LEAN MANUFACTURING AND REMANUFACTURING IMPLEMENTATION TOOLS

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Abstract

The presentation and paper represent several actual case studies of firms that the Missouri Enterprise has been involved as the facilitator and consultant. These case studies are used to illustrate the steps in implementation of lean manufacturing and remanufacturing, providing actual, very positive results.

Introduction

What if your company could dramatically reduce its production lead time and product costs while increasing its capacity? Most companies make 35 to 75% improvements on production lead time, reduce production costs by 10% to 25 %, and increase capacity by 20 % to 50 %.

What if your company completed customer orders on time? On time deliveries rates increase from 50% to 90% with lead times that are less time than your competitors.

Missouri Enterprise is one of 73 National Institute of Standards and Technology Manufacturing Extension Partnership (NIST MEP) Centers across the country. Each NIST MEP center is a part of a nationwide network of not-for-profit offices in over 400 locations, whose sole purpose is to provide small and medium-sized manufacturers with the help they need to be more competitive. That makes it possible for even the smallest firms to tap into the expertise of knowledgeable manufacturing and business specialists all over the U.S. These are people who have had engineering and technical experience on manufacturing floors and in managing plant operations. Small to medium-sized companies that have implemented lean manufacturing projects improve profitability while utilizing customer value and speed to gain competitive advantages in local, national, and global markets.

In addition, the Missouri Enterprise is supported by the Missouri Department of Economic Development (DED), with a grant that matches the NIST MEP contract funds. The client pays one-third the cost of the project because of the funding provided by NIST MEP and Missouri DED.

Initial Broad Steps

There are a series of steps that need to be followed to assure success:

1. Develop a clear sense of urgency to change.
2. Build the sense of urgency within the Senior Management Team.
3. Create an agreement on the Strategic / Business Plan and Strategic Vision with clear superior performance goals throughout the organization.
4. Communicate the Vision, Lean Implementation Plan, and Superior Performance Goals to the organization.
5. Empower and train the group that will start the implementation.
6. Implement a pilot with a liberal time line to demonstrate the feasibility and success of the plan.
7. Expand the effort to other areas.

For most companies, day-to-day activities steal the needed time to complete the study and gain the depth of knowledge to establish a vision and plan for implementation of lean manufacturing. Those companies that do develop these plans are usually amazed at the opportunities available to them to gain market share, improve products and quality, while reducing delivery times and costs. Having top management participate in business / strategic planning has huge benefits to the organization by developing this vision and plan.

Orientation - Lean Manufacturing and Remanufacturing Workshop

Lean Manufacturing is a technique originally developed in the automotive industry that concentrates on shortening the time between the customer's order and shipment. Lean manufacturing has been applied very successfully in manufacturing and remanufacturing operations, resulting in shorter production lead times, greatly reduced inventories, and significantly enhanced profitability. These techniques also promote improved flexibility, enhanced reliability and substantial cost reductions. Two workshop simulation games have been developed and used to orient participants in lean manufacturing:

- The Buzz Electronics Company game (developed by NIST MEP) uses assembly of circuit boards to illustrate lean manufacturing in a manufacturing environment.
- The Beach Buggy and Little Dump Truck game (developed by the author, borrowing liberally from the NIST MEP game) uses Lego blocks to illustrate disassembly and reassembly in a remanufacturing environment.

These workshops provide a concise introduction to the principles of this powerful tool and include thought provoking class discussion and hands-on simulations. Participants in the games learn the fundamentals of Lean Manufacturing - visual controls, set-up reduction, batch size reduction and others that will facilitate your move from traditional to lean manufacturing. The workshops present a comprehensive introduction to the essential components of lean manufacturing and start the participant's thoughts on how to modify the organization to speed the flow of product along with strategies on how to spot waste for elimination.

The courses are a mix of classroom and live simulation. Participants begin by manufacturing and remanufacturing product in a chaotic, traditional non-lean manufacturing setting. The results of the first simulation provide the basis on which lean principles are applied. For the remainder of the day, participants revisit the manufacturing and remanufacturing environment three additional times immediately following topical discussions and instructions to employ the lean techniques that have been presented. Participants walk away understanding the 8 wastes in manufacturing by following the "train and do" approach. They learn how to apply standardized work, workplace organization, visual controls, set-up reduction, batch size reduction, point of use storage, quality at the source, workforce practices, and pull systems to eliminate the 8 manufacturing wastes. Participants learn to calculate Takt time and balance the production line to produce to customer demand. Participants demonstrate to themselves that they are able to reduce manufacturing and remanufacturing turn-around-time up to 90%, improve on-time shipments up to 90%, reduce work in process up to 90%, improve quality up to 50%, and reduce floor space up to 75%. The outcome of each simulation exercise is product manufacturing and remanufacturing cost being calculated. Participants are amazed at the resulting improvements in net income when they apply lean principles.

Manufacturing companies add value to materials for customers. Manufacturers get paid for adding value. The "Value Stream" is the sequence of value-adding activities that satisfy a customer's specific needs. For example, a piece of wood is processed through various steps in a plant, eventually becoming part of a piece of furniture sold to a customer. Lean Conversions start with the value stream. Reconfiguring the value stream into cells is the first major milestone of a lean implementation. The value stream is rearranged to eliminate any activities that cause delays and that do not add value. In most cases, this requires a completely new layout where work cells are created. Within a cell, there is no work-in-process between value-adding steps. Between cells there is minimal work-in-process and it is managed by simple control system (kanban) that pulls from upstream cells.

Value Stream Mapping

Once a commitment has been garnered from top management, it is time to begin collecting and analyzing data to structure the transformation. The process begins by documenting the flow of material and information of the existing process, called the "current state". This involves following the product from the ordering and delivery of raw material, components, and core (remanufactured product), through to shipping and delivery to the customer. It begins with a single product family, but may be expanded to the entire plant and ultimately multiple plants and across companies as warranted. Major product families are determined by comparing individual product flows through the required processing steps, transportation methods, and standard I.E. times. The current state is typically drawn by hand, illustrating the major outside sources of material and core including order lead times, mode of shipment of materials including transportation frequencies and time, receiving and inventory points (including the warehouse for received material, work-in-process, and finished goods inventory), production processes, flow of work-in-process between production processes, mode of shipment of finished product to the customers including transportation frequencies and time, and major customers or distribution system. In addition current information flows are documented as electronic or manual and control systems, such as manufacturing resource planning / enterprise resource planning / supply chain management systems. Illustrations of a "current state" and a "future state" are shown at Figures 1 and 2, respectively

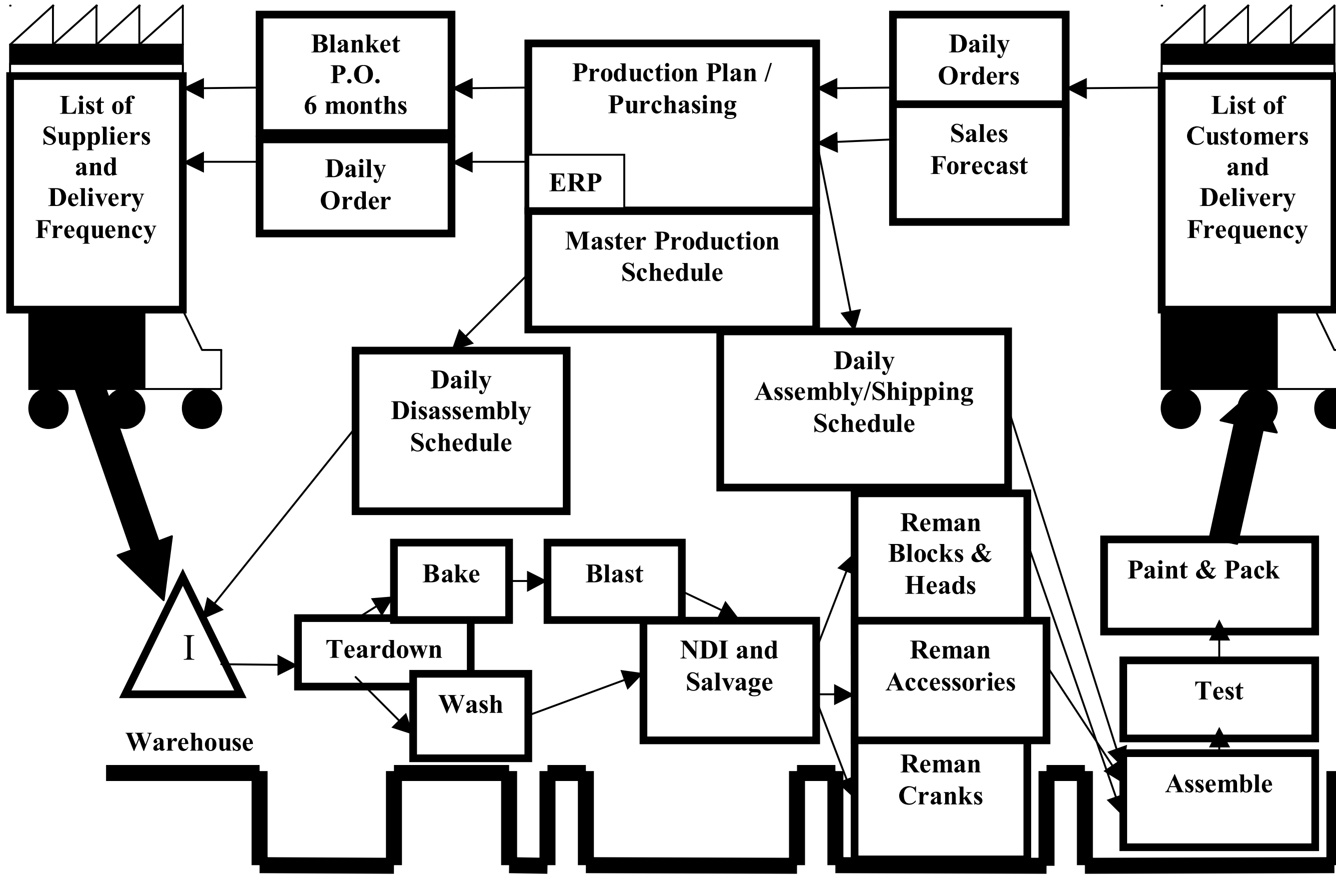

Figure 1. Example of "Current State" Map

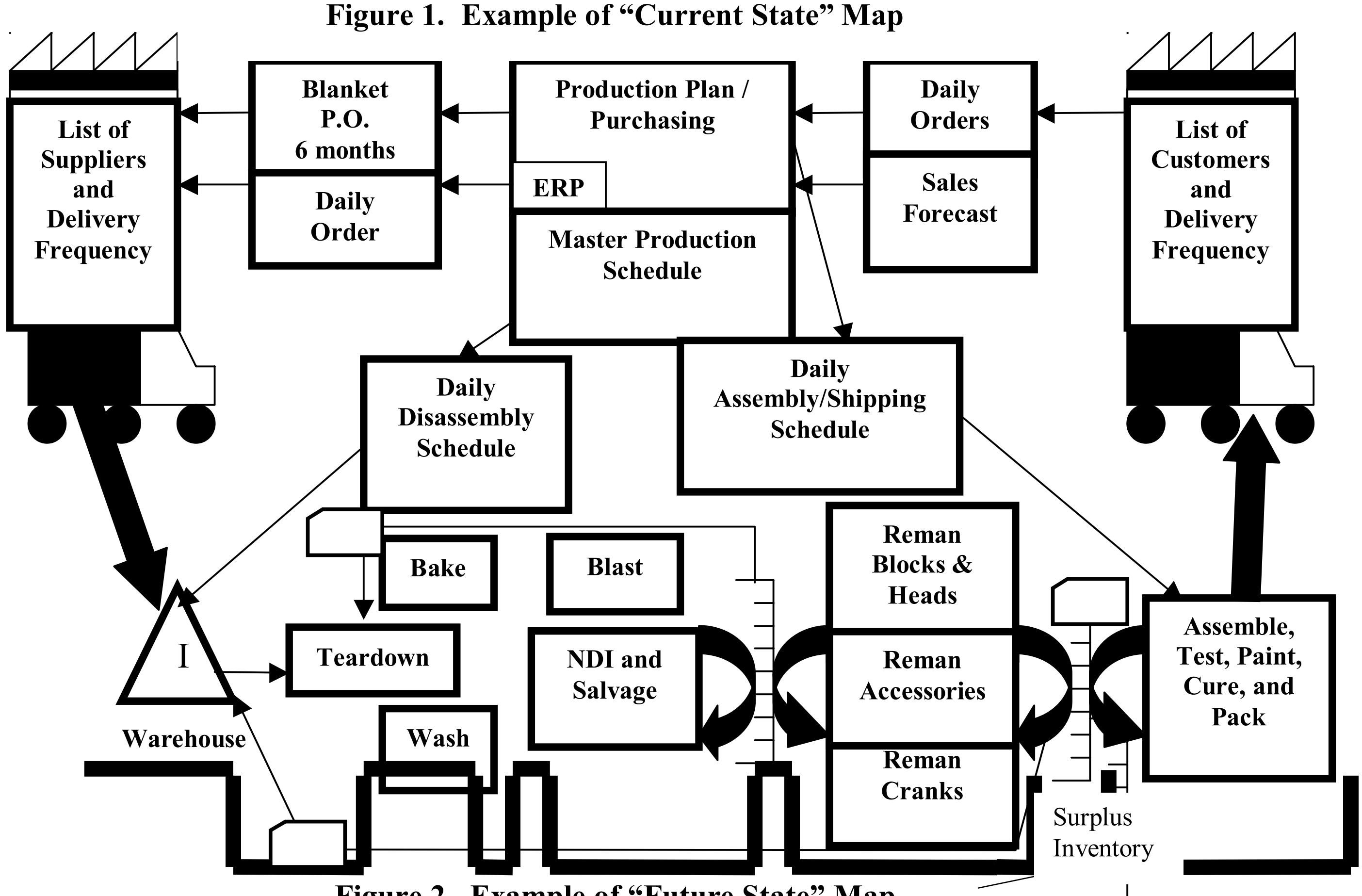

Figure 2. Example of "Future State" Map

The future state map is obtained by thinking about only producing what the next process needs and only when it needs it with the goal of moving product faster through the production system by eliminating wastes. These wastes are:

- Overproduction
  - Making <u>more</u> than is required by the next process
  - Making <u>earlier</u> than is required by the next process
  - Making <u>faster</u> than is required by the next process
- Inventory - Causes of excess Inventory
  - Protects the company from inefficiencies and unexpected problems.
  - Product complexity
  - Unleveled scheduling
  - Poor Market forecast
  - Unbalanced workload
  - Unreliable shipments by suppliers
  - Misunderstood communications
  - Reward system
  - Inventory of “Excess” Parts from Disassembly
  - Poor Forecasting of Recovery Rates
- Defects - Causes of Defects
  - Weak process control
  - Poor quality
  - Unbalanced inventory level
  - Deficient planned maintenance
  - Inadequate education/training/work instructions
  - Product design
  - Customer needs not understood
- Overprocessing - Causes of Processing Waste
  - Product changes without process changes
  - Just-in-case logic
  - True customer requirements undefined
  - Over processing to accommodate downtime
  - Lack of communications
  - Redundant approvals
  - Extra copies/excessive information
  - Extra copies/excessive information
- Waiting - Causes of Waiting Waste
  - Unbalanced work load
  - Unplanned maintenance
  - Long process set-up times
  - Misuses of automation
  - Upstream quality problems
  - Unleveled scheduling
  - No Structured Routings
  - Repairs not based upon material condition
  - Inspection/rework/repair
- Underutilized People - Causes of people waste
  - Old guard thinking, politics, the business culture
  - Poor hiring practices
  - Low or no investment in training
  - Low pay, high turn over strategy
  - Early Vs. Late Repair Decisions
  - Cannibalization/Backrob
- Motion - Any movement of people or machines that does not add value to the product or service. Causes of Motion Waste
  - Poor people/machine effectiveness
  - Inconsistent work methods

- ➢ Unfavorable facility or cell layout
- ➢ Poor workplace organization and housekeeping
- ➢ Extra “busy” movements while waiting
- ➢ Expediting

♦ Transportation - Causes of Transportation Waste
- ➢ Poor plant layout
- ➢ Poor understanding of the process flow for production
- ➢ Large batch sizes, long lead times, and large storage areas

The first step is to group products into families of similar production processes. An example here is shown in Figure 3 for the Dump Truck and the Beach Buggy from the Lean Remanufacturing Workshop.

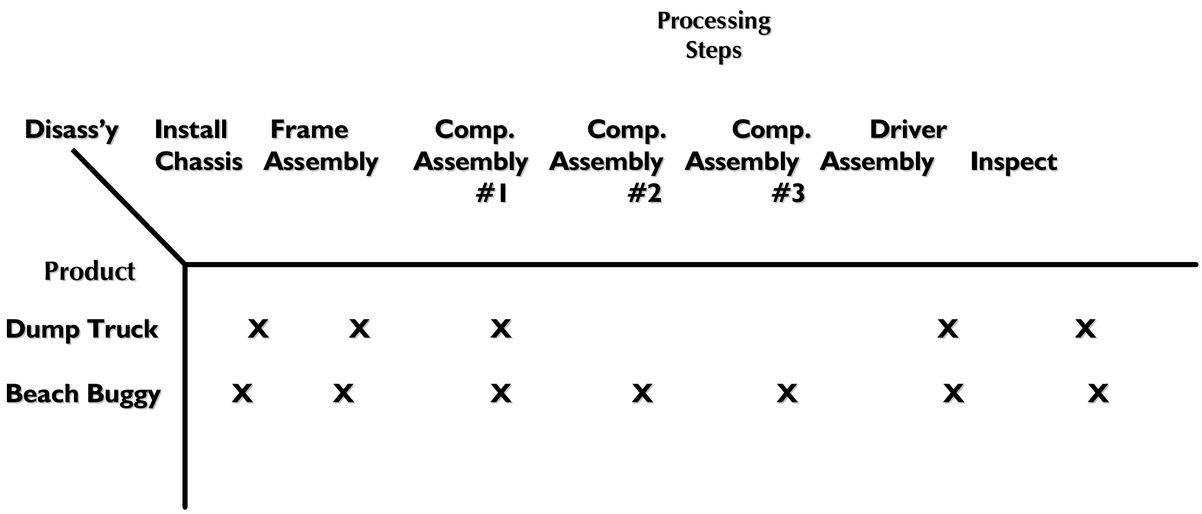

Figure 3. Products with similar processing requirements are grouped into product families

The second step is to establish the Takt time. The Takt time is the demand rate and consequently the time between completion of each product off of the production line. It is first necessary to find the available capacity of the production line:

Available Capacity = Time Available x PFS x
Utilization

Where:

Time Available = Hours / Time Period x Number of Employees

Personal, Fatigue, and Safety (PFS) = Standard Hours Produced / Hours Worked

Utilization = (Hours Available - Downtime) / Hours Available

An example from the Lean Remanufacturing Workshop are shown below:
Time Available = 1 shift x 1 employees x 1200 seconds/employee/shift = 1200 sec.
PFS = 1140 seconds / 1200 seconds = 0.95
Utilization = (1200 seconds - 20 seconds - 40 seconds setup)/ 1200 hours = 0.95
Available Capacity = 1200 seconds x 0.95 x 0.95 = 1083 seconds
Thus as the Takt time is equal to the demand rate,

$$\text{Takt time} = \frac{\text{Available Capacity}}{\text{Number of Units Sold}}$$

And for our example

$$\text{Takt time} = \frac{\text{1083 seconds}}{\text{115 Units}} = 9.4\ \frac{\text{Seconds}}{\text{Product}}$$

with the seconds representing engineered standards.

The third step is to review the work sequence by:

- Observing the sequence of tasks each worker performs,
- Break operations into observable elements,
- Identify value added versus non value added elements and minimize or eliminate non value added operations, and
- Study machine capacity, cycle times and change over times

In IE words, conduct methods and standards studies.

The fourth step is to balance the line using the calculated Takt times found in step two.

Step five is to design and construct the cell to:

- Implement a "U" shaped line to assure one way flow and maximize visibility,
- Provide a flexible layout to account for all members of the production family,
- Decrease distance between operations and integrating process operations wherever possible for simplicity, minimizing both transportation and production lot sizes, integrate in point of use storage next to each assembly operation
- Minimize material handling by concentrating on value added motion
- Establish replenishment procedures for point of use storage using the A-B-C rule
- Assure the personnel understand their role and are cross trained to use their skills at a variety of tasks and work stations
- Provide visibility to allow operator decisions on problem solving, moving to where work needs to be performed, and focus management attention on production disruptions.

Implementation of Subsequent Improvement Cycles

The first target of opportunity is to deploy lean manufacturing and the value stream mapping process to another product family. The same process illustrated above would be used for that family and subsequent families until approximately 80 per cent by sales volume are covered by lean manufacturing. The remaining 20 per cent should be evaluated to see if there are sufficient profit margins to retain those products, and if there is how they might best be integrated into the facility. Because of the low volumes, these products will not pull through the production line, but must still be pushed and intensely managed to assure meeting promised delivery dates.

The philosophy of lean manufacturing is that of continuous improvement. Once the initial lean manufacturing implementation has been completed, the future state value stream map developed for the first cycle becomes the current state map. The new current state map is then used to identify new lean projects and develop subsequent implementation plans.

Kaizen blitzes or accelerated improvement cycles for a specific support process or portion of the production line are used for rapid improvement in a limited area. Both Kaizen blitzes and accelerated improvement cycles use the same set of lean manufacturing tools illustrated previously with the priority for the project set based upon anticipated impact on production lead time, quality, profitability, and/or variability reduction. Kaizen blitzes and accelerated improvement cycles are carried out by dedicated teams including those working in the target areas as well as those supporting the affected area. Consultants or internal champions provide leadership and facilitation. The project is typically started and completed within a week.

Another important area is that of performance measurement, audit and review. Baseline metrics, such as production lead time, inventory turns, level of work-in-process and finished goods inventories, and other local performance indicators are gather on a regular basis, typically daily or weekly, and charted for trends and out-of-control conditions. In addition strategic requirements such as customer satisfaction levels, promised to actual deliveries, worker and senior management support, etc. should also be collected, tracked, and analyzed to assess progress towards meeting strategic objectives. The full cycle is illustrated in Figure 4.

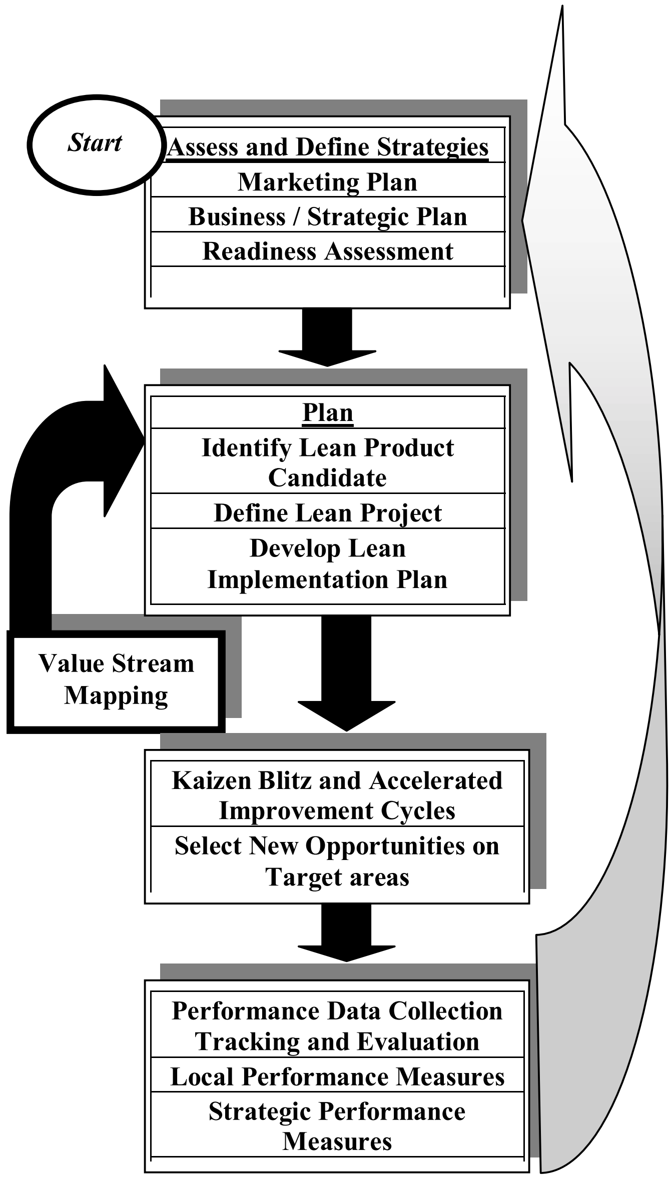

Figure 4. The Lean Implementation Cycle

Subsequent Improvement Tools

As the "future state" value stream map is developed, several Kaizen events are identified as required if the organization is to achieve the "future state" performance levels. The Kaizen events normally call for the following tools:

- Kanban design,
- Point of use design and improved vendor support,
- 5 S,
- The 6^{th} S (Safety and Ergonomics),
- Visual Management,

- Total Productive Maintenance (TPM),
- Set Up Reduction, and
- Quality improvements through Statistical Process Control (SPC), 6 Sigma, and Design of Experiments / Taguchi Methods.

Sample Courses

5 S

The purpose of 5 S is to assure that everything has a place or is accessed and everything is in its place. 5S stands for:

- Sieri – Sort (Housekeeping),
- Seiton – Set in order (Workplace Organization),
- Seison – Shine (Cleanup),
- Seiketsu – Standardize (Maintain Cleanliness and Order), and
- Shitsuke – Sustain (Discipline).

The author has developed a two day 5 S Workshop that has "hands on" in the shop that result in the selected shop:

- Being 80 % along the way to being 5 S,
- Having a "punchlist" of action items that are too long in duration to be accomplished by the team but are documented, and
- An assigned list of personnel with assigned responsibilities to maintain and continuously improve the shop as 5 S.

The "in plant" 5 S Workshop has the eight to ten participants break into two teams to cover two shops. Each team elects a team leader, recorder, gatekeeper, and timer. Each team then performs a set of six exercises in their assigned shop to:

- List examples of disorderliness and lack of cleaning that make the work less efficient, safe and pleasant (10 minutes);
- Identify and tag all unneeded and excess items within the assigned shop, audit the results and return with a summary of actions (3 hours);
- Develop a new layout of the shop considering material flow, placement of tools and fixtures and location indicators with before and after pictures and audits of the results (3 hours);
- Identify and develop a plan for shop cleaning and equipment inspection maintenance, take pictures before and after accomplishing the cleaning, and audit the results (2 hours);
- Summarize hoe the plant should standardize the 5 S program and audit the results (15 minutes); and
- Assign individuals by name that support or are within the shop to be responsible for all 5 S actions (cleaning, periodic maintenance, sorting and tagging excess material in the shop area, etc.), audit results and summarize actions taken (30 minutes).

The 5 S program is also an excellent "ice-breaker" for organizations that have entrenched resistance to change. The 5 S program provides a "kick start" with such substantial positive benefits to both the employees and employer that the 5 S implementation more than pays for itself while creating a positive climate for further change.

The 6th S (Safety and Ergonomics)

Building on the 5 S Workshop described above, the 6th S Workshop is also a two-day in plant series of "hands on" exercises. The 6th S Workshop has the eight to ten participants break into two teams to cover two shops. Each team elects a team leader, recorder, gatekeeper, and timer. Each team then performs a set of six exercises in their assigned shop to:

- Find and list examples of slip, trip, fall, struck by, pinch and nip hazards, and examples of lack of cleanliness and orderliness. Identify unsafe acts and conditions within the selected shop. (20 minutes).
- Develop a strategy for targeting unguarded machinery and equipment, identify and tag all unsafe items within the shop, and return with a summary of actions and "before' and "after" pictures taken (30 minutes).
- Develop a strategy for personnel protection equipment (PPE), identify where PPE should be worn, and tag all areas within the shop where PPE should be worn, and return with a summary of actions and "before' and "after" pictures taken (30 minutes).
- Develop a strategy for ergonomics (workspace, lifting limits, repetitive stress situations, etc.); identify work areas and workspace, lifting requirements and repetition rates; and other work stresses and tag all areas within the shop where the limits on stresses are reached or exceeded. Return with a summary of actions and "before' and "after" pictures taken (1 hour).

- Discuss how to standardize the 6th S program and the “yellow” tag system, develop targets and methods of cleaning, identify and develop a plan for shop audits and equipment inspections and maintenance, and return with a summary of actions and “before’ and “after” pictures taken (1 hour).
- Assign individuals by name that support or are within the shop to be responsible for all 6th S actions (cleaning, safety and ergonomic audits), audit results and summarize actions taken (30 minutes).

The 6th S Workshop is an ideal follow-on to the 5 S Workshop as it takes advantage of the cleanliness and orderliness of the shop just after 5 S, reinforces the importance of 5 S, and allows the 6th S to be better implemented.

Visual Management

The visual management workshop is still under development. The purpose of this Workshop is to allow the participants to better understand the visual components and importance of visual cues to the lean workplace. The team members attending the “in plant” workshop are assigned to develop and implement the visual workplace within the assigned production area. They come to understand the crucial role the visual workplace plays in meeting hourly/daily production goals, eliminating waste, accelerating process flow thus reducing production lead time, and quickly identifying problems for the team to solve quickly and permanently. The participants see that a visual workplace is one that can minimize defects, delays, distrust, and indifference. Through a series of exercises, the team members should;

- Develop the blueprint for a visual workplace,
- Identify where mistake-proofing (poka yoke) would be beneficial,
- Identify visual controls required to manage the production system with visual triggers when conditions are nearing or are out of control,
- Obtain employee involvement in the visual systems display,
- Use 5 S and the 6th S as part of the visual workplace,
- Select visual devices and design the Andon board to assist in tracking and controlling the production and support operations.

When the workshop has been completed, the selected production area should have simple visual systems that provide the necessary information to enable the entire workforce to accurately gauge minute-by-minute the “health” of the production flow through accurate, complete, and timely information.

Total Productive Maintenance (TPM)

The goal of total productive maintenance (TPM) is to:

- Build a robust equipment and equipment maintenance infrastructure to maximize manufacturing efficiency;
- Support zero waste of all types;
- Involve all departments to achieve a culture where operators develop ownership of their equipment; and
- Include maintenance, engineering, purchasing, production scheduling and management as full partners with production to assure that equipment operates properly everyday.

An “in-plant” two-day course has been developed to begin the transformation of the organization to total productive maintenance (TPM) selecting the company’s bottleneck equipment as the place to begin. The course is made up of eight “hands-on” exercises. Breaking into teams of 4-5 members, the teams perform the following exercises:

- Pinpoint a bottleneck machine in an area of production and perform an analysis of the root cause of the bottleneck (30 minutes);
- The team decides what two problems they would want to tackle and performs a 5 Whys analysis and draws a cause and effect diagram (1 hour);
- Calculate the overall equipment effectiveness (OEE) measure for the equipment selected for the analysis (1 hour);
- Create a preventive maintenance plan including a matrix of daily, weekly, monthly, quarterly and annual maintenance tasks to be performed and a simple chart where the maintenance is to be performed on the selected equipment using equipment maintenance manuals, engineering specifications and drawings (1 hour);
- Create a predictive maintenance plan for the same piece of equipment by pinpointing the failure modes and what can go wrong and the specify the necessary monitoring required to detect an out-of-control condition (1 hour);
- Calculate the equipment’s quality process capability, C_{pk}, analyze the major sources of defects, and conduct a root cause analysis of the major defects (1 hour);
- Analyze the lead times for spare parts and develop an approval threshold for small purchases by the group leader (30 minutes); and

- Make a list of safety problems with the specific piece of equipment under study, see if guards are in place, trip and bump hazards have been eliminated, the proper personnel protective gear is being worn properly, and the workspace is uncluttered with everything having a designated space and is in its space (1 hour).

The "in plant" TPM course also addresses the 12 steps to full TPM implementation.

Quality Improvements through Statistical Process Control (SPC), 6 Sigma, and Design of Experiments / Taguchi Methods

A series of four courses are available on Statistical Process Control (parts 1 and 2), Design of Experiments, and Taguchi Methods that provide a deep understanding of the subjects for both shop personnel and engineers / managers.

Case Studies

USA Vacuum

USA Vacuum is a manufacturer of residential and commercial vacuum cleaners for The Tacony Corp, in St. Louis, Missouri. The majority of their production is made under their flagship brands of Simplicity and Riccar. Prior to 1997, the Tacony Corp purchased Simplicity and Riccar vacuum cleaners from Zeng Hsing Industrial Co., Ltd in Taiwan. A joint venture with the Taiwanese manufacturer in 1997 led to the start of the USA Vacuum production facility in St. James, Missouri. The plant currently employs approximately 60 people from the St. James and Rolla, Missouri area. After USA started preliminary production in their new facility, they decided to make a variety of improvements to their operation.

Initially, USA Vacuum was struggling to produce vacuum cleaners in sufficient quantity to support their short and long-term sales forecasts. Consequently, their reserve finished goods stock was dwindling rapidly. Daily issues included process variations, component quality issues, and supplier delivery problems. Also, inventory was disorganized with inaccurate quantities. USA's primary need was a method to control their assembly processes and balance the assembly line workstations. Their secondary need was to redesign the assembly line to allow for balanced Just-in-Time production of subassemblies and finished goods.

The company contacted Missouri Enterprise for help in an overall operation review (CITE Survey) and a warehouse improvement project. Additionally, the Center provided technical assistance in the implementation of lean manufacturing in their assembly processes. The initial activity with the project involved identification and time study of all operations involved in the vacuum cleaner assembly. With this information, the production lines were broken down into workstations with assigned operator activity for each station, bringing balance and consistency to the assembly process. The production staff was organized into improvement teams that focused on process and workstation design improvements. Utilizing the information gathered during team meetings, two new production lines were designed with connected subassembly cells and Kanban materials replenishment for the workstations. Support areas, including the warehouse and receiving department were also redesigned to support the new production lines. Over a two-month period, Missouri Enterprise and USA Vacuum personnel implemented the new designs to the physical plant.

The bottom line result to the project is that USA Vacuum is now able to meet their customer's demand for vacuum cleaners. The line balances create an atmosphere of smooth, predictable production. Additionally, they have a system in place to control all of their production activity and implement changes in a controlled manner. The use of instructional process graphics assist operator training, and limit operator error due to model changeover. The Kanban replenishment system for workstation materials has reduced model changeover time, as all models' materials are present at the workstation. The reusable Kanban containers have greatly reduced the assembly line housekeeping issues by reducing the presence of cardboard boxes. Subassemblies are produced on an 'as needed' basis, reducing WIP and scheduling headaches. As a result of these changes, USA Vacuum believes they will save $1.5 million in inventory costs and $100,000 in labor costs.

USA Vacuum Testimonial

"Tacony Corporation had been a distribution company for 50 years, but had no manufacturing experience. We quickly learned that manufacturing was very different and VERY challenging. Missouri Enterprise identified areas when we really needed help during the CITE Survey and then provided us with a proposal with firm 'deliverables', i.e., production levels that we needed but doubted could be obtained. By providing a team of knowledgeable, hands on engineers, they designed and implemented a system that gave us the ability to consistently meet the deliverable quantities and to lower our costs. We will definitely continue to rely on them for future projects." Bill Hinderer, Executive Vice President, Tacony Corporation

Engines Plus, Inc.

Engines Plus, Inc. (EPI) is headquartered in Springfield, MO. EPI was founded in 1987, is a subsidiary of Springfield ReManufacturing Corporation (SRC). EPI was the first of 22 subsidiaries created by SRC. SRC and its subsidiaries pride themselves as being 100% employee owned. EPI was created to remanufacture the IH 466 diesel engine oil coolers for then J.I. Case and Navistar. In late 1989, EPI began packaging stationary irrigation power units for J.I. Case. This diversification into power systems packaging has led EPI to specialize in the design, material procurement, materials handling and packaging of stationary power systems for other OEMs and their some 500 Distributors. These products target a large range of irrigation and industrial applications.

EPI has been able to position itself as one of the largest independent power systems packagers in the industry. EPI is not affiliated with any OEM as a distributor and therefore can provide unbiased services. EPI is experienced in assisting OEMs and their distributors in finding solutions to current problems and developing a successful long-term program. EPI, Inc. takes pride in being a least cost producer in the industry, while maintaining quality and delivery standards. EPI services range from simply being a "silent manufacturing partner" to complete program and product development with assistance in Marketing and Training.

Currently EPI is housed in an 88,000 square feet building with two other SRC subsidiaries; SRC-Transcorp, Inc. and K & K manufacturing. Total floor space used for the EPI product line is 35,000 square feet. EPI is a manufacturer of new irrigation power units for Case Corporation, Detroit Diesel, Massey Ferguson and AGCO. Seven model sizes are produced for the Case Corporation, five model sizes for Detroit Diesel, and six models make up the Massey and AGCO product group. EPI works with their customers to design irrigation power units to meet their needs. In addition to the stationary power unit product line, EPI also remanufactures engine oil coolers for the SRC Heavy Duty division.

Engine Plus expects sales growth to be substantial due to increased customer demand, market share growth, and entering into new markets. The current production layout and assembly process limits production to approximately 7 units per day. Production is queued in batches throughout the manufacturing process. EPI management had identified that single piece flow could aide in increasing units produced per day as well as adding flexibility in mixing products throughout the assembly process. It was imperative that capacity be increased to meet the expected sales growth.

EPI desired to have a system that will provide a production output equal to the customer demand. Before implementing lean, when customer demand is greater than production output, customers were not served and sales were lost. When production output was greater than customer demand, waste was generated in the form of added material, labor and overhead costs. Lean Manufacturing provided a comprehensive group of system measures to link manual and machine operations into the most efficient combination that will maximize Value Added content, while minimizing waste.

Missouri Enterprise provided a general layout of the complete manufacturing facility at EPI. Missouri Enterprise worked with EPI Manufacturing Engineers to implement lean manufacturing at EPI. The project provided the following deliverables:

Production area

- Layout of all equipment.
- Flow of the product through the plant.
- Preliminary balance of the production line (by product).
- Re-alignment of work activities (by product).
- Number of Kanban spaces needed. (particularly at bottle necks)
- Operating instructions for the correct operation of the Kanban.
- A layout will be provided to EPI on AutoCAD Revision 14.

Warehouse

- Location of parts provided by group.
- Point of use for each part. (e.g. line stock versus warehoused parts)
- Parts flow from warehouse to production line.
- Method of delivery from warehouse to production areas.
- Inventory levels recommended for line stock and warehoused parts.

Other

- Equipment (if any) and/or tooling purchases. (E.g. Material handling equipment, fixturing air tools, etc.) recommended.

Missouri Enterprise provided a 4-hour class on the concepts of Lean Manufacturing. The class focused on the EPI Manufacturing processes and products (Power Units). The class outline consisted of:

- Background
- Kanban exercise for participants
- Definition and concepts of lean manufacturing
- Concept of Just-in-Time (JIT)
- Use of Kanbans to synchronize production flow
- Use of Andon for production status and control
- Point of Sale Supermarkets
- Use of Qualified Suppliers and point of sale stocking of parts
- Value of minimum work-in-process and parts inventory
- Use of Kaizen Blitz Team implementation
- Questions and Answers

Missouri Enterprise received the following support items from EPI:

- A current scaled AutoCAD drawing specifying equipment layout. (preferably on disk)
- Copy of Pick Tickets specific for each area and each Model produced.
- Bills of Material for each of the 18 models produced.
- Estimated part lead times of key component parts.
- Operation times for the non-Case product. (A copy has already been supplied for the Case products)
- An illustrated parts breakdown of the assemblies.
- Current warehouse identification code system.
- Current work instructions for material movement from warehouse to production.
- Forecast of expected customer demand.
- Other information as requested during the implementation phases.

EPI was able to triple production capacity while maintaining the same number of production personnel, utilizing 25 percent less floor space with significantly reduced inventories, and reducing production lead time for a 8-9 days to 1 ½ days. As a result of these changes, EPI estimated that they will be able to increase sales by $1.0 million, reduce inventory by $ 120,000, save $ 50,000 in labor costs, and will invest $ 65,000 in production equipment (mainly for the overhead power conveyor and modern paint booth).

Regen Technologies, Inc.

Regen Technologies is a joint partnership between Springfield Remanfacturing Corporation and John Deere Corporation, each company owns 50 percent of the business. The facility is located in the northeast industrial park of Springfield Missouri. The primary product produced at this facility is diesel engines specific to the agricultural market. Recently diesel engines for the John Deere construction market has been added to the product offering. In addition, 6.5 liter engines for General Motors is also being remanufactured at this facility to help offset a current slump in sales for John Deere engines. Once production of Deere engines rebound, the General Motors engines will be moved to another SRC facility.

A major competitive strength for this corporation is the fact that out of the 97 employees, most have several years experience working for other SRC subsidiaries in various hourly and managerial capacities.

Regen Technologies recognizes the value and importance of continuous improvement in quality and productivity. They recognize the fact that cost and quality have become minimum requirements to compete in the market place. In order to increase or maintain their profits, and to achieve a competitive edge, they must reduce costs, improve quality, and improve on-time and manufacturing-lead-time performances.

Regen Technologies L.L.C. has requested that Missouri Enterprise assist their company by facilitating the implementation of Lean Manufacturing concepts throughout the facility. Listed are key steps that represent a rough sequence of events for a successful execution of this project:

1. Missouri Enterprise facilitated meetings to develop a current process map of the existing flow for manufacturing within the plant. This included the current MRP-II scheduling system as well as product flow with verbal and written communication prompts. The process map is a flow chart that represents all of the actions and decisions that take place in the current production control and scheduling system throughout the plant.
2. After the “current state” map was constructed, meetings with key Regen personnel were conducted to develop a proposed “future state” system process map. This “future state” map was the result of a consensus decision on an improved, efficient system on which to base a future layout. These meetings included discussions on topics such

as point of use storage, quality at the source, kanbans, visual pull signals, batch size reduction, layout, standardized work, quick changeover, one piece flow, Takt time, teamwork, housekeeping and other related lean attributes.

3. Once a full understanding of the current and proposed production system is obtained, a proposed layout to implement those changes was constructed. Missouri Enterprise facilitated these changes with Regen personnel.
4. During the course of this project Missouri Enterprise provided consultation and direction to assist Regen implement lean concepts into there manufacturing environment.

This project has been completed with substantial changes taking place within the ReGen operation. As a result of value stream mapping the implementation was accomplished with minimum disruption to the operations. Value stream mapping greatly accelerated the lean manufacturing implementation by the Regen/ Missouri Enterprise team.

Lean implementation design was focused around assisting the facility meet its strategic goal of "being able to ship the proper remanufactured engine to the dealer or customer within 8 hours 95 percent of the time. Before implementation, Regen was able to ship from finished goods inventory an engine within 8 in the low 60 percentile. As implementation proceeded, the percentage went to the low to high 80's and most shipments were being made from work-in-process. Finished goods inventory dropped from $ 5 million to $ 3 million as the operating policies were changed, and are continuing to fall. The value of work-in-process has made similar reductions.

Conclusion

The benefits of implementing lean manufacturing are substantial while the cost of not being able to meet customers' expectations; especially short delivery cycles, are significant. The benefits reported in the case studies are typical. In at least one case, if the improvements had not been made, the company would have ceased to exist. In the other cases market share and market share growth would have been sacrificed in the name of "we have always done it this way and it has worked in the past". The global economy is changing and becoming much more competitive. Companies must focus on customer requirements, these customers being part of the "right now" culture.

Biographical Sketch

John S. W. Fargher, Jr., is presently the Director of Missouri Enterprise, assisting small and medium manufacturers throughout the State of Missouri become more competitive. He is a Fellow of the Institute of Industrial Engineers, past president of the Aerospace and Defense Society, and past chairman of the IIE's Special Productivity Projects Committee (SPPC). He is currently the past Chairman of the APICS REMAN SIG, having developed courses and the body of knowledge in REMAN. He has 30 + years experience as an engineer and manager of manufacturing and remanufacturing facilities throughout the world. He holds a Ph. D. in Industrial Engineering from North Carolina State University, where his dissertation was on the application of MRP-II, shop floor control, Just-in-Time, Theory of Constraints, and Activity-Based Cost Accounting in Remanufacturing.