

Bringing Your SMT Assembly In-House

Case Studies of Its Effects on Lead Time, Inventory, Quality, and Overall Cost

Growing numbers of low- to medium-volume manufacturers of specialized electronic products are reaping the rewards of bringing their SMT assembly in-house. How have some of these companies justified the cost of their endeavors? In this article, three OEM companies share their experiences.

by
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Campbell Company of Boise, Idaho, is a manufacturer of pedestrian safety systems that has been subcontracting PCB assembly for nearly two decades. In just the last two years, the company has invested in its own equipment and brought the production of all but a few of its 27 different, mixed-technology PCB designs in-house. “We’ve always had very good relationships with our subcontractors,” says Phil Tate, Campbell President and CEO. “They all did a very good job for us. There were occasional problems, as one might expect, but we always worked through them. Our decision to bring our production inside was not a reflection on them. We just came to the realization that it was the only way we could meet our goals for inventory reduction and process control.”

Recently acquired by Molex LLC, **Sensorcon** of Williamsville, New

York, manufactures poisonous gas detectors for industrial applications. Founder and President Mark Wagner subcontracted Sensorcon’s PCB assembly for only 18 months before deciding that in-house production capability would best serve their needs. “The need to accelerate development, take control of quality, guarantee product availability and, above all, reduce overall cost, were all key factors in our bringing production in house,” says Wagner. Sensorcon purchased its first SMT production line in July of 2013 and just recently installed a second line to keep up with the company’s steady growth. “The new line will be dedicated to regular production, freeing up our original line for new product development and prototyping,” Wagner adds.

While sheer desperation may have been the motivating force that drove



Sensorcon's high quality environmental sensor products meet the most demanding needs.



Campbell Company's pedestrian safety systems are used worldwide.

Verbos Electronics' synthesizer modules are well known throughout the electronic music industry.



Mark Verbos to start building boards for his synthesizer modules, the electronic music pioneer and founder of **Verbos Electronics** found himself in a similar situation. After receiving funding for the development and production of a new product line, followed by a very successful launch at an industry trade show, his company was sitting on an abundance of orders that appeared impossible to fill based on his sources of supply at the time. Fearing the cancellation of orders due to an inability to deliver, Verbos immediately started looking for other subcontracting services. “But the story was always the same; either too expensive or too slow. That’s when I knew I had to start thinking about getting the equipment to build the product in-house.”

Interestingly, other than working with EMS subcontractors, none of these three companies had any previous hands-on experience in SMT manufacturing. And, although the circumstances that led each of them to acquire and implement their own SMT assembly lines may be different, they were all seeking better control over some phase of their manufacturing process. Be it product development, quality assurance, inventory management, lead time, or product cost, increased control is the common impetus for these companies, and many others like them, to bring production in-house.

So how does a company determine the true cost of obtaining this level of control? How much does it cost to set up and maintain an SMT assembly line? What is the payback period for such an investment? An examination of some of the benefits of in-house production will show how these three companies have gauged their results.

Product Lead Times

In the fall of 2013, Mark Verbos placed an initial order with a subcontract assembler for 1000 pieces of his company's synthesizer modules. "We started taking our first deliveries in January of 2014, but deliveries were very slow and sporadic," Verbos explains. "Our boards are rather complex, some products having up to 400 components. Testing and final assembly still had to be completed in-house, and as we started to receive additional orders, we quickly knew we were going to have serious trouble meeting deliveries." After struggling through the summer of 2014, Verbos purchased a turnkey assembly line from Manncorp at the end of August, took delivery and received training in October, and in 6 weeks had shipped all his remaining backorders.

Of course, Verbos' experience with slow deliveries cannot be considered an indictment of all EMS subcontractors, but when weighing costs and selecting a new supplier, there is always the question as to whether they can deliver. "Working with a good vendor, lead times were typically 8-12 weeks," Campbell's Phil Tate explains, "and that's with everything going right! From time to time, deliveries could extend out to 16 weeks." Now that he has the capability in house, Tate can turn those same boards around in 1-2 weeks. "I can have Gerber drawings in a day or two, and bare PCBs in about 3 days," he says. "I generally try to avoid having to do that but, in an emergency, a few weeks is all we need to flip a board."

For Mark Wagner, the year and a half he spent using subcontract assembly services for Sensorcon's product was all the time it took for him to know that it was neither economical nor feasible. "New product development is such an important part of our long-term business strategy that subcontracting

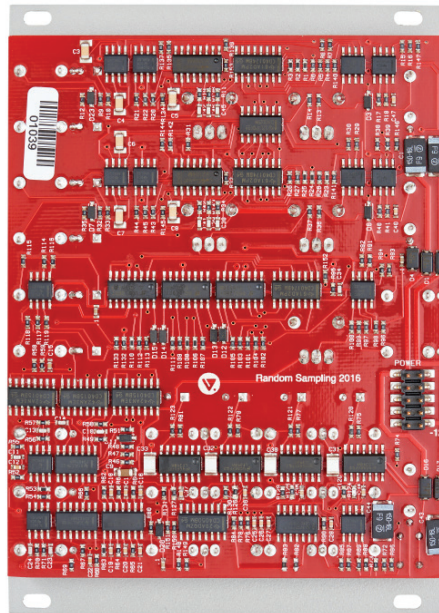
our prototype assembly, and even our initial production runs, just slowed us down to a point that it made little sense. And, despite their best intentions, we found that our subcontractors would sometimes make mistakes that not only cost us lots of money, but also wasted precious and unrecoverable time."

"It's a tremendous relief to not have to pay for product that has to be built in batches larger than orders demand."

Mark Verbos, Verbos Electronics

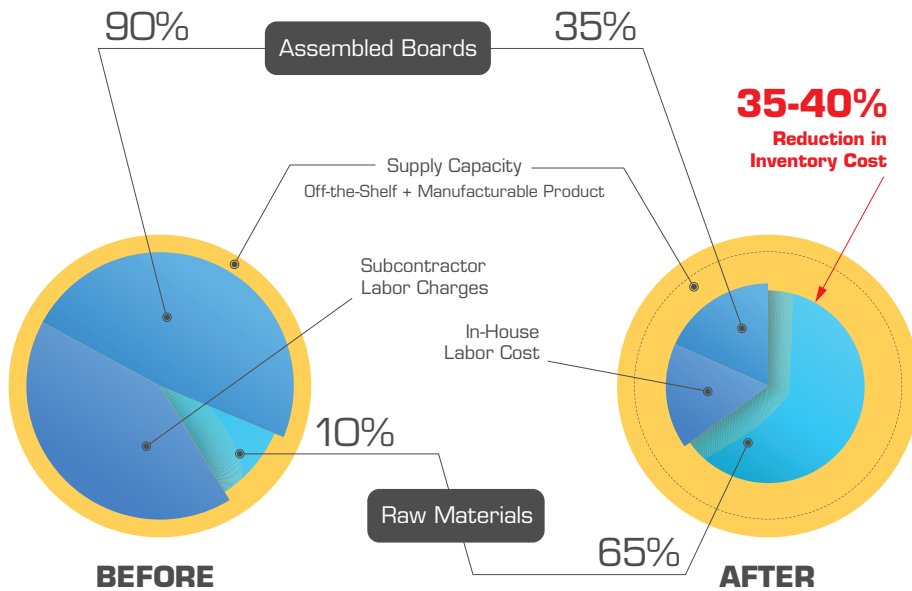
Inventory Control and Cash Flow

Quicker turnaround times lead to better control of inventory levels and reduced strain on cash flow. Prior to bringing their production in-house, Campbell Company's electronics inventory was heavily skewed toward a high percentage (almost 90%) of completed electronic assemblies that had been outsourced at a cost that included the subcontractors' labor. The remaining inventory (about 10%) consisted of the raw materials (bare PCBs and components) that the company purchased at the best possible prices and supplied to the subcontractors in kits to help reduce costs. "Now, it's almost the opposite," Tate explains. "Completed product now accounts for only about 30%-40% of our inventory and we build it at a much lower cost than what we were paying our subcontractors. Also, we are now very vertically integrated. We can be building PCB assemblies at the same time we are building the mechanical parts. This allows us to build smaller lots (and by small, we're talking quantities of 1500-2000 pieces at a time) of



Mark Verbos' random sampling synthesizer module is just one of his company's 12 exclusive designs which can have as many as 400 SMDs in a 2.5" x 4" area.

Effects of In-House Production on Inventory Cost



The chart above compares the Campbell Company's electronics inventory before and after bringing their SMT assembly in-house. The blue areas, which represent inventory cost, are enclosed by a yellow area representing total supply capacity (off-the-shelf + manufacturable product). For equivalent levels of supply capacity, the ratio of assembled boards to raw materials went from 90/10 before to 35/65 after, resulting in a 35-40% reduction in the total cost of their electronics inventory. Also of note is that subcontracted boards in inventory tied up a significant amount of cash that paid for the subcontractors' labor and overhead. The ability to produce smaller batches more quickly in-house (and presumably at lower cost) significantly reduces the burden on cash flow.

various products each month to keep inventories low, while still meeting demand and keeping up with sales volume." Less than a year and a half after bringing their production in-house, Campbell Company has reduced the cost of their total electronics inventory (finished PCB assemblies + components and bare PCBs) by a considerable 35%-40%.

According to Suzanna Sims, Campbell's Controller, in-house SMT production has been invaluable to the company's lean manufacturing initiatives and a boon to cash flow. "To meet price points, we used to have to place blanket orders for 25,000 pieces of one board that would tie up \$150K-\$175K in one shot," say Sims. "We'd make our best estimates to coordinate delivery schedules based on sales forecasts, but we'd often end up paying for product that would

sit in inventory a little longer than planned."

Large cash outlays for subcontract services were also a burden for Verbo Electronics. "It's a tremendous relief to not have to pay for product that has to be built in batches larger than orders demand. Setup charges from subcontractors necessitate a certain minimum volume; otherwise the cost per assembly becomes quite prohibitive," says Verbo.

Quality Control

For companies with no previous experience in SMT manufacturing, the thought of bringing production in-house and being able to maintain product quality can be somewhat daunting. "When we finally made the decision to take the plunge," says Campbell's Production Supervisor, Clark Hill, "we were all kind of asking

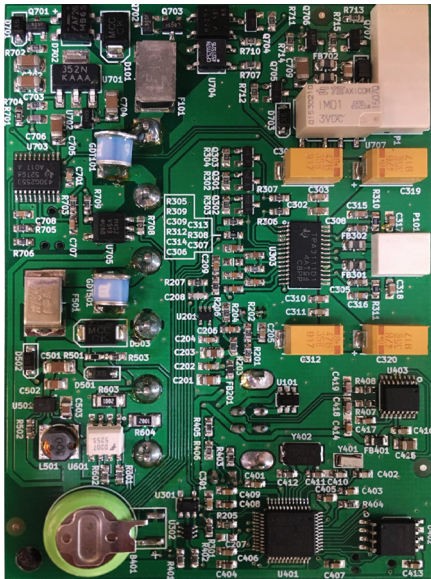
ourselves, 'Are we really going to be able to do this?'"

Campbell's state-of-the-art pedestrian safety systems, which allow traffic agency technicians to control their equipment via remote web-based management, currently meet IPC-A-610, Class 2, specifications. State and federal regulations, which already require performance testing at extreme temperatures ranging from -70°F to +150°F, are soon expected to demand Class 3 compliance, due to the mission critical nature of the equipment in a full range of environs worldwide. Campbell is an ISO 9001:2008 certified company that undergoes semi-annual auditing and stringent inspection of their SMT assembly processes and quality control methods.

"To be honest, the whole process of bringing our production in-house was much, much easier than I anticipated," says Hill, "and the learning curve was way shorter than I expected. We had some through-hole experience, but 80-90% of our crew were very green when it came to SMT." Hill credits industry associations like IPC for the standards and education they provide but is also quick to point out that, "the initial training and continued support provided by our

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Clark Hill, Campbell Company



The high-mix board for Campbell Company's Advisor Guide Accessible Pedestrian Station contains approx. 160 different components and is just one of 25 unique designs they now assemble in-house.

equipment supplier, Manncorp, have been invaluable. Any time we have a problem or question, technical help is always available.”

Per Phil Tate, there's no comparison between in-house production and subcontract assembly services when it comes to quality control. While subcontract assemblers may be extremely knowledgeable in SMT equipment, processes, and best-practice quality procedures, they're not intimately familiar with the nuances of any given product's design. This makes it much less likely that they will detect problems as quickly or

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Phil Tate, Campbell Company

as easily as the developer of the product. “Now, when we encounter problems, we can identify the root causes almost immediately and take whatever corrective action is necessary,” says Tate. “Troubleshooting is always much more difficult in a subcontracting situation. Our products also require a lot of in-process testing at various stages of assembly and it's nice to be able to monitor that activity very closely, especially today, as important as SPC reporting and traceability have become.”

Calculating Actual Cost

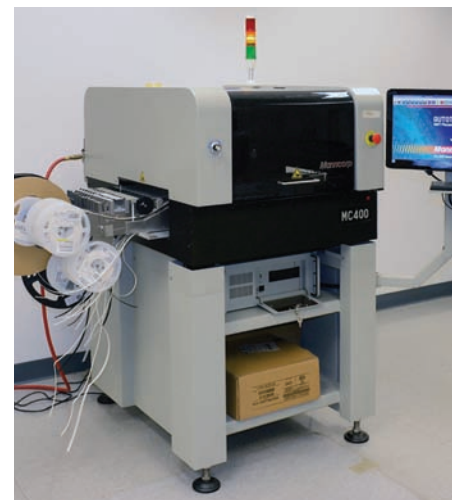
Thus far, all the aforementioned advantages of in-house SMT assembly (shorter lead times, reduced inventory, improved cash flow, and better product quality) provide significant cost savings and commercial benefits. Because return-on-investment and payback calculations all take generated savings into account, these factors must be included. But let's put these factors aside for a moment and look strictly at cost. How does one go about establishing the actual cost of building one's own boards? How long of a payback period is to be expected for the purchase of the necessary equipment?

The cost categories associated with manufacturing a product can be broken down into direct materials cost, direct labor cost, and manufacturing overhead, which, among many other things, includes the cost of the equipment depreciated over time, utilities, maintenance, training, etc. Overhead also includes a variety of other indirect product costs of greater and lesser significance, further complicating the calculation. As a result, one company may estimate its manufacturing costs quite differently from another.

While the services of an EMS subcontractor would seem to make it much easier to control and quantify the direct labor cost of a PCB assembly (cost of completed assembly less raw materials cost), without having to be concerned with manufacturing overhead, there are other indirect costs incurred when using these services. The amount of time and effort that goes into coordinating production and delivery schedules with a subcontract assembler can be significant. Costs for bare PCBs, components, and completed assemblies are a function of order quantities and, as mentioned above, balancing inventory levels for each of these, based on sales forecasts and actual

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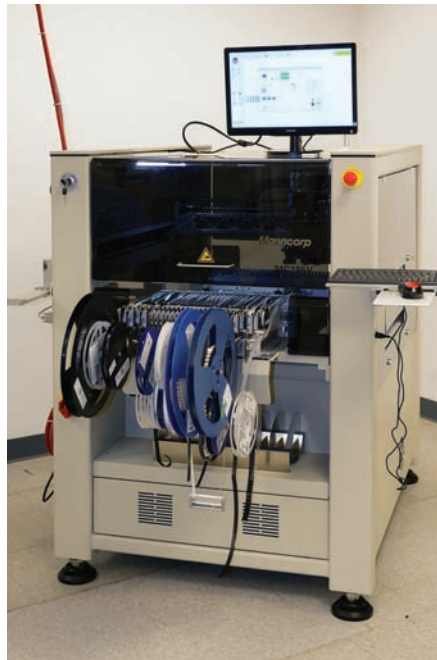
With the addition of their second Manncorp SMT line, Sensorcon's 3000 CPH MC-400 pick and place will now be used for new product development. Its feeders are interchangeable with their new MC-385.

product demand, can be extremely challenging.

“When we were first starting out, some of our vendors supplied turnkey product,” says Mark Wagner, meaning that the subcontractor supplied the boards, components, production, and anything else needed to deliver a complete PCB assembly. “Of course, you pay a premium for that, so as a next step toward reducing costs, we tried a pre-kitting service offered by one of our component suppliers. Despite some initial savings,” Wagner explains, “an excess of raw materials seemed to accumulate after each job, telling us this system was inefficient and wasting money. Typically, the problems centered around tape-and-reel component packaging and minimum order quantities, so we finally decided we’d be better off doing our own component purchasing and pre-kitting.”

As Sensorcon incurred the full cost of managing its raw materials inventory, Wagner continued to seek other suppliers that might be able to build his boards for less than the \$12-\$18 per board he was used to paying for each of his various products. “I visited several subcontractors and I often noticed there’d be lots of highly automated equipment that was frequently sitting idle,” Wagner recalls, “yet there were always lots of hand-assembly operations being performed at manual workstations. This made me realize that, when dealing with many of these subcontractors, I wasn’t just paying for direct labor; I was helping to pay their overhead for under-utilized equipment.”

Wagner soon concluded that he should acquire his own equipment to build Sensorcon’s products in-



Sensorcon’s new production line includes the 2-head MC-385 pick and place system, the same model Mark Verbos uses to build his synthesizer modules. At 8000 CPH and \$65K it ranks as one of Manncorp’s most popular systems.

house and purchased a small turnkey assembly system (manual stencil printer, 3000 CPH pick and place system, and batch reflow oven) from Manncorp. “I realized that, in our case, speed wasn’t an issue” he says, “and I wouldn’t be justifying the equipment based on how fast I could assemble boards. We would still be limited by our manual operations, which include test and final assembly, but at least now we’d be paying for our own equipment and not somebody else’s.”

“We’ve saved so much in production costs, I believe our equipment paid for itself in the first 6 months. Why should I care if the equipment occasionally sits idle until we’re ready for a production run.”

Mark Verbos, Verbos Electronics

Typically, Sensorcon builds its three main products in batches of just 200 pieces at a time, maintaining desired inventory levels using a just-in-time, Kanban production strategy. “Although we may have a little more money tied up in inventory, this takes a lot of the pressure off and allows us to maintain a steady supply of product,” Wagner points out. “I felt that the PCB assembly could very easily be integrated into our existing production at minimal additional cost, because staff can perform many of their regular tasks while the SMT equipment is running.” As it turns out, Wagner’s predictions have indeed come true, and the incorporation of SMT into their in-house capabilities has been so seamless that he believes he has reduced his direct labor cost to about \$2 or \$3 per assembly. Of course, this figure doesn’t include any manufacturing overhead but, compared to what he



For increased printing accuracy and easier stencil to board alignment, Sensorcon chose Manncorp’s PB2300 vision-assisted semi-automatic stencil printer. Like their original pick and place machine, their manual stencil printer will now be dedicated to prototyping and new product development.



Campbell Company's fully automated SMT assembly line includes Manncorp's high-precision AP430 inline stencil printer, the 3-head MC-389 pick and place system, and a CR-5000 convection reflow oven. With a full complement of component feeders and connecting conveyors, the line bore a price tag of nearly \$250K, yet Campbell management believes it paid for itself in 12-18 months.

“Bringing our PCB assembly in-house was a very good decision.”

Phil Tate, Campbell Company

lines (high-precision inline stencil printer, 10,500 CPH pick and place system, and a 5-zone convection reflow oven) for just under \$250,000. Due to their decades of experience in dealing with EMS subcontractors, their objectives from the start were less about reducing production costs than they were about reducing inventory and improving lead times. While Tate, Sims, and Hill all agree that their equipment probably paid for itself in the first 12-18 months, they are almost indifferent about payback. Their enthusiasm is evident, however, in their willingness to talk about the significant impact that in-house SMT assembly has had on their entire operation. “We’re doing some incredible things here,” says Phil Tate. “Bringing our PCB assembly in-house was a very good decision.”

The Bottom Line

SMT equipment, by its very nature, is inherently fast. After all, in addition to smaller, standardized package sizes and higher-density circuits, ease of automation and higher speed assembly have always been trademarks of the technology. But the fact of the matter is that, outside of Asia, the vast majority of SMT assembly equipment throughout the world is underutilized. Generally speaking, SMT is so cost-effective that when manufacturers first start to consider purchasing their own equipment, placement speeds typically throw them off track. For example, a small company looking

had been paying, his savings are considerable.

Mark Verbos saw himself in an almost identical situation with the subcontract assembly of the boards for his synthesizer modules. “For the prices I was paying just for labor (anywhere from \$30 to \$50 per board) and knowing exactly what my raw materials costs were, not to mention the slow lead times I was experiencing, I was totally convinced that I could easily justify the purchase of assembly equipment and pay for it in a very short period of time.”

Like Wagner at Sensorcon, Verbos purchased an SMT assembly line from Manncorp (manual stencil printer, 8000 CPH pick and place system, and batch reflow oven). “Everyone was telling me I was crazy,” he recalls. “They told me the only way I’d be able to make the equipment pay

for itself was to take on additional work to keep the equipment running 24/7.” But like Wagner, Verbos didn’t see it that way and, in his opinion, he has proven himself right. “We’ve saved so much in production costs, I believe our equipment paid for itself in the first 6 months. Why should I care if the equipment occasionally sits idle until we’re ready for a production run? It would be nice if the equipment were running all the time because that would only mean that we’re selling more. But right now, our priority is being able to fill orders and meet deliveries, and we’re doing that, even if our manufacturing cost isn’t the absolute lowest it could possibly be. What used to take 6-8 months from a subcontractor can now be produced in-house in 6-8 weeks.”

To meet throughput requirements, Campbell Company purchased one of Manncorp’s fully-automated SMT



Due to space limitations, a 90° turning conveyor is positioned between Campbell Company's 3-head MC-389 pick and place machine and their 5-zone CR5000 convection reflow oven. Single-sourcing a complete turnkey SMT production line from Manncorp provides such benefits as seamless equipment integration, special package pricing, coordinated delivery, installation and training, and extended warranties.

at a 5,000 CPH pick and place system to assemble a board with 200 components may immediately think, “25 boards per hour, 200 per 8-hour shift, 1000 assemblies per week! First of all, we don’t sell anywhere near that many, and besides that, our testing and final assembly couldn’t possibly keep pace. That machine is way out of our league and will be sitting idle half the time.” The point is that this thinking doesn’t really apply outside the world of very high volume SMT. For low- to medium-volume manufacturing of specialized products, it’s probably OK if in-house SMT equipment isn’t running at its fullest capacity 100% of the time.

If you look at an SMT equipment purchase from a total cost savings standpoint, instead of trying to base its justification on equipment utilization, it’s a whole different story. As these three examples show, a

more holistic approach is necessary. This is precisely the reason that “payback period” is of so little significance to Campbell, Sensorcon, and Verbos Electronics that none of the three have ever taken the time to go back and calculate it with any high degree of precision. Whether it was 6 months, 12 months, or 18 months doesn’t really matter—they know it was quick—and, they know that the benefits to their business operations and the overall cost savings, have been so substantial that they almost don’t care.

On this basis, one could even argue that the cost of equipment is so comparatively small, companies should make absolutely certain they don’t underspend when it comes to installing their first SMT assembly line. Nothing can be more frustrating than trying to produce a high-quality product with equipment that isn’t up

to the task. This being said, there’s certainly no need to overspend either. The key is to purchase the best equipment to get the job done right, while keeping an eye toward future needs and upgradeability.

Of course, trying to predict the future is perhaps the greatest challenge of all. Companies go to great lengths to keep abreast of changing technology and industry trends that can affect their businesses. But even the most optimistic among them will admit that it’s virtually impossible to foresee the role that world events, macroeconomics, and other things beyond their control might play in the years ahead. Nonetheless, it now appears that a new, business-friendly administration is intent on setting policy that will benefit American manufacturers. Wouldn’t it seem that now is a better time than ever for more OEMs to follow the examples of firms like Campbell Company, Sensorcon, Verbos Electronics, and countless others who have taken this logical next step?

These are just three of literally hundreds of examples of how Manncorp has successfully helped small- and medium-volume manufacturers bring their SMT assembly in-house. On a daily basis for no charge, Manncorp sales engineers work with customers to review bills-of-materials and board samples, and make equipment recommendations based on application requirements and budgets. They can also provide guidance on a variety of equipment financing options available. For additional information, visit www.manncorp.com or contact:

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