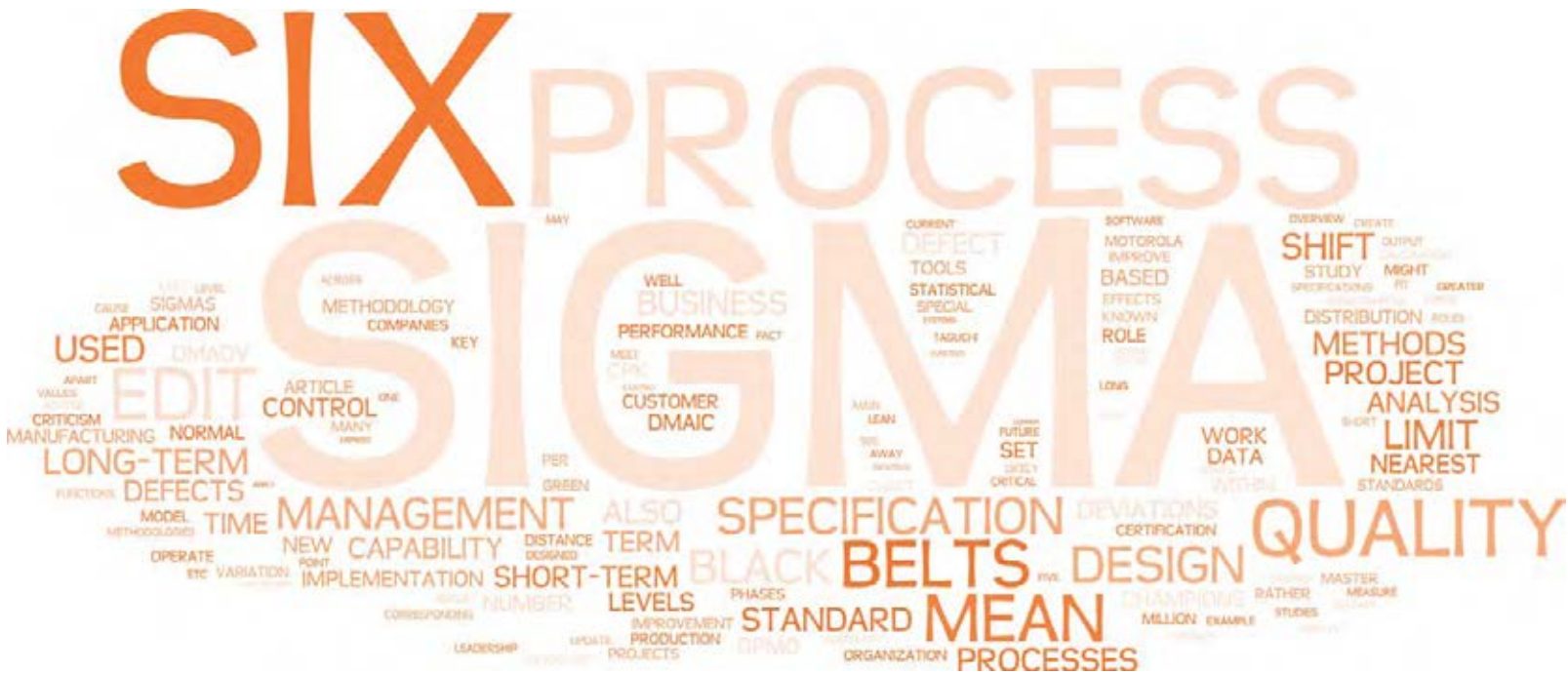


Cost Management & Lean Six Sigma

PRAFUL PATEL



In today's environment of fiscal austerity, it is imperative that government activities maximize cost benefits and improve capability at all levels. The cost management toolset consists of processes such as Lean Six Sigma (LSS), Value Engineering, Value Stream Mapping, Theory Of Constraints and 5S (Sort, Systematize, Shine, Standardize, Self-discipline), and various other continuous improvement processes. These continuous improvement (CI) processes are cost management tools that help maximize value to the customer, and are widely used in private and public sectors. Most of these CI tools have been used very effectively in manufacturing and service industry for the last several years to reduce life cycle cost. The key essence of cost management is to maximize value for the customer. Value to the customer is defined as capability divided by cost. In other words; to improve customer value for a given level of capability, cost has to be reduced.

Today, our focus is on Lean Six Sigma. We will discuss Lean and Six Sigma processes, how they are integrated to form LSS, and how LSS can be an effective cost management tool to increase value to the customer by reducing cost and achieving a shorter product development cycle. This frees up resources for greater improvements in capability.

WHAT IS LEAN?

Lean thinking is a dynamic, knowledge-driven, customer-focused, and structured employee thought process with the objective of continuous improvement and delivering measurable results. This thought process strives to eliminate waste and create value to the organization and customer. Lean principles can be applied to all key organization business processes:

- Management process, which governs the operation of a system. Examples include corporate governance and strategic management.

- Operational process, which constitutes the core business and creates the organization value stream. Examples include contracting, manufacturing, and engineering.
- Support process, which supports the management and operational processes. Examples include accounting, recruiting, and IT help desks.

Lean manufacturing can be traced back to the automobile industry with Henry Ford's innovative assembly process for the Model T, but its awareness grew significantly after being used at Toyota Motor Corporation in the early 1980s. More recently in the United States, James Womack of the Massachusetts Institute of Technology, has been a leader on developing lean thinking, researching lean tools, and developing training for employees.

Lean thinking seeks to identify and address non-value adding activities in any process, while leaving process steps that add value to the customer. The seven types of waste are overproduction, waiting, transport, inventory, rework, motion and defect. A key objective of any management strategy is elimination of waste. The objective of waste elimination needs to be flowed through the aligned business framework and into leadership goals and the organization's annual budget development process. These well-defined objectives can be measured and tracked through balanced score card techniques. The key for implementing Lean is competitive benchmarking, widely used in industry to develop organization objectives in support of meeting internal budgets. Benchmark can be a measurement of either functional or schedule outcome that can be transformed to cost.

The Value Stream Mapping process is an organized technique for developing the current state of the process, assigning value to each process step, and achieving a clear understanding of resources used in each step. This Value Stream Map can then serve as a starting point for lean thinking. An empowered team can develop an action plan to eliminate non value-added steps or combine steps to improve process for future state. The employees need to be trained for the future state and in turn implement the improved process.

SIX SIGMA

What is "Sigma"? Sigma is a statistical term that refers to standard deviation, which is a measure of variability or error in data. In our context, Sigma is an indication of the tolerance for undesirable outcomes in a process, with higher Sigma indicating tolerance for less defects and process deviations from perfection. For example, if we take height measurement of a class of students and tabulate results, we will find each student height to be different. We can measure each individual student height and calculate mean or average height of students by adding individual students heights

divided by number of students in the class. If we plot this data, a curve will be formed and in statistical terms, this plot is called normal distribution, also known as Bell curve.

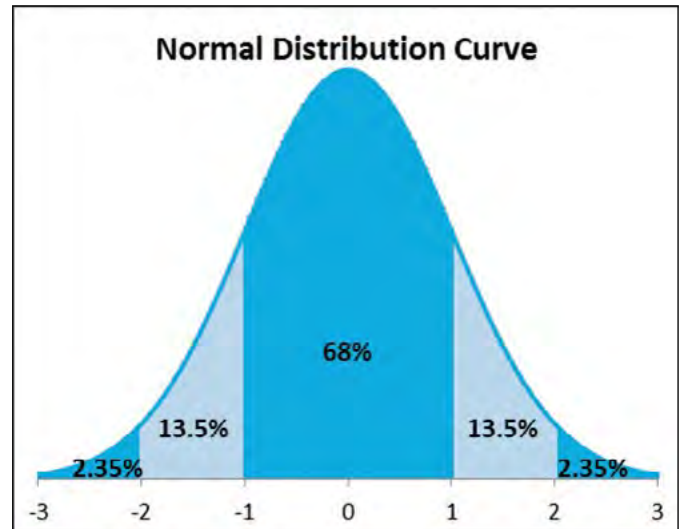


Figure 1.

Figure 1 shows a normal distribution curve. A normal distribution describes the variability in many natural systems. It is symmetrical with the center point, the mean or average, being the point where the most likely outcome can be expected. Another property of the normal distribution is that in general, most data points are clustered around the mean instead of the extremes. In Figure 1, one Sigma from the mean on either side covers 68% of the area under the curve. Two Sigma covers 95% of the area under the curve. Finally, three Sigma from the mean takes us out to the far corners of the bell curve at 99.7%. In the context of process improvement, we measure the frequency of unacceptable outcomes. A poor process may result in undesired outcomes occurring 68% of the time, or outside one Sigma of the mean. A stronger process may result in undesired outcomes only 0.3% of the time, or outside 3 Sigma. All processes have variability and reducing variability increases conformity, eliminating rework or scrap, and results in greater reliability.

During the 1980's, three Sigma (99.7%) was not enough granularity for Motorola management in high volume electronics manufacturing, as it still resulted in substantial waste from non-conforming parts, increased warranty cost, sales and quality reputation. Motorola management preferred to measure defects per million opportunities, so engineers created a new standard of Six Sigma (99.9998%) with greater accuracy. In other words, to achieve Six Sigma quality, a process must produce no more than 3.4 Defects per Million Opportunities (DPMO).

General Electric (GE) implemented Six Sigma across all divisions and used their GE Global Leadership Institute located at Crotonville, New York, to instill Six Sigma culture across the organization under the leadership of Jack Welch. Before Six Sigma at GE, the inside-out view of the business was based on average measures of recent past. GE's success for double digit growth and profitability in the late 1990s was attributed to Six Sigma implementation. Customers often feel the variance in each transaction or product and make judgment on their experience of variability. The Six Sigma

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process focuses on reducing variability first and then focuses on process capability. Ford Motor Company adopted the Six Sigma process in 2000 and named it consumer-driven Six Sigma to change the company focus from inside-out to outside-in. Along with this shift, the Ford management mantra changed to “the customer should be at the center of all we do.”

Lean Six Sigma is a marriage of lean and Six Sigma methodologies and it is a systematic, scientific and fact based decision process. The five steps of continuous improvement phases, called Define, Measure, Analyze, Improve, and Control (DMAIC), are the heart of the LSS process and are described in detail below.

Define: The purpose of this step is to clearly articulate the business problem, goal, potential resources, project scope and high-level project timeline. This information is typically captured within a project charter document. Voice of Customer (VOC) is a process where customer expectations, preferences and aversions are captured. Critical to Quality are the key measurable characteristics. Examples from the automotive industry include fuel economy or frontal crash impact requirement of 5 miles per hour must be met to satisfy the customer.

For example at Ford, customers were complaining about door moldings lifting at the edges and coming loose from the door sheet metal. The engineers did not see this concern in the assembly plant and the latent failure in the field resulted in significant warranty costs and created customer dissatisfaction. Engineers had to determine what the problem was, and understand the frequency of failure rate. By visiting dealerships and interviewing customers and mechanics, engineers were able to attribute four different factors which contributed towards failure. First the adhesive tape on the back of door molding was not fully contacting the sheet metal door. Second, the locating hole on the door was off location and caused stress in the molding. Third, automatic pressure applied on the molding at the assembly plant was too low for adhesive to activate fully. Fourth, the body side molding back surface was not clean and the tape was not sticking as designed. The team then wrote down the Voice of Customer (VOC) for body side molding expectations; and Critical to Quality (CTQ) outputs such as hole location, applied pressure, contact surface area, and cleaning area requirements.

In a business application, a vendor may complain that the payment processing time is too long and the team will have to investigate the vendor expectations of payment in days and the causes of delay in processing. The definition of the problem, as reflected by the Voice of the Customer and CTQ measurements in the project charter is an important step and needs to be clearly defined and communicated to key stakeholders and the organization with full support from management.

Measure: Measurement is a critical step that will provide raw data for analytical analysis in the next step. The team has to understand the different input and output factors that cause the variation in the process that results in customer complaints; and also needs to articulate measurements in clear, repeatable units.

In our automotive example, the engineers figured out how to measure the hole location by measuring doors in each shift and collected data to evaluate variability. Engineers were interested to learn about the variability through interviews with people, review of the stamping operation, and application of measurement. Also, engineers collected data on the flatness of body side moldings and developed a holding fixture so they could measure part flatness. Also, engineers collected data on part surface cleaning and pressure applied to the part surface over multiple shifts and different operators.

Similarly, in business application, the customer can be an external (war fighter) or internal customer (Finance, Contracts, Program Manager) and characteristics measured can be schedule, contracting process time, or payment processing, to name a few examples.

The Lean Six Sigma team needs to be knowledgeable in measurement variability and able to establish defect rate associated with current practices. Data collection and tabulation is methodical hard work and takes good amount of time and resources with experience in collecting a representative sample of measurement data that represents customer complaints or defects. This phase can last for weeks depending on the complexity of the project.

Analyze: Once data collection is complete, the analysis phase can start. The root causes of variations are identified and quantified. Engineers used statistical analysis to measure the variability and brainstormed on how to reduce variability that caused customer complaints. Simple root cause analysis tools like fishbone diagram and more advanced tools such as Design Of Experiments based on Taguchi principles, reliability hazard analysis, failure mode effects analysis (FMEA) and fault tree analysis can be utilized. The results are interpreted and the team develops their findings. This phase required the engineer to coordinate with suppliers, operators, and management to work together and apply systems engineering principles. Occasionally, the data may not be conclusive and the team may have to develop new measures or collect additional data.

Improve: In this phase, the key root causes for variations are translated to corrective actions based on conclusions from the data analysis. The resulting process changes are developed and incorporated. This required an engineering change to move door



holes two millimeters and change tooling to make molding flat on the backside where the adhesive tape was applied to get 100% contact area. Lab tests helped figure out the optimum application pressure required for the adhesive to activate and also identified changes to the machine that applied pressure. Engineers added automatic charting of applied pressure and contact time to ensure process capability. Also, engineers added a machine to clean the back of body side molding and added heat to the cleaning fixture.

The improvement step can take time, as there may be design, process, and tooling changes requiring investment and coordination with stakeholders. Employee training may be needed.

Control: After the improvement action was made, the process had to be monitored and data recorded to verify the improvement. The new control system was established and handed over to the process owner. The new controlled process forms the basis for next phase of continuous improvement.

The hole change in the body door produced a permanent change in the tooling, so the data was collected for a few weeks to ensure the location of the hole was as planned. The molding supplier added process steps for collecting molding flatness data and checking the applied adhesive pressure, and also spent time proving the process would work as designed. Also, engineers collected customer data after all the fixes were implemented for the next twelve months to measure effectiveness of design change. The team confirmed that the customer complaints were completely eliminated. Engineers changed engineering design requirements, added steps to the standard operating process and implemented this improved design and process across all vehicle models resulting in substantial warranty savings for the company.

Sometimes, a team may have to go through the DMAIC cycle several times before all root causes of an issue are completely resolved.

The continuous improvement actions using Six Sigma are very similar to the Lean process and hence marriage of Lean and Six Sigma results in a powerful cost and quality management tool. LSS is a team based process using engineering, analytical and statistical methods to develop optimized products and processes across the organization. For successful implementation of LSS, senior management support, employee training, balanced scorecard and committed resources are musts.

At Ford, we were able use Lean Six Sigma to reduce warranty costs by 20%, achieve labor savings of more than 10% and at the same time improve customer satisfaction. These business results have been sustainable and have become an integral part of the Ford budget development process for future years. LSS implementation was a top down process where all senior management were trained and assigned to champion projects in their respective organizations. Ford used the "LUTI" (Learn, Use, Train, and Improve) training model to train all employees in LSS methodology. Certification of Greenbelt (Novice), Blackbelt (Experienced) and Master Blackbelt (Expert) are integrated in Individual Training Development Plans. In addition, employee compensation was linked to LSS results, which helped accelerate implementation and change the corporate culture to a fact based decision making process.

The LSS projects encompassed product design, manufacturing, marketing, supply chain and corporate business processes. Ford was able to reengineer the product development process, reducing the product development cycle from 36 to 22 months, reducing warranty cost, and improving customer satisfaction, resulting in increased market share and profitability. The LSS is one of the key cost management tools that helped Ford sail through the financial crisis.

A FINAL WORD

Since the mid-1990s, process improvement has continuously combined principles of Lean Thinking, waste reduction, and Six Sigma to improve cost, quality, capability and customer satisfaction. The LSS is a universal cost management tool that can be used in private, public and government sectors. LSS can be the integral tool that successfully transforms organization culture and sets a path toward relentless pursuit of operational excellence.

The LSS can be the cost management tool for Program Managers to achieve "should cost" objectives for government and contractor cost. In a Department of Defense context, LSS might be applied to several areas:

- How many ships will the Navy be able to buy and sustain if the product development cycle can be reduced by 10%?
- What will be the impact on the Navy's Operation and Maintenance budget with LSS resulting in fewer turnovers of parts and reduced inventories?
- Can Agile Software development improve capability and reduce cost through reduced cycle time?

Lean Six Sigma has a community of practice inside and outside the government. Within the Navy, the Naval Air Systems Command (NAVAIR) has extensively implemented Lean Six Sigma practices via the NAVAIR AIRSpeed program, which provides CI tools to the Naval Aviation Enterprise (NAE). In addition, the Lean Enterprise Institute is a professional organization that provides extensive forums, training, and publications supporting the LSS community of practice.

In depth information on LSS process, tools and implementation strategy for NAVAIR's AIRSpeed initiative and Lean Enterprise Institute can be found at the following websites:

- <http://www.nae.navy.mil>
- <http://www.lean.org>



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