Total Electronics: Rising from the Ashes

When lean is the only option.

Lea A.P. Tonkin

Just how low can you go before figuring out that lean manufacturing is the way to go? Well, Total Electronics nearly hit the bottom several years ago. During a recent AME workshop at the company headquarters in Logansport, IN President John Yerger described how a private group bought out what was essentially a bankrupt company, with one major customer that accounted for three-quarters of its sales in the process of moving the sourcing of its products to China. Meanwhile, delivery and quality problems persisted. The company is a contract assembler of circuit boards and box assemblies.

"We didn't have the luxuries of time, money, or other resources," said Yerger. "Necessity is the mother of invention. We decided, 'Let's go lean!'" Yerger and other Total Electronics people shared how a customer-focused lean approach has resulted in quality, working capital, profitability, and productivity improvements. This article offers an overview of the lean tools used and performance improvements netted at the company, as well as their emphasis on effective performance measures.

**Tough Goals, No Margin for Error**

With no margin for error as they struggled to turn their organization around, management crafted a new company vision: "Be the premier electronic services company for mid-sized projects in niche market segments with industrial, automotive, and technology markets." Vice President of Operations Dave Stover outlined the components of their revamped operations vision: 1) Make people a top priority, 2) implement quality at the source, 3) aggressively improve customer response time, 4) create a continuous improvement (CI) culture, 5) competitively manufacture at any volume and be flexible to any request, 6) establish process measurements that contribute to Total Electronics' business goals, 7) drive the transformation process through knowledgeable and involved leadership, and 8) optimize the manufacturing system through balanced implementation of lean elements. Elements of the company's balanced lean approach are shown in Figure 1.

Value stream mapping and other lean tools helped Total Electronics employees detect and eliminate waste in their processes. Overproduction, material and infor-

**In Brief**

Things looked dismal for Total Electronics' future several years ago, until they turned to lean concepts and began pulling up performance in cycle times, quality, and other areas. The electronic manufacturing services company employees have learned that lean is a way of thinking, and continue to look for ways to effectively meet customer requirements through lean manufacturing.
The Total Electronics Balanced Approach to Lean

Employee Participation
- Natural work groups
- Empowered teams
- Multi-skilled members
- Training program
- Continuous improvement
- People recognition

Workplace Organization
- Cleared, cleaned, maintained, organized
- Standardized visual controls
- Andon system
- Address system
- Part and tool presentation
- Production status boards

Quality System
- Supports TS16949 (automotive quality certification)
- Error proofing
- Customer-focused
- Process capability
- Standard work practices
- Measurement feedback

Flow Manufacturing
- Value stream analysis
- Synchronous layout
- Constraint management
- Waste elimination
- Feeder process integration
- Cycle times charted and reducing
- Single piece flow

Material Movement
- Material and information flow
- Containerization and transportation
- Pull system (supplier, production)
- Level scheduling and cadence
- Delivery routes - timed
- At the right time and at the point of use
- Supermarkets and buffer management

Equipment Effectiveness
- Uptime measured
- Quick setup and changeovers
- Proactive versus reactive
- Planned maintenance
- Response system
- Workstation readiness.

Improvements Start to Roll In

Lean improvement events target specific process flows or work areas. Using the chart shown in Figure 3, such project teams mark their short-term and long-term progress in improved leadtime, inventory, floor space, effectiveness (units per hour), quality, and cost performance. These multi-functional teams have tackled 12 different value streams including automotive actuator boards, power meter, automotive wiper control, and others.

Notable lean performance gains are helping to turn things around at Total Electronics. For example, on one particular product (known as the money board), cycle time improvements from May 1 through November 17, 2004, for example, boosted boards processed per hour by more than 91 percent. Space requirements shrunk along with WIP; board carriers became obsolete.

"A high-speed line with a narrow mix of products combined two lines into one, reducing our labor costs by 60 percent (some area employees were shifted to other areas)," Stover said. "We took two concepts — heijunka and a changeover wheel — and combined them. Our production managers and materials planners determine which products will run on a daily or weekly or monthly basis.

"We have a comprehensive quality/factory management system," he added. "Our tight product focus helps us to ensure that product cannot be packed out that hasn't passed each process step, including test. Furthermore, we provide traceability by serial number on every board we ship." Smoother flows result from using a parts "supermarket" approach with a plant-wide address system, designated storage, and route runners making frequent deliveries. Supplier/partner Avnet has an in-plant store that supplies a significant portion of Total's purchased material.

About Total Electronics

Total Electronics, based in Logansport, IN, has production facilities in Logansport as well as Reynosa, Mexico. The company is an electronic manufacturing services company, producing electronics for other organizations (industrial, automotive, and technology markets).

Approximately 300 people work for Total Electronics (approximately 98 in production, 115 total at the IN plant). Sales are approximately $35 million annually. They offer make-to-order production, as well as made-to-forecast, with volumes at 50 to 4 million per part number (high mix).
## MATERIAL FLOW

<table>
<thead>
<tr>
<th>KEY POINTS</th>
<th>OBSERVED CONDITIONS</th>
<th>DESIRED IMPROVEMENTS</th>
<th>OBSTACLES</th>
</tr>
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<tbody>
<tr>
<td>CUSTOMER / SUPPLIER RELATIONS</td>
<td></td>
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<tr>
<td>PULL SYSTEM Provide, only what's needed when it's needed.</td>
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<tr>
<td>PULL SIGNALS Types, extent, how and why</td>
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<tr>
<td>SMALL LOTS Minimum information, quantity &amp; flow.</td>
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<tr>
<td>CONTAINERIZATION Size, orientation, format, etc.</td>
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<tr>
<td>LEVELING Smooth, stable, balanced flow vs too much / too little</td>
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<tr>
<td>QUICK SET-UP Flexible, quick, simple.</td>
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<tr>
<td>TRANSPORTATION LAYOUT AVAILABILITY SCHEDULING VARIATION</td>
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**Figure 2.**

<table>
<thead>
<tr>
<th>Team</th>
<th>Product</th>
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<tbody>
<tr>
<td>Value Stream</td>
<td>Date</td>
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<tr>
<td>ISO 9000 Requirements Addressed ?</td>
<td>Location</td>
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</tbody>
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<table>
<thead>
<tr>
<th>IMPROVEMENT MEASURES</th>
<th>CURRENT Measure</th>
<th>IMPROVEMENTS AFTER IMPLEMENTATION</th>
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<tr>
<td></td>
<td>SHORT TERM</td>
<td>LONG TERM</td>
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<tr>
<td></td>
<td>Measure</td>
<td>%</td>
</tr>
</tbody>
</table>

**Figure 3.**
Cockpit Charts, Discipline, and Measures; Don’t Forget the People Side of Improvement

Continuing attention to key metrics, reflected in what John Yerger calls "cockpit charts," is critical to Total Electronics’ progress. He cited metrics such as revenue and profit, working capital (order-to-cash cycle measured in days), quality (defects per million), and new product sales as a percentage of revenue.

The people side of performance is essential, according to Yerger. The "one team — owners, executives, employees" philosophy goes a long way toward building collaborative efforts. Respect for people extends to customers, suppliers, employees, and shareholders, he said. The company’s fundamental principles are shown in Figure 4.

"It doesn’t take money, time, or heavy training to make this transition. It takes leadership, teamwork, and focus," said Yerger. That said, the company had to focus on training in several areas and it received an Indiana Commerce Department grant for its competency-based (team and technical) training, structured on-the-job training, and performance checklist evaluations.

They now have two dedicated trainers. External education programs range from an organizational development plan to an Indiana workforce development grant, and a Purdue University on-site leadership and technology program.

Workshops: Learning How Lean Tools Work

Multi-functional lean workshops targeting specific improvement goals engage employees in continuous improvement, said Scott Smith, manager of operations. "We’ve done 11 workshops, starting with products where we can get the biggest bang for the buck," Smith said. Dave Stover and other company personnel conduct the lean workshops (a retired Delphi trainer led their first session), first reviewing lean fundamentals and the major sources of waste, then lean tools such as reduce, combine, eliminate, and simplify; multi-functional workers; and quick changeover. Then team members go out and record the selected process flow, documenting VA and NVA steps. They measure cycle times, floor space utilized, the amount of material in process, etc. (from the start of the line all the way to the packing station on a hand assembly line, for example). Then they break into smaller teams and brainstorm suggestions for eliminating the waste they’ve found. The sub-teams present their ideas to the whole group. They use pictures, flow charts, diagrams, dry-erase boards, and other means to show how to combine operations, balance a process, or make other improvements. After the team agrees on strategy, and presents their recommendations to management, they start making agreed-upon changes.

"For example, we worked on improving our CH530 line for Trane (air conditioning controller boards, with about 20 different variations); we run about 4000-5000 panels a week. One of our first workshops was to work on this family of products," Smith said. Panels on this line range from two to seven boards apiece. Carriers for the panels used to stack up, with little feedback in real time about any quality issues. WIP ballooned as rejected panels accumulated and product zigzagged its way through various processes.

A large amount of NVA activity was documented by the project team, which included representatives from process engineering, test engineering, materials, and four operators from the hand insertion line. They noted the volume of shorts, incorrect value parts, incorrectly-polarized parts, and other problems that slowed the process. It was difficult to trace the source of errors, but team members knew there had to be a way to eliminate problems before product reached in-circuit test.

"Our objective was to get from the head of the line to the packaging station with the highest level of quality," Smith said. "We drained a week’s worth of material from the assembly area, and we learned through prep work how to identify and eliminate errors earlier in the process. Team members understood that this change could help us

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to cut cycle time, reduce material in the process, and decrease floor space utilized. Using flow charts, diagrams, pictures, and other tools, our sub-teams focused on hand assembly and final test/packaging. We learned to reduce cycle times on particular models by making adjustments from the back end to balance the SMT line, so we had one operator on some hand-insert lines and two or three on others. It was an extremely successful project. Now any errors may involve 20-30 boards as compared to 1400 boards in the past.*

**People Power: Success Factors**

Cross-training employees in various operations boosts Total Electronics’ flexibility as lean workshops and more streamlined flows unfold. “We sometimes pull people in from other areas of the facility to work on a line as needed,” Smith said. Manufacturing workshops have targeted HVAC (heating, ventilation, and air conditioning) boards, HVAC controls, a money board (used in an actuator that detonates an alarm when a bank clerk hands a pile of fake money to a robber), automotive vent actuator boards, a power meter, a bowling pin setter control box (for Brunswick), automotive clocksprings, and automotive wiper controls.

*Another key to successful lean workshops is communication,* Smith continued. *Operators and managers need to share ideas about changes that can be made. When we have a workshop, the whole team critiques what the sub-teams present. Then after a workshop, we all get together on the team and put together recommendations on outputs after the workshop, listing immediate changes and any suggestions for intermediate and long-term changes. One of our biggest challenges is that issues vary with different models we are working on, so we need to fine tune on a continuous basis.*

During regular (usually weekly) quality walk-throughs by Smith and a process/quality engineer, supervisors and production techs discuss any issues such as quality on all products. "We have a good system for monitoring first-time pass rates," Smith said. "All output charts are updated for output and functional test, so we can tell what products we should pay attention to. We are getting closer to Paretos on what is wrong with particular models."

Visual management and work area team accountability for results are added keys to successful lean changes over time. "It became clear after we began lean changes that operators needed better tools to keep track of various products (such as the CH530 line for Trane)," Smith said. "Operators now can look at a display board, see what models are coming up, and then decide how many people they need to man the lines.*

Quality and productivity issues also are posted. Production techs used to manually record (defects, etc.) information on cumbersome sheets. Now they scan defect code sheets indicating the location of any defective component on a board (a diode or capacitor, for example).

**Actuator Circuit Board Production: Building Trust, Eliminating Waste**

Matt Price, business manager in the company’s automotive business unit, shared "lessons learned" in the leaning of actuator circuit board production for a high-volume automotive customer. "We supply Saia Burgess in Springfield, TN with a vent actuator (circuit board)," Price said. "We bid and won against others, including suppliers from China, when they were known as CEI. Our labor content was competitive.* Total Electronics was to start production of the boards in 2002. The program was delayed. Meanwhile, Total Electronics had sunk close to a half million dollars into capital equipment and put in two dedicated assembly lines.

“Then, when we started production, it was a very steep ramp,” Price recalled. "We had quoted with three assemblers, but we ended up with 40 people on three shifts because of initial quality problems." After product launch, volume went from 2000 a week to 300,000. "Our quality improved, but we knew we had to get better, because we were losing money," said Price. "We had our first lean manufacturing workshop with operators who volunteered from all three shifts. We looked at the entire process. First
we focused on forms of waste, such as the number of steps taken by an operator from one process to another." The team used Value Stream Mapping (VSM) and other lean tools to document and then eliminate NVA activities.

"Our largest gain was eliminating WIP," he continued. "We had thousands of boards — sometimes 20,000 at a time (30 per array) on a line before they were packed out at the end of the line. If we started producing bad assemblies, we could have had several thousand arrays sitting there before we realized the problem. We worked to get one-piece flow from beginning to end of the process. That meant changing our paradigms — not inspecting quality into your process, but instead, stopping the line to get it right."

Building trust and effectively communicating about the lean changes were critical to improvements. "At our first lean workshop, we discussed that eliminating a process step or a job duty could mean reassigning operators elsewhere in the plant, not eliminating operators. Then the ideas started to flow," Price said. "Operators are key to our success. They know their jobs best, and they have the knowledge to think outside of the box about improvements." He added that leadership support for lean changes is also essential to building trust.

This support encourages operators and other employees to devise innovative, tradition-busting improvements. One of the operators suggested in an early workshop that they run a "super line" by eliminating a couple of machines and combining two lines, for example. "We used a decision model to discuss the pros and cons, with operators and engineers participating," Price said. In two succeeding lean workshops, the team further developed plans for the "new" line. "We planned the details of the changeover down to the hour," said Price. "We made the decision to go ahead in early June, and then made the change during the first two weeks of July 2005, with the help of engineers and maintenance folks including the toolroom manager, Lenny Ricci. It worked better than I had hoped. We moved 12 pieces of equipment. These machines are complex and very sensitive. Everything came up on line, almost to a 'T' about how we had planned. The resulting performance improvements allowed us to keep this business in the face of steep global competition."

**Money Pack Boards: Eliminating Touch-ups, More Changes**

For customer 3SI, Total Electronics produces boards used in an actuator that triggers an explosive after a bank robber takes a fake money pack from a teller. Total places fine pitch surface mount parts on a flexible circuit board. "We've had this product for five years with various revisions and upgrades," Price said. "We were looking for ways to take waste out of this process."

Mapping the board production (SMT line), a lean team noted two touch-up stations where boards were visually inspected and any detectable defects (shorts, opens, etc.) were removed. After leaving the touch-up station, boards traveled to the bed of nails (or in-circuit test — one of five in the facility). Then they were routed across the plant to a final assembly operation where boards went to a bend press (a crease or bend was put in the board). Next came a coating operation where boards were conformal coated, followed by a final functional test. Then the boards were sent to a different location in the plant where they were packed out.

"All this handling involved a great deal of steps," Smith said. "We had batches of parts at each of these locations. Doing a cycle count was difficult. We looked at the process and saw a lot of waste."

After concluding that touch-ups were NVA, the lean project team decided to eliminate all touch-ups. Touch-up people were moved to VA operations elsewhere in the plant. First-pass yield (FPY) dropped 40 percent "It was extremely painful," recalled Smith. "But we got a true gauge of quality on the SMT line. It took us from June until October 2004 to work out improvements; we're now at 85-92 percent on FPY (without touch-up). We had to make changes to the geometry of the PCB itself, to make it more manufactureable, and in a screen print operation we made several modifications to minimize bridging and opens (defects). We also worked on improving component placement accuracy (machine programming was needed). That was painful, too. We had masked our problems with performance elsewhere in the plant, not eliminating operators. Then the ideas started to flow," Price said. "Operators are key to our success. They know their jobs best, and they have the knowledge to think outside of the box about improvements." He added that leadership support for lean changes is also essential to building trust.

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between different components, creating in some cases open, surface tension conditions that can cause components to teeter. We have good teamwork with 3SI on improvements. They have come to the plant to demonstrate how their product (with our board) works."

"Always More to Do:" Cross-Training, Preventive Maintenance, Workplace Organization

"There is always more to do in continuing to improve our FPY and other areas," Smith said. "We are continuing to work on issues we have found in lean workshops, testing by model to determine exact times and distribute work based on actual need. We realized after our first workshop in late May 2004 that we needed to balance shifts. At the time, we were a two-shift operation." They later added another shift, learning along the way that certain products requiring fewer production steps are more suitable to a third shift. Teamwork and trust were enhanced during the lean improvement activities, helping to smooth the transition to another shift. "We did not lose a single employee during the change," Smith said.

Operators and other employees have also learned to do cleaning and some PM (preventive maintenance) tasks so they can keep machines running with less downtime. When one machine goes down, eight or nine people can be idled. "One of the things we learned in our lean workshops was that not having all that WIP helps us to fix root problems such as equipment problems," said Price. "We also have workplace organization — a place for everything. We had training, for example, how to do color coding for equipment, supplies, raw material, etc."

An internal trainer provides skills training. "Train the trainer" efforts enable company personnel to share skills basics with others in the plant. Cross training is built into a pay-for-skills program. There are three skill levels in the assembly area, for example. An employee can move to the next level after achieving competency in four to six skills within the previous level. Skill levels are higher in the SMT area than on the assembly line; when SMT people work in the assembly area, they still receive the higher SMT pay. "Sometimes more people are needed to backfill, for example, when hand soldering is needed at the end of the SMT line," Stover said. "The more flexible they are, the easier our jobs are." He noted that the company offers annual profit sharing and that they're working on development of a fourth skill level.

Success factors for initial lean efforts include a willingness to be open to ideas from everyone in the operation, Stover said, adding, "You’ve got to include everybody, and lean workshops should include people from a good cross-section — manufacturing, operators, maintenance, engineering, and others. It’s important not to get comfortable, and to have an uninhibited perspective about improvements; you sometimes get the best ideas that way, through the creativity of the whole system.

"Don’t be reluctant to do the right things — feel the pain," Stover added. "The first few months before we improved yield were painful. Now it’s hard to believe that we are the same company. Things have gotten so much better. We’re more competitive than we’ve ever been. We’re ready to take the lessons we’ve learned to new opportunities."

Next Steps, Lessons Learned, Mistakes Along the Way: Change is Good

Building lean workshop cadence as well as more discipline in measuring and improving cycle times is on the "What’s Next" list, according to Dave Stover. He also cited the need for fully-implemented supplier pull, documented standardized work for every job, and relentlessly pursuing the elimination of waste.

John Yerger counseled that lean is a way of thinking, not just a series of steps. "Learn to eliminate WIP, and hoard spare capacity — give it up grudgingly," he said. "Make sure your grandparents would understand your process immediately — make everything obvious. Lean has no boundaries. It is not a 'manufacturing thing.'" Understanding the need for continuing lean improvements is essential, he believes: "After a successful lean implementation, there is still room for improvement — change is good."

Added "lessons learned" as shared by Yerger are:
• Stop fighting with your customer, especially over quality
• Encourage people to think lean, not drift back into old ways
• More people is never the answer
• Numerical reviews don’t build a team (provide flat pay increases, and reward team rather than individual accomplishments)
• Establish the flow and that will set the pace
• The next step after sophistication is simplicity.

Editor’s note: John Yerger and Dave Stover were presenters at the 2005 AME annual conference in Boston, as regional AME award winners.

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