May 15. My topic is process controls and their impact throughout the supply chain. I'll be focusing on some of the core process controls suppliers need, different opportunities for process validation, and correlating some of those to recent aerospace-related news.

Assemblers often say, "Basically, it's a hunk of plywood with some nails; you manually lay out the wires, zip-tie them, and when you're done, you have your harness." Is that still true today?

It's the general perception, especially with new suppliers starting to get into high reliability application products, that you have wires, you add stuff on the ends of the wires, and you have

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a functioning harness. People can be unaware of the level of controls that go into what's between point A and point B to make it work.

Christina Rutherford

When it comes time, you put all the electronics, circuit boards, buttons, and panels together into an enclosure and connect them with the wiring harness. What do assemblers need to know when the wiring harnesses come into their facility?

You have a lot of layers of process control and inspection. Maybe you're not used to requirements in such detail, but suddenly, you have more parts with pre-existing manufacturing standards, and they must be revalidated. It matters a lot more. My background is in aerospace and defense, and we are required to check things more often.

Standards are structured for box builds slightly different than harnesses. Requirements are more clearly defined for harnesses because it's a more mature standard. You will need to translate that level of process control and dedication from inspection through to the box build. Even though it doesn't necessarily have all the same controls today, we're working on getting there and making some reasonable steps in the right direction.

I take it that there are IPC standards for wiring harnesses and box build?

For cable and harness assembly, the standard is IPC/WHMA-A-620. A new revision of A-620 came out in October 2022. We also have the 620S Space addendum, which exceeds Class 3 high-reliability criteria, IPC-D-620 for the design, and IPC-HDBK-620. We have IPC-A-630 and IPC-HDBK-630 for box build. A-630 has been undergoing a massive revision over the past six years and is slated to come out later this year, which I'm excited about. We're updating the manufacturing and inspection requirements to the same level that we have already built into A-620.

What will assembly providers find in these standards to help them understand how to ramp up a box-build business?

For IPC-A-630, specifically for box build, it now has more content in terms of process. It specifies more of the internal manufacturing steps instead of just saying, "This is acceptable" or "This is a defect." It addresses topics like, "When inspecting painting, you should be looking at these types of things, and these considerations depend on what features it's delivering." The design will always take precedence, but if your design doesn't give specifics, here are the defaults. We're adding about 100 pages of detail in the revision.

I'm sensing these standards are for an EMS company to influence their incoming inspection?

The EMS company will get wiring harnesses that presumably were built to those standards before being shipped. Still, they'll be inspected at the EMS company to ensure that everything incoming is of appropriate quality. Because these processes are inherently operator-based, effort at the wiring harness supplier goes into ensuring you make the exact same thing every single time—you want to have more than just the one employee who's been doing this for 20 years. You need repeatability controls, which may increase cost.

I've worked with suppliers that haven't used A-620—or other industry standards, for that matter. They're just doing their own thing, making the product and sending it out. Then a company like us comes along, and says, "We have requirements, and you must follow them to do business with us." It's a significant shift in

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mindset. It's not so possible to say, "I'll solder this cup really quick." Now, it's more like, "I'll make sure that I have the proper gold removal process, and that my soldering iron temps and tips are calibrated." You might not necessarily pay attention to those steps unless you have something that explicitly tells you to pay attention. It's more documentation, too. Many engineering resources go into developing and maintaining all of that to ensure that you're delivering a consistently high-quality product.

With that extra overhead, what's the payoff? Why do it?

The payoff is that it's ultimately a better-quality product. For any industry, it's imperative. In aerospace, specifically, we are under scrutiny more often to ensure we have the best of the best. It's the same with automotive and EVs. Right now, there's a push to make sure we're maintaining the same quality standards for high voltage and new environments for electronics applications. The payoff is that once you build it up, you now have this wonderfully transferable skill set that you can apply to any product line in your factory.

So much attention is paid to supply chain resilience and traceability. OEM customers request and expect an understanding of what's in the supply chain, from the raw materials and even the copper mine. The documentation you mentioned is now critical.

Here's an example: We use an adhesive that underwent a color change. It originally was typically light green, then suddenly it was closer to a camouflage green. Our inspectors were flagging it, and of course, our customer was concerned. We traced it back to the epoxy manufacturer, which had started getting its raw materials from a quarry a quarter-mile further down the road. The rock they were grinding as an additive to the epoxy caused a color change. We had to go all the way up through these extra approvals because a change in rock shifted the color of our epoxy. We had an extensive discussion answering questions such as, "Is it okay? Do we need that type of rock? Are the performance characteristics going to be the same?" Having the traceability to go from the OEM level all the way back to that quarry was critical.

How are manufacturing processes changing in wiring harnesses? Is it still being done the same way everyone imagines, or are new approaches making it more effective, efficient, precise, and profitable?

It depends, and I've been seeing a couple of different things. There is a new Appendix D in IPC/WHMA-A-620 that I helped develop. You'll see the kudos to Team Bones (our A-Team) on the acknowledgments page in IPC/WHMA-A-620. This appendix discusses X-ray guidelines. Some suppliers are starting to incorporate X-ray inspection of final product. Depending on how you look at it, it can be good because it gives us new information. But because we don't have hard requirements for acceptability using X-ray inspection, we don't know how to apply the new information to current practices. For example, if we see something on an X-ray image, what does it mean for the acceptability of our hardware? We've seen that come up more in the last few years.

In the industry, we are also trying to shift toward more automation. In some cases, that's worked out well for higher-volume products. But fully automated processes don't always make sense for low-volume work, like for aerospace, where we might make 10 to 100 a year. Let's say you've got a machine for injecting potting or molding material into a fixture. What happens when you don't have production for a

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couple of months, or you run through a really high volume, and then you don't need to use the equipment and material for a while? How do you maintain that material in the machine? How do you adjust your preventative maintenance to manage the varying volume demands? There are some challenges there.

In aerospace, we might move at a different rate than the rest of the world. We have some of those 30-year-old techniques we absolutely still need because they're qualified, and we're still building those parts. There's a bit more wiggle room for Class 1 and 2 suppliers to innovate because they have a wider range of tolerances for acceptability. There are more opportunities there as well.

So, there will be an increased interest in more thorough final inspection processes.

We see more things in inspection because we're choosing to. We're choosing not to rely just on inspection at the beginning and the end. Instead, we're emphasizing the importance of in-process inspection. In the supply chain I work with, we stress to our suppliers that everything in the middle—after kitting and before you get to the final product—matters. Every single process control matters.

By establishing more in-process inspection controls, you don't have as much risk to final yield. Then, you don't have to add additional inspections like X-ray, which can drive inspection costs higher.

Assembly houses led the way in adopting digital factory in our industry. Where do you see digital factory techniques or protocols fitting in wire harnesses? We're talking a lot about traceability and provenance, so what's in the future for the wire harness sector?

For wire harness—at least for our part of the supply chain—processes are so manual that finding different things to automate is challenging. It's inherently a very individualized, manual process for many things. We have some semi-automated and automated processes, such as wire stripping and cutting, injection molding, semi-automatic crimping, and automatic torquing.

In general, most of the processes are still manual. We have to identify more opportunities for things that don't have to be explicitly manual or where those steps feed into the processes. Right now, we have automatic wire strippers as an example, but you still have to inspect them before they go to the next manual process. There are opportunities for automation.

What do you want an assembly house to know who might be adding box build to their business? What's the most critical to know?

I will share this in my keynote, but one of the most important things is the importance of building up those process controls before your first delivery. Have those controls built into your system, because if you get to a point where you've accepted this order with a three-month delivery schedule, and then you find out about all the requirements, it's an uphill battle to figure things out quickly. To have a successful product launch, make sure you take the time to build it up in advance.

Perfect, thank you. This is a great place to end.

You're very welcome. **SMT007**

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ADCO Circuits Case Study:

From Inspection Skeptic to Innovative Enthusiast

Article by Brent Fischthal
KOH YOUNG AMERICA, INC.

ADCO Circuits has grown steadily over nearly 40 years, and while situated near Detroit, Michigan, the "Motor City," the company is in no way dependent on the automotive industry. In fact, it has had increasing success in sectors like diagnostic tools and aerospace and continues to diversify its portfolio of customers and industries. ADCO carries numerous certifications, including AS9100d, ISO, ITAR, and those essential for the automotive and aerospace industries.

Some of its success can be attributed to investing in the latest technology. "We have ERP, everything is bar-coded," says Marc Damman, president. "If you go on the plant floor, you don't see a lot of paper because everything is electronic, including all the inventory in our vertical storage systems. On top of first-rate equipment, we have a really good manufacturing, engineering, and test engineering team."

Starting Out as Skeptics

Kevin Barrett is ADCO Circuits' head of operations. "Like most companies, to monitor our yields, we collected data from the AOI machine and then used that data to judge our process," he says. "Our original concern came when we began to receive more requirements for blind solder joints on assemblies and felt some limitations of AOI. While the AOI systems could detect the presence of parts, they were limited to the details of solder joints. Our local Koh Young rep, Jim Rittman, had been talking to us about the benefits of solder paste inspection (SPI) so we thought it was worth taking a deeper look."

When the company first considered SPI, "we didn't see that there was any value to it," Barrett says. "But after we had replaced a lot of our older equipment with newer machines, we decided to take the plunge." That came when

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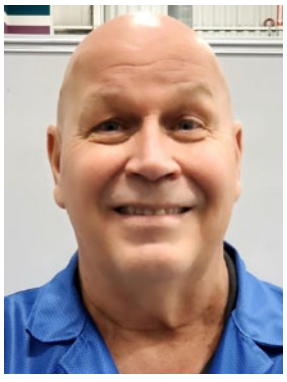
Kevin Barrett

Rittman offered to bring demo equipment and let the ADCO Circuits team play with it, as well as someone to help ADCO install, use, and understand the equipment.

"Through Jim, we were offered to test drive a system," Barrett says. "They would deliver it and train us on its use. We figured a demo machine would help us try out the process and determine whether there was a benefit. To our surprise, the demo unit turned out to be a brand-new machine. They believed that once we learned about the machine and its benefits, we wouldn't send it back. And we didn't."

ADCO placed the machine on one of its lines, and after set up and initial operator training, they were running every board through it. "At first, we thought that because it makes a good go/no-go process control—so that no missing solder paste gets through—we believed we were done," Barrett says. "Luckily, the machine demo also included process and process control training. Koh Young worked with us to better understand the capabilities of the machine in the process, not just as a go/no-go test. We looked at the equipment a little differently after that, and somewhat redeveloped our printing process."

Once that happened and they got past that initial stage, Barrett concludes, "It was a question of 'How did we run so long without it?'"

Adding Value with Optics

Damman says this was just one part of a transition to more optics, inspection, and measurement. "We started with the SPI, then AOI (automatic optical inspection), and now leveraging that to do the through-hole AOI, so it has expanded capabilities and created efficiencies," he says. "All these new optics have helped us immensely, not only the SPI systems, but also X-ray reel counting and a new optical system at incoming inspection to read the labels. Anything we can do to improve the process will help."


Marc Damman

For example, with Koh Young's through-hole inspection system, "if we can make the process more automated and scientific, rather than relying on the human eye, it makes for a better system all around," Damman says.

Adding Value With Data

What Barrett and his team noticed initially was the sense of security the inspection equipment gave them when running boards day-to-day. "We knew nothing was getting past that didn't have the paste position or volume we specified," he says.

ADCO started to think more about what inspection could do on the front end of manufacturing before they even built the board; in other words, this included the design phase. "It really allowed us to understand better how the printer worked, how the stencils worked in correlation with that, and then, with an engineering review up front, it allowed us an opportunity to understand our objectives, the certain parts we needed, the requirements of the board and the components on the board," Barrett says. "Maybe you need a certain amount of paste in one area and a little less in a different area."

Now that they're getting measurements, they have the critical data they need, even on hidden joints like BGA or GFNs. "It's not just knowing whether paste is there, but how much is there, what kind, and what it's doing for us," he says.

Data That Drives Process Improvement

Inspection outcomes could be as straightforward as go/no-go, but that really doesn't

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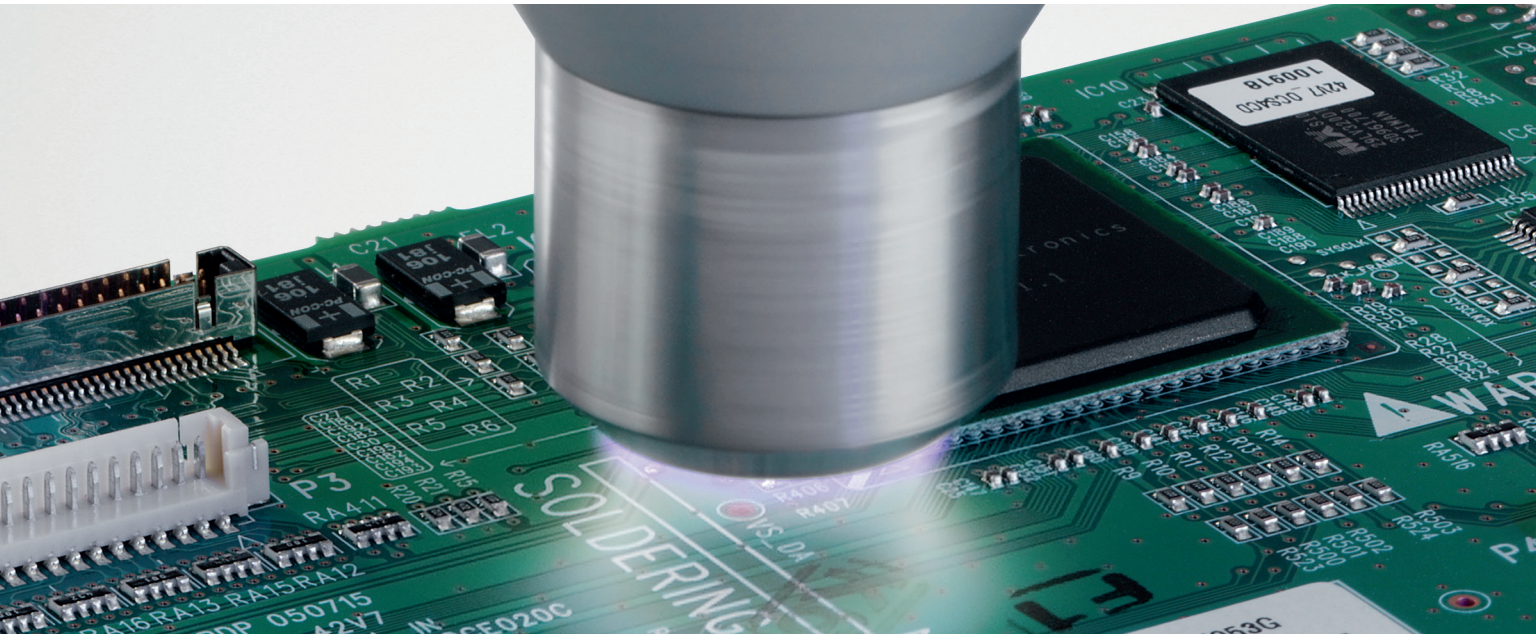

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address issues and variances with the product or the process. What Barrett appreciates is that the systems communicate between SPI and AOI. "Blind solder joints can be broken down to three things: paste, part, and profile," he says. "If any one of these fails, the joint fails. If I know what's going on at the SPI, I can better predict what will happen at the AOI. For me, it's a much better sense of control at the front end of the process. We purchased the machines for process monitoring but found that we needed them to help set up the process first. Right off the bat, we realized the impact of any printing variability on false calls at the AOI. We could make a change in the printing process, measure the change with the SPI, and then watch the AOI flag the change. By setting up the process to the desired results and tuning the SPI to this process, we significantly reduced the number of false calls at the AOI."

The largest variable is paste, "not just whether it's there, but how much is there," he says. "Koh Young's SPI allows us to measure it, which means we control it. Now we just do the work upfront to determine what we want to obtain in the desired results, and then we have confidence that every board will meet that requirement or be rejected with details (measurements) on the reason for that rejection."

TJ Peacock is a manufacturing engineer at ADCO Circuits and says that some of the new products require intense engineering throughout the entire process. "Koh Young's solution really helps us," he says. "We verify the stencil and heights on the Speedprint printer, for example."

He's able to make use of the data collected on the machines. "We have been able to see most of our problems in the screen printer, whether that be board support or something else," Peacock says. "If we see line defects, we can trace them back to a specific problem with the screen printer, and in some cases, we've found real problems with the boards. Sometimes board-stretch is an issue, and Koh Young can detect that for us."

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"When we get a bad reading," says Barrett, "not only do we understand exactly where, but we can then correlate it back to why it might be bad, the root cause. It gives us reaction time with which to stop the line, correct it, and proceed with only good boards."

User Experience and Support

Barrett says the equipment has proven to be easy to set up and program, and the operators learn very quickly and enjoy it. ADCO Senior Programmer John Westfall says, "The machines integrate with the EPM software, and then they install their own C editor on top of that. That C editor translates the output from EPM, turning it into a machine program. It's simple, quick, and reliable."

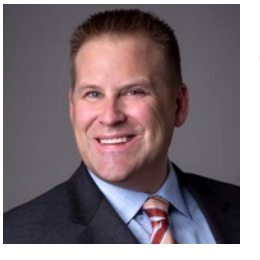
A Lasting Partnership

ADCO Circuits and Koh Young have had much more than a customer-supplier relationship over the years. They've forged a working partnership driving value in both directions. Most recently, they collaborated on developing an AOI solution for through-hole technology.

"We've looked at the conformal coating measurement equipment as well," Barrett says. "We put down different levels of epoxy. To improve our process control, we need to measure that. Now that we're using their equipment, we've found benefits beyond just the measurement of solder paste, and knowing if something is there. We want to move those benefits to other areas and processes as well."

He appreciates the partnership. "As a CM, we have very little design control," Barrett says. "Instead, we build to the instructions the customer supplies. This can be challenging, for example, when some components need a 4-mil deposit, and some want 6-mil.

"With the SPI, we are able to determine what we want and develop a stencil to give us that," he says. "Then we use the SPI to make sure it is correct. We can do this in a short time and make sure that, even on fast turns or short runs, the first and the last assembly are the same and have been measured to verify they are the same. Supplying our customers the best assembly we can produce in the shortest amount of time is what is best for our business. They've been a big part in supporting that." **SMT007**



Brent Fischthal is head of global marketing for Koh Young America, Inc.

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DARPA Explores Additive Manufacturing's Potential for Futuristic Microsystems ▸

DARPA played a seminal role in establishing materials science as a discipline. One of the latest disruptive efforts in new materials and applications, the Additive Manufacturing of Microelectronic systEms (AMME) program, seeks to launch microsystems manufacturing far beyond today's state of the art.

The Government Circuit: Driving Resiliency and Economic Security on Both Sides of the Atlantic ▸

Welcome to the latest edition of The Government Circuit, where I share updates on the government policy developments shaping the electronics manufacturing industry. Since the year began, we've already witnessed several significant milestones and strategic engagements that may ultimately affect the way you do business.

Major Investors Expect First Commercial eVTOL Passenger Routes by 2026 ▸

New Horizon Aircraft Ltd. indicates global investors are anticipating the first commercial passenger routes of electric vertical takeoff and landing (eVTOL) aircraft to be operational in the next few years as the future air mobility market continues to advance rapidly.

BAE Systems Launches MethaneSAT Satellite for Global Greenhouse Gas Emissions Data ▸

BAE Systems is celebrating alongside its customers at the Environmental Defense Fund (EDF) following the successful launch of the MethaneSAT satellite from Vandenberg Space Force Base in California. The satellite will provide the public with reliable scientific data about the sources and scale of methane emissions globally, with the ultimate goal of driving reductions in the near future.

Lockheed Martin Awarded $219M To Produce PrSM Units for U.S. Army ▸

The U.S. Army has awarded Lockheed Martin a $219 million contract to produce more Early Operational Capability (EOC) Precision Strike Missiles (PrSM). The award is the fourth production contract to date for the long-range surface-to-surface missile, which will allow for a significant increase in production capacity to meet Army demand.

Sikorsky Looks to Future Family of VTOL Systems ▸

Sikorsky, a Lockheed Martin company unveiled its plan to build, test and fly a hybrid-electric vertical takeoff and landing demonstrator (HEX / VTOL) with a tilt-wing configuration. The design is the first in a series of large, next generation VTOL aircraft—ranging from more traditional helicopters to winged configurations—which will feature varying degrees of electrification, and an advanced autonomy system for optionally piloted flight.

DARPA's REMA Program to Add Mission Autonomy to Commercial Drones ▸

DARPA's Rapid Experimental Missionized Autonomy (REMA) program aims to enable a drone to autonomously continue its predefined mission when connection to the operator is lost.

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What is minimum space and trace? The answer depends on the starting copper weight.

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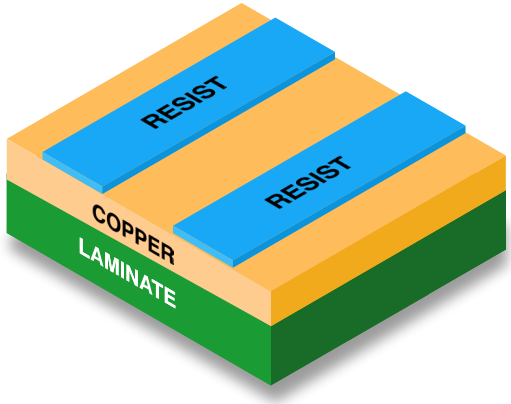
The lower the spacing width, the higher the cost. Designers don't always account for the proper starting copper weight after edge compensation.

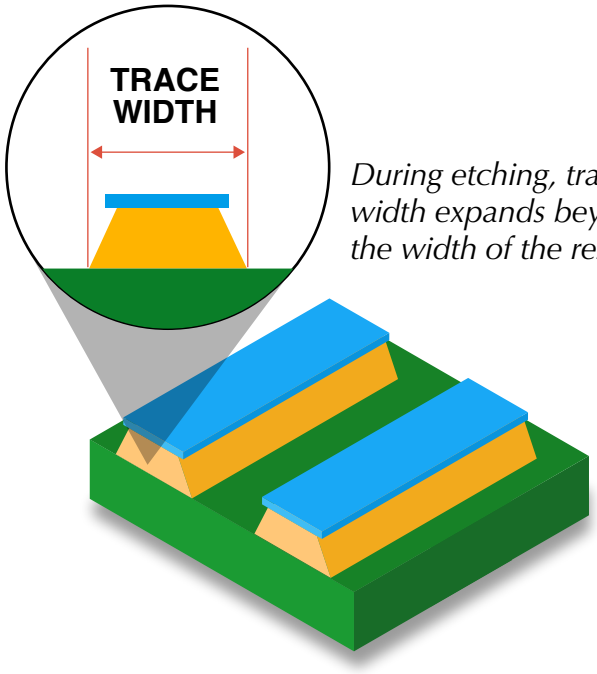
Design tips:

- For accurate starting copper weight, **add a half mil (.0005″) to all copper features**.
- **Start with 3/8 or 1/4 oz. foil**, reducing etch comp and less likely to cause a spacing issue.
- **Boards that call for full body electrolytic gold are not comped** to avoid gold slivers occurring during the etching process.

Before etching



After etching



During etching, trace width expands beyond the width of the resist.

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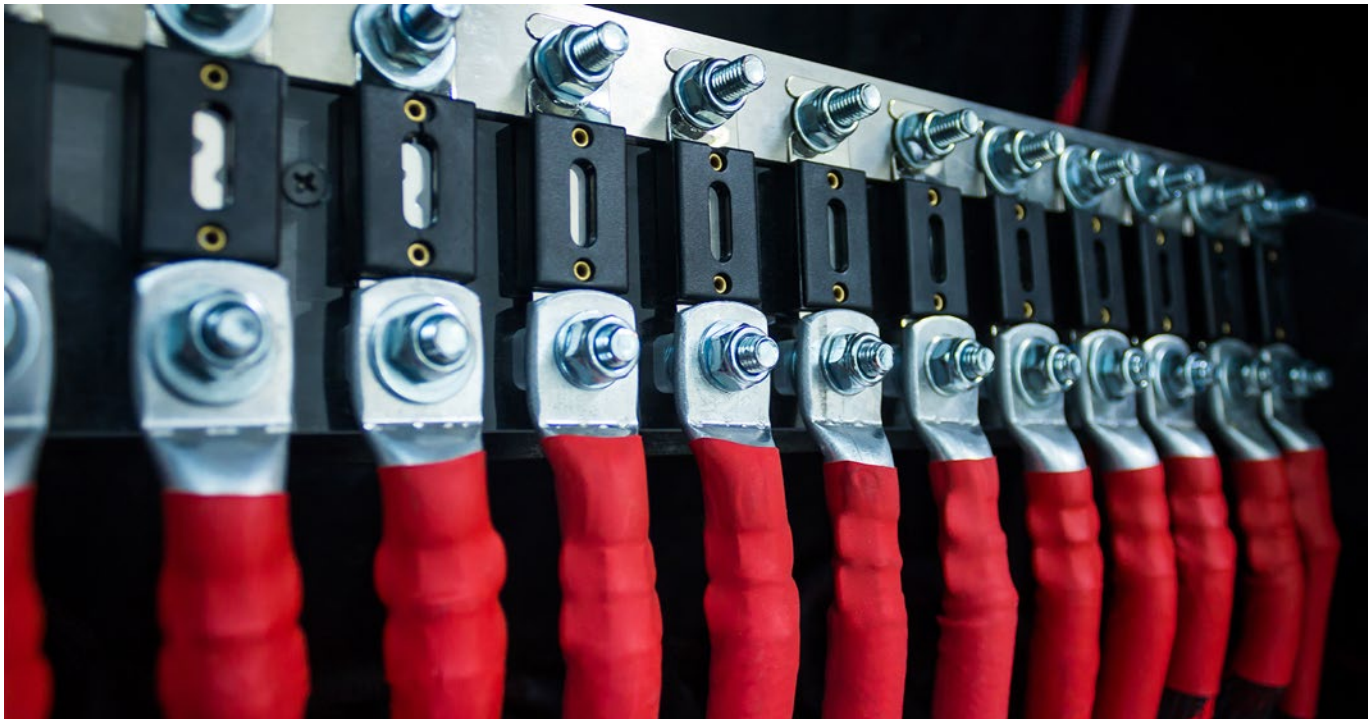

WHITE PAPER EXCERPT:

Analysis of Pull Force Test Results for Crimped Connections

Article by Alejandra Constante and Chris Fitzgerald
MILLENNIUM, ENGINEERING & INTEGRATION COMPANY ARLINGTON, VIRGINIA, UNITED STATES,
and by Alvin Boutte
NASA GODDARD SPACE FLIGHT CENTER (GSFC) GREENBELT, MARYLAND, UNITED STATES

Crimped electrical contact reliability is controlled through strict manufacturing processes and verifications, including pull-force testing. Cable and wire harness assemblies' standards provide the minimum pull force for reliable cables. However, in practice, failures occur at a much higher tensile strength than the minimum required.

The first section of this paper reviewed 780 pull force tests provided by NASA that were analyzed to determine how the data compared to NASA's pre-existing requirements from cable/harness standards. The measured tensile strength of most of the contact/conductor pairs exceeded the minimum pull force values of NASA-STD-8739.4 and IPC/WHMA-A-620 by at least 100%. The contact/conductor pair samples' tensile strengths followed a normal distribution with an average tensile strength that was at least 182% of the minimum requirement, and all samples analyzed passed pull force testing. In addition, the 95% confidence interval of the average tensile strength distributions for several contact/conductor pairs was plotted as error bars to show that the contact/conductor pairs will meet and surpass the requirements.

The frequency of pull force testing can be problematic for projects because of the cost and availability of spare contacts for the destructive

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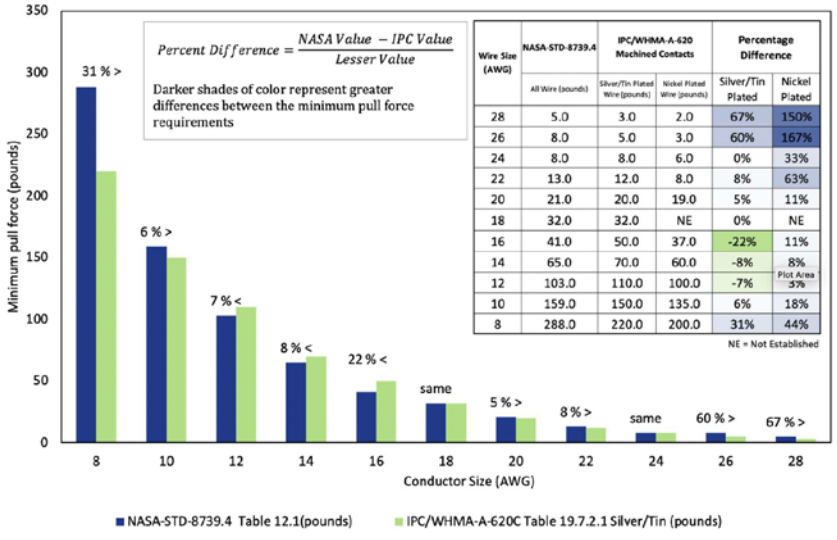
test. It is possible to reduce the frequency of pull force testing if at the beginning of the production run, the conditions of the crimp tool and materials are verified, and the settings of the tool remain unchanged throughout the process. However, the project needs to evaluate the impact to risk from reducing the frequency of testing prior to implementing process changes.

Introduction

This work presents a comparison of the pull test requirements of the NASA-STD-8739.4 Change 2 and the IPC/WHMA-A-620C standard[1–2]. It is known that the pull force strength requirements in both standards are similar, except for large gauges (i.e. 8 AWG wire size). However, in practice pull force strength test failures occur at significantly higher values. In this paper we are presenting a statistical analysis of the pull test records for past NASA projects and the results of an investigation into recent crimp-related problem failure reports documented at NASA Goddard Space Flight Center (GSFC). The percentage difference between the pull force test values tabulated in the NASA-STD-8739.4 Change 2, Table 12-1 *Crimp Tensile Strength* and the IPC/WHMA-A-620C, Table 19-12 *Pull Test Force Values* were plotted for the machined contacts' silver/tin plated wires and nickel-plated wire as shown in Figure 1 and Figure 2, respectively.

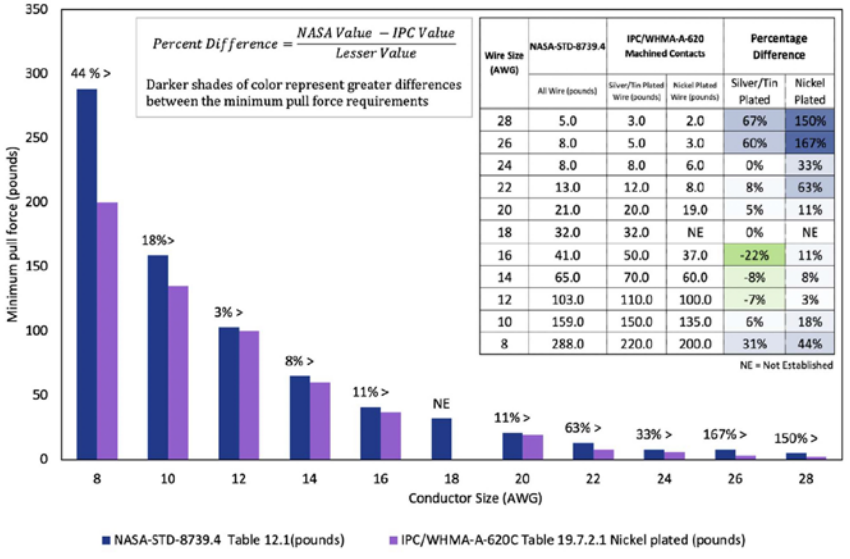
Crimping is the process of deforming one contact member around the other to establish an electrical and mechanical joint between the members. Typically, one of the members is a wire and the other is a cylinder that is deformed around the wire. The reliability of the crimping process depends on the formation of an adequate metallic contact between the wire and the connector and the creation of a permanent crimped termination[3].



Wire Size (AWG)	NASA-STD-8739.4	IPC/WHMA-A-620 Machined Contacts		Percentage Difference	
	All Wire (pounds)	Silver/Tin Plated Wire (pounds)	Nickel Plated Wire (pounds)	Silver/Tin Plated	Nickel Plated
28	5.0	3.0	2.0	67%	150%
26	8.0	5.0	3.0	60%	167%
24	8.0	8.0	6.0	0%	33%
22	13.0	12.0	8.0	8%	63%
20	21.0	20.0	19.0	5%	11%
18	32.0	32.0	NE	0%	NE
16	41.0	50.0	37.0	-22%	11%
14	65.0	70.0	60.0	-8%	8%
12	103.0	110.0	100.0	-7%	3%
10	159.0	150.0	135.0	6%	18%
8	288.0	220.0	200.0	31%	44%

NE = Not Established

Figure 1: Percentage difference between the NASA-STD-8739.4 and IPC/WHMA-A-620C Silver/tin requirements for pull force testing.



Wire Size (AWG)	NASA-STD-8739.4	IPC/WHMA-A-620 Machined Contacts		Percentage Difference	
	All Wire (pounds)	Silver/Tin Plated Wire (pounds)	Nickel Plated Wire (pounds)	Silver/Tin Plated	Nickel Plated
28	5.0	3.0	2.0	67%	150%
26	8.0	5.0	3.0	60%	167%
24	8.0	8.0	6.0	0%	33%
22	13.0	12.0	8.0	8%	63%
20	21.0	20.0	19.0	5%	11%
18	32.0	32.0	NE	0%	NE
16	41.0	50.0	37.0	-22%	11%
14	65.0	70.0	60.0	-8%	8%
12	103.0	110.0	100.0	-7%	3%
10	159.0	150.0	135.0	6%	18%
8	288.0	220.0	200.0	31%	44%

NE = Not Established

Figure 2: Percentage difference between the NASA-STD-8739.4 and IPC/WHMA-A-620C nickel plated requirements for pull force testing.

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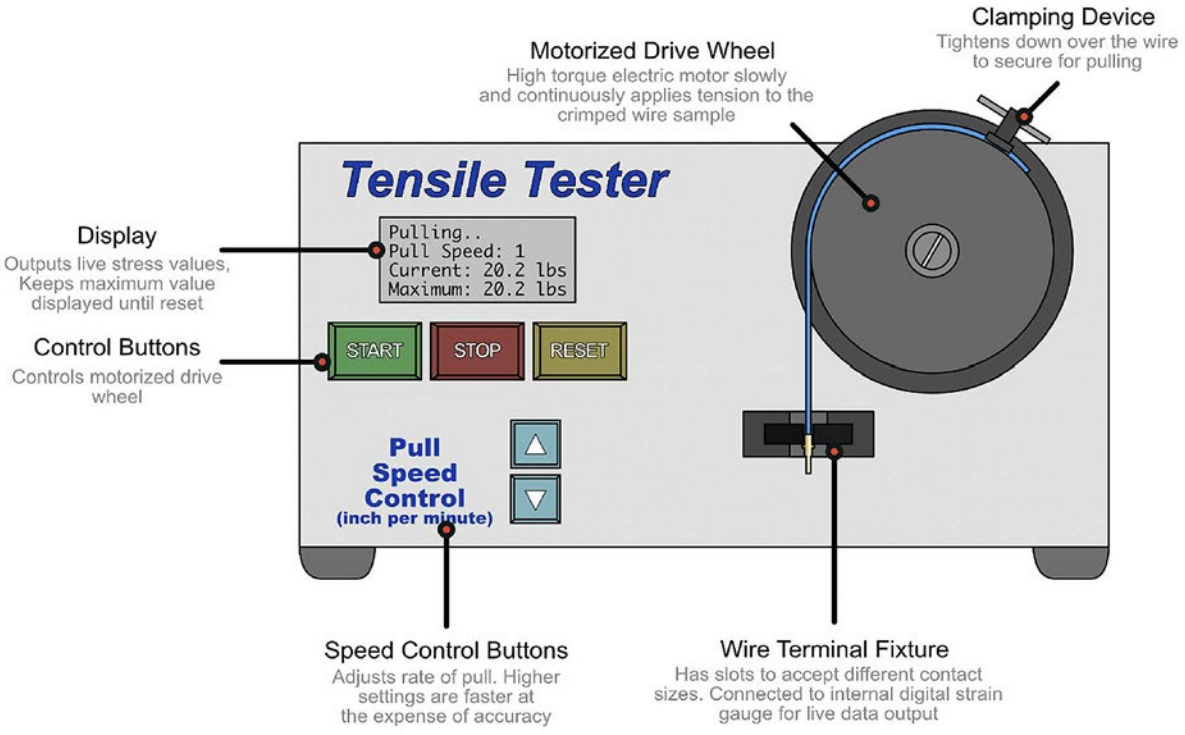

Figure 3: Example of a pull force tensile tester.

For electrical cables and harnesses, each connector is populated with electrical contacts. A reliable crimping process should consider several factors, such as the tool used, the materials being crimped, and the settings of the tool. Each of these factors need to be controlled to ensure that each crimp connection is made consistently throughout the manufacturing process from beginning to end. This process is validated through a test called pull force testing. An example of a pull force tester machine is shown in Figure 3.

Permanent crimped terminations can be affected by spring-back, which is the tendency of metallic materials to elastically rebound. This effect is more frequently observed on the outer crimped contact (i.e. terminal) than in the wire.

NASA defines the minimum pull force requirements in NASA-STD-8739.4A[1] Workmanship Standard for Crimping, Interconnecting Cables, Harnesses, and Wiring. Pull force testing, commonly referred to as a "pull test" or "tensile test," is typically conducted before and after the preparation of a crimp termination for flight hardware. This is always performed as a destructive test for flight hardware, such that the test samples are rendered unusable after the test rig separates the contact from the wire. For harness designs with electrical contacts which are not mass-produced, full adherence to the existing pull force testing requirements can add costs to the project. The pull test results are recorded in a log sheet for traceability, with pass/fail criteria defined by the applicable standard. For high-volume production environments, the results of the pull tests can be statistically analyzed to identify anomalies in the crimping process, such as crimp die wear, tool setting adjustments, and improper tool usage.

An advantage of some pull test machines is that they offer network-connected computer interfaces to assist in operating the machine, as well as data collection tools for statistical analysis[4]. However, NASA missions tend to have a smaller production volume such that both the crimp process and pull force test are often conducted with hand tools and test machines without data collection mechanisms beyond a physical log sheet.

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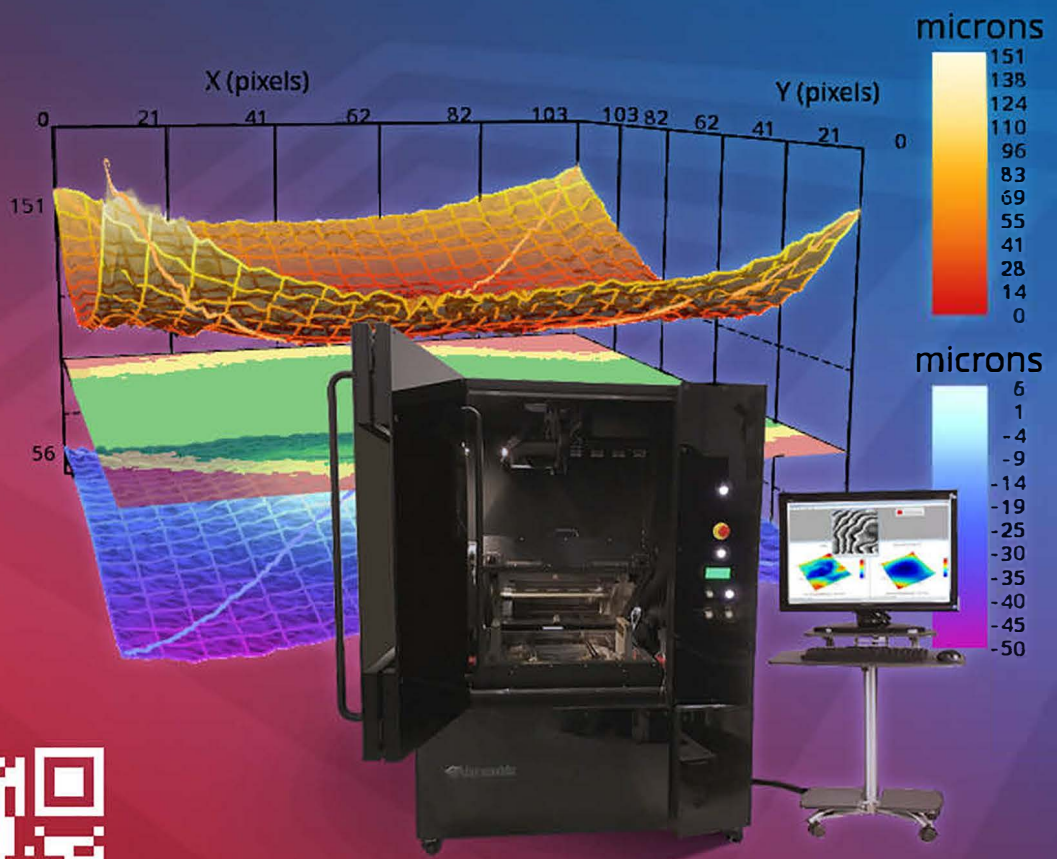

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The use of hand crimp tools and manual pull testers requires additional process controls that are needed to maintain consistency and limit the variability of the results.

Hand Crimp Tools

The quality of the finished crimp depends on the tooling setup and its operability with the contacts (i.e. terminals) being crimped. Tool manufacturers provide specification sheets for hand tools with defined parameters such as the manufacturer's contact type, wire size range, insulation diameter, and strip length.

According to the MOLEX *Quality Crimping Handbook,* a typical crimping procedure using a hand crimp tool is as follows[5]:

1. Identify the appropriate crimp tool for the contact and wire being crimped.
2. Strip the wire and inspect for damage.
3. Select the appropriate positioner/color-coded crimp nest for the contact and tool being used and insert the crimp contact.
4. If a locator bar is used for the crimp design, ensure the locator bar is engaged properly with the contact and the contact is unable to move.
5. Insert the wire into the crimp contact.
6. Engage the ratchet by squeezing the actuation handle, following through for a full cycle.
7. Inspect for proper crimp location and inspect for damage.

Not only does the technician need to operate the tool appropriately for consistent crimping action, the tool itself often needs to meet certain minimum process control requirements. For example, according to the NASA-STD-8739.4A Change 2, Section (i.e., §) 12.3.1, crimp tools must contain a full-cycle ratcheting mechanism and that calibration adjustments are made only by the tool manufacturer or by a calibration laboratory[1].

For commercial applications and some high-reliability applications, the cable/harness standard levied is IPC/WHMA-A-620B, *Requirements and Acceptance for Cable and Wire Harness Assemblies,* which defines three unique end product classes reflecting various levels of controls that need to apply to the manufacturing process. For aerospace applications, these controls may not be sufficient for hardware safety, and as a result the aerospace industry has developed an addendum to the original IPC/WHMA-A-620B base document, titled IPC/WHMA-A- 620B-S, Space Applications Electronic Hardware Addendum to IPC/WHMA-A-620B. Furthermore, according to IPC/WHMA-A-620B-S §19.6.1, Mechanical Test—Selection, the "crimp tools shall not be used for longer than 30 days between verification testing"[6]. Periodic tool calibration is needed due to the wear-out of the indenter blades (Figure 4). Calibrated tools should have records and a quick verification method, such as sticker, on the tool.

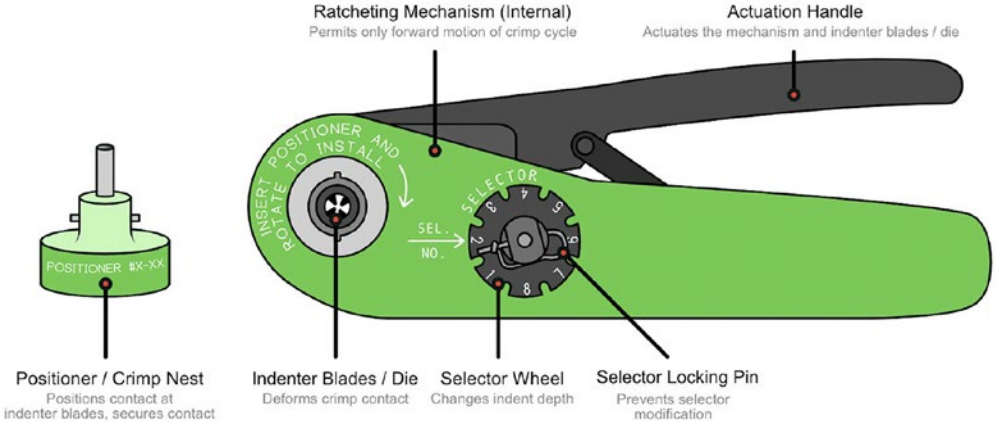

Figure 4: Typical crimp tool for machined contacts.

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Requirements for Crimping Process Control

To minimize variation in manufacturing, process controls should be applied to all tools, equipment, and contact/conductor pairs (i.e. contact/wires or C/W). The crimp process is validated for each new crimp configuration where tool settings must be determined for a contact/conductor pair. Both the NASA-STD-8739.4 and the IPC/WHMA-A-620C standards require a three-sample pull test. For example, the NASA-STD-8739.4 § 12.3.5.a states:

(1) For each new crimp process where a crimp tool setting must be determined for a contact-conductor pair (or a crimp ferrule-conductor combination), a three-sample pull test at each of the different crimp tool settings considered for use are required using the force and pull strength criteria in Table 12-1.

Furthermore, the IPC/WHMA-A-620C Space Applications Requirements §19.7.2, states the following:

"Three test samples shall be prepared for each contact/conductor combination test. A crimp-contact-conductor combination is defined as a specific contact used with a specific wire construction, e.g., if a drawing calls out a combination of single wires and twisted pairs of the same construction, e.g., gauge, strand count, alloy (base metal), and plating, the test samples of the single wire qualifies the tool to be used on the twisted pairs."

The NASA-STD-8739.4A w/Change 2, §12.3.5 c, Integrity of Crimped Connections, describes the pull force and pull strength criteria as follows[1]:

(1) The crimp contacts or ferrules shall be placed in a tensile-testing device with appropriate fixtures, and sufficient force shall be applied to pull the wire out of the assembly or to break the wire or crimped item.

(2) The head travel speed of the tensile device shall be 25.4 ± 6.3 mm (1.0 ± .25 in) per minute. The holding surfaces of the tensile device clamp may be serrated to provide sufficient gripping and holding ability.

(3) Crimp pull strengths shall meet the values in Table 12-1. Wire pull out, wire breaks at the crimp, and contact rupture which occur below the minimum pull strength value are considered test failures.

(4) For those contact-conductor crimp connections not contained in Table 12-1, the tensile strength of the crimp connection shall be no less than 60 percent of the tensile strength of the wire. Reference the manufacturer's datasheet for wire tensile strength.

(5) For crimp ferrule-conductor combinations the wire pulled shall meet the tensile requirement for a single wire of the same gauge being tested in its "properly sized" contact.

(6) Examination of Test Samples. Each individual test sample shall be inspected to the requirements of 12.3.5.c(3) and the observations should be recorded and maintained for passing units and shall be recorded for failing units.

(7) The pull strength and break or release condition for test failures shall be recorded.

In addition to these controls, further acceptance and rejection criteria are described in NASA-STD-8739.4A w/ Change 2, § 20.5, Inspection Criteria[1]. Rejectable criteria for crimped connections include improperly located crimp indents, plating problems, discoloration, and out of roundness of the contact barrel. In many cases, these product quality issues can be identified by inspecting contacts before insertion of wire and crimping, which is also a requirement from NASA-STD-8739.4A w/Change 2, § 12.2.1.

Conductors

Wire sizes are specified in units of American Wire Gauge (AWG) or Circular Mil Area (CMA). The wire selection depends on the current needs for the application and the operating environment [6]. A crimped termination is recommended on the following types of wires as shown in Table 1[7]:

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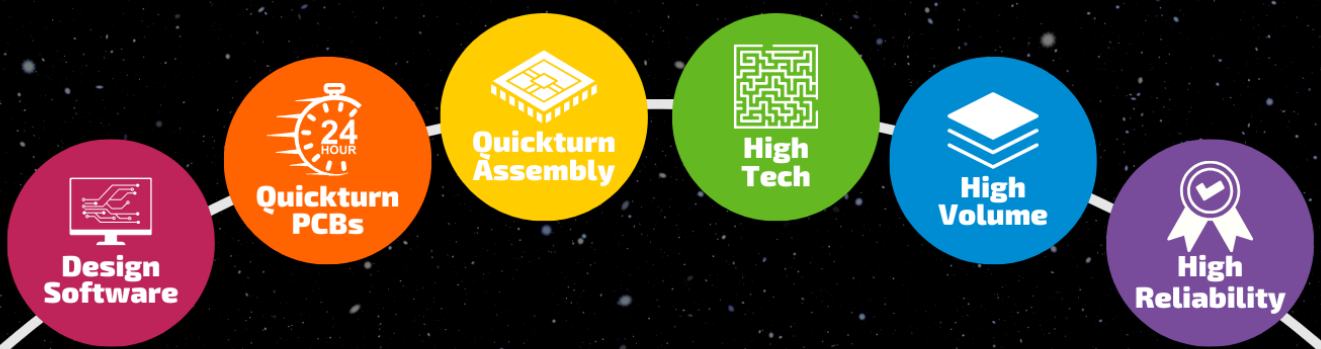

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Table 1: Maximum Operating Temperature of Common Wire

Wire Type	Use Purpose	Maximum Operating Temperature
Uncoated copper	General purpose	< 100°C (212°F)
Nickel-coated copper	High temperature extremes	< 260°C (500°F)
Silver-coated copper	High temperature extremes	< 200°C (392°F)
Tin-coated copper	General purpose, high solderability	< 150°C (302°F)

Furthermore, the standard SAE AS22759 Rev D. covers insulated single conductor electrical wires made with tin-coated, silver-coated, or nickel-coated copper/copper alloy conductors[8]. This standard has 196 detailed specifications that describe variations of wires according to the insulation type, the coating type, and the type of copper material.

Contacts

Contacts, also known as terminals, are components that terminate a conductor (i.e. wire) that is to be affixed to a wire or a cable to establish an electrical connectio[3]. Figure 5 shows the components of a typical machined contact, which comprise a wire barrel, shoulder/locking ring, and the contact area. The wire barrel is where the crimping will take place. These contacts fully contain the end of the wire, preventing conductor strands from becoming loose over time. Examples of machined contacts are shown in Figure 6.

Stamped and formed contacts are inexpensive to manufacture, and often are configured on reels for high volume manufacturing facilities. These contacts are cost-effective, readily available for any manufacturer, and very common across all electronics manufacturing industries. However, the end of the conductor strands, also known as the wire brush, remain exposed after crimping as shown in

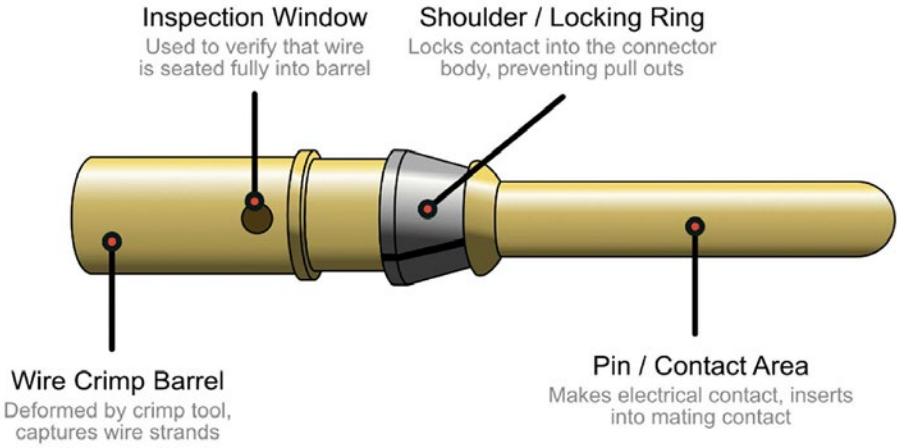

Figure 5: Components of a machined contact.

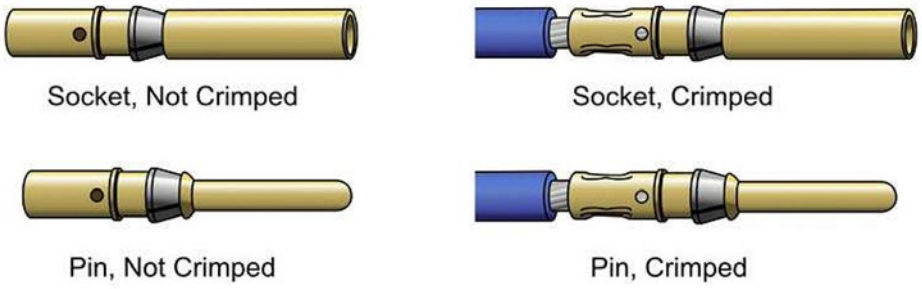

Figure 6: Examples of machined contacts.

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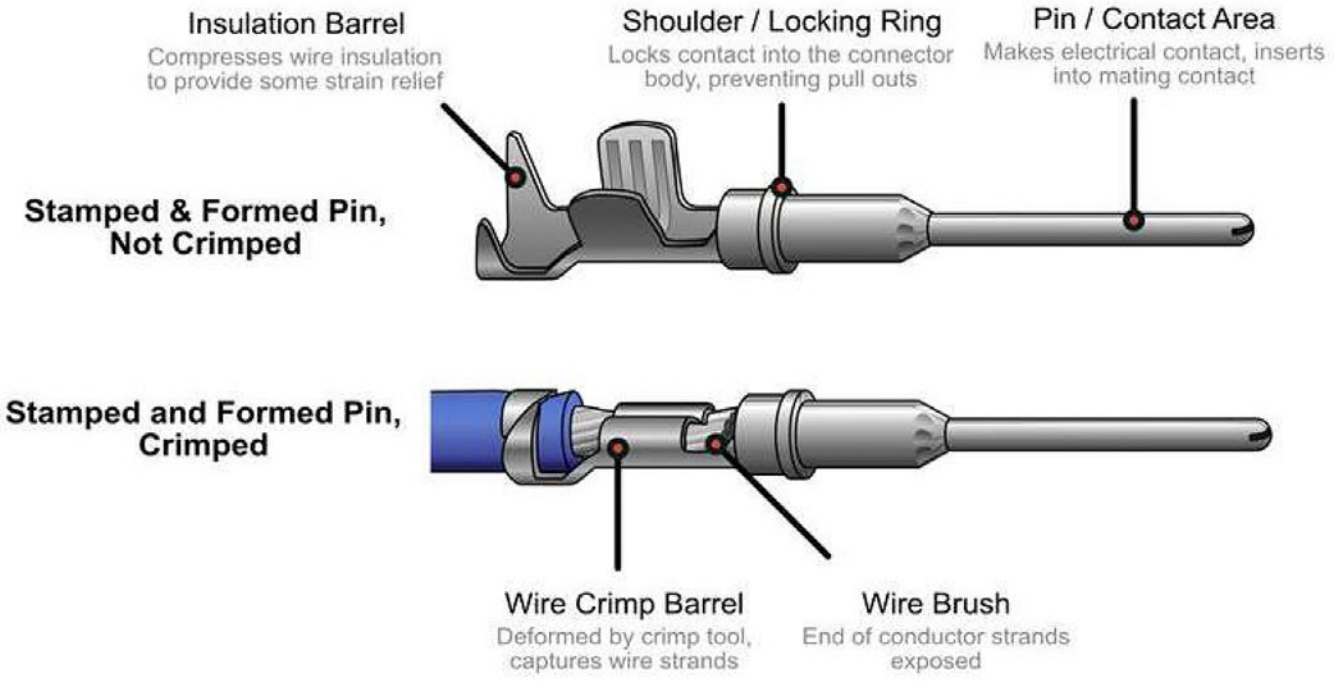

Figure 7: Stamped and formed contact components. The crimped contact is showed at the bottom with exposed wire brush.

Figure 7. Therefore, due to the exposed conductor ends, stamped and formed contacts are typically only used for ground systems at NASA because in a microgravity environment, conductor strands have the potential to float inside the system and cause short circuits. For this reason, NASA primarily uses machined contacts for space flight hardware. Additionally, as a result, stamped and formed contacts were excluded from this study.

Contacts are sized in accordance with the AWG size of the largest diameter wire that the contact can accept. However, adjustable crimp tools allow the modification of the crimp depth of the indenter blades, allowing a larger contact to be crimped to a wire a size or two smaller, e.g., a 20 AWG wire is able to fit into a larger 16 AWG contact. The size of the contact in a crimped connection is irrelevant for crimp pull testing, instead, the size and composition of the wire is the dominant factor in the tensile strength of the connection. Furthermore, it is recommended to select the correct size of wire and contact combination (C/W) pair to avoid excessive compression of the wires that will result in extensive compaction of the conductor strands as shown in Figure 8[3].

Conclusion

This analysis on crimp pull force testing has concentrated on past NASA project data from multiple NASA centers. These results may offer some validation into the relaxation or revision of the pull force test requirements, but only assuming good training, process documentation, calibration, and tool verification procedures are in place. The measures to mitigate the risk should be formulated if pull test requirements are relaxed.

If the frequency of pull force testing is being reduced, additional process control methods should be followed, such as incoming material inspection, tool and equipment calibration, and tool verification during crimp process. Periodic training to identify bad practices and lack of attention to details will also help prevent crimped termination defects. An allowance to reduce pull force testing frequency

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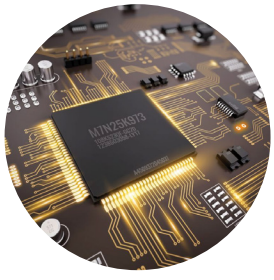

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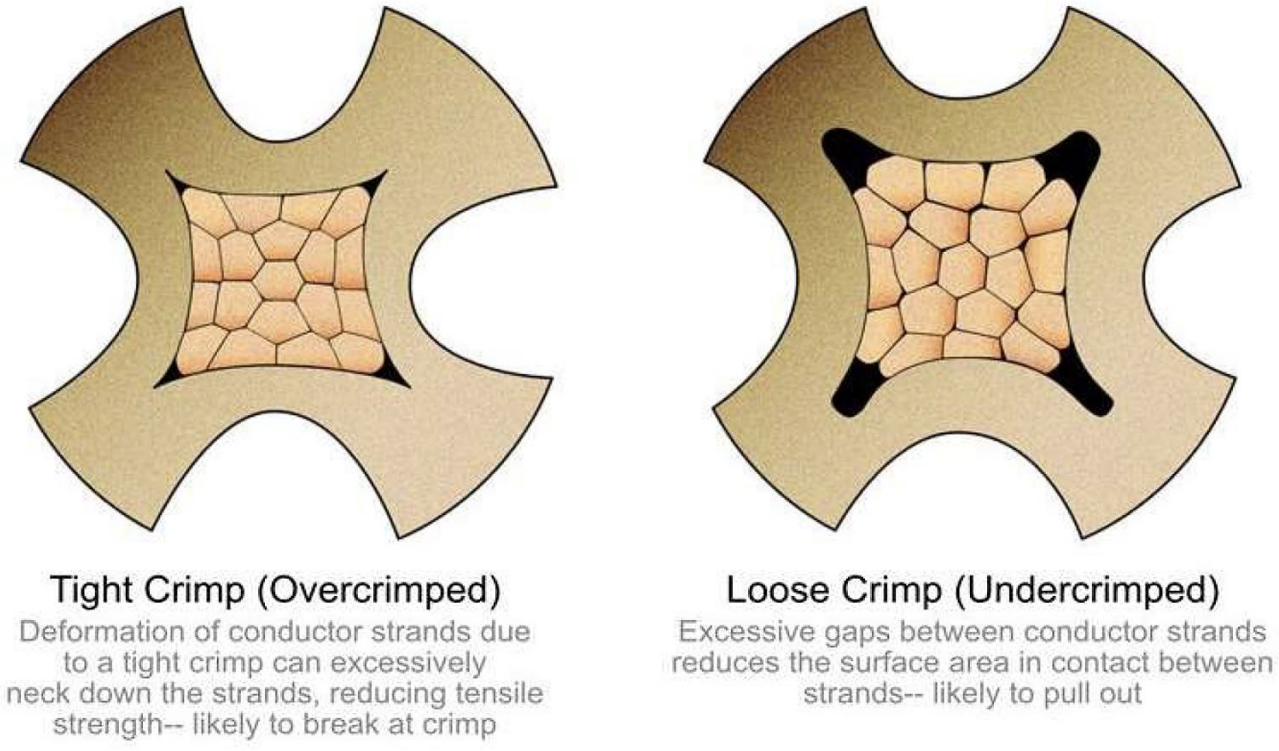

Figure 8: Cross-section of machined contacts.

was first introduced in the C-revision of IPC/WHMA-A-620 Space Addendum § 19.7.2, *Mechanical Test Methods—Pull Force (Tensile).*

For manufacturers of cables or harnesses, the team responsible for the crimping process should plan to meet pull force test needs according to the frequency and number of samples required. The plan should include the purchasing of enough contacts to perform the minimum number of tests. This may require communication between engineering, procurement, and manufacturing.

This article's comparison of pull test requirements to technical standards has been conducted with respect to the NASA-STD- 8739.4 and IPC/WHMA-A-620 requirements. The requirements were compared with 780 data points retrieved from tensile test logs. All data points met or exceeded the requirements, and no defects were inferred from the records.

Despite the study analyzing 780 data points for pull force testing, and all samples passed, this is an insufficient quantity of data points to identify trends on material properties of wires from different suppliers which may have differing metallurgical composition. Additional access to pull testing logs will provide further analysis of crimped termination data to identify additional process control and opportunities to mitigate risk. A sample size of data at least 1 order of magnitude larger will be required to effectively analyze contact/conductor pairs distinguishing between silver/tin plated and nickel-plated wires, and how they vary between suppliers. Machine-readable data from tensile logs, or digital data capture of tensile testing, can significantly ease the burden of sorting and filtering tensile test data, which is commonly hand-written on a paper log.

However, defects related to incorrect or malformed contacts were observed in the investigation on crimp-related problem failure reports. These crimp-related incidents were evaluated, and many of the conditions identified were determined to be undetectable by a pull force test (e.g., conductor strands not captured in crimp barrel, damaged insulation, traceability errors, etc.). For this reason, the testing proce-

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dure cannot be used to detect defects in crimp materials. Instead, the tensile test must only be used as a tool to verify that the tool and the action of crimp is correctly performed. SMT007

Acknowledgments

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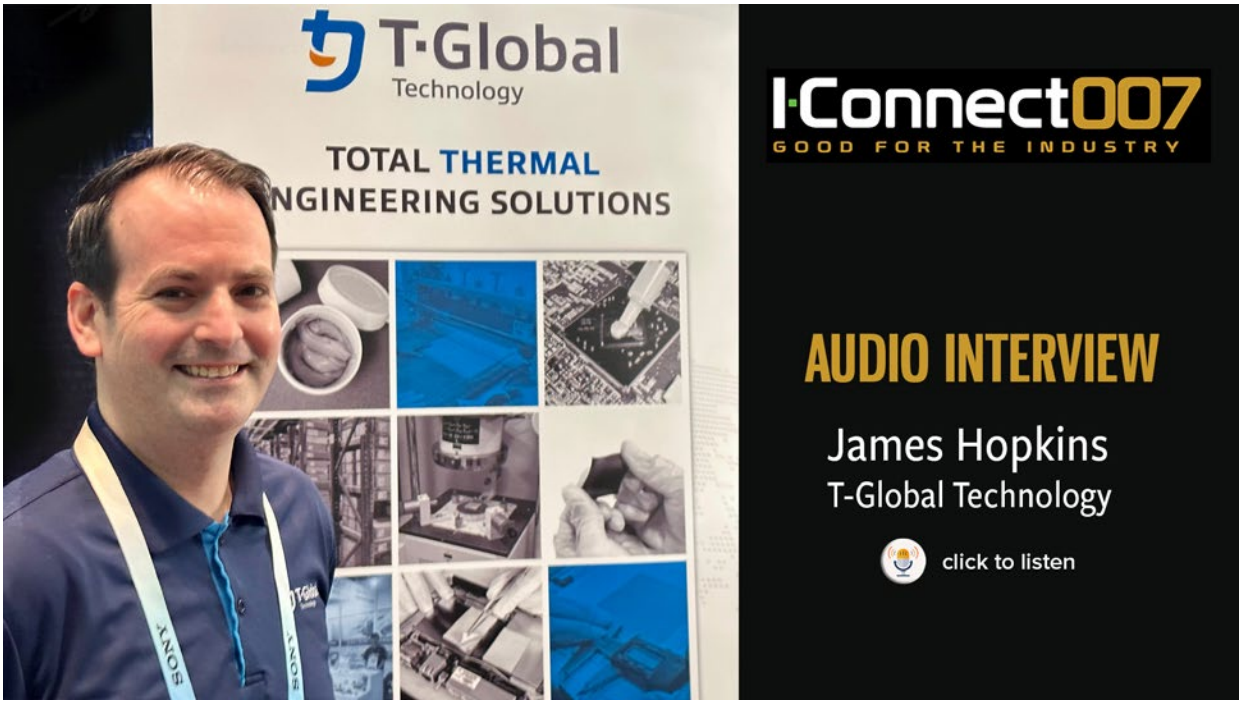

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WHITE PAPER EXCERPT:

The Brave New World of PCB Design Validation—Cloud-based DFM and Collaboration

Article by Susan Kayesar
SIEMENS DIGITAL INDUSTRIES SOFTWARE, AIRPORT CITY, ISRAEL

Editor's note: Susan Kayesar's complete paper is available in the 2023 IPC APEX EXPO Proceedings.

The electronics industry is constantly evolving and changing. This means that the way companies design and manufacture their products must also change and adapt to new trends.

One of the most important changes in recent years has been the shift to adopt design for manufacturing (DFM) analysis as part of the standard printed circuit board (PCB) development lifecycle. DFM is a process that helps companies optimize their designs for manufacturability. It is a critical step in the product development process, and it has become more essential as the electronics industry becomes more complex.

The electronics industry is also in the midst of a major shift toward cloud-based solutions and services. This shift is being driven by several factors, including the growing popularity of cloud computing, the declining cost of cloud services, improved data security, and increased availability of reliable high-speed internet access. In the general push to move business to the cloud, the electronics industry is following suit. This shift will bring about several changes in the way that electronics are designed, manufactured, and sold, and it will further drive the need to lower cost and reduce time-to-market for new product introductions. As the

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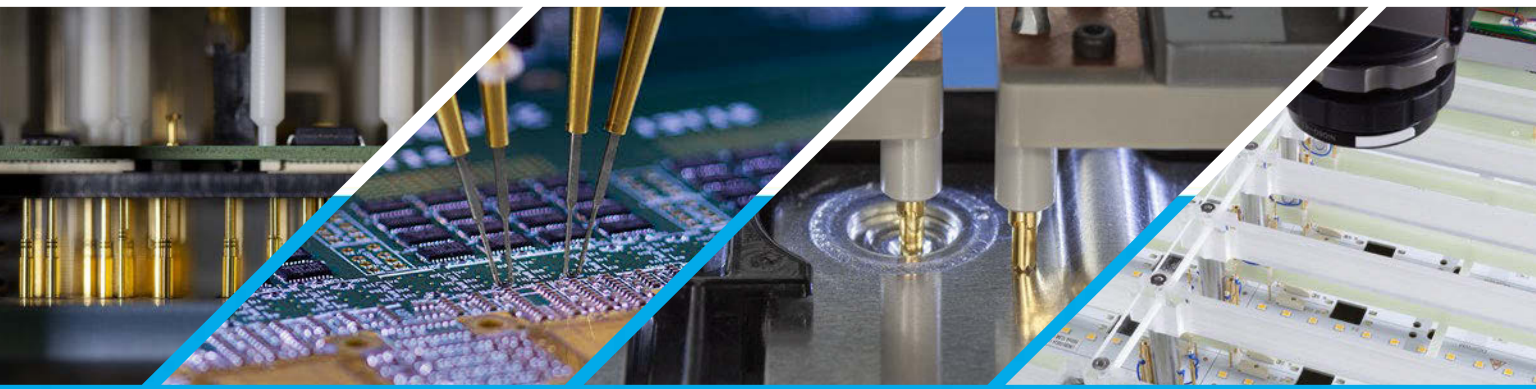

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electronics industry moves toward cloudification, we can expect to see more manufacturers offering cloud-based solutions and services, and the shift to online DFM is a natural extension of this trend.

Results

The extensive literature survey resulted in an in-depth review and exploration of recent trends of cloudification in the electronics industry with a focus on the printed circuit board industry, detailed in the discussion section of this article.

This literature survey confirms that cloudification is a foregone conclusion for the electronics industry and we may infer that the pace of cloudification is increasing as time goes by. Moving resources and managing the development process in cloud-based tools is viewed as a way to reduce cost, improve workflow efficiency, and reduce time to market. Adoption of cloud-based tools as standard practice in electronic design is a clear industry trend, and companies are vying for position in the market to provide cloud-based services and tools to this emerging market.

We propose that DFM analysis is the next PCB lifecycle event that will migrate to the cloud. We also propose that further research is warranted to determine what specific markets will evolve for services in the cloud paradigm, and how the shift of market share to smaller companies will affect the services provision and consumption models.

The electronics industry is grappling with multiple interrelated challenges as described below.

Increasing Customization of Electronic Products

As complex electronic devices become ubiquitous in our everyday lives, there is an increasing demand for devices that are customizable to individual needs.

An indication of the rise in customization is the growing number of companies that allow consumers to configure and order products that are individualized to their specific requirements. By way of example: one database lists more than 1,200 configurator companies, organized in 17 categories[1]. In 2020, Jagjit Singh Srai, head of the Center for International Manufacturing at the University of Cambridge, told the New York Times that he predicted most major consumer companies would offer customization by 2025[2].

From all this, it is clear that the trend toward customization is here to stay. As electronic devices become integral to our lives, the market will continue to demand devices that are tailored to individual needs and preferences.

Development Cycles in the Electronics Industry Are Getting Shorter

Among the benefits of shorter development cycles is the ability to respond quickly to changes in the market and customer demands. Shorter development cycles also allow for more frequent release of new features and functionality, which can help to keep customers engaged.

However, shorter development cycles can also lead to increased pressure on development teams and can make it more difficult to ensure the quality of the final product. There is also the risk that products may be released before they are fully ready, which can lead to customer dissatisfaction. Despite the challenges, the trend of shorter development cycles is likely to continue, as the benefits outweigh the risks. Development teams that can adapt to the challenges and learn to work in an agile way will be well-positioned to succeed in the future.

As development cycles contract, and time to market becomes increasingly important, factories are being forced to digitize in order to improve efficiency, bring their manufacturing closer to customers, and shorten the new product introduction (NPI) process. One survey of manufacturers in Germany found that just over 90% of factories are investing in digital technologies[3]. Of those, almost all (98%)

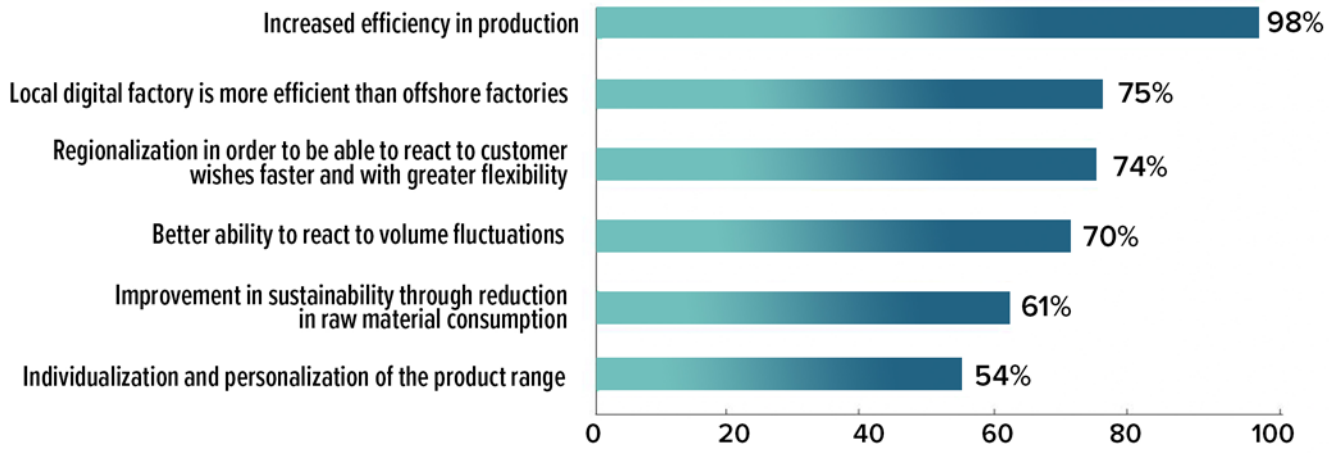

Figure 1: Key reasons for digitizing factories[3].

highlighted the need to increase production efficiency as a key reason for digitization.

Is Supply Chain Really an Issue in the Electronics Industry?

In today's business world, the supply chain is critical to the success of any company, but especially so in the electronics industry, which is extremely globalized. A company's supply chain is the network of suppliers, manufacturers, warehouses, and distribution centers that are involved in getting a product from the raw material stage to the finished product stage. In the electronics industry, the supply chain is especially complex and globally disparate, with components typically originating from multiple countries and being assembled in a different country. A single finished product can contain hundreds of individual parts and numerous subsystems or modules, each of which may itself be made up of dozens or even hundreds of parts.

An efficient supply chain is also crucial to manage and minimize time to market. As previously noted, in the electronics industry, new products are constantly being introduced and the competition is fierce. Companies that can get their products to market quickly have a major advantage.

Semiconductor shortages account for a large part of the supply chain discussions. Pandemic-era lockdowns are widely thought to be the cause of semiconductor shortages. However, while the pandemic was certainly a factor in 2020 and 2021, the further we get from that extended period of closures, the clearer it becomes that the main issue is fast-growing demand that is outstripping supply. With more and more products requiring electronic components, such as toys and cars, and even clothing, semiconductor producers have not been able to keep up with demand[4].

The path forward looks equally dire, indicating that in the near future supply chain issues will only continue to grow. Returning to our automobile industry as an example, the growth in electronic vehicles will further exacerbate demand for semiconductors. It is predicted that in the U.S. alone more than 7 million electric vehicles will be in production by 2028, each of them requiring numerous chips[5].

Supply Chain Intellectual Security is a Hidden Issue That Makes Procurement Even More Challenging

The electronics industry is built on a global supply chain that is often complex and opaque. Components and finished goods are sourced

Table 1: Value and quantity of global customs seizures of counterfeit ICT products, 2011–13[6,7]

Period	Value in USD million	Number of seizures	% of total seized value	% of total number of seizures
2011	263.43	17558	12.70%	12.50%
2012	271.73	20846	14.30%	10.90%
2013	309.43	21960	15.40%	10.40%
2011-13	804.59	60364	14.10%	11.30%

from all over the world, and the lines between original equipment manufacturers (OEMs), contract manufacturers (CMs), and original design manufacturers (ODMs) are often blurred. This complexity makes it difficult for companies to know where their products are, and it makes it easier for criminals to introduce counterfeit parts or to steal IP. In addition, the constant pressure to innovate and bring new products to market quickly can lead to shortcuts in the supply chain that can create vulnerabilities.

The electronics industry is taking steps to improve supply chain security. The U.S. government has also been working to raise awareness of the issue and has taken action to protect the U.S. supply chain.

SMBs Now Dominate the Electronics Manufacturing Industry

Small and medium businesses (SMBs) are vital to the electronics industry. They provide many of the products and services that larger businesses and consumers depend on. SMBs make the printed circuit boards that are found in almost all electronic devices. They also design and manufacture the electronic components that go into these devices. In addition, SMBs provide assembly, packaging, and other services to the electronics industry. The growing trend of SMBs providing contract manufacturing services is due to an effort to avoid financial investments in production lines and take advantage of the design expertise and manufacturing capabilities of the service providers[8].

Figure 2: SMBs play a significant role across industries and particularly in developing countries.


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SMBs are under pressure to adopt new technologies and expand their product portfolios. A key reason for this is that the electronics industry is highly competitive, and SMBs must continuously innovate and offer unique products and services to survive and thrive.

A 2019 report on U.S. SMBs noted that more than 80% used digital tools for internal management and logistics, to improve business processes and productivity[9]. Examples of these tools are cloud-based software solutions, enterprise resource planning (ERP) software, and proprietary software to connect sales with supply chain operations.

However, SMBs face many challenges. They often lack the financial resources and the economies of scale that larger businesses have. As a result, they may find it difficult to compete against large enterprises. In addition, SMBs may have difficulty accessing the latest technology and tools due to their cost and the resources required to onboard them. They may also struggle to attract and retain qualified employees.

Market Trends for Adoption of Cloud-based Tools

The market for cloud-based tools is growing, with businesses of all sizes adopting these tools to improve their efficiency, agility, and productivity. Indeed, use of cloud computing is nearly ubiquitous. An international survey conducted by O'Reilly in July 2021 found that 90% of companies are using cloud computing, up from 88% in 2020[11]. There are a few key enablers to the trend:

1. Cloud-based tools require no on-premises installation or integration, eliminating a significant burden on information technology (IT) and administration staff.
2. Cloud-based tools are becoming more user-friendly, making them easier for businesses to adopt.
3. The cost of cloud-based tools is dropping, making them more affordable for businesses. Some of the cost decreases are the natural result of technologies maturing. However, a major element in their growing affordability is lower operational costs that come with experience in using cloud-based tools. A 2020-2021 study found that for companies requiring fewer than 1000 licenses of Unified Communications as a Service (UCaaS) cloud-based software tools, the annual total spend per license was about 37% cheaper than it would be for each on-premises license. This takes

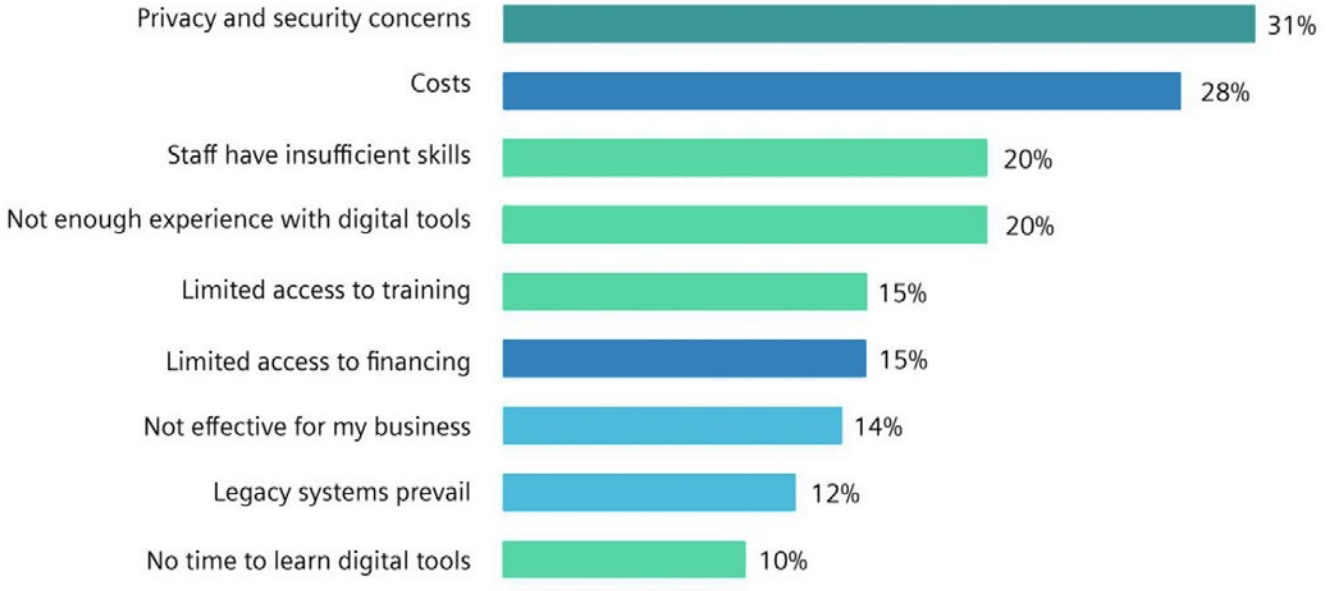

Figure 3, 4: SMBs' top barriers to adopting digital tools[10].

into account the license cost as well as operational costs such as IT staff, equipment maintenance, training and power[11].

4. The security and reliability of cloud-based tools is improving, making them more attractive to businesses. For example, security is being incorporated continuously starting at the development stage and across the entire lifecycle of software tools, instead of being almost an afterthought. And frameworks like customized cloud disaster recovery strategies and secure access service edge (SASE) are now commonly implemented as part of the adoption strategy for cloud-based tools.

These trends indicate that the market for cloud-based tools will continue to grow at a rapid pace in the coming years. In light of the pressure on the electronics manufacturing industry to increase productivity and efficiency as noted earlier in this paper, EMS companies are increasingly adopting cloud-based solutions to help them streamline their operations.

EDA is Moving to the Cloud

As the world increasingly moves toward cloud-based services, more companies are finding that their electronic design needs can be met using cloud-based tools and platforms. While there are still some companies who cling to on-premises electronic design automation (EDA) tools, the trend is definitely moving toward the cloud. Examples of companies that are making the switch to cloud-based electronics design include:

- Autodesk: In 2015, the company announced that its AutoCAD3D design software would be available as a cloud-based service. Since then, the company has released additional cloud-based design tools.
- Siemens: The company's NX design software is now available as a cloud-based service, and it offers various cloud-based design tools for several of its other products.
- PTC: The company has also been moving to the cloud with its electronic design offerings. Its Windchill product lifecycle management (PLM) software is now available as a cloud-based service, and it has been investing in other cloud-based design tools.
- Dassault Systèmes: The company's Solidworks software is now available as a cloud-based service, and it is investing in additional cloud-based design tools.
- Cadence: The company's Allegro and OrCAD EDA software products are now available as cloud-based services, and it has been investing in other cloud-based design tools as well.

It is not just software companies that are shifting EDA to the cloud. In May 2022, Advanced Micro Devices announced it would move some of its EDA workloads for chip design onto a public cloud. Its stated reasons for the move were to extend the capabilities of its own data centers and gain advanced networking, storage and artificial intelligence capabilities.

The Next Logical Step: Moving Design for Manufacture (DFM) Analysis into the Cloud

Following the general trends of cloudification examined in this paper, we propose that DFM analysis is the next logical step in taking PCB design and manufacture to the cloud. There are many reasons to do this, but the most compelling are speed, collaboration, scalability, and accessibility.

Speed is perhaps the most obvious reason to move DFM to the cloud. With on-premises solutions, engineers must wait to requisition, install, and configure the necessary software, which is often a time-consuming step. With a cloud solution, they can get started immediately. But speed is not just about getting started

quickly. Cloud-based DFM solutions can also help designers iterate faster. With the ability to make changes and see the results in real-time, designers can experiment and get to the optimal solution faster.

Collaboration is another key reason to move DFM to the cloud. With on-premises solutions, it can be difficult to get everyone on the same page. With a cloud solution, multiple engineers can work on the same DFM analysis at the same time. This can be a huge time-saver, especially for large projects. Collaboration between geographically disparate design teams is no longer an issue, since all are working on the same project simultaneously. Likewise, collaboration between designer and manufacturer no longer needs to be an arduous process. Cloud storage and collaboration can offer secure data transfer between stakeholders as well as direct communication to clarify design intent and reduce time-to-market.

DFM analysis is particularly influenced by the improved collaboration offered by the cloud environment. To date, communication between designer and manufacturer was a time-consuming process, with no standard format to accurately and efficiently convey true manufacturing constraints to designers. Previously, manufacturing rules, such as for design rule checking (DRC) and DFM, had to be conveyed between parties by phone, or in complex standards documents and spreadsheets. Now, a single cloud collaboration platform can serve both designer and manufacturer, providing the opportunity for manufacturers to directly communicate both their capabilities and limitations. Designs can be quickly modified to conform, and any uncertainties can be clarified using in-app tools such as chat, notifications, etc.

Scalability and resulting cost savings form the third reason to move DFM to the cloud. On-premises solutions can be limited by the number of software licenses purchased, whereas cloud-based solutions are typically subscription-based with no upfront cost. Cloud-based solutions can be scaled up or down as needed, paying for what is used, resulting in cost savings. This is especially relevant for SMBs where the use of DFM software can be sporadic, and purchase of permanent tools might not be justifiable.

Accessibility is the fourth reason to do DFM on the cloud. Cloud-based solutions can be accessed from anywhere, so engineers can work on DFM analysis even when they are not physically in an office or onsite at the fabrication or assembly plant. In the emerging post-COVID19 hybrid mode of work, this is a big advantage for maintaining efficiency. The online software needs no maintenance or updating, guaranteeing access to the most recent version, latest features and functionality with no additional operator or IT investment. These solutions are accessible to all potential users, regardless of the company's size or budget. We expect that this egalitarian access will further disrupt the balance of enterprises vs. SMBs in the PCB design industry since it makes possible quality DFM and collaboration with previously unreachable partners.

Conclusions

There is a definite push to move the electronic design and manufacture industry into the cloud. Regardless of company size, the ever-present pressure to lower costs and reduce time to market for new product introductions is now leading most businesses in the industry to adopt tools and practices that are

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de-facto decentralized and globally accessible. Cloud tools are considered central to improving communication, implementing sustainable development processes, mitigating potential supply chain risks, and adopting agile practices that lead to robust manufacturing capability that can bridge gaps in a globally disparate production environment.

We note that design processes have already successfully launched into the cloud and are available to designers from a wide range of service providers. We propose that the next logical step of cloud adoption will be DFM analysis, bringing the verification of designs into the cloud as well. We expect that a number of companies will vie for position in this emerging market, in a similar manner to what is already taking place in the cloud-based EDA market.

Furthermore, we propose that new markets will evolve for services in the cloud, to meet the needs of PCB design and manufacturing at each step of the new product introduction workflow. We predict that the rising importance of small-to-medium businesses (SMBs) in the electronics industry will increase demand for and drive provision of affordable solutions in the cloud for all PCB lifecycle events. This emerging market deserves the attention of all current software and service providers as it may disrupt and displace the legacy, on-premises, monolithic approach to PCB design, verification, manufacturing, assembly, and testing. **SMT007**

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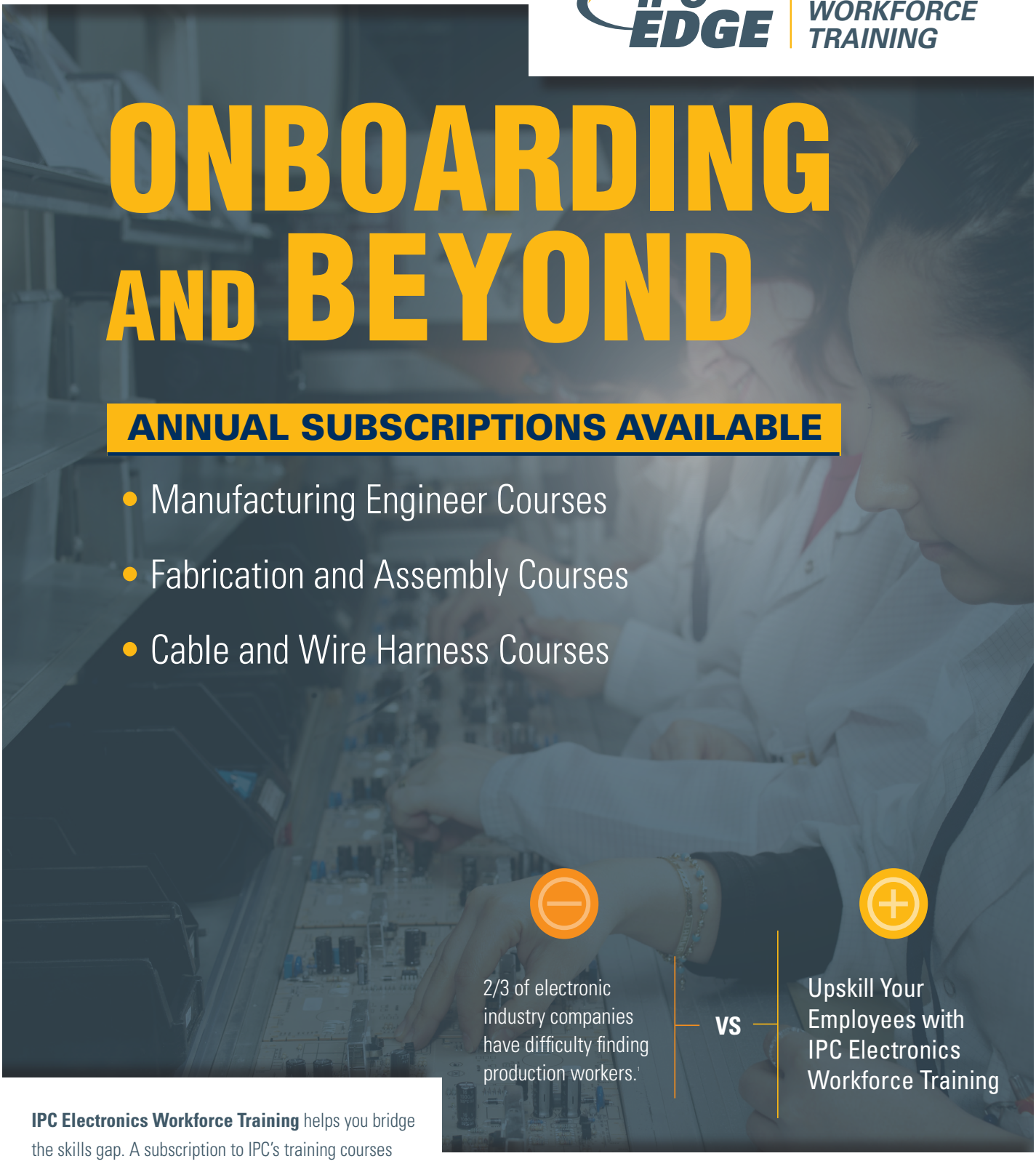

2/3 of electronic industry companies have difficulty finding production workers.[1]

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

TOP TEN

EDITOR'S PICKS

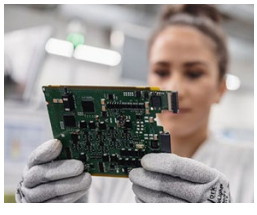
Renesas to Acquire PCB Design Software Leader Altium

Renesas will acquire all outstanding shares of Altium for a cash price of A$68.50 per share, representing a total equity value of approximately A$9.1 billion. The acquisition enables two industry leaders to join forces and establish an integrated and open electronics system design and lifecycle management platform that allows for collaboration across component, subsystem, and system-level design. The transaction strongly aligns with Renesas' digitalization strategy and represents the company's first significant step in bringing enhanced user experience and innovation at the system level for electronics system designers.

Department of Defense to Expand Manufacturing of PCBA for Hypersonic Weapons

The Department of Defense announced an award of $11.7 million via the Defense Production Act Investment (DPAI) Program to Ensign-Bickford Aerospace & Defense (EBAD) that will provide additional PCBA production capacity at their Simsbury, Conn., location. EBAD will increase existing capacity and manufacturing processes to reduce cost and accelerate PCBA production.

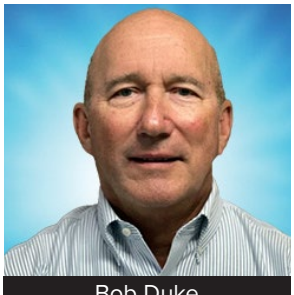
Siemens Joins Semiconductor Education Alliance to Address Skills and Talent Shortage in Global Semiconductor Industry



Siemens Digital Industries Software announced it has joined the Semiconductor Education Alliance to help build and nurture thriving communities of practice across the integrated circuit (IC) design and Electronic Design Automation (EDA) industries, from teachers and schools to universities, publishers, educational technology companies and research organizations.

Global Sourcing Spotlight: Global Sourcing is Good for Everyone

In business, as in life, it's important to have an open mind. Take the people you work with at face value rather than what you are told by politicians and the media. It has always been amazing to me how easy it is to have resentment toward a people, as a country (or nationality) until you get up close and personal. Then it is not so easy. Dealing with people face to face, as human beings and fellow citizens of the world, where you get to see them as they are, is so much better and more productive. Global sourcing is a great place to start.



Bob Duke

iNEMI End-of-Project Webinar: Connector Reliability Test Recommendations

The iNEMI Connector Reliability Test Recommendations Project, Phases 1–3, addressed the need for a standardized reliability evaluation method for connectors. The project was driven by the need for a more complete understanding of a component's reliability to determine whether it could potentially have more uses/applications than it was initially designed and tested for.

Walmart Acquires Vizio, Set to Overtake Samsung as the Largest TV Brand in the U.S.

U.S. retail giant Walmart announced that it has acquired smart TV brand Vizio for $2.3 billion, aiming to accelerate the growth of its advertising business: Walmart Connect. Since its launch in 2021, Walmart Connect has seen double-digit annual growth in both its online and offline retail media advertising ventures.

North American EMS Industry Up 2.6% in January 2024

IPC's monthly EMS industry statistics are based on data provided by a representative sample of assembly equipment manufacturers selling in the USA and Canada. IPC publishes the EMS book-to-bill ratio by the end of each month.

IPC Releases Newest List of Standards Updates, Revisions

Each quarter, IPC releases a list of standards that are new or have been updated. Mentioned here: IPC-1791D, IPC-6012F, IPC-1782B, IPC/WHMA-A-620E-S, IPC-2591-V1.6, and IPC-9203A. To view a complete list of newly published standards and standards revisions, translations, proposed standards for ballot, final drafts for industry review, working drafts, and project approvals, visit ipc.org/status.

Top 5 Robot Trends 2024

The stock of operational robots around the globe hit a new record of about 3.9 million units. This demand is driven by a number of exciting technological innovations. The International Federation of Robotics reports about the top 5 automation trends in 2024.

Global Semiconductor Manufacturing Industry Poised for 2024 Recovery, SEMI Reports

The global semiconductor manufacturing industry recovery is taking hold with electronics and IC sales increasing in the final quarter of 2023 and more growth projected for 2024, SEMI announced in its fourth quarter 2023 publication of the Semiconductor Manufacturing Monitor (SMM) report, prepared in partnership with TechInsights.

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- Leads advancement of team capabilities through identification and definition of eCAD Library technical strategy
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Prototron Circuits

Sales Representatives

Prototron Circuits, a market-leading, quick-turn PCB manufacturer located in Tucson, AZ, is looking for sales representatives for the Utah/Colorado, and Northern California territories. With 35+ years of experience, our PCB manufacturing capabilities reach far beyond that of your typical fabricator.

Reasons you should work with Prototron:

- Solid reputation for on-time delivery (98+% on-time)
- Capacity for growth
- Excellent quality
- Production quality quick-turn services in as little as 24 hours
- 5-day standard lead time
- RF/microwave and special materials
- AS9100D
- MIL-PRF- 31032
- ITAR
- Global sourcing option (Taiwan)
- Engineering consultation, impedance modeling
- Completely customer focused team

Interested? Please contact Russ Adams at (206) 351-0281 or russa@prototron.com.

apply now

EMA Design Automation

Technical Marketing Engineer

EMA Design Automation, a leader in product development solutions, is in search of a detail-oriented individual who can apply their knowledge of electrical design and CAD software to assist marketing in the creation of videos, training materials, blog posts, and more. This Technical Marketing Engineer role is ideal for analytical problem-solvers who enjoy educating and teaching others.

Requirements:

- Bachelor's degree in electrical engineering or related field with a basic understanding of engineering theories and terminology required
- Basic knowledge of schematic design, PCB design, and simulation with experience in OrCAD or Allegro preferred
- Candidates must possess excellent writing skills with an understanding of sentence structure and grammar
- Basic knowledge of video editing and experience using Camtasia or Adobe Premiere Pro is preferred but not required
- Must be able to collaborate well with others and have excellent written and verbal communication skills for this remote position

EMA Design Automation is a small, family-owned company that fosters a flexible, collaborative environment and promotes professional growth.

Send Resumes to: resumes@ema-eda.com

apply now

Career Opportunities

ARLON ELECTRONIC MATERIALS

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

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

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

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

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

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

apply now

INSULECTRO

Are You Our Next Superstar?!

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

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

apply now

Career Opportunities

MivaTek Global

Field Service Technician

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

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

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

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

More About Us

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

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eptac

TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

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

Qualifications and skills

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

Benefits

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

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Career Opportunities

American Standard Circuits
Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

Summary of Functions

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

Essential Duties and Responsibilities

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

Organizational Relationship

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

Qualifications

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

Physical Demands

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

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LOOK INSIDE

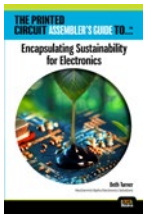
IPC BUILD ELECTRONICS BETTER

Contact us to become an advertiser

PODCAST! Designing for Reality with ASC Sunstone

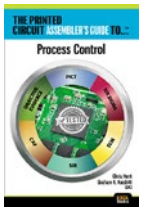
In Season 2, listeners can expect in-depth conversations with VP/manager and published author Matt Stevenson about the specifics that can affect your circuit board during the manufacturing process. Part tutorial, part tips and tricks, Stevenson details the interrelationships between design, fabrication, yields and cost optimization.

I-007eBooks



New! Encapsulating Sustainability for Electronics

This is a guide to encapsulation resins and their use in ruggedizing electronics. Learn about aspects such as their chemistry, application, and relevant test methods in different industries. The book also discusses the growing demand for sustainable solutions in the market and highlights examples of bio-based resins and the demand from emerging technologies.



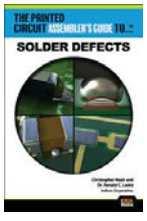
Process Control

by Chris Hunt and Graham K. Naisbitt, GEN3

In this book, the authors examine the role of SEC test and how it is used in maintaining process control and support for objective evidence (OE.) Issues, including solution choices, solution sensitivities, and test duration are explored.

The Companion Guide to... SMT Inspection: Today, Tomorrow, and Beyond

Advances in artificial intelligence have been limited exclusively to the human world until now, but there are far-reaching applications within the manufacturing sector, too. In this guide book, learn how equipment providers like Koh Young are enabling the Smart Factory of the Future by adopting AI to generate "knowledge" from "experience."



Solder Defects

by Christopher Nash and Dr. Ronald C. Lasky, Indium Corporation

This book is specifically dedicated to educating the printed circuit board assembly sector and serves as a valuable resource for people seeking the most relevant information available.

Smarter Manufacturing Enabled with Inspection Data

with expert Ivan Aduna

In this 12-part webinar series, viewers will learn about secure data collection, AI-powered solutions to manage and analyze data, and how to leverage the IPC CFX-QPL to succeed in the transformation to Industry 4.0.

Our library is open 24/7/365. Visit us at: I-007eBooks.com

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