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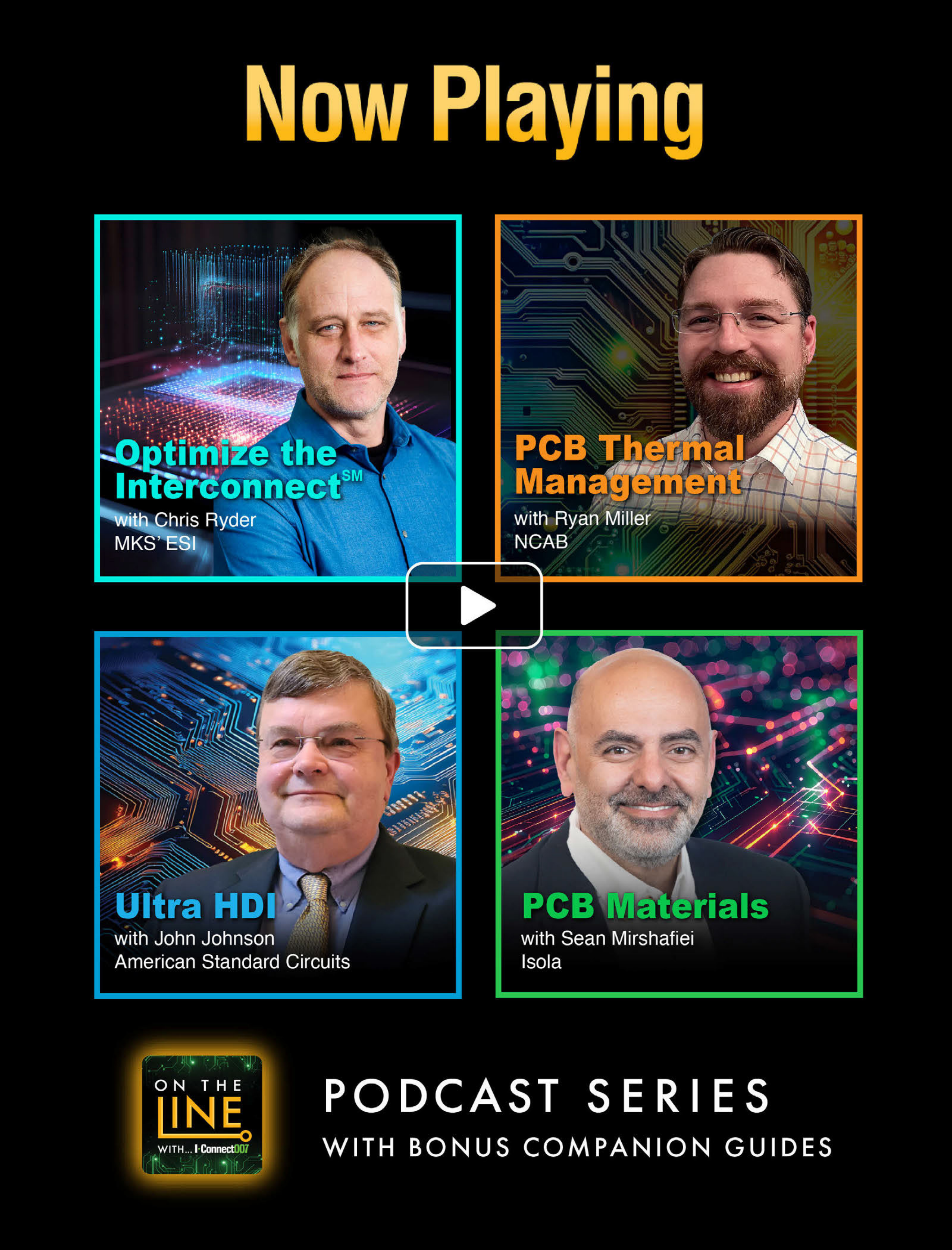
SMT007 MAGAZINE

SPOTLIGHT ON NORTH AMERICA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Spotlight on North America

This issue spotlights North America, examining the forces reshaping electronics manufacturing across the U.S. and Canada. From tariffs and reshoring to AI-driven demand, cybersecurity, workforce development, and supply chain strain, we explore a region navigating uncertainty while rebuilding domestic capability and redefining its role in the global electronics ecosystem.

May 2026

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SMT007 MAGAZINE

Our Spotlight on North America

BY NOLAN JOHNSON, I-CONNECT007

In this issue of *SMT007 Magazine*, we wrap up our electronics world tour with a final stop in the United States and Canada, where we look at the challenges, opportunities, and geopolitical dynamics affecting the market today. What makes American electronics unique?

"You can always count on the Americans to do the right thing, after they have exhausted all other possibilities," said Winston Churchill (or at least it's been attributed to him). Benjamin Franklin, publisher, inventor, and a Founding Father, said he invented so many things to make life easier because he was "industriously lazy." As an American, I see how these observations describe our "do more with less" culture. You can count on us to try all the "industriously lazy" options before we do the often much harder, but proper, right thing. Which could explain so much about current American politics, but that's a discussion for another day. Still, key U.S. administration policy decisions, like tariffs, are significantly affecting electronics manufacturing. Others, such as the current conflict with Iran and

the associated closures of the Strait of Hormuz, affect the raw materials that feed our supply chain.

U.S. trade policy is seeking to accelerate the return of critical electronics manufacturing capabilities to U.S. soil, and no matter your opinion on the subject, we know that the U.S. and Canada are exposed when it comes to mission-critical manufacturing. We invited trade and tariff attorney James Kim to help us better understand the new policies, and he gets specific in his piece about Section 232: What is it, how will it be implemented, and how does it directly impact electronics manufacturing? His analysis is crisp, well-grounded in context, and includes practical responses for you to take away.

I'm also including an interview with Joe Schneider, vice president of U.S. and Canada operations for the Global Electronics Association. I talked with Joe at APEX EXPO 2026, where he laid out a mission to develop domestic manufacturing in both countries through stronger relationships with regional membership, customers, and partners.

You can't talk about North American electronics without mentioning security, so I'm sharing the *Real Time with...* APEX EXPO cybersecurity roundtable discussion about CMMC. Like the experts say, "If you're not already preparing for CMMC, you're behind."

Building a healthy electronics manufacturing ecosystem in North America will require skilled staff. We've got a great article about some Michigan folks who are introducing grade schoolers to electronics and manufacturing. Kids can't pursue a career that they don't know exists. Finally, we have a profile on Omega EMS, a rapidly growing San Jose-based EMS company that recently opened another factory in Vietnam. Let's learn about their secret to success.

Elsewhere in this issue, Retronix, a rework company, writes about how to respond to the growing effect on the supply chain from the DRAM shortages. Columnist Nash Bell educates us on precision-milling underfills, among other topics.

In the automotive sector, we continue our series on EV reliability with Stanton Rak, and MacDermid Alpha Electronics Solutions' Beth Massey takes an in-depth look at protecting advanced electronics in the trucking industry.

While retooling America seems to be taking a topsy-turvy route to success, there are so many positives to consider. We may try all sorts of "industriously lazy" programs, but they all ultimately lead to doing the right thing. Besides, what if that crazy solution turns out to be the right one?

We're always looking for your comments, feedback, and suggestions. What do you want us to investigate? Let us know at info@iconnect007.com.

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**.

BY NOLAN JOHNSON, I-CONNECT007

NORTH AMERICAN ELECTRONICS Growth and Challenges

Nolan Johnson interviews Joe Schneider, vice president of U.S. and Canada for the Global Electronics Association, about trends in the North American electronics industry. Joe discusses the surge in U.S. data center demand, the Association's work on AI standards, and strategic focus on aerospace and defense. The conversation addresses workforce development and capacity challenges, highlighting the Association's commitment to supporting member growth and knowledge acquisition in 2026.

Nolan Johnson: Yours is a new role that did not exist before. You represent our first customer-facing program, direction overview, and oversight for North America. How did this come about?

Joe Schneider: Before it was renamed Global Electronics Association, IPC was growing internationally, creating regional leaders in Southeast Asia, China, and Europe. It was thought, "Hey, we still need to have a region lead for North America, where we came from, to make sure we're addressing the needs and wants of our members here locally in this region."

WATCH THE FULL INTERVIEW

When we're having regional impact, when this works as a strategy, it should be everywhere. North America just happened to be the last one?
That's right. We are a global association, but each region has unique profiles and unique needs. It's important that we're listening to this large member contingent that is here in the United States, and in North America.

What are the current opportunities, challenges, and dynamics that you're seeing in North America?
Just in my first year, without question, it's the extreme growth in data centers. The United States is huge, and it's put a lot of stress on our EMS and manufacturing communities, and on our membership, of breaking ground, hiring thousands of employees, and getting them ramped up. It has called for our Association to develop standards for AI data centers. Also unique are educational programs that are directed exactly toward how to manufacture data centers. It's an exciting time on that. In addition, there's a huge emphasis here in the United States for aerospace and defense. Not only because of current situations, but historically, aerospace and defense are a strategic direction for our Association.

We've brought on a new account director, George Rivera. He's here at the show, and he has extensive experience working with defense companies. He's a U.S. Marine veteran, and it's definitely a signal to our region that this is an important strategic direction for us.

There's a need to build out data centers and defense, so very cutting-edge manufacturing, design, and electronics make total sense there. Our capacity here in North America may not be sufficient to deliver all those needs, so the response would be to go overseas. But with current geopolitical situations, how do we address that?
I'd say today we are addressing that with significant investment in infrastructure and new facilities with our manufacturing community here in the U.S. For our large members, it used to be where all the manufacturing focus was to go outside the U.S., and that's changed. It's quickly becoming a very focused region globally, with certain markets like data centers growing here in the United States, which is great news.

Inside your team to help accomplish that sort of a mission, what would be your top three priorities for 2026?
The top three priorities are to help with workforce training so our members can achieve their goals in terms of ramp-up, using apprentice programs, and developing unique curricula for dedicated programs such as data centers.

That's key. The additional focus is on defense. What else do our defense members need from us? We're here to learn and focus on them. As they grow and are challenged to do things they haven't done before, we need to be there for them.

What's your call to action for non-members here in North America? Why should they get involved with the Global Electronics Association?
What I have seen in my first year with the Global Electronics Association, is not only do we have a tremendous technical capability from our standards and education team, but there's just a positive community aspect.

Our wire harness and EMS communities are strong. They love getting together and sharing stories, comparing notes, and figuring out how to grow. That community aspect is a big reason why our membership continues to grow. That's my message to companies that are thinking about why they should join.

We have free training and discounts for members. Overall, our Association really represents the entire ecosystem of the electronics industry. So, there's always something for any company in that ecosystem, whether you're a distributor, a supplier, or a manufacturer. Give us a call, we'd be happy to help. **SMT007**

BY JAMES KIM, ARENTFOX SCHIFF LLP

How New Metals Tariffs Impact the Electronics Industry

Editor's note: Tariff Terminal is a new series exploring how trade policy, tariffs, and customs developments impact the electronics manufacturing industry. This is the first installment.

If you work in surface mount assembly, EMS, or anywhere along the electronics supply chain, you probably think of tariffs as something that happens upstream: raw materials, bulk commodities, maybe the occasional headache with Chinese imports. Steel and aluminum tariffs? That's someone else's problem.

Not anymore.

On April 2, President Trump signed a sweeping new proclamation that fundamentally restructures how Section 232 "national security" tariffs apply to steel, aluminum, copper, and their derivative products. The changes took effect on April 6, and the ripple effects are headed straight for the electronics industry.

A Quick Primer on Section 232

Since 2018, the U.S. has imposed tariffs on imported steel and aluminum under Section 232 of the Trade Expansion Act of 1962, a statute that allows the President to restrict imports that threaten national security. Over time, the program expanded to

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Embedded DFM Oversight | Dedicated Program Managers | Global Production Capability | 80+ Years Combined EMS Leadership include copper and hundreds of "derivative" products: Goods that contain these metals but aren't raw metal themselves, such as cables, transformers, connectors, enclosures, and circuit board materials.

Under the old rules, importers of derivative products paid tariffs only on the metal content portion of the product's value. That meant if you imported a cable harness worth $100 and the copper inside it accounted for $30 of that value, you paid the tariff on $30. It was complicated to calculate, but for many electronics importers, it kept the duty bill manageable.

That system is gone.

Full Value, Full Impact

The new proclamation eliminates the metal-content methodology entirely. Now, Section 232 duties apply to the full customs value of the imported product. That same $100 cable harness? The 25% tariff now applies to the full $100, not just the $30 of copper. For products where the metal is a relatively small share of total value, which describes a lot of electronics, this is a significant increase in duty exposure.

The administration has organized covered products into a tiered structure. Primary metals and closely related articles are subject to a 50% tariff. A large category of downstream derivatives, including many electronics components, falls under a 25% rate. A temporary category of metal-intensive industrial and electrical grid equipment is eligible for a reduced 15% rate through Dec. 31, 2027, before stepping up to 25%.

So, What's Actually Affected?

For the SMT and EMS worlds, the new tariff lists capture a surprisingly broad range of products that move through electronics assembly operations every day:

- **Wire, cable, and harnesses.** Insulated conductors (the copper and aluminum wiring that connects everything) are now squarely in scope at 25% on full value. This includes everything from winding wire used in coil assemblies to finished cable harnesses with connectors.
- **Transformers and power conversion.** Both liquid-filled and dry-type transformers are covered at 25%. Power supply printed circuit assemblies, ferrite cores, and inductor components are on the temporary 15% list through 2027, a meaningful but time-limited reprieve.
- **Connectors, switches, and enclosures.** A wide swath of switching and connection devices, terminal blocks, boards, panels, and control cabinets now draw 25% on full value.
- **Copper foil and clad laminates.** This is the upstream gut punch. Copper foils and copper-clad laminates, foundational inputs for PCB fabrication, face the top-tier 50% rate with no de minimis escape. That cost pressure will flow through to laminate pricing across the industry.

The 15% Weight Escape Hatch

There is one important relief valve. For derivative products classified outside the primary metal chapters of the tariff schedule, which includes most electronics, Section 232 duties apply only if the covered metal accounts for at least 15% of the product's total weight. If the product falls below that threshold, the tariff doesn't apply.

This matters for mixed-material electronic assemblies. A data cable with lightweight copper conductors wrapped in heavy polymer jacketing might qualify. A printed circuit assembly where the FR-4 substrate dominates the weight could also clear the bar, but it's not likely for a power harness with heavy-gauge copper.

The catch is that you need to prove it. Importers claiming this exemption should expect scrutiny from U.S. Customs and Border Protection, including requests for a bill of materials and detailed weight breakdowns.

Supply Chain Tremors Ahead

These changes will reshape sourcing decisions. Electronics supply chains have been diversifying toward Southeast Asia and Mexico for years, driven by the China Plus One strategy. But Section 232 tariffs apply on a most-favored-nation basis. Unlike the China-specific Section 301 tariffs, these tariffs generally apply to imports regardless of origin. Moving production to Vietnam or Thailand doesn't sidestep Section 232.

That said, the temporary 15% rate on power supply PCAs and magnetics components creates a narrow window for companies to adjust. If your sourcing strategy includes products on the temporary list, the clock is already ticking toward 2028 when those rates jump to 25%. Now is the time to evaluate designs, classify your products accurately, and model cost scenarios under both the current and future rate structures.

What Comes Next

The new Section 232 framework is broader and simpler in some ways, and more expensive in many others. For an industry that already operates on thin margins, the shift from metal content to full-value assessment is not a rounding error but a material change in the cost of doing business.

In the next installment, I'll dig deeper into compliance strategies, documentation best practices, and how the new tariffs interact with other trade measures affecting electronics imports. In the meantime, if you haven't already mapped your product lines against the new tariff annexes, that should be at the top of your to-do list. The rules have changed, and for this industry, the stakes are higher than most people realize.

James Kim is an international trade lawyer at ArentFox Schiff LLP.

Cybersecurity Roundtable: Start Now

This multi-expert roundtable explores cybersecurity measures specific to electronics manufacturing. NEC's Watanabe Hiroyuki, Divyash Patel, CEO of MX2 Technologies, and Ali Pabrai, CEO at EC First, join moderator Nolan Johnson for a deeper discussion on cybersecurity certifications.

The most important asset to a manufacturer is their data. Leadership must protect that data from attack. During this discussion, these experts lay the groundwork for cybersecurity strategies, security up and down the supply chain, and specific programs, such as CMMC, IPC-1792, and NIST800-171. Security is only as strong as your weakest link, and ensuring cybersecurity along the supply chain means we'll all be links in much longer chains.

BY NOLAN JOHNSON, I-CONNECT007

Is U.S. EMS Growth Real or Just *Repositioning?*

Based on survey data, U.S. EMS providers are reporting a noticeable uptick in orders, and the narrative forming around what's driving that growth is familiar: tariffs, reshoring, and a long-awaited revival of domestic manufacturing. Some analysts even claim we've entered a super-cycle, a prolonged period of demand-driven economic growth that can last years to decades. But as is often the case in this industry, the reality is more nuanced.

A closer look at the data suggests two competing truths. First, there is real growth, but that growth seems concentrated, uneven, and, in some cases, distorted by policy-driven timing effects. Next, what kind of growth are we actually seeing, and how durable is it?

In this article, we present both bullish and bearish perspectives, then reconcile them into an analysis as holistically as possible.

The Bull Argument

Survey data from the Reshoring Initiative[1] suggests that U.S. tariff policies are not only significantly affecting reshoring, but supply chain risk, logistics costs (currently spiking since February 2026), and the value of physical proximity to OEM engineering teams are also influencing reshoring. The takeaway is that reshoring was already underway and, perhaps, tariff policies simply reinforced the trend. On the other hand, the CHIPS Act can be credited with 17 semiconductor fabs and multiple advanced packaging facilities announced in the U.S., reaffirming that investment policies can create manufacturing tailwinds.[2]

It's very clear that AI-related infrastructure buildout is reshaping demand in multiple ways. This matters to EMS providers because it is not cyclical consumer demand, but long-duration, capital-intensive construction. Jabil,[3] Flex, and Sanmina have all pointed to data center, AI, and cloud infrastructure as major market drivers.

> **In other words, this is not a rising tide, but a river with some strong currents here and there, bordered by eddies and stagnant spots."**

The Bear Perspective

Other sources argue that the "go-go" growth story may not be as robust. For example, sales and shipments reports from the Global Electronics Association note a 12.7% sales spike in March,[4] followed by a drop almost as large (-10%) in April.[5] Market economists tagged this as pull-forward demand, not sustained growth. This belief is backed by flat shipments in April and year-to-date. So, why the pull-forward behavior? The Association cited tariff-related uncertainty as a primary cause. In fact, it indicates that, while orders are up, shipments remain essentially flat.

When it comes to assigning credit for the growth, reshoring is often a beneficiary. But the Reshoring Initiative has some data that tempers this enthusiasm. For example, just one in three reshoring opportunities includes both assembly and sourcing; two out of three are only shifts in component sourcing. When the hype suggests active reshoring, simply shifting sourcing does not create significant new jobs.

Furthermore, the reported growth is scattered. Company-level data spreads the growth trend as follows:

- **Strong:** AI, semiconductor capital equipment, aerospace and defense
- **Flat:** Industrial, some medical
- **Weak/volatile:** Automotive, renewables, telecom

In other words, this is not a rising tide, but a river with some strong currents here and there, bordered by eddies and stagnant spots. How you see the market depends upon how that river behaves in your section of it.

Finally, it's worth remembering that financial reports from global U.S. companies do not necessarily reflect U.S. domestic growth. Given that the large EMS firms typically are multinational, the growth they report does not necessarily happen within the U.S. borders. This can blur the overall U.S. outlook.

What's Really Happening?

Merging these two perspectives provides a good take on the current market. We've confirmed that the growth is real, especially in defense, semiconductor capital equipment, and AI. EMS companies well entrenched in these sectors are seeing strong demand, while other application segments are turning in flat or volatile numbers, especially when factoring in tariff effects. Furthermore, EMS companies with entirely U.S. domestic footprints may not have the same growth as more diversified multinational companies.

Tariffs don't create demand; they simply influence timing. Sourcing shifts (including new second-sourcing activity) are accelerating to minimize tariff impacts wherever possible. Pair that with the order timing changes, exacerbated by the U.S. administration's shifting tariff enforcement timelines, and scheduling optimization looks like increased demand in the short term. Those chickens will come to roost later.

There is a wave of reshoring, but it is, at most, incremental. The U.S.'s tariff policies are not triggering a groundswell of transformation in the domestic supply chain. It's more of a regional balancing, but not the industrial resurgence that was announced.

Rather than a historically significant super-cycle, the current U.S. market is best described as a selective upcycle, driven by AI and high reliability, amplified by tariffs and policies, and underway amid regionalization of the supply chain.

Is This a Super-cycle?

The bullish information suggests a super-cycle. The AI demand makes the strongest case for a super-cycle, as this buildout tracks more closely with the cloud buildout in the 2010s and the telecom buildouts in earlier years. The AI buildout will be capital-intensive and long-term, potentially sustaining growth for multiple years.

The geopolitical and U.S. policy changes that began in 2025 upended the supply chain equilibrium, altering not only U.S. supply chains but also rerouting those of other countries worldwide and affecting trade agreements. These changes can fuel a global super-cycle. That said, larger U.S. companies are indeed building new facilities. This sort of investment suggests the current cycle is not a short-term bump.

The bearish counterargument is equally compelling. While AI is leading the spike, one strong sector does not make for a strong industry. The U.S. tariffs have triggered behavior that distorts the demand signals—the pull-forward ordering, for example. This is inventory hedging driven by policy, not growth. Additionally, much of the reshoring is actually supplier switching, which downplays any reshoring statistics we might see.

For this to become a true super-cycle, the following will need to happen:

- Shipment rise, not just bookings
- Growth broadens to additional segments
- Durable sourcing changes need to emerge from the current tariff uncertainty behavior
- Reshoring must include assembly as well as component re-sourcing
- The workforce bottleneck eases
- CHIPS Act investment must spill over into the rest of the manufacturing ecosystem
- Margins must improve enough to pay for capacity expansion

Most importantly, to trigger a super-cycle, all this needs to happen simultaneously.

With strong arguments on both sides, the obvious conclusion is that, while we may be seeing a super-cycle in AI, defense-related, and semiconductor equipment, this is not a broad U.S. EMS super-cycle. Looking at what's required of a broad super-cycle, much more needs to happen. **SMT007**

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BY MICHIGAN TECH ELECTRONICS HUB

MORE THAN A FIELD TRIP

Young Students Step Into the World of Electronics and Semiconductors

The energy is electric at Michigan Technological University as 164 fourth graders from Michigan's western Upper Peninsula trade their traditional desks for a day of high-tech exploration. The students are here to pilot Stories & Semiconductors, a new educational series. By following the adventures of characters who solve problems through electronics, young students don't just read about technology; they build it themselves.

Created by entrepreneur and research scientist Joe Licavoli-Wall, *Stories & Semiconductors* introduces young learners to complex concepts, like electrons, atoms, and bonding, and how those affect a material's conductivity. They're also learning how semiconductors allow us to make tiny microchips, and how those microchips allow computers to talk in code to do useful things. Morse code was integrated into the student exercises to demonstrate how short and long beeps are similar to binary code used in programming.

Fourth graders from several local schools—Dollar Bay, Barkell, Calumet, and Copper Island Academy—visited Michigan Tech for an all-day launch of the series last fall. By all accounts, the inaugural event was a huge success.

"It's important for kids to have mentors and people to look up to when they are exploring technology," Licavoli-Wall said.

Michigan Tech Professor Chris Middlebrook provided lab space, electronics expertise, and recruited a small army of ECE students to join the effort. "Stories & Semiconductors paves the way for

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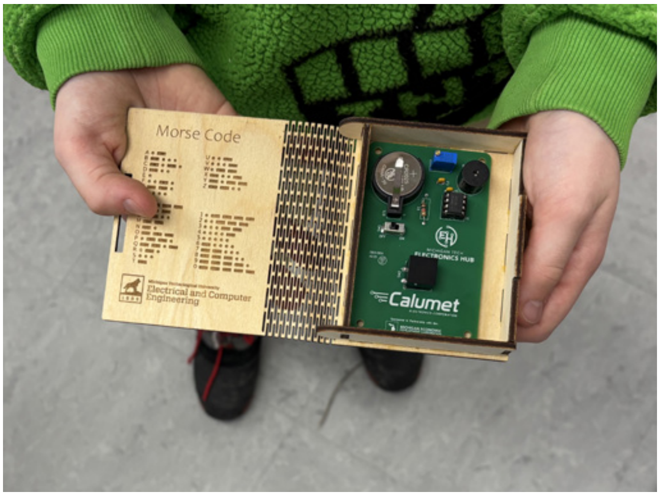

Each young student received a Stories & Semiconductors balsa wood "book" containing a morse code device—one they would learn to create themselves.

a next-level approach to experiential learning," he said. "It's a lot of fun but also technically advanced, in order to challenge younger kids."

The series is specifically designed to support workforce development in electronics and semiconductors by bridging the gap between imaginative storytelling and real-world science.

Jace Krasselt, a teacher at Copper Island Academy, attended the event along with his students. "The entire experience was a learning adventure," he said. "It gave them confidence and helped make their science learning come alive in a whole new way. Several students told me it was the coolest thing they'd ever done."

Licavoli-Wall earned his B.S. and Ph.D. in Materials Science and Engineering from MTU in 2006 and 2013. He wears a lot of hats these days, serving as chief metallurgist at Völundr Scientific, subject matter expert at Verdigris Group, and research scientist at Michigan Tech. Past positions include stints at Daimler Chrysler CIE, Sandvik Hard Materials, Alcoa Howmet, and the National Energy Technology Laboratory. He has also written for The Why Files, an entertaining, well-researched, and skeptical look into paranormal, UFO, and conspiracy theories, with over 5 million subscribers on YouTube.

Joining the fourth graders on campus just before Thanksgiving, Licavoli-Wall got to see his creative vision come to life for the very first time.

Like a Dream Come True

Licavoli-Wall walked into the Plexus Lab makerspace before the lunch break just in time to see ECE undergraduate and graduate students help the fourth graders adjust the volume level on their morse code boards. "It was almost like watching past and future versions of the students, together in the same room, and everyone was having a blast," he said. "I loved the ludicrous levels of excitement during the mineral museum scavenger hunts. I loved watching the Scanning Electron Microscope (SEM) demonstrations and seeing the students operate advanced equipment that I didn't learn about until I was in college.

He continued, "Several kids walked around with their morse code beeper devices. One student even opened it up and pretended to time travel. It seemed like the stories and demos were really coming together for the students, enhancing their learning experience."

MTU Professors John Jasczak (Physics) and Smitha Rao Hatti (Biomedical Engineering) were

Five young students embark on a time-traveling adventure while chasing a meddlesome AI transformed into a cat. They'll learn from engineers and scientists, visit local landmarks, technology companies, and build devices to help them catch the cat before it destabilizes the future. Their adventures help prepare them to build a better world.


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also in attendance. “They helped out tremendously,” Licavoli-Wall said. “Watching them show off different mineral samples and piezoelectric devices to so many excited students was nothing short of amazing.”

MTU student volunteers Ben Keppers, Peter Kocour, Michael Maurer, and Rishin Patra took care of many details. “Hands-on experiences for the kids simply would not have been possible without them,” said Middlebrook.

To bring the ideas for Stories & Semiconductors to life, Licavoli-Wall collaborated closely with fellow MTU alumna Emily Geiger. She serves as interim superintendent for Lake Linden Hubbell Schools, and previously worked as MiSTEM Regional Network Director for the Western Upper Peninsula. She earned her B.S in Biochemistry and Ph.D in Molecular Biology at Michigan Tech in 2011 and 2015.

“I never would have thought to target a fourth grade audience until Emily and I discussed the importance of trying to teach younger kids about the rather intimidating topic of electrical conductivity in materials,” Licavoli-Wall said.

Peter Kocour demonstrates how to use the scanning electron microscope.

“I love seeing students break ‘molds’ of what they can and cannot do,” Geiger said. “Stories & Semiconductors captures the ability of young students to physically be able to practice skills that many may deem ‘too old’ or ‘too high of a skill level’ for their age group.”

She points out that STEM efficacy is not the leading metric on whether a student decides to commit to a STEM career. “STEM interest is what guides their decision,” she said. “The fourth grade is an opportune age to expose students to what could be, so that they can form interest.

They cannot be interested in careers that they do not know about, or see.

“My takeaway is not to limit curriculum design to what we think students are capable of, all the time. We should provide opportunities for them to challenge themselves and exceed our expectations more frequently.”

Ashley Hendrickson attended the field trip to Michigan Tech with her son, Cruz, as a parent chaperone. “It was incredibly inspiring to see the children watch a demonstration in the lab and then put it into action. Soldering was challenging for my son’s group of three, due to the precision involved. However, they all stayed determined and successfully created their circuit boards. Their enthusiasm was contagious!”

Funding for Stories & Semiconductors was provided by the Michigan Economic Development Corporation (MEDC). Geiger wrote the initial grant proposal, making sure to incorporate elements of English and Language Arts into the project to ensure teacher/classroom buy-in. She also included the Michigan Department of Education’s fourth grade curriculum standards: science, math, computer science, and literacy.

Geiger recently secured a second MEDC round of funding, one that involves fifth and sixth grade students in the Western U.P., along with Calumet Electronics and Orbion Space Technology as MEDC Talent Action Team (TAT) partners.

“We plan to introduce fifth graders to computer-aided design (CAD) using Onshape, a powerful open source CAD software,” she said. “The second year of the grant will focus on field trips for sixth graders to see how CAD is used in the real-world, right here in our region."

Meanwhile, Licavoli-Wall is arranging new funding for a Stories & Steel program, along the same lines as Stories & Semiconductors. This time he aims to create a series easily adaptable for different age groups.

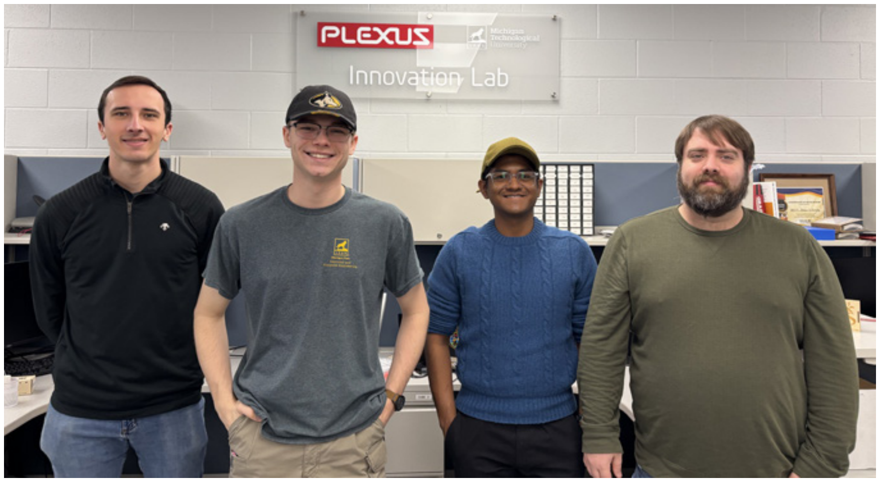
To bring Stories & Semiconductors to life, Licavoli-Wall and Geiger also worked closely with Steve Kass, CTE instructor and associate work-based learning coordinator for the Copper Country Intermediate School District. CTE (Career and Technical Education) prepares high school students for a range of high-skill, in-demand careers.

A few weeks before their field trip to the Michigan Tech campus, the fourth-graders took a tour of the CCISD CTE Center in the nearby town of Hancock. The tour was led by a team of CTE high school students, who highlighted the various programs and industries CTE represents.

"Stories & Semiconductors has been a powerful way to connect classroom learning with real-world careers," Kass said. "Through this program, all the students learned firsthand just how integral semiconductor technology is to every industry. Whether in business, automotive technology, construction, welding and manufacturing, education, engineering, or health sciences, semiconductor technology plays a vital role. This awareness is critical as we work to build a strong talent pipeline and prepare students for careers that are essential to our economy and future workforce."

Coming up this spring are two more fourth-grade field trips for Stories & Semiconductors. Their first stop will be Calumet Electronics, located in Calumet, Michigan, about 30 minutes from the Michigan Tech campus. The company provided circuit boards and background information for Stories & Semiconductors story and demos.

"The ultra-modern Calumet Electronics fab is almost other-worldly," Licavoli-Wall said. "It will be fascinating for the kids to explore. We'll see if anyone dresses up like Willy Wonka!"



L–R: Ben Keppers, Peter Kocour, Rishin Patra, and Michael Maurer.

For their final field trip in the Stories & Semiconductors program, the fourth graders will visit the Quincy Mine Hoist in Hancock. There they will get a direct look at one of the settings in the book, and a chance to learn about the local technological history that inspired the stories.

Licavoli-Wall's youth outreach efforts started early in life. "My mom worked as a paraprofessional at my K-8 parochial school. During my high school years, I'd join my mom in the classroom to read to the kids," he recalled. "I was taking advanced calculus at the time, so I started doing that kind of math on the chalkboard. I was able to 'lightly' explain the fundamental theory of calculus to second grade students. They were interested in what I was writing on the board and some even got it on a very basic level, which helped make math less intimidating for them. Demystifying tough topics is key."

Several others played substantial roles in the creative development of Stories & Semiconductors. Carolyn Yarina, principal consultant at the Verdigris Group and her team helped to refine the book and demo materials into a clear, stylish set of instructions. Alicia Truett was instrumental in developing the story art and events, working alongside the Verdigris Group. Michigan Tech alum Matt Monte did rapid turnaround work to assist with identity and branding. Helen Rau, who recently earned her PhD in Materials Science and Engineering at Michigan Tech, helped design the hands-on demos and took part in many writing sessions. **SMT007**

WHY TRUE CERAMIC CIRCUITS Are Not Just 'Better PCBs'

BY **BRIAN BUYEA,** REMTEC INC.

There's a dangerous misconception among engineers who still think ceramic circuits are just a little tougher version of a PCB, a little better at handling heat, and a premium option when FR-4 starts to struggle. That thinking will cost you performance and reliability; in some applications, it may cost you the entire design. Remtec builds are not "better PCBs," but fundamentally different platforms. Here are eight "truths" to demonstrate that difference.

1. FR-4 Is an Organic Compromise

Most engineers understand that in traditional PCBs, FR-4 and similar materials are essentially

woven glass fibers embedded in epoxy resin. They were designed to be low cost, easy to manufacture, and electrically functional for most applications, but they come with inherent limitations.

Their thermal conductivity is poor, their mechanical stability at high temperatures is limited, and their coefficient of thermal expansion (CTE) is mismatched with silicon. That matters because as power densities increase and frequencies climb, those weaknesses dominate performance. Ceramic circuits were not created to improve FR-4, but to eliminate their limitations.

2. Ceramics Are Engineered Platforms

Here's where the shift happens: A true ceramic circuit is not built by laminating layers together. It is built on a solid ceramic foundation. Materials like alumina (Al_2O_3), aluminum nitride (AlN), silicon nitride (Si_3N_4) are not fillers. They are the structure, and that changes everything. Rather than incremental improvement, it's a completely different physical behavior.

Ceramic substrates offer:

- Thermal conductivity up to 100x higher than FR-4
- Excellent electrical insulation even at high temperatures
- Stable mechanical properties across extreme environments

3. Heat Is the Real Battleground

Electronics don't fail because of electronics; they fail because of heat. Ceramic circuits dominate because traditional PCBs trap heat, while ceramics move it.

Our technologies—like direct bond copper (DBC), active metal brazed (AMB), and PCTF®—are specifically designed to pull heat away from the die, spread it efficiently across the substrate, and maintain structural integrity under thermal cycling. This enables higher power density, longer operational life, and more compact designs.

Their ceramic cores—Al_2O_3, AlN, Si_3N_4—are selected specifically for thermal conductivity and CTE matching, reducing stress on semiconductor devices. That matters more than most people realize because thermal mismatch is one of the leading causes of failure in high-power electronics. Ceramics align with the physics.

4. Metallization Changes the Game

Most PCB designers overlook metallization. In traditional PCBs, copper is laminated or etched onto a surface, whereas in ceramic circuits, especially with our plated-copper thick-film technology, the copper is engineered into the structure. This creates:

- Higher current carrying capability (50+ amps)
- Superior adhesion and durability
- Fine-line capability for high-frequency circuits
- Integrated features like vias, resistors, and multilayers

The key difference is that you're routing signals, and engineering an electrical and thermal system simultaneously.

5. Reliability Is Built In, Not Designed Around

With FR-4, reliability is something you design around, adding heat sinks, thermal vias, and cooling systems. With ceramic circuits, reliability is built into the material itself. Ceramic substrates can:

- Withstand thermal cycling from -65°C to 150°C for over 1,000 cycles
- Maintain adhesion, via integrity, and hermetic performance
- Operate in extreme environments like space, defense, and medical systems

This is why ceramic circuits are found in EV power modules, aerospace and defense electronics, RF and microwave systems, and medical devices. These are failure-is-not-an-option environments.

6. Frequency Changes Everything

As we move into higher frequency applications, such as RF, microwave, mmWave, the differences become even more pronounced. Ceramic circuits offer lower signal loss, stable dielectric properties, and high-frequency performance into mmWave ranges. That stability is critical because at high frequencies, small variations become big problems and material inconsistencies become signal integrity issues. Ceramics provide consistency, and consistency is performance.

7. Integration Eliminates Failure Points

One of the most overlooked advantages of ceramic technology is integration. Ceramics provide a platform that can include metalized circuits, vias and interconnects, integrated resistors, packaging features, and compatibility with die attach, wire bonding, and SMT. This reduces assembly complexity, interconnect failures, and supply chain fragmentation. It means fewer parts, interfaces, and things going wrong.

8. You Don't Upgrade to Ceramics, You Transition to Them

Rather than upgrading from FR-4 to ceramic, you adopt a different approach to designing electronics that prioritizes thermal performance, mechanical stability, electrical integrity, and system-level reliability.

The Future Is Not Built on Compromise

If your application is high power, frequency, and reliability, you're already pushing beyond what traditional PCB materials were designed to do. At this point, ceramic circuits aren't an option. They're the standard. **SMT007**

Brian Buyea is president of Remtec Inc. To read past columns, click here.

DOCOMO, Keio University Demonstrate High-Fidelity Robot Teleoperation

NTT DOCOMO, INC. and Keio University Haptics Research Center have successfully conducted a demonstration of high-precision remote robot operation over commercial 5G. By combining a low-latency network slicing technology, with haptics technology, delicate force feedback and tactile sensations were transmitted stably. This marks the world's first demonstration of practical robot teleoperation over commercial 5G.

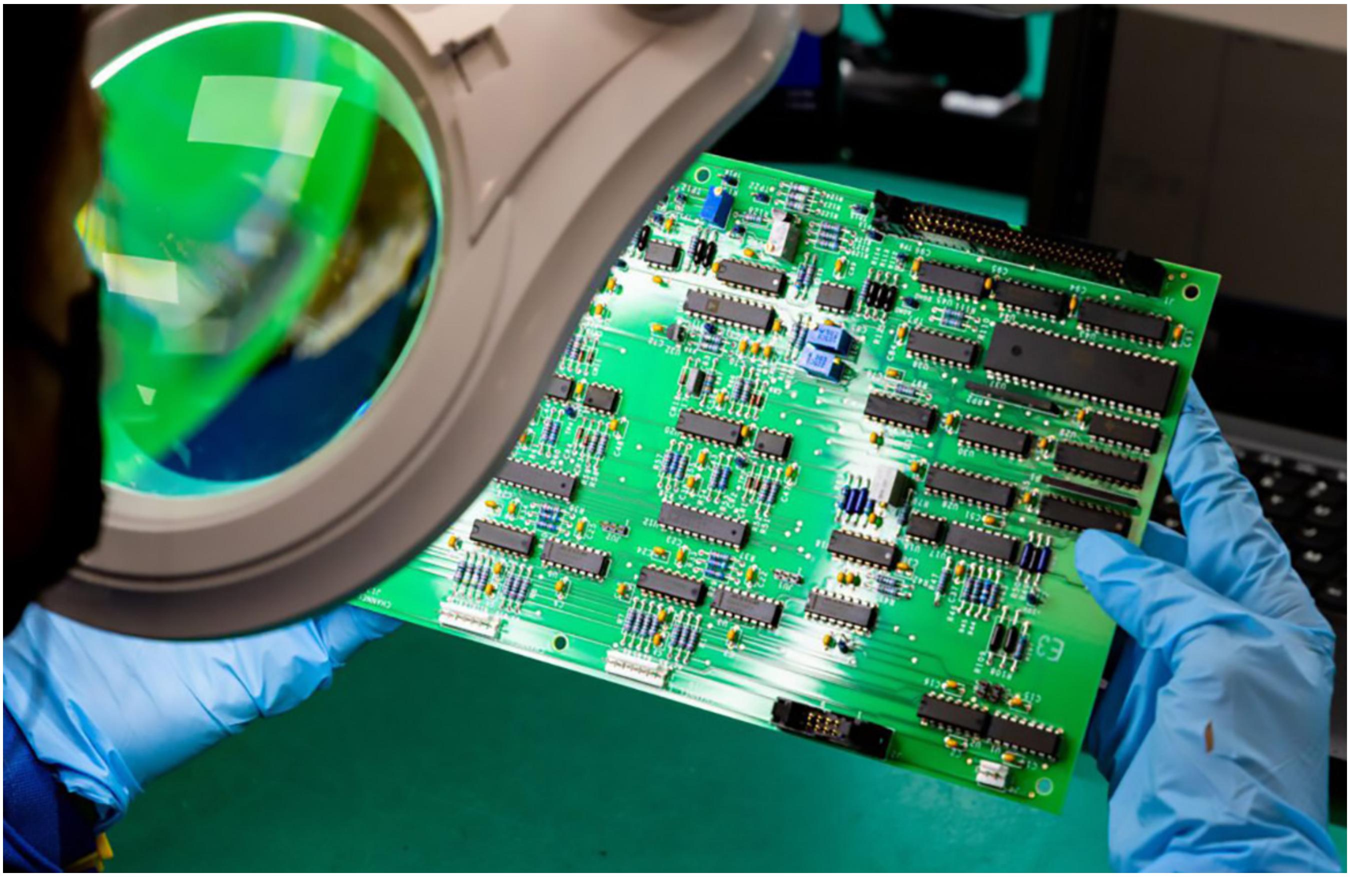
To convey precise force feedback when a remote robot interacts with objects controlled by an operator at a distant location, mobile data communication must maintain low latency and minimal jitter. High or fluctuating latency can disrupt synchronization between the operator and remote robot. This compromises the precise force reproduction of haptics, hindering delicate robot operation.

DOCOMO and Keio University have previously collaborated on the development and testing of robot teleoperation over mobile networks. By reducing the impact of latency in the wireless segment, highly precise and delicate remote robot control can now be performed stably even under network congestion.

Source: ACN Newswire

BY NOLAN JOHNSON, I-CONNECT007

OMEGA EMS
Going Where the Growth Is



When you start with a well-proven management team and a chance to start from scratch, it doesn't take long to become well established. Omega EMS CEO Chris Alessio discusses the company's rapid 10-year growth from startup to an international electronics manufacturing organization. We find out what makes things click so well.

Nolan Johnson: Chris, it's great to talk with you. Tell me about Omega's line of services. It seems there's very little you don't do.

Chris Alessio: Today, Omega EMS operates as a full-service electronics manufacturing partner supporting high-reliability industries, including mil/aero, networking, and energy systems. Over the years, we've expanded our service offerings in a largely opportunistic way. We look to understand a customer's needs, then determine whether we can bring those capabilities in-house to enhance flexibility and responsiveness rather than relying on external vendors, which can often introduce delays through shipping, queue times, and reprocessing. We've expanded into test infrastructure, cable harnessing, system integration, and potting solutions, among other capabilities. Given the strong growth in mil/aero programs, we've also increased our investment in conformal

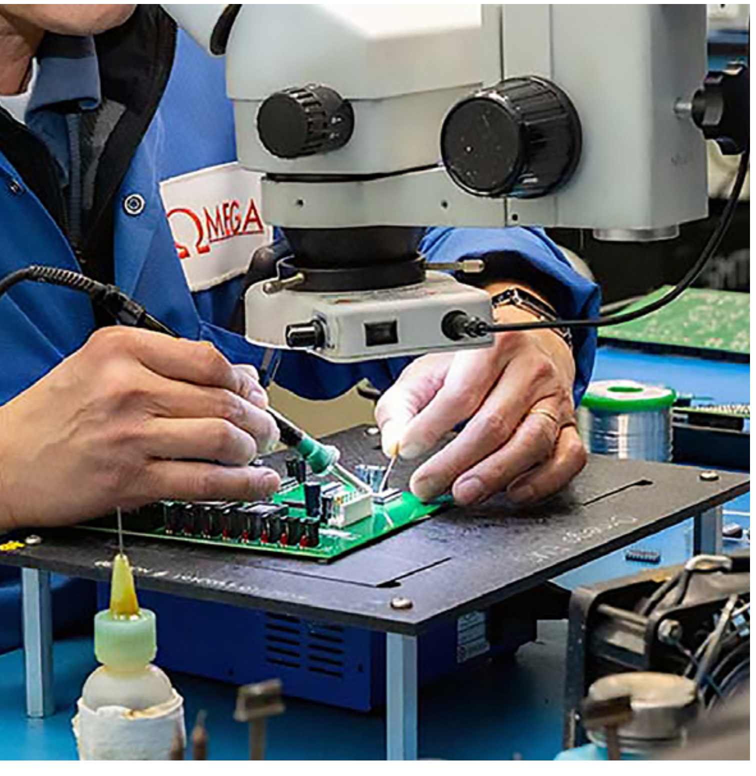
coating and related processes. It's an opportunistic approach to growing the business through services and capabilities.


Chris Alessio

That seems to be in keeping with what's going on in the market. How do you grow and find the right opportunity in the right place?

We've been very fortunate with the pedigree of our management team. In the early 2000s, we accumulated a stable of relationships with the engineering community in Silicon Valley. Those people now say, "I remember these Omega guys. Let's give them a call." Just like that, we have a new customer who already knows what kind of business we are, and then we do our thing: "make it happen (MIH)." We really lived and breathed that early on: whatever it took—answering calls and emails after hours, working weekends—to perform a service or complete a job for a customer.

That DNA is still there. With 200 people, we're much bigger now, and company culture sometimes morphs over time. We're approaching $100 million in sales, and we've added a Vietnam location. That makes it harder to maintain the grassroots culture, but it's still there, and we still do our best to MIH wherever we possibly can.



What specific type of work are you referring to—prototyping, high-mix, or high-volume runs?

In 2015, we started with a prototyping and NPI focus, but we have morphed into a production-oriented EMS company. Roughly 80% of our revenue is production-related and not just PCBA. We do full system integration, full functional testing, build-outs, and even logistics services, including order fulfillment. We are a rapidly maturing EMS company with roots in prototyping and MIH. We haven't lost that recipe.

We're structured with two primary operating flows: a dedicated NPI environment focused on speed and flexibility, and a production environment optimized for scale and efficiency. This dual structure allows us to support early-stage engineering while seamlessly transitioning customers into volume production.

You've had a lot of growth in these 10 years. How do you feel about the growth in revenue and headcount, plus the new locations you've mentioned?

We've done great, and we continue to do great. We've had years up and flat years here or there. Now we're back to having big growth years—we grew about 20% last year and will do so again this year. It's exciting times for us. We have great offerings, culture, and employees. Our plan is to keep growing.

Our Vietnam plant came online in December, and our plan, as you would imagine, is to move some of our steady-runner programs there to offload some production work and free up some space in our California plant for NPI and high-mix, low- to moderate-volume solutions. We received our ISO certification about 45 days ago, and we're now hosting customer qualification audits. We'll grow in this dual footprint fashion, at least for the next several years, and then we'll see if we need more infrastructure in the U.S.

That growth defies what most EMS companies are doing. What do you attribute that to?

I attribute it to several things. Our people are the core of everything. Our employees are dedicated and committed. Everyone here cares about fulfilling customer requirements with a strong focus on first-pass yield, quality, and minimizing returns.

Honestly, I think the sectors that we're playing in, like networking, telecommunications, and mil/aero, are the reasons for our growth. Mil/aero is growing very quickly for us. We're also now working in the renewable energy space. We have an exciting partnership with Duracell Power Center (a North American Duracell licensee). When you combine that with our core company values and staff, we're benefiting from those factors and market sectors.

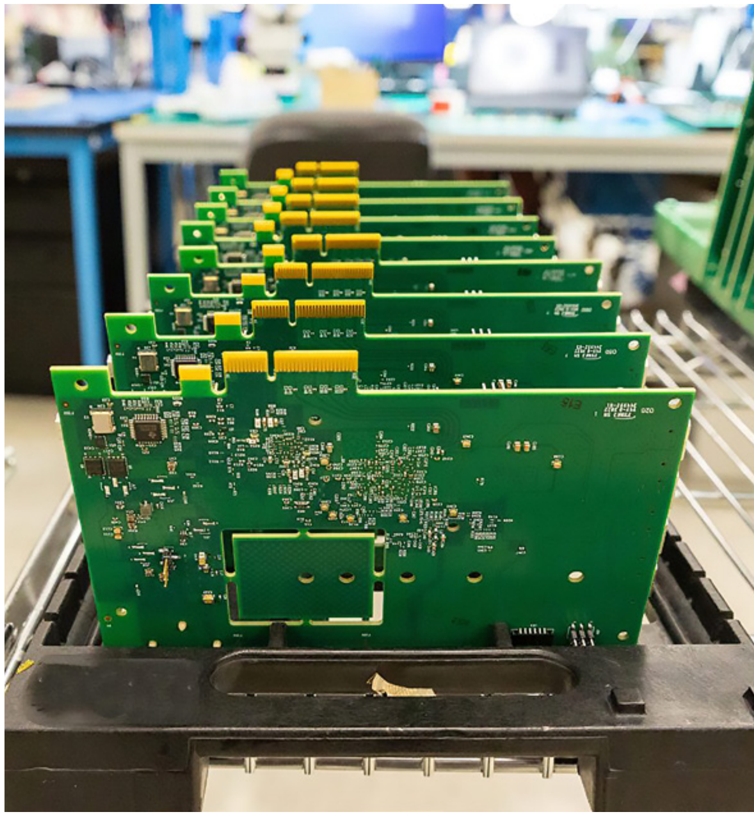
You've targeted the sectors currently in the spotlight for returning business to North America, and your metrics are clearly demonstrating that's a good choice. What about your Vietnam facility?

We made that decision about a year ago. When the tariffs hit, we questioned whether this was the right move. We explored logistical structures and material flows, and we found we had a nice flow of material going into and out of Vietnam, where we only paid tariffs on the value-add, i.e., the labor. Twenty percent on a value-add service that costs one-sixth the cost in the U.S. is still a significant cost advantage. Given those numbers, the cost savings, and the labor-only tariff, it is still very much worth it.

The vision was there, and we decided to continue down the path. Luckily, the tariff landscape has turned more favorable, and now we're proving we can shift production to Vietnam, deliver cost reductions to our customers, and execute on our growth strategy in both places.

Without giving away the secret sauce, what do you see the market doing, and who is your ideal customer over the next couple of years?

I see the trend continuing to provide more manufacturing services in the U.S. Our ability to do that is augmented by some cost savings in a lower-cost region that is identified as a "friendly nation" rather than a "prohibited foreign entity" or a "foreign entity of concern." Those are critical terms related to U.S.-based manufacturing and tax incentives. We're participating in all of that, with or without the tax incentives. The market segments that we're playing in will continue to expand.



While policy support for solar and energy storage may vary, the underlying market fundamentals remain very strong. The rapid expansion of U.S. data centers is driving unprecedented demand for reliable power, making energy storage an increasingly critical part of the solution. We're seeing that play out in real time—particularly in markets like Texas, where residential battery adoption is accelerating quickly. Through our partnership with Duracell Power Center, we're directly supporting that growth. At the same time, we continue to see strong momentum in mil/aero, where we are actively engaged in multiple hardware programs. Together, these sectors represent meaningful and sustained growth opportunities for Omega EMS.

Chris, thanks so much.

You got it, Nolan. Take care. **SMT007**

DARPA-developed Autonomous Helicopter Technology Transitions to U.S. Army ▶

As part of the technology transition agreement between DARPA and the Army's Project Manager for Utility Helicopters, an experimental, fly-by-wire H-60Mx Black Hawk, fully equipped with the DARPA-funded Sikorsky MATRIX™ autonomy suite, has been delivered to the U.S. Army for advanced operational testing.

Lockheed Martin Completes Live Target Tracking Exercise for the Aegis System Equipped Vessel System ▶

The first live target tracking exercise using the SPY-7 radar has been completed. The ASEV system demonstrated the ability to search, detect, identify, track, and discriminate against live targets and concluded with virtual target engagements. This successful exercise highlights ASEV's maturity of the integrated SPY-7 Aegis System.

Airbus' Bird of Prey Destroys Kamikaze Drone in First Demo ▶

The interceptor drone autonomously searched, detected, and classified a medium-sized one-way attack drone. The interceptor engaged the target with a Mark I air-to-air missile.

Honeywell Aerospace, Defense Department Sign Deal to Boost Defense Tech Production ▶

Honeywell Aerospace is among the first Tier 1 suppliers to sign a framework agreement of this nature with the DoW. This supplier framework agreement is to rapidly increase the production of critical defense technologies with a $500 million multi-year investment to upgrade the company's production capacity.

£14 Million Funding Boost to Power UK Space Technology Innovation ▶

The funding is available through the European Space Agency's (ESA) General Support Technology Programme (GSTP), its flagship programme for maturing new space technologies from early-stage research to flight-ready demonstration.

NUBURU Activates U.S. Defense Manufacturing Infrastructure, Initiates Phase ▶

This milestone marks NUBURU's transition into an operational U.S.-based defense manufacturing participant, with active infrastructure now being deployed to support current and future government and allied demand. NUBURU develops directed-energy technologies, electronic warfare, and software-orchestrated defense systems.

Teledyne to Supply Detectors for Lazuli Space Observatory ▶

Lazuli, a state-of-the-art 3-meter–class observatory, is designed for rapid-response observations and precision astrophysics across optical and near-infrared wavelengths. The Teledyne focal plane arrays and electronics will enable Lazuli's spectrograph to capture and analyze the faint light from these supernovae with unprecedented sensitivity and spectral resolution

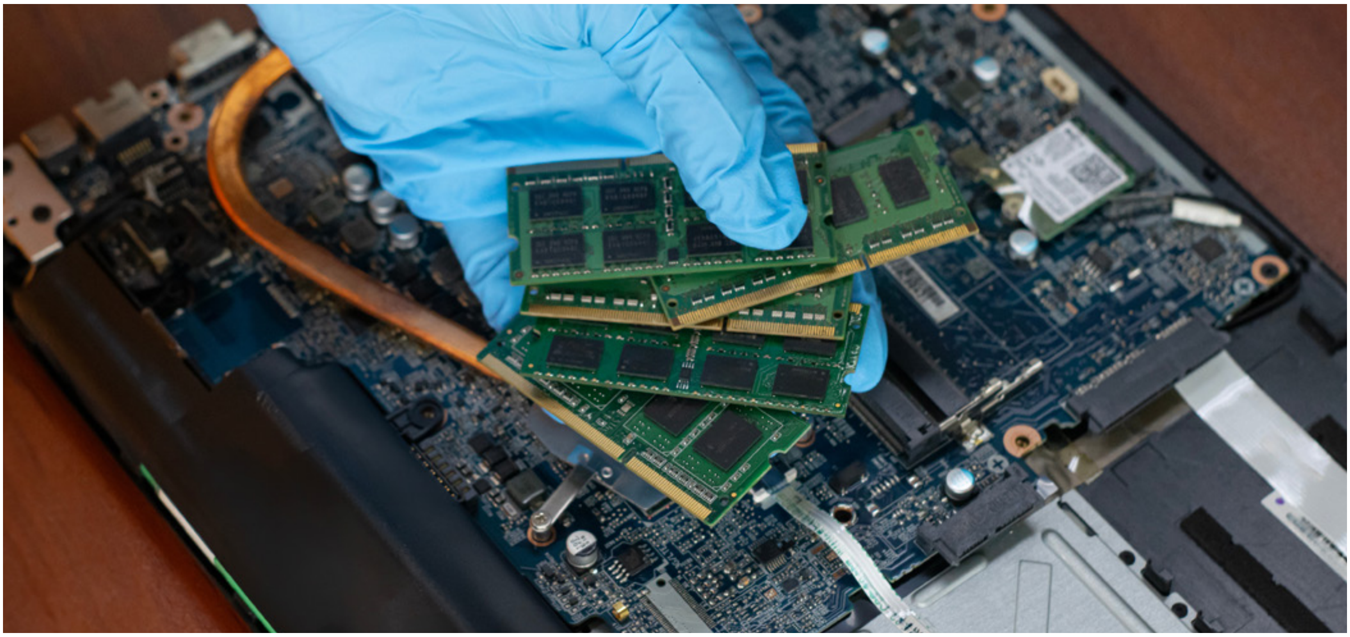
Vertical Aerospace Launches Battery Pilot Production Line for Valo ▶

Opened in 2023, the Vertical Energy Centre has produced the battery systems used in the company's piloted flight testing since 2024. The facility has now been upgraded with automated, aerospace-grade manufacturing processes designed to support certification and production, improving efficiency, consistency, and battery performance.

RTX Collins Aerospace Completes Clean Aviation HECATE Project ▶

As a part of the European Union's Clean Aviation Joint Undertaking, with support from UK Research and Innovation, the program completed testing, verification and validation of its Electrical Power Generation and Distribution System; a hybrid-electric system producing more than 500 kilowatts of power for use in hybrid-electric aircraft.

BY ROB RONAN, RETRONIX LTD.



Managing DDR4, DDR5, and HBM Supply Challenges

The global electronics industry is no stranger to supply chain disruption, yet memory devices, particularly DRAM and NAND flash, sit at the center of a uniquely persistent challenge. The situation is particularly complex because constraints are not isolated; they are occurring simultaneously across both legacy and next-generation memory technologies.

From DDR4 shortages driven by supplier exits to DDR5 demand being pulled by AI infrastructure, the market is facing a perfect storm of reduced supply, shifting demand, and aggressive pricing increases. For OEMs, EMS providers, and high-reliability sectors, this is a serious operational challenge. This article explores the underlying causes of ongoing memory constraints, the specific risks they introduce, and, most importantly, the practical, engineering-led strategies organizations are using to maintain continuity. Among these approaches, component recovery and reuse are a credible, scalable solution that complements traditional sourcing strategies.

Understanding the Nature of Memory Shortages

DDR4 and LPDDR4: Structural supply reduction. DDR4 and LPDDR4 are among the most constrained memory categories. A major contributing factor is the exit of leading DRAM manufacturers from these nodes, which has significantly reduced global production capacity. With fewer suppliers and limited new investment in these technologies, allocation has tightened, leaving many organisations struggling to secure a consistent supply.

DDR5 and LPDDR5: AI is consuming capacity. While newer technologies like DDR5 and LPDDR5 are still in production, they are far from immune to disruption. Demand has surged due to the rapid expansion of AI-driven infrastructure. This shift is absorbing a disproportionate share of manufacturing capacity, leaving other sectors competing for limited availability.

DDR3: Unexpected pressure from substitution. DDR3 is facing renewed pressure not only from legacy demand but also from substitution trends. As LPDDR4 availability tightens, some consumer and industrial applications are shifting back to DDR3L as an alternative. At the same time, manufacturers are prioritising DDR4 output, further restricting DDR3 supply.

The Real-World Impact and Risks

Lead times stretching beyond 40–60 weeks have become common for certain memory devices. Even when supply exists, allocation mechanisms can limit access, particularly for lower-volume or specialized programs.

For organizations operating in high-reliability environments, memory shortages introduce a complex mix of technical, commercial, and operational risks. When a critical memory device is unavailable, entire production lines can stall. Unlike passive components, memory is often central to system functionality; there is no simple workaround. These industries cannot simply substitute components or redesign overnight. Qualification cycles are long, approvals are stringent, and the cost of change is high.

Many systems are designed around specific memory architectures. Redesigning to accommodate alternative devices is not always feasible. Spot market sourcing may provide short-term relief, but often at significantly inflated prices and increased risk of counterfeit or substandard parts.

Rethinking Supply Chain Strategy Beyond Traditional Sourcing

Historically, the response to component shortages has centered on procurement: finding new suppliers, negotiating allocations, or increasing inventory buffers. While these remain important, they are no longer sufficient on their own.

Component recovery and reuse offer a practical alternative. This strategy can help mitigate short-term supply challenges and reduce production disruptions while organizations put a robust long-term plan in place.

Memory components, particularly packaged ICs such as BGA-based DRAM and NAND, are often robust enough to withstand controlled de-soldering and reprocessing. In many cases, the limiting factor is not the device itself, but the confidence in its integrity after removal.

With the right processes in place, this barrier can be effectively addressed. Despite its technical validity, recovery and reuse can still face skepticism. Concerns typically revolve around reliability, consistency, and long-term performance. However, when executed within a controlled, accredited environment, recovered components can meet or in some cases exceed the assurance levels of newly sourced parts from uncertain supply chains. In fact, for organizations facing the alternative of unverified grey-market sourcing, recovery offers a significantly lower-risk option.

A highly accredited service provider can provide a practical, immediate solution as they can unlock value from surplus or stranded inventory, recover memory devices from PCBs for reuse, maintain continuity without waiting for new supply, and reduce exposure to price volatility and allocation constraints.

Looking Ahead: Building Resilience in an Uncertain Market

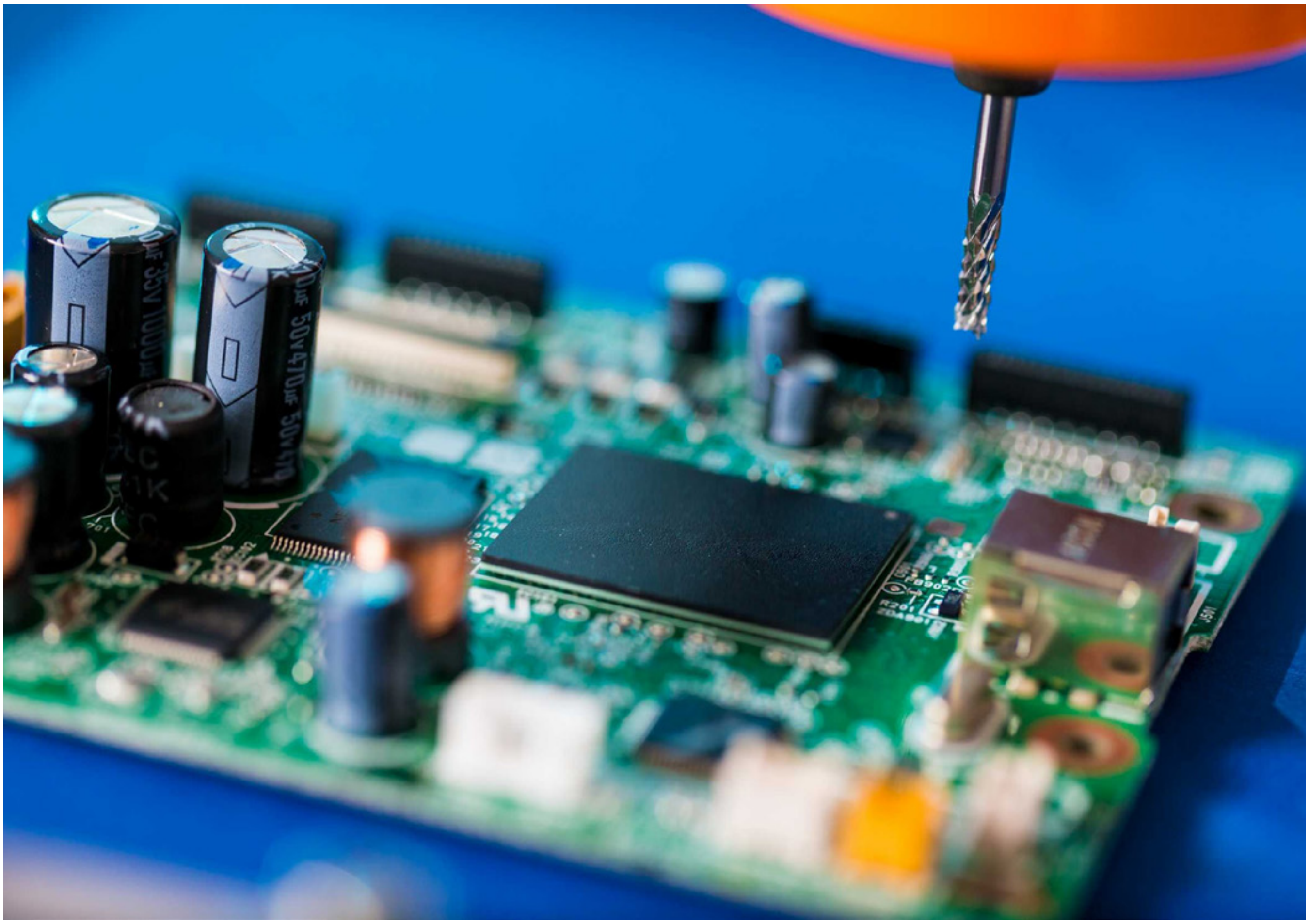
Memory shortages are unlikely to disappear entirely. As technology continues to evolve and demand patterns shift, periods of constraint will remain a feature of the semiconductor landscape.

The organizations that navigate these challenges most effectively will be those that move beyond reactive procurement and embrace a more integrated, engineering-led approach to supply chain management.

Recovery and reuse is not about replacing traditional sourcing. It offers more than short-term relief during periods of shortage. It reduces reliance on volatile global markets and helps companies avoid turning to unknown or higher-risk sourcing channels.

As the industry adapts to constrained supply and extended lifecycles, those who embrace these approaches will be better positioned to maintain continuity, manage risk, and deliver on their commitments, regardless of market conditions. **SMT007**

Rob Ronan is the UK sales and support manager for Retronix.



PRECISION MILLING OF Underfilled SMT Components

BY NASH BELL, BEST, INC.

Underfill is a polymeric material used to fill the gap between a printed circuit board and the underside of surface-mount area-array packages such as BGA, QFP, and QFN devices, thereby surrounding and protecting the solder interconnections. This material increases the component's reliability when subjected to mechanical impacts and shocks by distributing forces.

Conventional rework methods for underfilled SMT components that use heat can result in physical damage to the PCB, including laminate damage, mask destruction, and lifted or missing pads, thereby reducing manufacturing yields and product reliability. In most cases, these defects are irreparable and can result in the scrapping of a very expensive multilayer PCB.

Available Underfill Rework Methods

The downside of using underfill is that it makes the rework process extremely difficult. While some underfills are categorized as "reworkable," this does not mean that the underfill removal process is without challenges. There are several problems that arise when removing an underfilled surface

mount component, regardless of whether it is underfilled with a “reworkable” or “non-reworkable” material.

Each available rework method is tasked with breaking the bond between the PCB and the underfilled surface mount component. These methods include:

- **Hot air rework:** Utilizes a stream of hot air to heat the surface mount component and PCB.
- **Infrared rework:** Uses infrared emitters to target the surface-mount component, minimizing thermal impact on surrounding areas
- **Manual removal:** Typically used only for “reworkable” underfill material and requires skilled and highly trained technical operators
- **Chemical agents:** Involves the use of a specialized softening agent to reduce the adhesive strength of the underfill material, thereby facilitating easier removal of the underfilled component
- **Laser ablation:** Utilizes focused laser beams for precise heating, allowing selective reflow while minimizing damage to adjacent components
- **Precision milling:** Used for removing underfilled surface mount components, this process employs high-precision milling equipment to remove the component one layer at a time

Potential Issues With Underfill Rework

Rework methods that rely on heat are generally not recommended for underfilled surface-mount components. When the underfill is heated to near-reflow temperatures, it can soften or become fluid, interfering with the formation of reliable solder connections and potentially compromising product integrity.

- **Hot air rework:** Heating the solder beneath the component to a liquidus state can also cause the underfill to soften or reflow. As a result, adjacent underfilled components may be displaced from their pads during removal.
- **Infrared rework:** Infrared emitters apply heat directly to the component, creating a risk of excessive localized overheating. This can also cause adjacent underfilled components to be displaced from their pads during removal.
- **Manual removal:** Although highly flexible, this method is generally unsuitable for “non-reworkable” underfill materials and may damage the board if not performed by skilled, highly trained operators.
- **Chemical agents:** “Non-reworkable” underfills are often difficult to remove through chemical processing. In addition, some OEMs object to the use of chemical softening agents because they may aggressively attack components and/or the board.
- **Laser ablation:** Effective use of laser ablation requires careful selection of the laser source and wavelength to match the material’s absorption characteristics. If the beam is not properly controlled or focused, underfilled components can be damaged.
- **Precision milling:** This “cold” removal process offers a significant advantage over heated rework methods for underfilled components. Although it is destructive to the component being removed, precision milling allows for subsequent component placement in the target area and is a low-risk option when component salvage is not the primary objective.

In general, component removal processes that do not rely on heat are preferred for underfilled components. Heated rework methods introduce greater unpredictability and increase the risk of

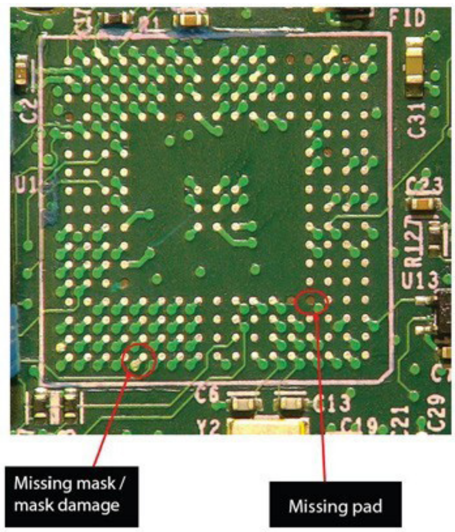


Figure 1: Example of BGA location with pad lifting and solder mask damage.

PCB damage, which may, in some cases, be irreparable. Selecting the best approach for reworking an underfilled component requires evaluating multiple factors to identify the lowest-risk method for the specific application.

Precision Milling Process

The primary goal of the precision milling process is to preserve the printed circuit board assembly, whereas destruction of the underfilled surface mount component is acceptable.

Potential Issues

Precision milling requires adequate clearance around the rework site to minimize the risk of damage to adjacent components. This method is most effective when the target component is fully underfilled. If the component is only partially underfilled or if voids are present in the underfill, pad damage may occur during removal.

Advantages of Precision Milling

A key advantage of precision milling for reworking underfilled surface-mount components is that it preserves the PCB assembly while avoiding heat, which is why it is often referred to as a “cold removal” process.

In a properly controlled milling operation, the component package is either removed completely or milled down until approximately 100–150 microns of material remain above the board surface, along with a thin layer of underfill. This process typically leaves a thin layer of solder visible on top of the PCB pads. Any residual underfill and solder can then be removed by wicking and board cleaning, preparing the site for placement of a replacement component in the same location and allowing the assembly to be salvaged.

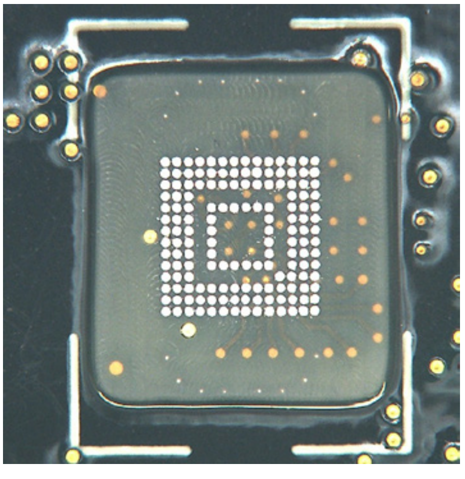


Figure 2: Remnant solder on PCB serving as pre-tinned pads for new component.

Precision milling also avoids several challenges commonly associated with heat-based rework methods. Factors such as conformal coatings, ceramic packages, and large heat sinks rarely interfere with the success of the milling process.

Lower milling heights may allow removal of all remaining solder and underfill in a single step, but they also increase the risk of damaging the board. For that reason, the lower the milling height, the flatter and more stable the board must be during processing to prevent unintended contact with the board surface.

Conclusion

Underfilled surface-mount components are becoming increasingly common in high-technology electronics applications, including aerospace, defense, medical, and other high-reliability products. Reworking these components is especially challenging because thermal removal methods can cause physical damage to the PCB, increasing the risk of scrapping expensive multilayer assemblies.

Precision milling offers a low-risk alternative to traditional rework methods when the priority is to preserve the assembly rather than salvage the component. One of the key advantages of precision milling is that it can leave a remnant layer of solder on the board, effectively providing pre-tinned pads for placement of a replacement component in the same location. This makes it possible to salvage the printed circuit board assembly while reducing the risks associated with heat-based rework. **SMT007**

Nash Bell is president of BEST, Inc. To read past columns, click here.

BY BETH MASSEY, MACDERMID ALPHA ELECTRONICS SOLUTIONS

Protecting Advanced Trucking Electronics in Harsh Environments

For decades, trucking was defined by horsepower, payload, and driver endurance. Today, the competitive edge lies in electronics, as advanced sensing, communications, and data processing systems reshape how commercial vehicles operate. The industry is rapidly digitizing, with electronic systems now critical to safety, uptime, and fleet efficiency. Technologies like ADAS, radar, lidar, and telematics enable real-time decision-making, while distributed sensors monitor key vehicle functions. Because these systems operate in harsh conditions—vibration, temperature swings, moisture, and chemicals—environmental protection using potting, coatings, and encapsulation is now a core design priority.

Telematics platforms serve as the fleet's data backbone, transmitting information via Bluetooth, cellular, GPS, and V2X. Often placed in exposed locations, these modules require durable protection that maintains mechanical integrity and RF performance.

To meet these demands, circuit protection materials such as epoxy, silicone, and polyurethane are engineered for specific trade-offs. Polyurethane is increasingly favored for wireless applications, offering strong environmental protection without degrading signal performance.

Barrier Protection Solutions for Thermally Efficient, RF-Transparent Telematics Electronics

Barrier protection solutions are critical in enabling reliable sensing and communication within modern telematics systems, as they shield electronics from harsh operating environments while preserving functional performance. Telematics modules integrate processors, power management circuitry, RF transceivers, antennas, and distributed sensors

within compact enclosures. These units are often mounted on frames, axles, or trailers, where airflow is limited, with constant exposure to vibration, moisture, and contaminants. Barrier materials such as conformal coatings, gels, and encapsulants must provide robust environmental isolation, and support effective thermal pathways that prevent heat buildup, which can degrade sensor accuracy, RF stability, and long-term reliability.

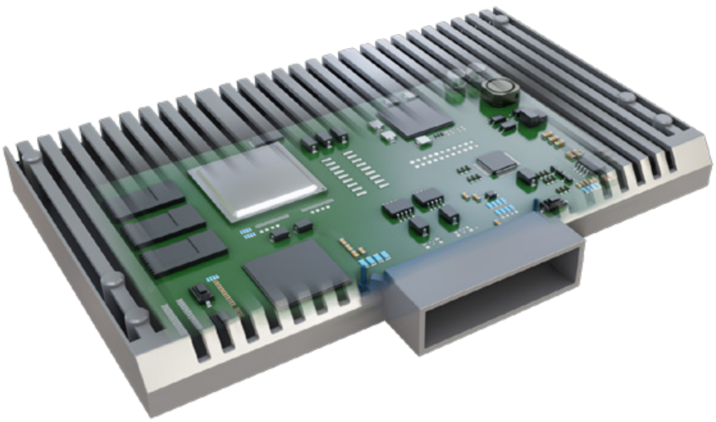


Figure 1: Telematics modules integrate processors, power management circuitry, RF transceivers, antennas and distributed sensors within compact enclosures.

Thermal management considerations strongly influence material selection for telematics barrier protection. Low-modulus materials are increasingly engineered with enhanced thermal conductivity which improves heat dissipation from densely packed electronics without introducing excessive mechanical stress during thermal cycling. These materials maintain flexibility across wide temperature ranges, accommodating coefficient of thermal expansion (CTE) mismatches between components, substrates, and enclosures. By reducing localized hotspots and stabilizing operating temperatures, thermally optimized barrier solutions help maintain consistent sensor output and RF performance in applications such as tire pressure monitoring, lighting diagnostics, and distributed vehicle health sensing.

Equally important is the preservation of radio-frequency performance in wireless telematics architectures. Barrier protection materials must exhibit low dielectric constant and low dielectric loss to minimize signal attenuation, detuning, and phase distortion across cellular, GPS, Bluetooth, and V2X frequency bands. Advanced RF-transparent encapsulants and selectively applied conformal coatings are designed to protect antennas and RF front-end circuitry without interfering with signal propagation. When properly engineered, these barrier solutions enable reliable, high-bandwidth data transmission while delivering the mechanical durability and environmental resistance required for long-term telematics operation in demanding trucking environments.

Electronics as the New Powertrain

Distributed sensors feed situational data to control units that fuse information from lidar, radar, cameras, accelerometers, and telematics modules. These systems enable blind-spot detection, collision avoidance, adaptive cruise control, lane centering, and semi-autonomous operation in complex driving environments. Even the trailer, once viewed as a passive asset, has become an intelligent, connected node, using telematics to monitor tire pressure, brake performance, lighting status, cargo conditions, and real-time location across the fleet.

This shift from mechanical dominance to electronic intelligence elevates reliability to the primary measure of performance. Unlike traditional drivetrains, ADAS and telematics electronics are highly sensitive to vibration, thermal cycling, moisture, and chemical exposure encountered throughout daily operation. Ensuring long-term functionality requires deliberate protection strategies integrated at the design level. Potting, conformal coating, and encapsulation materials have become as essential to system integrity as gears and axles once were, safeguarding both sensing and wireless communication hardware while enabling the data-driven operation that defines modern trucking fleets.

Harsh Operating Conditions Demand Protection

Trucks operate in some of the harshest environments of any vehicle class. Continuous vibration from diesel engines and rough roadways can fatigue solder joints and fracture component leads. Sudden shocks from potholes or loading docks

Figure 2: ADAS camera and radar modules are mounted externally on tractors.

place additional mechanical strain on PCBs. Externally mounted electronics, including radar, lidar, and telematics modules, are routinely exposed to road spray, salt, oils, and abrasive particulates. These stresses are compounded by extreme temperature cycling, ranging from sub-zero cold starts in winter to elevated temperatures under direct sunlight or within engine compartments.

Moisture represents a significant threat. Even limited condensation within an enclosure can accelerate corrosion, promote dendritic growth, and compromise high-density circuitry. Mechanical housings alone are rarely sufficient to prevent ingress under repeated humidity and pressure cycles. Potting and conformal coating fill voids, encapsulate sensitive components, and form a continuous barrier against liquid- and vapor-phase moisture. In addition to environmental sealing, these materials mechanically stabilize assemblies, damping vibration and accommodating stresses caused by thermal expansion mismatch between components and substrates.

For telematics, ADAS, and sensor-rich trucking electronics, protection strategies must be selectively applied. While components and interconnects benefit from potting or conformal coating, antenna structures and RF transmission paths must remain free of these materials to avoid detuning, signal attenuation, or interference. Effective designs intentionally isolate antennas from encapsulated regions. This allows electronic assemblies to be fully protected while preserving wireless performance across Bluetooth, cellular, Wi-Fi, and various frequency bands. This selective approach of potting the electronics while leaving antennas uncoated is essential to achieving both long-term reliability and uninterrupted communication in modern trucking systems.

Protecting the Most Vulnerable Interface in Harsh Environments

Connector interfaces are among the most vulnerable points in electronic systems operating in harsh environments, particularly in commercial trucking and mobile telematics applications. While enclosures and circuit board potting protect internal electronics, connectors remain exposed to vibration, moisture, dust, road salts, fuels, and oils introduced through cable entry points and mating interfaces. Repeated mechanical loading from harness movement can lead to fretting corrosion, intermittent electrical contact, and fatigue failures at crimped or soldered terminations. Without additional protection, connector interface failures often become the primary cause of system downtime, even when the electronics themselves remain fully functional.

Connector potting provides a critical secondary barrier by sealing wire entry points, backshells, and termination zones against environmental ingress while also stabilizing conductors under vibration. Properly selected potting materials encapsulate individual wires and connector terminations, preventing capillary moisture wicking along cable jackets and blocking contaminants from reaching conductive surfaces. At the same time, potting compounds act as strain relief, distributing mechanical loads away from crimped contacts and solder joints. This combination of environmental sealing and mechanical reinforcement significantly improves connector reliability in applications subject to constant motion, shock, and thermal cycling.

In systems that rely on wireless communication and high-speed data, connector potting must also be carefully engineered to preserve electrical and signal integrity. Selective application techniques allow power and data connectors to be sealed without interfering with antenna feeds or RF pathways, ensuring uninterrupted performance for telematics, ADAS sensors, and distributed monitoring systems. When integrated into the overall protection strategy, connector potting reduces field failures, extends service intervals, and enhances system robustness, making it an essential design practice for electronics deployed in the most demanding operating environments.

Material Options and Tradeoffs

The three dominant classes of circuit board protection materials are epoxies, silicones, and polyurethanes. Each offers strengths and limitations that influence their suitability for trucking electronics:

- Epoxies deliver excellent adhesion and strong chemical resistance, making them highly effective barriers against fuels, oils, and corrosive agents. While they also provide outstanding moisture protection, their drawback lies in post-cure rigidity. Once cured, epoxies become hard and brittle, which can place significant stress on components during thermal cycling. When the CTE of the epoxy differs from that of the PCB or semiconductor package, cycling between −40°C and 120°C can warp boards or crack solder joints. For sensitive modules such as lidar controllers, this mechanical stress poses serious risks. Epoxies also tend to have higher dielectric constants, which can compromise RF transparency unless specifically engineered for low-loss formulations.
- Silicones occupy the opposite end of the spectrum. They are soft, flexible, and stable across very high temperatures, often up to 200°C. Their elastomeric nature allows them to absorb mechanical stress and easily accommodate CTE mismatch. Silicones are inherently RF transparent, a major advantage for wireless devices. Yet they have limited adhesion to substrates and are permeable to water vapor, which reduces their long-term protective capability in humid or submerged environments. They can also swell in the presence of oils, a critical concern for under-hood or under-chassis modules.
- Polyurethanes offer a middle ground, combining toughness with flexibility. They provide sufficient elasticity to relieve CTE stresses, while maintaining stronger adhesion and better moisture resistance than silicones. Many polyurethane formulations can withstand exposure to chemicals and operate reliably at temperatures up to 125°C. Critically, their dielectric properties can be tuned to support RF transparency. For automotive electronics and trucking applications that demand both environmental ruggedness and signal integrity, polyurethane is increasingly becoming the material of choice.

RF Transparency and Signal Integrity

As sensor fusion and continuous data exchange become central to ADAS, semi-autonomous operation, and fleet telematics, maintaining uninterrupted RF communication is non-negotiable. Telematics modules depend on reliable transmission of GPS, cellular, Wi-Fi, Bluetooth, and V2X signals to support real-time vehicle tracking, tire pressure monitoring, lighting diagnostics, and system health reporting. Potting compounds used to protect these electronics must therefore allow wireless signals to pass with minimal attenuation, reflection, or phase delay, which typically requires a dielectric constant below approximately 3.5 and very low dielectric loss across relevant frequency bands.

Material selection plays a decisive role in meeting these combined requirements. Silicones naturally exhibit low dielectric constants and favorable RF transparency, but their comparatively higher moisture permeability can limit long-term performance in externally mounted or highly exposed trucking environments. Epoxies can be formulated for improved RF compatibility, though these modifications often reduce mechanical flexibility and increase stress on assemblies during vibration and thermal cycling. Polyurethanes offer the most versatile solution, as their molecular architecture can be engineered to deliver low dielectric behavior, strong hydrophobicity, and balanced mechanical compliance.

In practical telematics deployments, this enables control units and sensor electronics to be fully protected with RF-compatible polyurethane potting while maintaining reliable wireless performance. GPS location data, cellular connectivity, and short-range communications can be transmitted from within sealed, ruggedized housings without degradation, even under prolonged exposure to vibration, moisture, and temperature extremes. This combination of RF integrity and environmental durability is essential to the long-term reliability of telematics-enabled trucking systems.

Lessons Learned Relevant to Trucking

The lessons learned in automotive and industrial electronics translate directly into trucking applications.

For example, in tire pressure monitoring systems (TPMS),each sensor integrates a MEMS pressure transducer, an ASIC, a battery, and an RF transmitter inside a compact package mounted at the wheel. These modules endure constant rotation, centrifugal force, heat from braking, and chemical exposure from road debris. Polyurethane potting compounds have become standard, protecting electronics while allowing the RF transmitter to communicate with the truck's central system. The performance requirements mirror those of other wireless truck sensors, making TPMS a model for successful encapsulation.

ADAS camera and radar modules mounted externally on tractors are equally dependent on circuit board protection. Exposure to rain, road salts, high-pressure washes, and wide thermal cycling can quickly degrade unprotected electronics. Silicone gels can provide temporary relief but may allow water vapor penetration over time. Polyurethane encapsulants, tailored for RF transparency, create a more durable solution. They provide mechanical stability against vibration while ensuring that radar or lidar signals are not degraded (as shown in Figure 2, page 48).

Telematics hubs, which manage Wi-Fi, Bluetooth, and V2X communication between the truck and external infrastructure, represent a third critical application. These modules are frequently housed in areas exposed to condensation and temperature cycling. Potting and conformal coating with RF-friendly polyurethane compounds enable these hubs to maintain continuous connectivity without bulky metal housings or elaborate sealing gaskets. In an industry where space, weight, and durability are at a premium, this approach offers significant advantages.

Beyond performance, these examples highlight broader industry trends. The move toward autonomy demands sensors that function flawlessly in every scenario, making robust circuit board protection strategies essential for safety. Fleet operators are also under pressure to meet sustainability targets, driving interest in encapsulants that can be disassembled or recycled at end of life. At the same time, supply chain resilience has become a business imperative. Circuit board protection solutions that extend sensor lifespans and reduce replacement rates lower the risks of downtime, maintenance delays, and parts shortages.

Processing Considerations

The success of any potting strategy depends not only on material chemistry, but also on processing precision. Two-part systems require accurate ratio control and thorough mixing to achieve full cure and expected properties. Incomplete mixing can leave unreacted components that compromise adhesion or moisture resistance.

Void-free encapsulation is equally critical. Trapped air bubbles create weak points that allow moisture ingress or concentrate mechanical stresses. Techniques such as vacuum mixing, slow

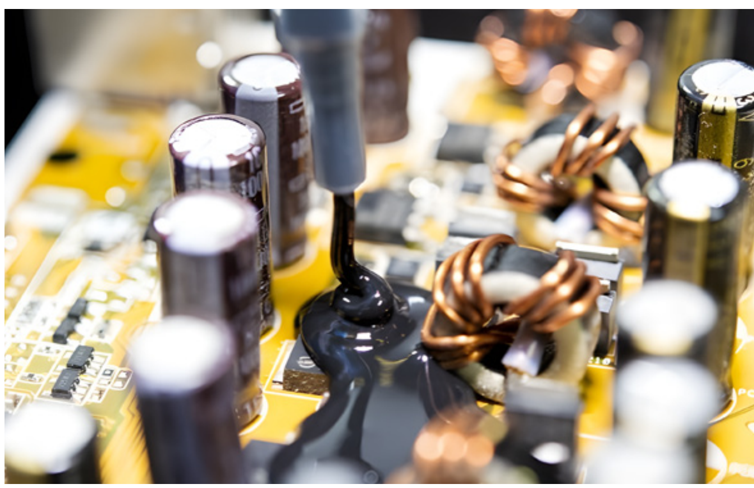


Figure 3: Controlled dispensing of potting material onto a PCB ensures complete coverage while minimizing air entrapment and defects.

dispensing, and post-pour degassing help achieve uniform encapsulation.

Curing must also be managed carefully. Exothermic heat generated during polymerization can damage nearby components if volumes are large or heat dissipation is poor. Controlled thermal profiles or staged curing can mitigate this risk.

Finally, validation testing is essential. Standards such as ISO 16750 (covering vibration, climatic stress, and chemical exposure) and ISO 20653 (IP67/IP68 ingress protection) provide benchmarks for automotive and trucking electronics. Accelerated tests such as pressure cooker testing (PCT) and highly accelerated stress testing (HAST) simulate years of humidity exposure within days, providing confidence in long-term reliability.

Outlook

The next decade of trucking will be defined as much by electronics resilience as by powertrain efficiency. Circuit board protection materials, once viewed primarily as barriers against dust and moisture, are becoming strategic enablers of industry megatrends. Autonomy demands sensors and controllers that remain operational in every conceivable scenario, from subzero nights to chemical-soaked highways, leaving no margin for electronic failure. As trucks assume greater decision-making responsibilities, circuit board protection materials will serve as critical contributors to safety, preserving sensor fidelity and system uptime.

Sustainability will also shape material innovation. Fleets are under increasing regulatory and customer pressure to adopt greener practices. Chemistries that allow partial rework, simplified disassembly, or recyclability will support circular-economy initiatives without compromising protection. Developers are already experimenting with low-carbon backbones, bio-derived resins, and hybrid encapsulants that balance environmental goals with electronic reliability.

Conclusion

Electronics have become the functional core of the modern trucking platform, redefining how safety, efficiency, and fleet intelligence are delivered across commercial fleets. ADAS, lidar, radar, and telematics systems now perform roles once reserved for mechanical subsystems. They enable real-time sensing, decision-making, and connectivity across tractors and trailers. However, the value of these technologies depends entirely on their ability to operate reliably under sustained vibration, extreme temperature cycling, moisture exposure, and chemical attack. In this environment, circuit board protection is no longer a packaging afterthought but a foundational design requirement.

Potting, conformal coating, and encapsulation materials serve as critical enablers of electronic reliability by shielding sensitive components while preserving thermal performance and wireless communication. Effective protection strategies must balance environmental sealing with RF transparency, particularly for telematics modules that rely on uninterrupted GPS, cellular, Bluetooth, and V2X connectivity. Selective application techniques that protect electronics while isolating antennas, combined with materials engineered for low dielectric loss and mechanical compliance, are essential to maintaining signal integrity alongside long-term durability.

As fleets continue to adopt connected and semi-autonomous technologies, the role of potting materials will continue to expand from protective barriers to strategic enablers of data integrity, system uptime, and fleet-level intelligence. In this context, the future of trucking will be shaped not only by software and sensors, but by the materials that protect the electronic systems driving the industry forward.

To learn more about advanced potting materials and how MacDermid Alpha Electronics Solutions supports next-generation electronic designs, visit macdermidalpha.com or contact us to explore solutions optimized for your application. **SMT007**

Beth Massey is the global product manager at MacDermid Alpha Electronics Solutions.

BY STANTON RAK, SF RAK COMPANY

ENGINEERING HIGH UPTIME in EV Charging Infrastructure

The transition to EVs is no longer constrained solely by vehicle capability. Instead, it is increasingly defined by a simpler, but more unforgiving question: Will the charger work when I arrive? This high uptime does not happen by accident. As EV technology has matured, limitations in battery range, power electronics, and thermal management are no longer the primary barriers to adoption.

As charging infrastructure moves from early deployment into the realm of critical energy systems, expectations now mirror those of traditional fueling networks. Governments are mandating uptime levels as high as 97%, and drivers expect charging to "just work" every time.[1] Meeting this expectation is about engineering, not deployment.

For electronics designers and manufacturers, EV supply equipment (EVSE) represents a convergence of high-voltage power electronics, outdoor-rated electronic assemblies, software-driven control systems, and grid-connected infrastructure. Public charging infrastructure is at the intersection of automotive, industrial, and utility electronics. Reliability is the cumulative result of numerous design, material, process, and validation decisions made long before a charger is installed in the field. Engineering high-uptime EV charging infrastructure requires a mindset shift where uptime must be treated as a core design requirement, equal in importance to power level, efficiency, and cost.

Engineering Reliability Across Charging Architectures

EV charging technologies differ substantially in power level, architecture, and reliability exposure. AC Level 1 and Level 2 charging rely heavily on the vehicle's onboard charger, shifting much of the power electronics burden onto the vehicle itself. As a result, AC charging infrastructure is comparatively simple and operates at lower power levels. These systems have historically demonstrated higher inherent reliability, though they remain vulnerable to connector wear, nuisance ground-fault interruptions, relay failures, and grid-side disturbances, particularly in outdoor and multi-unit residential installations.[2]

Level 3 DC fast charging (DCFC) introduces a fundamentally different reliability profile. These systems integrate high-voltage rectification, power factor correction, galvanic isolation, and advanced thermal management directly within the charging station, typically operating at 400–800 V and with power levels up to 350 kW. This architecture dramatically increases sensitivity to thermal cycling, moisture ingress, contamination, and insulation coordination failures, making DCFC reliability disproportionately dependent on design for reliability (DFR) practices long used in automotive and industrial power electronics.[3]

Figure 1. Level 2 charger. (Source: Adobe Stock)

Figure 2: Level 3 DC fast charger. (Source: Creative Commons, Kgbo, 2020)

Wireless and smart charging architectures further increase system complexity. Inductive charging removes mechanical connectors but introduces alignment sensitivity, EMC challenges, and additional control electronics. Smart and bi-directional charging systems depend heavily on software integrity, protocol interoperability, and communications reliability. These are areas where failures can disable otherwise functional hardware.

Each charging architecture introduces distinct reliability risks, but in all cases, uptime is governed by electronics design, materials, and manufacturing discipline.

Reliability Expectations Meet Field Reality

In electronics manufacturing, uptime is often treated as a downstream performance indicator. In EV charging infrastructure, that approach no longer works. Regulatory programs such as the U.S. National Electric Vehicle Infrastructure (NEVI) initiative now mandate 97% operational uptime, transforming uptime into a compliance-driven

Figure 3: Induction wireless charger. (Source: Creative Commons, Neo, 2011)

design constraint rather than a post-deployment metric.[4] The 2025 ChargerHelp Annual Reliability Report[5] reinforces a critical industry inflection point that, while reported uptime continues to improve, uptime alone no longer reflects the real-world charging experience. A dataset of more than 100 million OCPP (Open Charge Point Protocol) messages and nearly 300,000 charging sessions shows that although many networks approach NEVI's 97% uptime target, successful charge initiation lags far behind. Most notably, the report identifies a ≥25 percentage point gap between reported charger availability and charge-start success, with only 71% of charging attempts succeeding on the first try. Even more concerning, 35% of failed charge attempts occurred on chargers reporting an "available" status, revealing a blind spot in traditional uptime metrics.

The 2024 ChargerHelp Annual Reliability Report[6] analyzed charging-related data across public Level 2 and DC fast charging stations and highlighted a persistent gap between network-reported uptime and "true uptime" experienced by drivers. It showed that downtime was rarely driven by rare catastrophic events, but rather component degradation, connector and cable damage, internal power electronics faults, and communications errors together accounted for more than two-thirds of observed failures. The report also identified a critical Pareto effect: A small subset of "problem stations" accounted for a disproportionate share of downtime, with some DCFC sites experiencing multiple extended outages lasting weeks or more.

Software inaccuracies often masked these failures, leading to inflated reported uptime and frustrated drivers attempting to use "available" chargers that could not deliver power. Field data also showed that DCFC stations experienced higher downtime rates than Level 2 chargers. Power module degradation, cooling system faults, connector overheating, and control electronics failures were recurring contributors. Older EV charging stations experience higher downtime, with a notable increase in failure rates around the four-year mark.

Compounding the environmental thermal challenges was the fact that Level 3 chargers typically operated at high voltages within the 400–800V range, aligning with the battery architectures of

EVs. Newer EV models are trending toward 800V battery systems to facilitate faster charging times. Higher voltages accelerate wear-out mechanisms on PCB assemblies (PCBAs), especially in combination with harsh outdoor environments.

Several high-voltage failure mechanisms have been described in technical papers presented at recent IPC APEX EXPO Technical Conferences.[7–9]

The 2025 data further showed that hardware swaps and site refreshes, while effective at boosting short-term uptime, often fail to address the root causes of recurring failures. ChargerHelp found that without coordinated firmware updates, validated interoperability, and attention to environmental stressors, many upgraded stations re-enter a failure cycle within months. This finding reinforces that high uptime cannot be sustained through component replacement alone; it must be engineered through robust system design and lifecycle management.

As charging systems become more integrated with the grid, utilities, and energy markets, reliability increasingly emerges as a cyber-physical systems problem. As emphasized in the 2025 ChargerHelp report, EVSE reliability must now be evaluated across technical performance, user experience, and temporal dynamics, recognizing that aging hardware, firmware updates, and software interoperability collectively determine long-term uptime and driver trust.

Designing for Uptime: Connect-Clean-Coat

In addition to temperature extremes, charging stations and their electronic assemblies are exposed to humidity, rain, snow, ice, salt spray, dust, corrosive gases, and even insects.[2] Achieving high uptime in harsh outdoor environments requires disciplined execution of proven electronics reliability principles. The Connect–Clean–Coat methodology,[10] coined by the Global Electronics Association's e-Mobility Quality and Reliability Advisory Group (EVQR),[11] translates these principles into practical design and manufacturing framework for addressing hardware risks.

- **Connect:** High-integrity solder joints, press-fit interfaces, busbars, and connectors capable of surviving thermal cycling, vibration, and high-current operation
- **Clean:** Control of ionic and particulate contamination that can drive leakage currents, corrosion, and insulation breakdown under high voltage
- **Coat:** Appropriate conformal coating or encapsulation strategies that protect electronics from moisture, condensation, salt, and corrosive gases without compromising serviceability

These are well-established practices in IPC Class 3 automotive, aerospace, and industrial electronics.[12–15] Their inconsistent application in EVSE manufacturing can help to explain some of the field reliability challenges observed today.

> **"Uptime is no longer a sufficient proxy for reliability. From an engineering perspective, charge-start success is emerging as the most actionable indicator of whether EVSE electronics, firmware, and communications are functioning as a system."**

Reliability, Sustainability, and Total Cost of Ownership

High-uptime design is a sustainability and cost imperative.[16] Unreliable chargers drive increased service truck rolls, premature equipment replacement, lost revenue, and negative user perception, all of which increase environmental and economic burden. Designing EVSE electronics for long service life reduces the total cost of ownership while supporting sustainability goals. In this context, reliability becomes the missing link between infrastructure investment and long-term environmental benefit.

The Road to Reliable Power Delivery

As EV adoption accelerates, charging infrastructure must evolve into dependable energy systems with automotive-grade reliability expectations. The 2025 ChargerHelp findings make clear that the industry's next reliability gains will not come from higher reported uptime alone, but from engineering systems that consistently initiate, sustain, and complete charging sessions under real-world conditions. It can be achieved by engineering charging systems with the same rigor applied to automotive power electronics, from materials selection and PCB design to assembly cleanliness, environmental protection, and validation testing. Achieving sustained high uptime will require:

- Adoption of proven electronics DFR practices
- Harmonized standards and test methods for high-voltage assemblies
- Transparent, standardized uptime definitions tied to successful charge events
- Integration of hardware, software, and communications reliability engineering

The road to reliable power delivery is not paved solely with faster chargers or denser networks. It is built on durable electronics, disciplined manufacturing, and system-level reliability thinking. Charging ahead means recognizing that reliability is not a feature; it's the foundation. For designers and manufacturers, high-uptime EV charging infrastructure is built, not just reported. **SMT007**

Stanton Rak is principal consultant for SF Rak Company, and co-chair of the APEX EXPO Technical Program Committee.

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- **Employee Training & Development:** Create and deliver training programs for inspectors and production staff on IPC standards, quality procedures, and inspection tools to maintain certification
- **Failure Analysis & Corrective Actions:** Investigate nonconforming boards—including internal findings and customer returns/RMAs—analyze root causes, and lead corrective/preventive actions (8D/CAPA)
- **Procedure Optimization:** Analyze quality trends and RMA data to update processes, inspection checklists, and control plans

Qualifications:

- Associate degree or equivalent experience in electronics manufacturing
- 3+ years in bare board PCB QA, with IPCA600/CIS and IPC6012 certification
- Strong auditing, training, documentation, and cross-functional collaboration skills
- Proficient in rootcause failure analysis

Join us to ensure rigorous compliance, elevate fabrication quality, and continuously improve manufacturing standards.

Contact brandon@ace-pcb.com and James@ace-pcb.com to apply.

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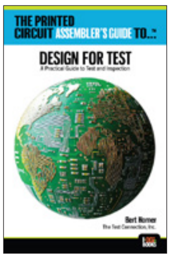

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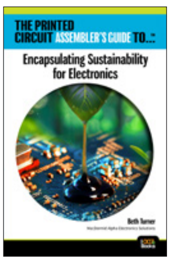

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