April 11, 2012

My experiences with Lean Manufacturing began at Texas Instruments, Sherman which was a highly efficient semiconductor manufacturing division building the highest volume bipolar integrated circuit components. The person in charge of manufacturing was quite astute in his control of inventory and production flow. His factory ran the shortest manufacturing times of all the TI factories. He kept a highly disciplined production line. One of his statements has stuck with me over the years. This is a principle I have implemented. He said, “Do not put a shelf in my manufacturing area. If you do someone will put my production in it and it will slow down or be misplaced.” This concept may seem simplistic; however, it is profound in it’s implications. Cycle time is defined by one word, “inventory.”

Consider the principles of lean management:

- Specify value from customer point of view as per product family
- Identify all the steps in the value stream for each product family and eliminate whenever, wherever possible those steps that do not create value
- Make the value-creating steps occur in tight sequence; so the product will flow smoothly towards the customer.
- As flow is introduced, let customers **pull** value from the next upstream activity.
- As value is specified, value streams are identified, wasted steps are removed, flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste.

In Sherman workflow inventory or “Work-In-Progress” was on the equipment or be transported to the next work station.

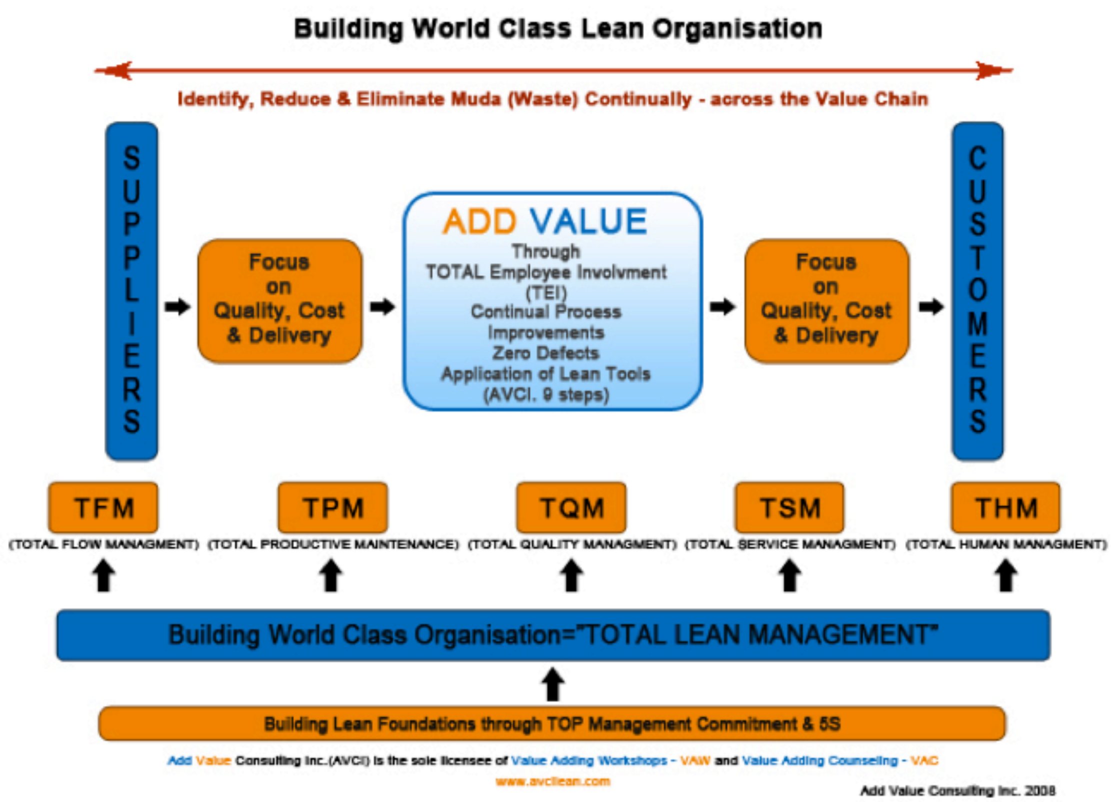
Lean or Toyota 5s Training

1. 5s Seiri (Sort) identification of the most successful physical Organization of the workplace.
2. 5s Seiton (Set) steps by which the optimum organization identified in the first pillar are put into place. The standard translation is Orderliness so that to everyone it is clear what, when, where things are and include poka-yoke or error-proofing.
3. 5s Seiso (Shine) Cleanliness but again the initial S can be retained in Shine, or Sweeping. The principle here is that more productive in clean, bright environments. Everything is clean: it is immediately ready for use. In other words, to minimize the downtime needed to keep the facilities clean and orderly reducing confusion.
4. 5s Seiketsu (Standardization) is the means by which we maintain the first three pillars. The danger in any improvement activity is that once the focus is removed and another 'hot button' grabs management attention, things go back to the way they were before. Standarization is the set of techniques adopted to prevent this happening. In Western Culture there is a tendency to have people judge importance and work from habit. To remedy this

tendency basically involves setting a schedule by which all the elements are revisited on a regular basis - usually referred to as the '5S Job Cycle.'

5. 5. 5s Shitsuke (Sustain) The final stage is that of Discipline. Discipline is not a 4-letter word. Sustain or Self-discipline is one of the major differences is Western versus Eastern manufacturing. This becam clear to me when I visited TI Japan in an effort to determine why TI Japan was performing better than the TI factories in the USA. There is a fundamental difference between Standardization and Sustain. The fourth pillar is the introduction of a formal, rigorous review program to ensure that the benefits of the approach are maintained. Sustain is the rigorous adherence to the standardization as well as the previous pillars of Lean.

Lean is not just manufacturing processes. It is Business practices as well. In studying Total Cycle Time all processes and systems are examined and the principles of "Lean" applied so that only optimized total value steps are kept. This applies to the process of receiving and acknowledging a RFQ as well as the stamping of a piece of sheet metal. See the graphic below that illustrated the structure and principles of a "Lean" Organization across many functions.



In my visit to Japan the "5S" was not a banner on the wall; it was inherent in the way people worked. To apply these principles to the TI factories in the USA the approach had to be different. Our culture was different. To execute this we created a Operator Enhancement Program which was a integrated training, certification, incentive program focused on Quality and the elimination of redundant steps, cross training, increasing overall understanding rather than single process step focus. The impact of these efforts dramatically impacted productivity, reduction of waste and scrap and employee moral. It became a model for all of TI.

In the start-up of HMOS-3 factory, I applied the same principles and extended these to a work-cell based manufacturing flow. HMOS-3 was a highly automated wafer fabrication facility, but had equipment reliability issues associated with a single point of failure shutting down the entire work flow. Working with my colleagues in Japan, we reconfigured the line to improve overall reliability and used the principles of "Set" as well as the other pillars of "lean" to optimize the production flow.

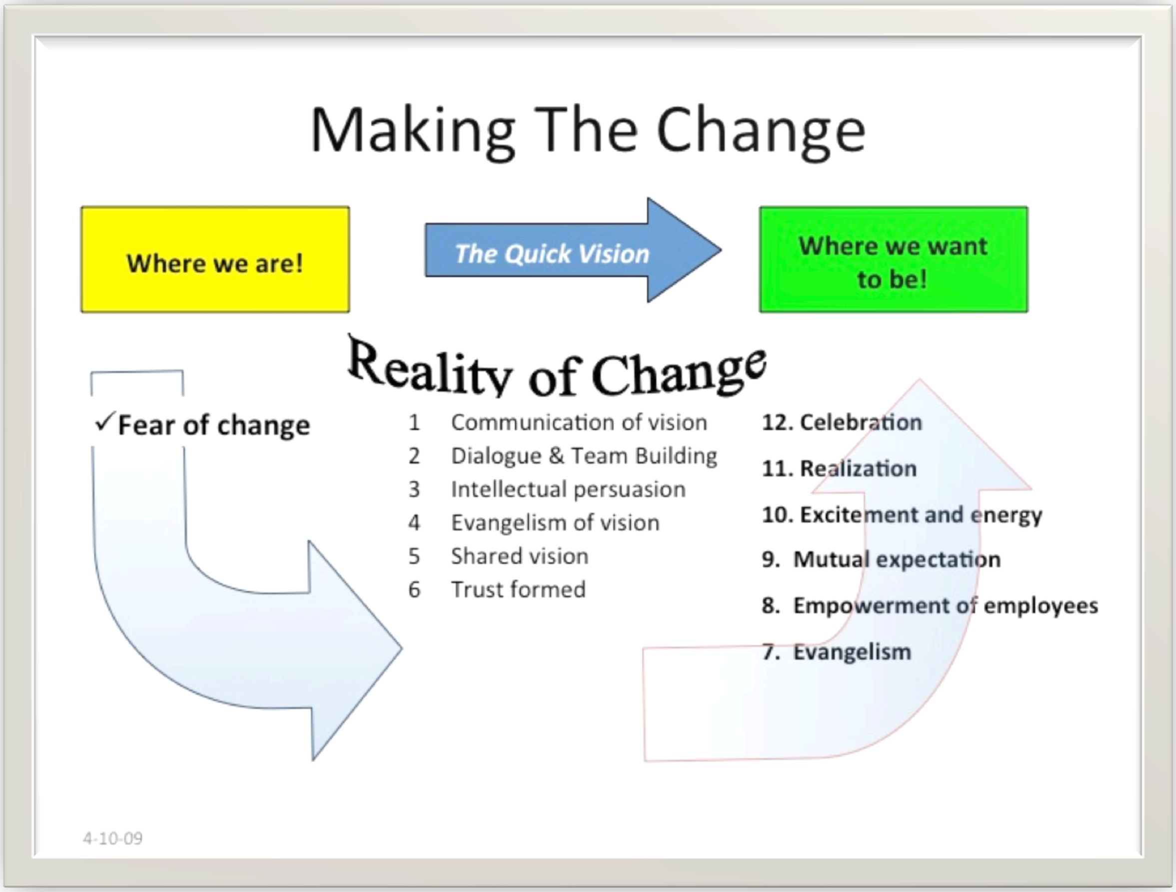
Then the VLSI Technology, Inc. facility in California was being created and the factory organization was chaotic. My Team and I changed the layout and workflow to meet the unique requirements of single lot processing in critical cycletimes. Again the Sort-Set-Shine-Standardization-Sustain principles were at work. Our factory grew so rapidly I was selected to build another factory. Given the vulnerability of the company I opted to grow a subcontracted manufacturing support system working with TSMC and others. I also worked with a number of VLSI's customers consulting on manufacturing excellence incorporating the principles of 6-sigma and Lean manufacturing.

The creation of the San Antonio Wafer Fabrication Facility starting from a green field site was a major undertaking where the principles of Lean manufacturing, 6-sigma and total cycle-time were designed into the factory. The factory, its' location, its' services were designed to eliminate potential negative impact on production and yields, eliminating waste, human error. The information processes to deliver instruction to people, equipment and report results to engineers and management were automated putting the right information, real time to all the people from the same data base. Order, cleanliness, scheduling, staging of work, control of processes and data control were optimized. The factory was completely paperless and changes and instructions were communicated instantly to specific people, places, equipment and individual production lots. Inventory was controlled and monitored continuously. This system was then implemented throughout VLSI. One goal of the factory was industry leading cycle time for Application Specific Products. Which could be a single lot for the entire life of the product. To ensure this goal was met we applied modeling of constraints and dynamic simulation to insure success.

To employ constraint programming to solve this goal and resolve any potential problems, it first must be modeled, by a set of constraints on decision variables that solutions must satisfy. Modeling is difficult and requires expertise, thus limiting widespread use of constraint technology. The vast majority of research on constraint modeling presents alternative models to a particular problem and evaluates them through analysis and/or experiment. The process by which the alternative models are generated is rarely discussed. Determination of the factors affecting constraints in a process or system focus is on generating a set of correct models that includes those that a human expert would generate.

A first contribution to the determination and optimization of constraint modeling is the determination of combinatorial problems albeit in abstraction. The level of abstraction is a consequence of three features contributing to constraint. (1) The problem of the potential of a wide range of types (including sets, multi-sets, relations, functions, partitions) and decision variables can be of these types. (2) All types can exist to an arbitrary state; for example, a constraint variable can be of type set, set of sets, set of set of sets depending on the flow and options at point of use. (3) Constraints can contain quantifiers that range over decision variables. Such as different capacity and processing times. In establishing the dynamic simulation of the San Antonio Wafer Fabrication factory we created models of the constraints between individual wafer processes and batch process which required queuing of inventory. In some cases maximum batch sizes were not used; rather, the sub optimization of these high batch process reduced total process times and smoothed the flow of material and reduced inventory therefore cycletimes. These models were then tested in a dynamic simulation where inventory levels were examined over many cycletimes to determine if the optimum levels were maintained and a bottleneck was not created or that productivity was excessively impacted. This would require the addition of another tool to reduce process times by staging output in shorter periods smoothing material flows and reducing bubbles and gaps.

Dr. Eli Goldratt, father of the ”Theory of Constraints, author of “The Goal,” is quoted as saying concerning the ‘Theory of Constraints’, “There are two pillars. The first is that in all real-life systems there is inherent simplicity. If you can just find that inherent simplicity, you can manage, control and improve the system. The second pillar is that people are not stupid!” When one finds successively the key factors that really impact **total** system performance, you find the “inherent simplicity,” and management and controls becomes relatively easy. There is a basic notion that people resist change, and that this is a huge barrier to improvement. The bigger the change, there is bigger resistance. Does that not in essence say that people are stupid if someone comes up and suggests a change that is good for you, that people would automatically resist it. Goldratt says,“Most changes may be right for the company, but not right for the majority of the people for whom they are seeking collaboration with the change”, Goldratt continues to say, “So no wonder there is resistance.” Goldratt’s answer is at one level a cliché – you must find a “win-win.” This involves the steps in the reality of change. That is illustrated in the following diagram:



"*CAM* System *Requirements for ASIC Manufacturing*", Dick Lang and Perry *Denning*, Solid State Technology, Volume 29, Number 5, May 1986.

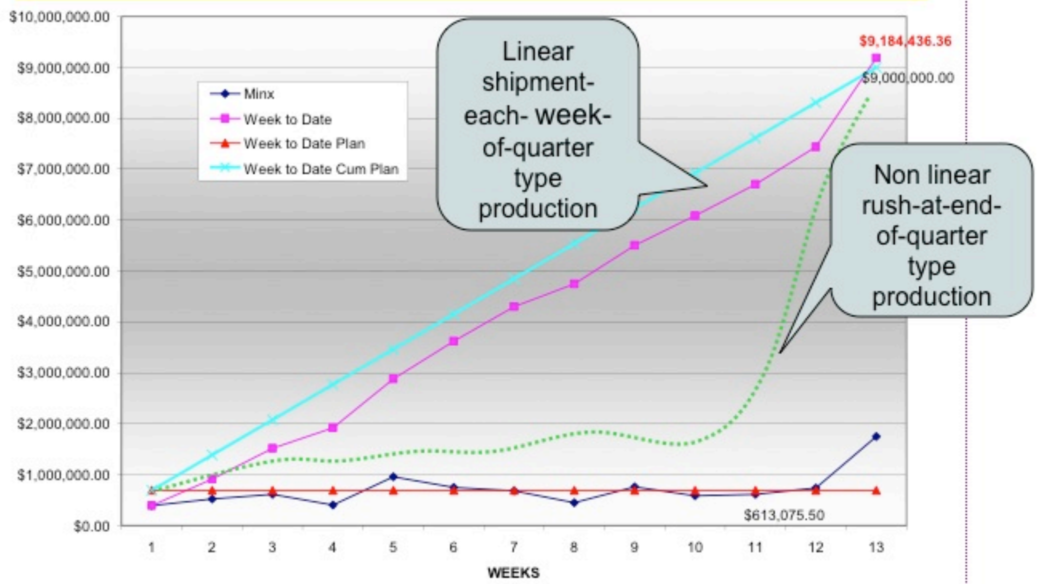
The next implementation of Lean manufacturing was for a company Integrated Circuit Systems. There were excessive subcontractors making the "sort and set" functions confusing and unproductive. We simplified and consolidated and created standardization to sustain a smooth flow. Communication and reporting were thus greatly improved.

At Celeritek, Inc. we were a start-up Division which had rudimentary laboratory style production. The creation of ERP systems, efficient production layout, improvement of processes and elimination of clutter and inefficient production and shipping non-linearly were common. This caused enormous overtime, late shipments fostered many errors and increased scrap. We started measuring our performance to a linear schedule and quickly saw improvement.

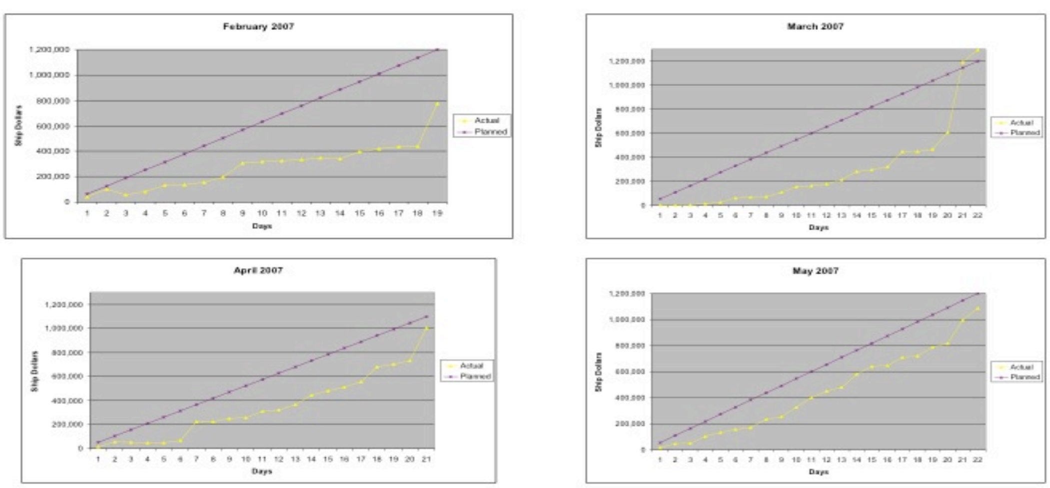
The charts below is illustrative of the linearity issue:

Balanced Shipments

We set a goal to achieve even weekly shipments



Monthly Linearity Improved



The next opportunity for "Lean" implementation was at SEMICOA. Here the business and manufacturing processes were anything but Lean. The elimination of delinquencies to customers was a top priority as new business could not be booked because the narrow customer base had orders that were months late and refused to provide new orders until these were eliminated. Examination of the production flows indicated that there were several major constraints and that the principles of Sort, set and shine needed immediate attention. Test appeared to be the worst offender and examination showed a highly over congested production area where lots were required to receive multiple electrical tests after each environmental stress test. Orderliness, scheduling only did so much the processes were too long and error prone. New systems with much short process time and greater accuracy were required. Once we did this the attention was turned to other steps such as the sealing processes.

The implementation of the "Lean", "6-Sigma" and "Constraint Analysis" together with employee empowerment and team building transformed SEMICOA and enable 40 year record productivity, revenue and profitability.

There are other examples and experiences, but I hope these provide sufficient record of my implementation of Lean Processes.

Sincere Regards,
Perry Denning