Implementation of Lean Six Sigma Concept - A Review

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Abstract:- **Lean Six Sigma is a combination of waste elimination and process improvement principles. Initially, this concept was well-known in the government and service sectors and industries with the capability of providing good resources and technology. But today, it is widely gaining popularity into SMEs (Small and Medium scale Enterprises) and retail sectors. It applies the tools and techniques of both Lean manufacturing and Six Sigma. Lean Six Sigma utilizes the DMAIC (Define – Measure – Analyze – Improve - Control) phases of Six Sigma in Lean environment to achieve bottom line results. A brief review of Lean Six Sigma is given in this paper. It focuses on the implementation of Lean Six Sigma principles and the application of DMIAC processes by reviewing a case study.**

Keywords: Lean Six Sigma; Implementation; DMAIC process.

I. INTRODUCTION

Six Sigma evolved as a total quality management system in which process improvement was a continual goal, not just implemented when vendors or customers decried poor quality. Motorola was one of the first U.S. companies in the 1980s to implement a continuous process improvement methodology. What Motorola started eventually became Six Sigma in 1986 in an effort to catch up with the Japanese. On the other hand, in Japan Lean manufacturing is traced to the Toyota Production System with its emphasis on a minimum of waste. Lean manufacturing grew in popularity both as a cost savings measure and in response to environmentalism. Zero waste facilities that produce no trash, hazardous waste or defective products are the ultimate in Lean manufacturing. Lean Six Sigma, also called Lean Sigma, is a fusion of Lean engineering with Six Sigma quality. The concept of Lean Six Sigma can be traced to Michael George, author of the 2002 book "Lean Six Sigma: Combining Six Sigma with Lean Speed [1] This was the first book to combine the principles of Leanmanufacturing with the mathematical techniques popularly referred to as Six Sigma. The main difference between Lean Six Sigma and Six Sigma methodologies is in the project prioritizations and analysis.

II. SIX SIGMA

Six Sigma is a comprehensive and flexible system for achieving, sustaining and maximizing business success. It is a set of techniques and tools for process improvement. It seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in processes. Each Six Sigma project carried out within an organization follows a defined sequence of steps and has quantified value targets, for example: reduce process cycle time, reduce pollution, reduce costs, increase customer satisfaction and increase profits [2]. The maturity of a manufacturing process can be described by a Sigma rating indicating its yield or the percentage of defect-free products it creates. A Six Sigma process is one in which 99.99966% of all opportunities to produce some feature of a part are statistically expected to be free of defects (3.4 defective features / million opportunities), this defect level corresponds to only a 4.5 Sigma level.[3]

III. WHAT MAKES SIX SIGMA DIFFERENT?

Six Sigma is uniquely driven by a close understanding of customer needs, disciplined use of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business processes. The Six Sigma methodology is based on the concept that "process variation" (e.g., customer waiting times at a call center waiting varying between ten seconds and three minutes) can be reduced using statistical tools[4].

IV. LEAN MANUFACTURING

Lean manufacturing, often simply "Lean", is a systemic method for the elimination of waste ("Muda") within a process. Lean also takes into account waste created through overburden ("Muri") and waste created through unevenness in workloads ("Mura"). Prime goals of Lean manufacturing systems are:

Improve quality: To stay competitive in today's marketplace, a company must understand its customers' needs and design processes to meet their expectations and requirements.

Eliminate waste: Waste is any activity that consumes time, resources, or space but does not add any value to the product or service.

Reduce time: Reducing the time taken to finish an activity from start to end is one of the most effective way to eliminate waste and lower costs

Reduce total costs: To minimize cost, a company must produce only according to customer demand. Overproduction increases a company's inventory costs because of storage requirements.

V. TYPES OF WASTES [5]

Toyota defined three broad types of waste: muda, muri and mura:

A. *MUDA*
It is defined as any activity in the process that does not add value for the customer.

B. *MURI*
It is defined as the unreasonable work that management imposes on workers and machines because of poor organization, such as carrying heavy weights, moving things around, dangerous tasks, even working significantly faster than usual.

C. *MURA*
This primarily focuses on how the work design is implemented and the elimination of fluctuation at the scheduling or operations level, such as quality and volume.

VI. INTEGRATION OF LEAN AND SIX SIGMA

Both the Lean and the Six Sigma methodologies have proven that it is possible to achieve dramatic improvements in cost, quality and time by focusing on process performance. However, using either one of them alone has limitations. Six Sigma is focused on reducing variation and improving process yield by following a problem-solving approach using statistical tools. It eliminates defects but it will not address the question of how to optimize process flow. Lean is primarily concerned with eliminating waste and improving flow by following the Lean principles and a defined approach to implement each of these principles. Lean principles exclude the advanced statistical tools often required to achieve the process capabilities needed to be truly 'Lean'. Therefore, these two methods as complement each other. Each approach can result in dramatic improvement and utilizing both methods simultaneously holds the promise of being able to address all types of process problemst. For example, inventory reduction not only requires reducing batch sizes and linking operations by using Lean, but also minimizing process variation by utilizing Six Sigma tools. The integrated approach to process improvement using Lean and Six Sigma will include:

A. Using value stream mapping to develop a pipeline of projects that lend themselves either to applying Six Sigma or Lean tools.

B. Teaching Lean principles first to increase momentum, introducing the Six Sigma process later on to tackle the more advanced problems.

C. Adjusting the content of the training to the needs of the specific organization – while some manufacturing locations could benefit from implementing the Lean principles with respect to housekeeping, others will have these basics already in place and will be ready for advanced tools.

The following roadmap (Fig 1) shows how one could approach the integration of Lean and Six Sigma[6].

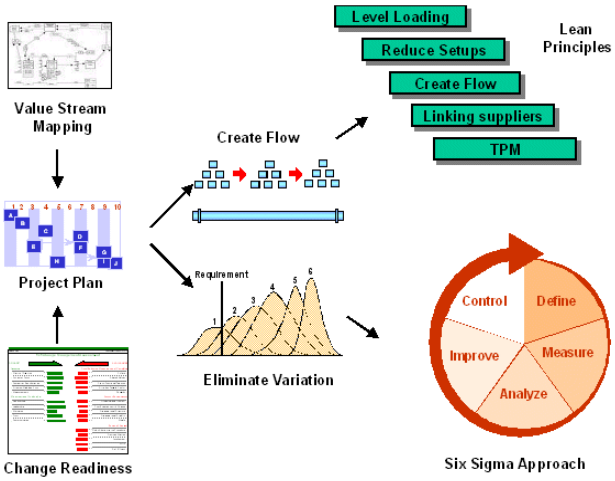

Fig.1. Roadmap

VII. THE BENEFITS OF USING LEAN SIX SIGMA [7]

Of all the various methodologies, Lean Six Sigma concept is the most promising alternative due to the following reasons:

A. *Increases revenue*- LeanSix Sigma increases the organization's revenue by streamlining processes.
B. *Decreases costs*- Lean Six Sigma decreases the organization's costs by: Removing "Waste" from a process. Solving problems caused by a process
C. *Improves efficiency* Lean Six Sigma improves the efficiency of the organization by: Maximizing the organization's efforts towards delivering a satisfactory product or service to the customers. Allowing the organization to allocate resources/revenue produced from newly improved processes towards growing the business.
D. Develops effective people/employees Lean Six Sigma develops effective employees within the organization by: Involving employees in the improvement process. This promotes active participation and results in an engaged, accountable team. Building trust. Transparency throughout all levels of the organization promotes a shared understanding of how each person is important to the organization's success.

Basically, Lean Six Sigma develops a sense of ownership and accountability for the employees. This increases their effectiveness at delivering results for any improvement project they are involved in.

VIII. DMAIC PROCESS [2,8,9,10]

Lean Six Sigma concept emphasizes the utilization of phases of DMAIC process of Six Sigma in a Lean environment. DMAIC stands for: **D**efine, **M**easure,

Analyze, **I**mprove, **C**ontrol. The table 1 below shows the various tools used in different phases:

TABLE I. Tools used in different phases

Define	Measure	Analyze	Improve	Control
•Project Charter • Stakeholder Analysis • SIPOC • Process Map • Project Plan • Responsibilities Matrix • Ground Rules • CTS tree	• VOC • Data collection plan • Pareto Chart • Histogram • Scatter Diagram • Process Capability • Process Statistics • Benchmarking • Gauge R&R • Cost of Poor Quality •Current State Map	•Cause & Effect Diagram • 5 Whys • Test for Normality • FMEA • Correlation Analysis • Regression Analysis • Hypothesis Tests • 8 Wastes • 5S • Kaizen	• Quality Function Deployment • Action Plan • Cost/benefit Analysis • Future State Map • Design of Experiments • Main effects and interaction plots •Dashboard/ Scorecards	•Control Plan • Mistake Proofing • Standard Work • FMEA • Training Plan • Process Capability • Statistical Process • Control (SPC) • Standard work • SOP

A. Define:

The purpose of the first phase of the DMAIC process is to identify and refine a process in order to meet or exceed the customer's expectations. The Define phase includes developing the team charter, critical to quality characteristics, problem statement, communication plan, project scope and goal statements.
In this stage the following questions are addressed:
• Who are the team members?
• Have the team members been properly trained?
• Is the team adequately staffed with the desired cross-functionality?
• Has the customer(s) been identified?
• Has the team collected the voice of the customer?
• Have the customer needs been translated into measurable requirements?
• Has the team developed and communicated the project charter?
• What specifically is the problem?
• What is the project scope?

B. Measure:

The purpose of the Measure phase is to develop, execute and verify a data collection plan. Tools that are typically used in the Measure phase are Process Flow Diagrams, Process Failure Mode and Effects Analysis (FMEA), and Measurement System Analysis. In this stage the following questions are addressed:
• What processes are involved?
• Who are the team members?
• Which processes are of the highest priority to improve?
• What data supports the decision? (Metric)
• How is the process performed?
• How is the process performance measured?
• What are the customer driven specifications for the performance measures?
• What are the improvement goals?
• What are the sources of variation in the process?
• What sources of variability are controlled and how?

One of the key tools used in the Measure phase is the Supplier- Inputs- Process- Outputs -Customer (SIPOC) diagram.

C. Analyze:

The purpose of the Analyze phase is to develop and test hypotheses about the causes of process defects. Therefore, Hypothesis Testing is a common tool in this phase. In the Analyze stage
there are three main questions:
• What are the key variables affecting the average and variation of the performance measures?
• What are the relationships between the key variables and the process output?
• Is there interaction between any of the key variables?

D. Improve:

The Improve phase focuses on formulating and implementing process improvement ideas. Tools
in this stage include Multiple Regression and Design of Experiments. In the Improve phase the following questions are addressed:
• What are the key variable settings that optimize the performance measures?
• At the optimal setting for the key variables, what variability is in the performance measure?
In addition to the basic quality tools used in the DMAIC methodology, Lean tools such as the future state value stream map and visual management are critical. There should be focus on reducing variation not only in the process setting but also in the overall process flow. This provides a more holistic approach to the improvement process.

E. Control:

The final phase of the DMAIC process includes controlling and monitoring the process. This stage addresses:
• How much improvement has the process shown?
• How much time and/or money was saved?
In the control phase, a strategic approach is taken to ensure the long-term success of the improvements. Information is given on various costs and times and results are interpreted. This final phase is set up as a culmination of the previous phases to finalize and conclude. At this phase in the case study the process has been improved. The students now must assimilate their learning to sustain the improvements. Tools such as statistical process control, standard work, and mistake proofing are focused on to ensure the process continues operating as expected.

IX. EXAMPLE [11]

A.OVERVIEW

In alignment with the company X's strategic goals, the Distribution and Transportation Executive team has jointly set an achievable objective to reduce their internal operating costs by 25%. This has translated to a 35% reduction of operating costs in the Midwest Distribution and Transportation (D&T) region. The Midwest D&T region's Six Sigma team has examined multiple projects

that may impact the breakthrough goal and has identified optimizing trailer utilization as a high priority.

B. PROBLEM STATEMENT

The Midwest Distribution and Transportation (D&T) region needs to reduce operating costs by 35%. Improving trailer utilization has been identified as the quickest way to reduce costs within their direct control. The Six Sigma team needs to analyze the current state of trailer utilization and then suggest improvements based on an optimized process. If the Midwest D&T region fails to show an opportunity to reduce operating costs as directed by the company's strategic plans, the company may not be able to meet its predicted growth

C. GOAL OF THE PROJECT

Reduce trailer use costs by 20-35%

D. SCOPE

The project was limited to the Midwest region in which Anita Baker and Joe Thompson were responsible. The Lean Six Sigma team examined and recommended changes to the major process steps for the use of a trailer: dispatch, load, transport, dispatch update, unload. The investigation was limited to the

two methods of live unload and drop and hook, which could occur at a vendor, distribution center, or store.

E. PROJECTED FINANCIAL BENEFIT (S)

Based on an operating budget of $1.5 million, this project attempted to avoid costs connected with trailer use. The avoidance target was $0.3 – 0.525 million

F. PROCESS FLOW

The flow of the process is as shown in the outline process chart as shown in fig.2.

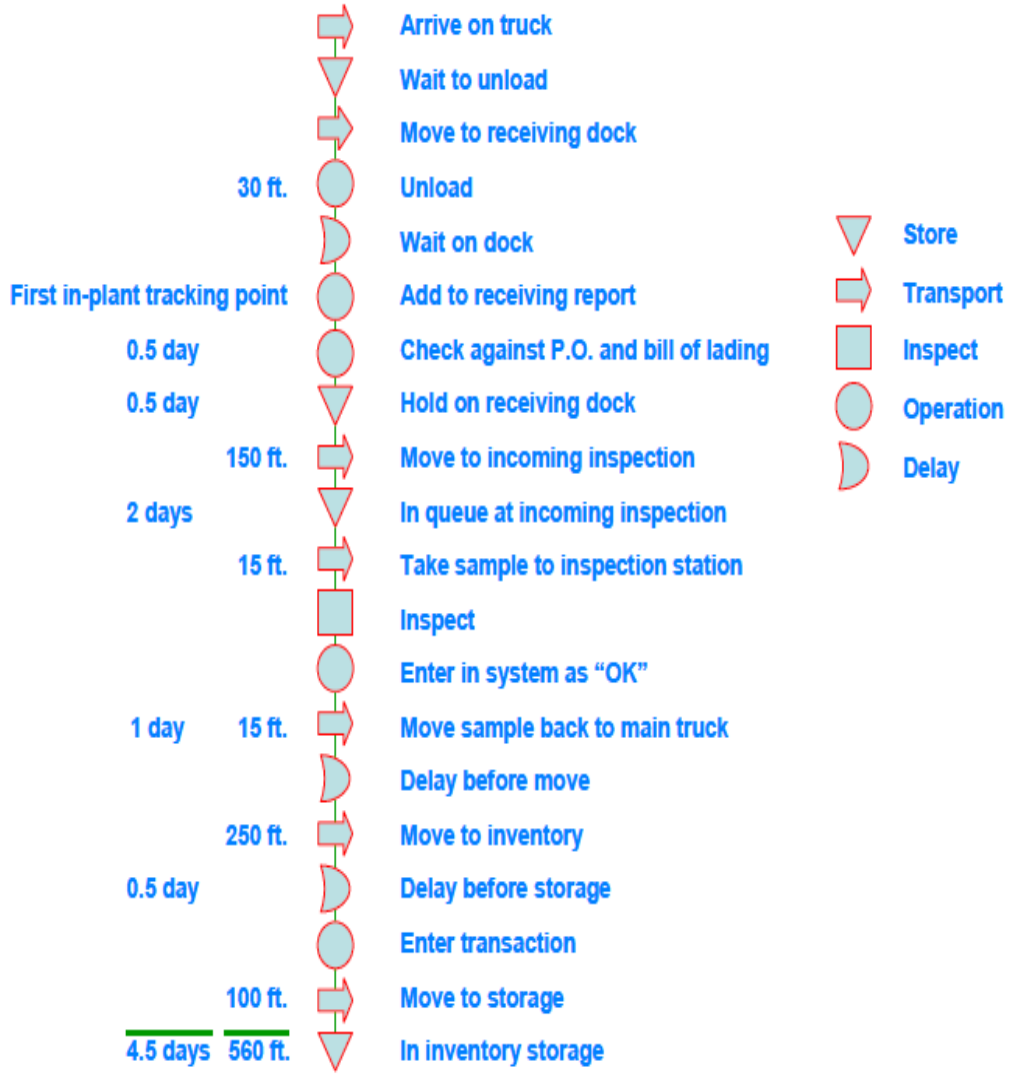

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Fig.2. Process flow diagram

G. SIPOC DIAGRAM

The table II.shows the various input-output data required to conduct analysis

TABLE II. Supplier-Input-Process-Output–Customer Chart

Suppliers	Inputs	Processes		Outputs	Customers	
(Providers of the required resources)	(Resources required by the process)	(Top level description of the activity)		(Deliverables from the process)	(Anyone who receives a deliverable from the process)	
		Requirements			Requirements	
Driver Coord.	Dispatch Plan, Phone, Tractor, Trailer, Driver		Dispatch to Shipping Dock	Dock Location, Trailer at Dock		Driver, Shipping Personnel
Shipping Personnel	Product		Load Product	Trailer Ready to Transport	Leave On Schedule (LOS)	Driver
Driver			Transport Trailer			
Driver	Cell phone	30 min. before arriving at rec. dock	Driver Reports Status	verbal communication		Driver Coord.
Driver Coord.	Dispatch Plan, phone	before product is unloaded	Driver Receives Dispatch Update	verbal communication		Driver
Driver		Arrive On Schedule (AOS)	Arrives at Receiving Dock			Receiving Personnel
Receiving Personnel		LOS	Product Unloaded	Product		Driver, Warehouse or Store

H. ANALYSIS

The table III. Shows the analysis of waste and the actions that are recommended to be taken

TABLE III.Waste and Recommendations

Type of Waste	Examples in the Case	Recommended Actions
Transportation	Movement to inspection	Perform inspection during unload
Inventory	Excessive inventory	Level load deliveries
Motion	Excessive lifting to reach labels	5S labeling bench
Waiting	Drivers waiting on orders	Kaizen event on shipping order process
Overproduction	Containers pre-shrink wrapped and may not be needed as grouped	Only package when the order is received
Overprocessing	Extra padding added to protect certain products	Determine padding requirement
Defects	Incorrect shipping orders	Auto-populate cells in shipping order
Skill	Dispatch team underutilized in scheduling	Update job roles and provide training

X. RESULT AND CONTROL

By taking the improvement measures theprocess has been improved.To sustain the improvements, tools such as statistical process control, standard work and mistake proofing are used to ensure the process continues to operate as expected. Deming's Plan-Do-Check-act cycle can be utilized to see the nature of continuous.

XI. CONCLUSION

The case study was developed by Elizabeth Cudney and Rodney Kestle in order to show how DMAIC process is used to implement the principles of Lean Six Sigma. It clearly shows the various tools used in the various phases of the DMAIC process. Thus, from the data collected the process used for implementation of Lean Six Sigma was understood. It is also found that the concept of Lean Six Sigma has been very useful. It has been equally beneficial both for manufacturing or service concerns and Large or small scale organizations. It can be implemented in different industries with little modifications as per industry requirement. SMEs do not have enough resources and technology. Also, finance is another major hindrance in the successful implementation of Lean Six Sigma in such industries. A lot of creativity and innovation breakthrough is required for such implementation. There is a lot of scope research for implementation of Lean Six Sigma in SMEs where the financial capability is big hurdle.

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