Originally published in the Proceedings of the SMTA Medical Electronics Symposium, Anaheim, CA
January 29-31, 2008.

TEAMING FOR LEAN

Todd Baggett
EPIC Technologies
Norwalk, Ohio, USA
todd.baggett@epictech.com

ABSTRACT
There is no question that Lean manufacturing can provide cost reduction. However, in EMS settings Lean methodologies often underperform because of lack of a comprehensive implementation strategy. This presentation looks at the key contributions customers, suppliers and the EMS provider should make in effective implementation of Lean philosophy. It also looks at constraints at medical device manufacturers and discusses how these challenges have been addressed in outsourced medical manufacturing programs.

Key words: Lean manufacturing, EMS, supply chain management, contract manufacturing, medical.

BACKGROUND
Properly implemented Lean manufacturing techniques reduce working capital, add production schedule flexibility and reduce total manufacturing cost. Most original equipment manufacturers (OEMs) are very interested in Lean manufacturing when these benefits are presented. However, cost reductions attributable to Lean manufacturing do not occur in a vacuum. Instead, cost benefits accrue incrementally as the product and associated processes are optimized for Lean. When the product is outsourced, that optimization involves not only the EMS provider, but also the OEM and the supply base.

Medical OEMs face additional challenges because often product design and processes cannot be changed without a costly requalification process. On the other hand, medical instrumentation OEMs can often benefit more from Lean manufacturing processes than their consumer product counterparts because the basic tenet of small production lots supports both the lower volume frontend and extended lifecycle backend that accompanies the product lifecycle found in many medical instrumentation projects.

In developing realistic expectations it is important to consider several issues which need to be addressed in achieving Lean benefits:

- Product design should support process flexibility and minimize sole-sourced or limited availability components
- The supply base needs to be willing to work to forecasts and stock in lot sizes appropriate to the preferred buffer sizes
- OEM forecasting methodology and acceptance practices should align with the Lean forecasting model
- Production equipment, personnel and processes should be optimized to support rapid changeover
- All stakeholders should be willing to team in corrective action identification and resolution.

DESIGN CONSIDERATIONS
Two potential bottlenecks can be averted in the design phase. First, designs which are not optimized for manufacturability or testability can create production bottlenecks in terms of process flexibility and/or quality. Second, designs which have sole-sourced, unique or limited availability components can create bottlenecks in material flow.

When outsourcing is involved, it is important for the EMS provider to analyze the design early from both a design for manufacturability/testability (DFM/DFT) standpoint and from an approved vendor list (AVL) standpoint. This analysis helps ensure that manufacturing process and procurement flexibility are achieved.

In the EPIC Synchronous Flow Manufacturing (SFM) model, this analysis is done in the project launch phase. The customer data package is analyzed and advanced product quality planning (APQP) techniques are used to identify potential areas for improvement. Improvement focus can include pad spacing, mixed technology conversion, double-sided to single-sided redesign, component orientation, component availability considerations, test coverage, and bare board array design. This process can take time because a customer must often analyze and qualify recommended changes.

Medical OEMs may face significant challenges in this area because the cost of regulatory approval or product re-qualification may limit the cost savings derived from redesign of existing product. Similarly, even when extensive product qualification is not required, lower volume, high mix product may make it difficult to cost justify redesign in a reasonable period of time. In these cases, this focus may be more valuable as a tool used primarily in new product design and the savings from Lean may come incrementally as new products are developed.

TEAMING WITH SUPPLIERS

Material flow can make or break schedule flexibility. Additionally, savings from implementing a Lean process are often driven by reduction in raw material or finished goods inventories, and more efficient transaction processing. The key to developing a strong, yet Lean process is to clearly communicate the expectations and forecast, and spend the bulk of material management time on managing exceptions rather than the basic ordering process. The SFM philosophy does this by incorporating the following principles:

- Strong focus must be placed on developing and qualifying suppliers that embrace the Lean manufacturing principles of short cycle times, flexible batch sizes and high quality
- Suppliers must be responsible for managing production to forecast, yet deliver to "pull signals" vs. requiring firm release dates over an extended lead-time
- Appropriate buffer sizes for current production rates must be established, maintained, and continuously monitored for adequacy
- Material buffers should be maintained in close proximity to the manufacturing facilities to allow frequent release of small batches to the production floor and maximum flexibility in responding to changing demands
- The material pipeline must be proactively and regularly monitored over the medium-to-long-term horizon through bond reports to identify and resolve potential supply disruptions.

In the SFM system, a kanban "pull" system, postponement of commitments and utilization of Electronic Data Interchange (EDI) support this focus. Strategic Suppliers produce to the MRP forecast and ship to EDI release signals. Buffers are established at key locations in the pipeline and are regularly reviewed and revised as market and demand conditions vary. Consignment, in-house stores and Vendor Managed Inventory (VMI) programs are used with strategic suppliers to maintain buffers closest to the point of use.

Pipeline status or "bond" reports are regularly reviewed with supplier teams to ensure buffers and replenishment streams are able to support planned production within a range of variation levels based on past historical demand, current forecasts, customer service lead-time guarantees to their end market, manufacturing lead-times and transit lead-times.

On the factory floor, a two-bin system and color-coded cards identify raw material and work-in-process (WIP) status. Material shortages are easily visible on a walk through of the material area. Between facilities, an "E-Kanban" system allows employees to electronically view status of inbound material shipped from suppliers.

While in theory the system appears to be achievable, the reality is that achieving optimum bin sizing for every purchased part generally takes time and in many cases, negotiation with suppliers and customers. Most customers are interested in obtaining cost reduction and enhancing schedule flexibility, but may balk at significant changes to their AVL. When bulk of suppliers on a new AVL are common with other customers and therefore already supporting kanban min/max planning systems, optimizing material management may not be difficult. The challenge often arises with more complex products whose AVLs include suppliers of custom and/or mechanical components who aren't existing suppliers. These suppliers can be reluctant to change their lot sizes or production frequency to accommodate the SFM system.

A customer's reluctance to switch from suppliers who don't support SFM practices is often driven by very valid rationale. In some cases, the OEM's pricing may be based on annual or quarterly builds of these components. In that situation, a supplier substitution may drive cost increases in their internal production costs. Or, a sole-sourced supplier may feel they have the leverage to set delivery terms. In other cases, regulatory issues may limit a customer's ability to change suppliers of critical components without a costly requalification process. In those situations, the total cost of non-compliance must be analyzed and discussed with the customer and supplier. Sometimes the supply base complies and other times there are some holdouts that may require less than optimum inventory buffers. Noncompliant suppliers may be designed out in subsequent product generations, providing some incentive for eventual compliance. The end result of an optimized kanban strategy is reduced working capital, a high percentage of on-time delivery performance, optimum flexibility in meeting unanticipated demand and high inventory turns. As customers observe these improvements over time, there is typically increasing momentum for selection of suppliers willing to team in the Lean strategy.

CUSTOMER FORECASTING

Kanban systems only work well if correct bin sizing is in place. Achieving that goal requires good visibility in customer demand patterns. When customers have embraced Lean practices, aligning systems is fairly easy. However, when a customer admires the benefits of Lean, but hasn't implemented Lean principles internally, there may be some disconnect in forecasting methodologies.

In SFM, the program manager defines points of order management interface between organizations, identifying peers that are as close to the factory floor and points of consumption as possible. Order replenishment lead time is based on:

- Actual manufacturing lead time based on product specifics (technology, test requirements, coating/ potting requirements, etc)
- Transit lead time from EPIC to customer consumption point
- Desired safety stock at customer location.

Once these issues are addressed, initial finished goods kanban bin sizes are established. The program manager communicates with planners to implement pull signals that reflect those bin sizes. Production is launched and bins are filled, with the highest volume assemblies typically prioritized. The program manager must then monitor bin sizes often to insure that finished goods bins are adequately sized to provide an uninterrupted flow of material at the customer site, while minimizing overall inventory exposure and maximizing inventory turns for their company and the customer. Bins are resized as appropriate with customer approval.

ACHIEVING FLEXIBILITY ON THE FACTORY FLOOR

Many production bottlenecks are driven by production equipment or process inflexibility. In some cases, inefficiency is driven by changeover time. In other cases it may be driven by capacity constraints.

SFM focuses on increasing factory throughput by optimizing and standardizing production. Rather than optimizing the factory floor process-by-process, it takes a large-scale systems approach. This systems approach actually eliminates some changeovers through use of modified equipment and minimizes capacity constraints through standardization and workforce cross-training. Key principles include:

- Detailed process mapping to understand the key processes involved in transforming production inputs to customer-desired outputs
- Identification of constraints in key processes that limited flexibility
- Development of strategies to eliminate constraints which included working with equipment suppliers, material suppliers and employees to develop unique solutions for maximum flexibility
- Standardizing the manufacturing solution through common equipment selections which further improves the flexibility of the assembly process
- Development of simple tools that ensure rapid exchange of real-time information.

To better illustrate, all placement equipment has been standardized to a single manufacturer. Extra feeders have been purchased and raw material is loaded directly onto feeders from point of use stocking locations. These feeders are loaded onto the line as the prior project clears each machine.

In the SFM model, multiple lines of placement equipment feed into a single wave solder and vapor phase system. These systems have been adapted to allow for continuous product change.

The wave solder equipment was modified to enable it to change process parameters “on the fly”, allowing multiple products to run over a single wave solder machine simultaneously with virtually zero changeover time. The initial equipment choice focused on a European manufacturer whose standard equipment supported a fairly broad profile window. The manufacturer modified the machine to allow it to change temperature profiles based on signals received from a bar code scanner. The wave solder is linked to the conveyor system with a bar code reader which transmits data to change process parameters dynamically based on each product’s characteristics. The automated conveyor line changes speed to accommodate temperature profile adjustment time. Multiple lines with a diverse range of products now feed into one wave solder system.

For reflow, the Company selected a vapor phase system which uses an inert Teflon®-based fog. Because the high moisture content atmosphere has superior thermal transfer properties compared to traditional IR or convection systems, the entire board reaches the same temperature at the same time. This eliminates shadowing effects or hot spots, and allows one “profile to fit all”. An additional benefit of this focus on equipment optimization was the vapor phase oven’s ability to support lead-free soldering at conventional reflow temperatures. The Company has been producing SMT assemblies with lead-free solder since Jan. 2004 and can support use of tin/silver, tin/silver/copper or tin/silver/bismuth lead-free alloys.

MONITORING EFFICIENCY

Real-time feedback which is shared appropriately across the team is key to ensuring a robust process.

In the SFM system, production order status is easily visible using simple color-coded card systems held in slots adjacent to each work cell. Operators are empowered to prioritize production sequence for each line based on the color-coded pull signal with red having highest scheduling priority, yellow the next highest and green representing the lowest priority. A factory with a high number of green cards in queue is running optimally. The intranet supports extended visibility into production status at other facilities.

Management performance information is shared via a Plant Operating Review (POR) system which drives the monitoring of approximately 50 metrics company-wide down to the floor level. These metrics are reviewed on a daily/weekly basis by project personnel; monthly by the plant managers and vice president of operations; and quarterly by the senior management team. The same metrics are used in all facilities, which drives comparisons in plant performance.

At supplier level, bond reports are the key feedback mechanism.

With customers, a scorecard system is used. The scorecard format may be determined by the customer or use internal metrics. At a minimum, performance to defined Lean metrics is measured. This measurement include on-time delivery (OTD) and inventory turns.

Periodic review meetings are held with customers to discuss performance to project goals, and discuss any open action items.

The end result is that team members have real-time visibility into key project statistics and also tools and venues for tracking long-term performance and discussing strategic improvement initiatives.

CALIBRATING THE COST SAVINGS

The total cost savings achieved is normally based on the combination of:

- Reduced factory cycle times
- Elimination of frozen schedule windows
- Minimization of both raw material and finished goods inventories.

As mentioned throughout this paper, some cost savings are achievable immediately. However, the bulk of the savings occur once the project and supply base are fully aligned with Lean principles. Implementing Lean principles in product design or redesign processes drives greater savings than is often achievable when no design or AVL modifications are allowed. The end result is the greater the focus on using Lean principles throughout the product realization process, the greater the savings achieved over time.

To illustrate, a large medical device manufacturer selected EPIC as its primary electronics manufacturer in 2005 based on the Company's Lean Operating philosophy. The customer was outgrowing internal floor space and needed suppliers who could minimize inventory on the factory floor and significantly improve flexibility and on-time delivery in printed circuit board assemblies. The business was moved from a larger EMS provider in 2005. It set up first products on kanban and implemented lean operating methodologies during Q4 2005 (First 10 assemblies) and 2006 (balance of 50+ assemblies) A min/max system was established, whereby bin replenishment is triggered upon consumption of the first bin. Bin size was based on order replenishment lead time.

The results after two years of production included:

- Order lead time on printed circuit board assemblies has been reduced from over 3 weeks with previous supplier down to 3-5 days currently
- Inventory turns on printed circuit board assemblies has improved from 4 turns to 26 turns today
- OTD performance has improved from 55% in 2004 to 97% today
- Cost reductions resulting from DFx and Lean initiatives of over $1.1M (11%) for FY 2007.

CONCLUSION

The cost benefits of a properly implemented Lean manufacturing philosophy are significant. However, implementing a robust Lean process takes time and usually involves changes in forecasting practices, product design focus and optimum supply base cooperation.

The magnitude of the result is usually tied to the level of teaming achieved among the EMS provider, supply base and customer. The more systemic the focus, the greater the benefit.

REFERENCES

[1] Baggett, T. "Does Lean Manufacturing Really Save Money," Global SMT & Packaging, January 2007, pp. 38-42.

[2] Lipp, J. and C. Munroe, "Lean + Flexibility = Throughput," Assembly, January 2006, pp. 70-76.