A Look Inside SEL's New PCB Factory

Feature Interview by Barry Matties
I-CONNECT007

After years of planning, Schweitzer Engineering Laboratories is now manufacturing printed circuit boards in its new $100 million captive facility in Moscow, Idaho. I recently toured the facility with Engineering Director John Hendrickson, who managed the design and setup of the greenfield site, along with Mike Brask, president of Integrated Process Systems (IPS), a key supplier for the new Moscow facility.

The facility showcases the latest technology in PCB fabrication, along with a zero liquid discharge water treatment system. The site is surrounded by wheat fields—not a location where you would traditionally expect to find a PCB manufacturing facility. How-

ever, with their environmentally friendly factory, the city officials have welcomed SEL, and the facility has already been honored with the Idaho Association of Commerce & Industry Environmental Excellence Award.

The manufacturing area is set up on an open floorplan with only a couple of processes—drill and route—in closed rooms. As you would expect, data automation is in full use here. Each panel starts off with a serial number read by scanning equipment that connects with the MES to identify the job and program, and then loads that program onto the machine. SEL's in-house software team builds and maintains these systems. They also employ automation/integration software engineers as well.

Laser etched barcoder for material traceability.

Now, the goal of automation here was not to reduce headcount?

John Hendrickson: Correct. That's not why we focused on automation; we automated first to drive quality. The number one defect at board shops is typically handling damage. So, how do you reduce that? You put in equipment, like we have from GreenSource and others, to help eliminate handling. Quite frankly, now our operators aren't just feeding panels on a line. They're managing an entire line, and they're learning more about how those lines work and

From left: GreenSource Engineering (GSE) double loader, photoresist strip line, GSE unloader.

Schmoll's Modul drills in a Cube line shown with optional automation.

how to maintain them. They have a lot more ownership of that, even more than our maintenance team on a day-to-day basis.

All our lines are integrated. One of the cool things we're doing here is using SEL equipment to collect real-time process data. We have a product called RTAC (Real-Time Automation Controller) that communicates with PLCs, and we use that to get information using a range of industrial communication protocols. Using our software-defined network, we control all network traffic between MES, RTAC, and equipment. This increases the security between our systems and our equipment in case there's ever a security vulnerability with piece of equipment.

What sort of volume are you producing?

Hendrickson: While we have relatively high volume, we also have a lot of part numbers. I believe that 20% of our part numbers are 80–90% of our volume, which means 80% of our part numbers are lower volume. This requires us to have flexibility to change over and run the lower-volume jobs. For example, the drill room features a number of Schmoll single-spindle drill machines, which load and unload through automation.

What sort of tolerances and line spacing are you trying to achieve?

Hendrickson: The traces and spaces we're targeting right now are about 2.5 mil traces and 3 mil spaces, especially for outer layers. We're also using pinless lamination to help get tighter registration there. We also have an Impex Pro X3 machine that will scan a panel with 150,000 holes in 20 seconds. It provides us the SPC data for diameter and location. It's been an instrumental tool in qualifying

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drill. We've seen tighter registration and tolerance in our drill process because of a data driven process.

Are you doing continuous flow manufacturing?

Hendrickson: Our goal is to be as close to continuous flow as possible. We have small queues at the beginning and end of our lines. It's a balancing act to ensure a process does not run out of work.

As I entered the manufacturing area, the first piece of equipment I saw was a nearly 300-foot long Atotech horizontal plating line. The line will produce about around 100 panels per hour when it's fully up and running.

Hendrickson: We have four electroplaters with the first plater acting as a flash plate. Between platers two and three we installed automation to rotate the panel 180 degrees. The purpose of rotating the panel is to balance the copper across the panel.

Is that recommended by the supplier, or is it something that you decided to do, based on experience?

Hendrickson: That's something we decided to do. Another thing we're doing that isn't really done in North America too much is panel plating. We're not pattern plating. We're not applying dry film, putting on a reverse image, plating, tinning and then strip, etch, strip. Everything goes through develop, etch, strip, whether it's

Atotech's 300-foot long horizontal plating line at SEL's Idaho facility.

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Chemcut CC8000 inner layer develop-etch-strip (DES) system using cupric chloride etchant. The two large portions of the line shown are the etching chambers.

an outer layer or an inner layer. This simplifies the factory by removing unique processes and providing redundancy as we will have two Chemcut DES lines. Panel plating also gives us a little bit more repeatability on copper thickness across the surface of the panel, where you only have the density of holes driving copper thickness variation.

On our Chemcut etching line, we've added a Sigma Mecer etch recirculation and reclamation system. The copper is removed from the etchant, plated on big copper sheets, and then sent out for recycling. The long-term goal is plate out in a form that we can reuse in our platers. Before dry film, we are cleaning the copper surface, microetching for adhesion, going through an electrostatic cleaner, and then we do a preheat. Not a lot of people do that, but we're getting the panel up to temperature. In the film laminator, we have heated rollers; we are helping promote adhesion as much as possible.

Is that a measurable improvement that you can come back and quantify? Most shops don't do that.

Hendrickson: Not yet. We're starting with our lower-complexity boards; I expect the extra cleaning and heating of the panels to pay off when we produce our boards with finer features. After dry film, we put it in a buffer to get the panel back down to room temp before imaging.

We have a Schmoll MDI imager, which has a tandem table with two robots; a scanner on the line will scan the barcode and automatically load the program. The panel is loaded in the first drawer to image the top side, and then the robot flips it to the second drawer and images the backside. Panels are then put in a buffer to let the dry film settle for five minutes before moving on to develop.

In your lamination area, you went all in with induction presses. What was your thinking behind that?

Mecer's acidic etchant copper recycling system—capacity 180,000 lbs. copper per year—helps make SEL's Moscow factory a zero liquid discharge facility.

Right to left: GSE double loader, followed by Chemcut preclean line, electrostatic cleaner and preheat oven, cut-sheet laminator, GSE UV-protected lift-up gate, GSE FIFO FILO-capable buffer with cooling, and partial view of Mylar peeler.

InduBond lamination press profile data.

Hendrickson: Well, they're definitely nice, clean machines. The energy savings alone is crazy. There are no thermal management challenges in the building like we would see with a hot oil press; we don't have to worry about any of that with the induction press technology. When the machine is running, you can put your hand on it and it's not even hot, because all the energy is going to the panels in the book. Each plate is stainless steel and conductive, so you get even heating throughout, as opposed to a hot oil press, where you have to get the heat from the outside in. Also, heat-up time is rapid compared to an oil process. Each book has thermocouples that provide immediate response to the system, which automatically adjusts the energy to put drive the induction coils to keep the profile within spec. Eventually, we'll build this out to 10 two-opening presses.

For solder mask, you're doing nothing but inkjet printers. Was speed an issue here?

Hendrickson: Yes, we went with Notion Systems. This technology is newer, and speed is definitely a concern. But if you start to look at how long it takes for an imager to image solder mask, like laser or LED, these printers are getting pretty close to on par with that.

Notion Systems' n.jet technology saves multiple process steps, large investments in valuable space, energy, and labor. This completely digital process also uses UV-curable inks instead of solvent-based inks, which has far reaching effects on the environment.

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Mike Brask, IPS president (left), and John Hendrickson, SEL engineering director (right), in front of the automated IPS ENIG Line.

It's quite a statement going exclusively with this technology.

Hendrickson: Yes, it was a leap. We did our research, but it was one of our bigger risks on the project. Most of the other processes are pretty tried and true, but this is newer on the market. This is one area where I didn't want to be saying in two years, "Man, I should have gone with inkjet printers."

The balance was the cost of a line like this versus the cost of a traditional line and, ultimately, the throughput these lines could give you versus a traditional line. All said and done, four printer lines fit in the area of one traditional line. Footprint space would have been four times that amount in a traditional process. In final finish, we are still using tin-lead HASL because we have some older products that are exempt from some of the RoHS regulations in Europe. We also have a large IPS ENIG line, with baskets that hold 40 panels apiece. Mike, tell us about the IPS line.

Mike Brask: Sure. This is basically a big ENIG line. When you get into the line details, you have the whole chemical management scheme. There are a lot of baths to make up and chemicals to maintain, along with analyses. When you compare this to a typical plating line, you find the blue chemical drums everywhere, with employees transferring chemicals using handheld drum pumps. Here, every tank has continuous level control on it, baths are made up to specific concentrations, and everything's automatically dosed.

n.jet soldermask

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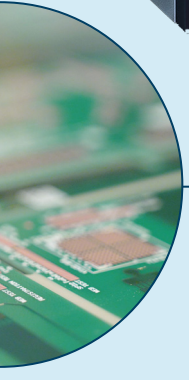

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IPS ENIG line process control and data capture panel.

The basket counter keeps track of how much product and square footage goes through the line. There's a robot system to move the work into, through it, and then out of the line. To start, it puts the serial-numbered boards in the basket to load the program. As that basket goes through the process, we fully record everything that each basket encounters. IPS worked with SEL to design a system to transfer that data.

When you look at controlling odor and fumes in this kind of environment, with SEL's open floor plan, the line benefits from a full enclosure system. It has an inner environment that's under negative pressure, so you don't have odor on the other side of the building. And it's a lot cheaper to design and add the enclosure than it is to build an isolated room around it.

Hendrickson: To maintain air quality in the shop, we have a main duct that's five feet in diameter that goes into our fume scrubber; it's a big workhorse pulling exhaust off all our wet lines. Our HVAC is replenishing that air. Also, for all of the chemical management, almost everything is dosed from day tanks across the factory.

It certainly smells fresh and clean in here. Now, what about expansion?

Hendrickson: We reserved space for a second plating line in the future. Plating is usually your limiting factor and as our product complexity continues to increase, we will get less output because we will have to slow down the line to make sure we get good copper thickness in high-density areas. Maybe with the technology

Internal view of IPS automated ENIG line.

ATG flying probe electrical testers.

we're doing at that point, we'll have to put a vertical line in versus all horizontal, but we left ourselves options, just in case.

How did you approach electrical test?

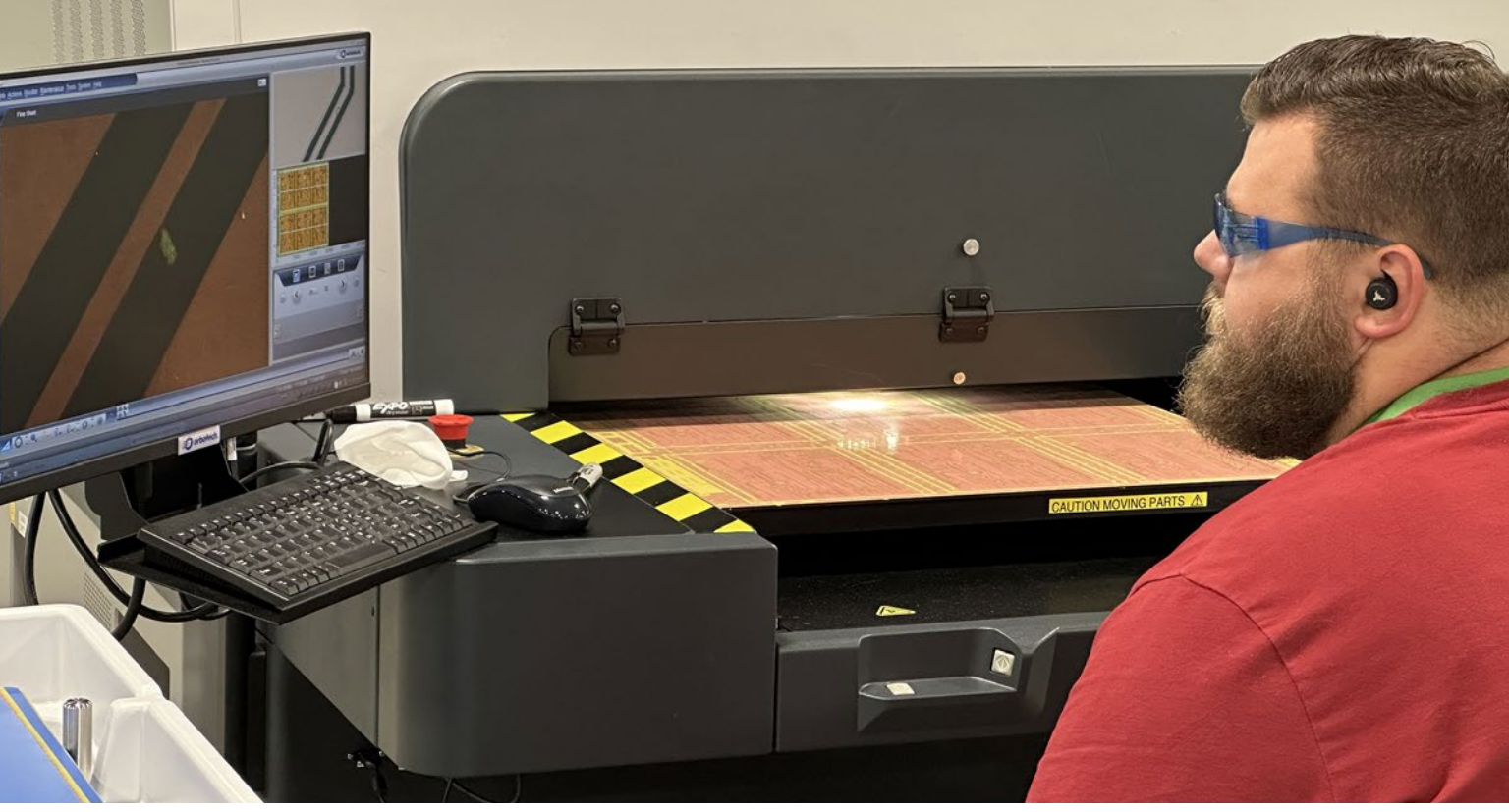
Hendrickson: For electrical test, we went with flying probe and did not bring in any bed of nails. With the throughput of the new flying probe, it is very comparable to some of the bed of nails, and we do not have to build and manage fixtures. It simplifies this whole department.

What was the greatest challenge for you in setting up this facility?

Hendrickson: I think bringing the factory up will be the easy part. Our property team served as the general contractor on this project. We were designing and constructing the building concurrently with the factory processes: If we had gone more linear, we would still be building the facility right now. We built our first board a couple of days ahead of schedule and have beat every other milestone so far on the project. With the technology, there were challenges all over the place, but working with all our suppliers and our internal partners helped us through it. Currently we're ramping up production volume, installing new equipment for capacity and capabilities, and making sure we have a quality product. I think over the next six to 12 months, the most challenging part for us will be bringing everything up to speed with the quality we expect.

Brask: Well, you also have a unique situation where you're choosing specific processes for your product. You don't have to have a full wet process room or the capabilities to be a job shop; you can pick and choose what you're going to do for your products and then automate those key points. You're able to skip a lot of steps.

Hendrickson: Mike has a good point. My background is coming from R&D, and we spent the last 20 years simplifying our designs, and we now have one material set. We worked with our suppliers to consolidate that. Within that material set, we have standardized stackups with one resin system. To Mike's point about streamlining the process and factory design,



AOI inspection process.

how we've simplified our designs, overall, has really helped us.

When you're choosing a supplier in a critical aspect, what are you really looking for?
Hendrickson: Our priority is to find suppliers as close to home as possible. We look to understand if their business philosophies align with ours, and do they have the right equipment to meet our needs? If we find the right partner, maybe their equipment sets don't meet our needs today, but that's where we want to build those deep relationships and work together to develop things to meet goals for both of us.

When you look at the labor market, what attracts somebody to modern PCB manufacturing, compared to what I would call a "jet appeal" or "tech appeal" company?
Hendrickson: There are still a lot of folks who don't necessarily want to get an engineering degree; they want to get into a tech field or work with their hands. I think we have factories in areas where there are a lot of folks who want to have this type of job. What sets us

apart from other manufacturing facilities are the work environment and how we treat our employees. We are a 100% employee-owned company.

You invested about $100 million to set up this facility. What's the ROI expectation?
Hendrickson: It's two to three years.

In addition to the dollars, are you factoring in the innovation that comes out of this? That's a soft return that could accelerate. Do you think more companies will start keeping in mind that zero waste is a big factor?
Hendrickson: I definitely think they will.

With all the supply chain challenges in reshoring or near-shoring, it seems like $100 million is not a bad investment if you have capital available.
Hendrickson: It's not. We were able to think differently, challenging how things are being done today. Greenfield for us was the advantage. If we were trying to retrofit an existing facility, we would not have been able to do a lot of the things that we've done here.

Looking at older brownfield sites, does it may make sense for them to expand by setting up a greenfield site? Even though the upfront cost may be greater, they could be dollars ahead in the long run. It seems like there's an investment community that's willing to invest, especially in a zero-discharge facility. What are your feelings about that?
Hendrickson: Oh, definitely. I think this is what future board factories should look like.

The process flow can be streamlined, reducing cycle time, the employees' work environment is clean and bright, and the impact to the local community, in terms of resources being consumed, are great advantages in the greenfield development.

Very good. Thank you for everything. This has been great.
Hendrickson: Thank you for visiting our facility, Barry. We appreciate it. **PCB007**

Centralized dosing stations.

Schweitzer Engineering Laboratories' 162K-square-foot, $100M manufacturing facility in Moscow, Idaho.

Going Green

Q&A with John Hendrickson

SEL is going green at its new 162,000-square-foot, environmentally friendly PCB manufacturing facility in Moscow, Idaho. As John Hendrickson explains, being a zero liquid discharge (ZLD) facility—a trend you are likely to hear more of in our industry—is not just a smart business decision, it's driven by SEL's core values.

Barry Matties: As far as waste treatment goes, this is a zero liquid discharge (ZLD) facility, correct?

John Hendrickson: Yes, it's zero discharge. We have zero drains in our manufacturing floor and zero drains in our water recycling room. The only drains we have are in our bathrooms and sinks; even the sinks in our lab are all pumped to our water recycling. There's no opportunity for somebody to dump something down the wrong sink.

We designed the factory with a chemical-resistant membrane underneath the facility. We designed the floor so that it slopes a little bit to the center. If we ever had a major spill on this floor, it would all go to the center of the floor and it would all be contained within the building. In the water recycling room, we dropped the floor six inches.

The way this system works is that we have two primary inputs in the system for our rinse waters, which we manage separately from our concentrate side. On the concentrate side, we take the material and drop the metals out and then change the pH. Then we take that through our filter press. So that's where our metals are, and that goes out for recycling.

Everything else will move over to what we call a pH batch tank. We adjust that to a pH of 7 and then we run that through our evaporators. After the concentrate goes to the evaporators, then we take it to a dryer, and we're still putting it under pressure and heat evaporating and then it goes back to the rinse inside. On the rinse side, we'll take it through ozone, then we'll destruct the ozone with UV. We run that through a GAC (granular activated carbon) column, through ion exchange columns, and then eventually run it through reverse osmosis. That's how we generate our DI water.

Matties: Is this kind of thinking why the city got behind this factory?

Hendrickson: Yes. The fume scrubber and everything else definitely helped us with our EPA requirements. Visiting officials have all been very impressed by how clean the factory is and how we've managed some of these things. In fact, some of the things that we're doing with this equipment have never seen an application in the state before.

Matties: Thank you, John. PCB007

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Innovations in Final Finishing

Feature Interview by Barry Matties
I-CONNECT007

In this interview, IPS President Mike Brask shares some insights about the company's latest automated ENIG line installed at SEL's new $100 million PCB facility in Moscow, Idaho. As Mike explains, this line features quite a few innovations not usually seen in North America.

Mike, let's start with some details about the features of this fully enclosed ENIG line. Just how long is this line?

Overall, this line is 81 feet long. Typically, ENIG lines haven't been this big in North America. One of the things we also had to do on this line was to elevate it two feet to facilitate the above-ground drain system SEL installed. Everything has gravity feeds into their pump stations to move solutions to their zero-discharge waste treatment area.

One other feature to note is that each tank has a continuous level-control system to automate the dosing of chemicals, which allows them to dial in their concentrations of water and chemistry. They're totalizing water flow usages, productivity on all the rinses, and maintaining checks and balances on all the key tanks so that this line can run without constant operator intervention.

We have installed individual double-jacketed nickel tanks that allow for smaller batches of boards to work. With any of these hot pro-


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cesses, the trick is to cool that tank quickly. These have jacket coolers on them that are plate heat exchangers and will refrigerate that jacket down out of that active plating zone within an hour. We also have our latest 45-degree oscillation features here, along with bump vibration.

How are you offering ongoing support to your customers?

All of our lines are networked into our facility. So, if customers have questions or need troubleshooting support, we employ two full-time programmers who do remote training to solve problems, or whatever is needed. That remote work gives us instant access to all our lines in the field.

Mike Brask, IPS president.

Along with the support, the whole data management of that board going through a wet process is a big move for IPS to be compliant with Industry 4.0. It's not just what's happening to the board on the front end, it's the whole turnkey chemical management side of things. For example, this line has a complete turnkey nickel dosing. There are individual Palm controllers on every single tank and all that data is logged into the computer, so you know all your metal turns over the life of the bath. All the data from our lines at SEL are compatible and seamlessly integrated into their MES.

Also, we know one of the nasty processes is stripping nickel and the NOX gas and the safety hazard with all that. So, we automated it for them. There is a nitric holding tank that will automatically transfer the nitric, do the rinsing process, and transfer the nitric back. You don't need a guy with a drum and hoses. We are doing that now for other customers—we're automating that chemical handling of the stripping process.

So, when someone is looking into acquiring a final finish line these days, what should they consider?

I would do my homework and look at all the upcoming final finishes. Nickel and gold are the conventional ones, but you also have ENEPIG, EPIG, and all these other autocatalytic golds and things coming in. It's critical to define the capacity and what you want to do with the line early on, because it's hard to modify after the fact.

Congratulations to you and your team on IPS's success.

Thanks. It really is because of that persistence, waking up every morning, and knowing what you want to do as a business. That's one of the key things about being fabricators and tool builders. When I get my people out in the field, and they get to see the end-game of the product they're making, they're not just welding a piece of a frame together; they're building a system. In addition, this helps our team stay in tune and evolve with the newest manufacturing processes in the industry.

Well said. Thank you.

Thank you, Barry. **PCB007**