International Journal of Recent Research and Review, Vol. VI, Issue 3, December 2013

ISSN 2277 – 8322

LEAN SIX SIGMA – PROCESS IMPROVEMENT TECHNIQUES

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Abstract **- Six Sigma was a concept developed in 1985 by Bill Smith of Motorola. Six Sigma is a business transformation methodology that maximizes profits and delivers value to customers by focusing on the reduction of variation and elimination of defects by using various statistical, data-based tools and techniques. Whereas, Lean is a business transformation methodology which was derived from the Toyota Production System (TPS) which focuses on increasing customer value by reducing the cycle time of product or service delivery through the elimination of all forms of waste and unevenness in the workflow. The concept of Lean Six Sigma is a combination of both the Lean and Six Sigma.**

The aim of this paper is to define the meaning and basic principles of Process Improvement Techniques. For this purpose, Process Improvement Techniques focused on Lean, Six Sigma and blended approach as Lean Six Sigma. These techniques have been used in private sector, manufacturing and service organisations for several years.

Keywords **- Process improvement Techniques, Lean thinking, Six Sigma, Lean Six Sigma**

I. INTRODUCTION

Due to increased globalization and constant technological advances and other competitive pressures, the organizations have to accelerate the pace of change to adapt to new situations. Six Sigma is the most popular quality and process improvement methodology which strives for elimination of defects in the processes whose origin is traced back to the pioneering and innovation work done at Motorola and its adoption by many companies including GE, Ford, General Motors, Xerox etc. The primary objective of Six Sigma is to reduce variations, in products and processes, to achieve quality levels of less than 3.4 defects per million opportunities (DPMO). Lean was an another quality and productivity improvement methodology introduced in Toyota Production Systems (TPS) which is based on the concept of elimination of waste in processes which had resulted in productivity gain and improvement of speed and flow in the value stream. Six Sigma when coupled with Lean Principles is called Lean Six Sigma which professes eliminating waste in process steps by using Lean tools which enhances value in Six Sigma implementation one step further by increasing speed by identifying and removing non-value adding steps in a process. Execution of Lean Six Sigma project uses a structured method of approaching problem solving normally described by acronym DMAIC which stands for Define, Measure, Analyze, Improve and Control. Many organizations have achieved phenomenal success by implementing Lean Six Sigma. This paper focuses and highlights overview and details of some of the important aspects of Lean, Six Sigma and Lean Six Sigma.

II. LEAN DEVELOPMENT

Lean Thinking is specifying value by specific products, identifying the value stream for each product, make value flow without interruptions, let the customer pull value from the producer, and pursue perfection [1]. Lean Thinking has its roots in the Toyota Production System and has been development over time, with Womack and Jones regarded as the originators of the term and its associated principles. Lean is considered to be a radical alternative to the traditional method of mass production and batching principles for optimal efficiency, quality, speed and cost [2]. The five core principles of Lean, based on an underlying assumption that organisations are made up of processes are [1]:

i) Specify the value desired by the customer. It is also useful to identify who the real customer is and better understand their requirements, which can be complex.

ii) Identify the value stream for each product providing that value and challenge all of the wasted steps.

iii) Make the product flow continuously. Standardising processes around best practice allows them to run more

smoothly, freeing up time for creativity and innovation.

iv) Introduce pull between all steps where continuous flow is impossible. This focuses upon the demand from the customer and triggers events backwards through the value chain. In this way inventory and human activity is linked to customer needs.

v) Manage towards perfection so that non-value adding activity will be removed from the value chain and the number of steps and the amount of time and information needed to serve the customer continually falls.

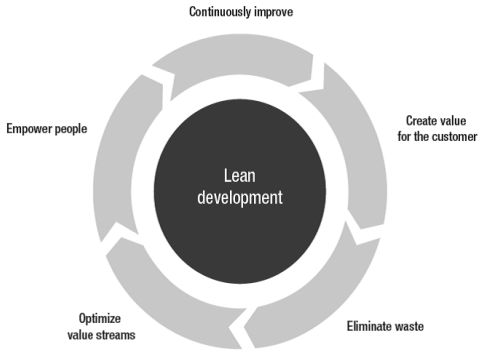

Fig. 1: Lean Development Cycle

Within Lean it is stated that all other activities that do not provide value are a waste and should be eliminated [3]. Therefore, a crucial element of Lean is the removal of non added value or waste, variability and inflexibility [4]. These also have Japanese terms of muda (waste), mura (unevenness) and muri (overburden) [3].

Bhatia and Drew [4] identify those which are of particular relevance to the any business are:

i) Waste; scrap and rework, waiting, inventory, unnecessary motion, unnecessary transport, over production and over processing.

ii) Variability; examples of which in public services include the variation is gathering evidence for a trial.

iii) Inflexibility especially with regard to staffing levels being inflexible and the same every day on the assumption that a standard service necessarily offers economies of scale, whereas customer segments require different levels and types of service.

Many tools for Lean implementation have also been suggested and are capable of being utilised within any business [5], [6]:

i) Understanding customer value and what the customer considers waste. Focusing on not only the ultimate customer but internal and external customers as well. Reviewing customer complaints, and assigning team members tasks to determine their internal and external customers values and what they consider waste in this process.

ii) Running Kaizen Blitz or rapid improvement events involving employees from with and/or across departments, which scope out issues to be resolved and implement the required changes.

iii) Carrying out process mapping and value stream: Mapping out the process and assigning cycle and value-added time to each step, looking for bottlenecks, and listing any team concerns or questions to be addressed at a later time. Also root cause analysis and brainstorming can be used to analyse the bottlenecks, find solutions, and streamline the process.

iv) 5S activity as part of, or separate to, the Kaizen Blitz and process mapping. 5S is a rigorous form of housekeeping which supports the pursuit of waste elimination. It consists of:

a) Seiri (Sifting): Comprises of the removal of all unnecessary items.

b) Seiton (Simplifying): This is when work site items are arranged in the most effective way which could be influenced by frequency of use, work sequence or weight/size. The location for each item is clearly visible and labelled – so if something is missing or in the wrong place it can be clearly seen.

c) Seiso (Sweeping): The traditional view of housekeeping about keeping everything clean, even spotless.

d) Shitsuke (Standardise): Regularly auditing the workplace to ensure standards are being maintained and improved.

e) Seiketsu (Self Discipline): To do with general working environment, provision of work wear and sustaining the housekeeping.

v) Implement cross-functional teams involving all relevant employees that work directly on the process at all levels within and outside of the department.

vi) The implementation of standard work, which is a method of defining, organising and agreeing the activity in a process to ensure the most effective and efficient use of resources, people, tools and equipment.

vii) Using Visual Management as a means to display standards or targets in a process area, together with the current performance achieved. The purpose of this is to make problems visible to the whole team quickly, so that they can be tackled promptly.

It is important to note that Lean is argued to be a philosophy suggesting that what organisations need or are

creating is a Lean lifestyle [3],[6]. Also the implementation of Lean is described as a journey with the various stages of the implementation being landmarks of the total journey [6].

III. SIX SIGMA METHODOLOGY

The basic goal of a Six Sigma strategy is to reduce variation within the tolerance or specification limits of a service performance characteristic. In order to improve the quality of a typical service, it is imperative to measure or quantify variation and then develop potential strategies to reduce variation [7]. Six Sigma aims to reduce organisational costs and enhancing customer satisfaction through the reduction of defects or service failure. It concentrates on measuring product/service quality, reducing variation, driving process improvements and reducing cost, using a set of statistical and management tools to make improvement leaps [8]. Six Sigma projects aim to reduce the defect rate to a maximum of 3.44 errors per million exposures (i.e. 0.00000344%) [9] as shown in Table I [10]. Although Antony [7] reminds us that the focus of Six Sigma is not on counting the defects in processes, but the number of opportunities within a process that could result in defects.

TABLE I

Sigma level	**DPMO**	**Percent defective**	**Percentage yield**
1	691,462	69%	31%
2	308,538	31%	69%
3	66,807	6.7%	93.3%
4	6,210	0.62%	99.38%
5	233	0.023%	99.977%
6	**3.4**	**0.00034%**	**99.99966%**
7	0.019	0.0000019%	99.9999981%

A key focus of the Six Sigma approach is the implementation of projects using a defined methodology called DMAIC (Define, Measure, Analyse, Improve and Control).

Six Sigma implementations use a DMAIC methodology [8]:

i) Define: A clear and explicit definition of the problem is vital in project selection and prioritisation. A well defined problem sets ground rules for improvement.
ii) Measure: Measurement points, sources, tools and equipment, and precision and accuracy play a vital role in the project. Without measurement there is no control. Measurements are essential to collect data.
iii) Analyse: Using the right approach, analytical tools or methods will help to find a clearly defined solution. Data is analysed into information to create a knowledge base and make decisions for actions.
iv) Improve: Select and implement the best solution to remove the cause of a problem will bring the desired result. Improvements are corrective and preventive actions.
v) Control: After the implementation of improvement activities, monitoring becomes essential to control the processes.

There is a clear team structure within a Six Sigma project with members moving from a Green Belt to a Master Black Belt depending on their training and level of involvements within projects. In summary, team members on Six Sigma projects have the following roles [8]:

i) Executive who commits resources and sponsors the projects.
ii) Master Black Belt who provides training and coaching.
iii) Black Belt who leads the improvement project.
iv) Green Belt who supports and runs projects.
v) Champion who is involved in supporting the project.

Champions lead projects and ensure that all improvements become cemented. Green Belts participate in projects and are usually can engineers, supervisors and quality control experts. They receive mentoring from the Black Belts [11].

The tools used in Six Sigma deployments vary from the development and analysis of visual charts to the use of similar tools used in Lean Implementations [9]. The use of pareto charts, scatter diagrams, histograms, regression analysis and statistical process control, combine the rigor and objectivity of statistical analysis with the ability to visually interpret quantitative information, thereby revealing more process information. These allow differentiation between common variations and special variations to be highlighted. Statistical Process Control (SPC) charts show variation in process through data points over time relative to a central line with upper and lower control limits. They highlight whether a process is in control or whether corrective action is needed. Effective change and sustained improvement can only be claimed if the process is known to be in control [12].

IV. A COMBINED APPROACH - LEAN SIX SIGMA

The concept of Lean Six Sigma is a combination of both the Lean and Six Sigma. Anderson et al. [13] suggest that Lean manufacturing addresses process flow and waste

whereas Six Sigma addresses variation and design. Smith [11] highlights that removing the low hanging fruit with Lean allows challenges to be identified that require a Six Sigma approach using statistical tools to uncover unseen roots and problems.

Finally, Dedhia [8] suggests that enhanced savings can be achieved through combining the approaches stating that Lean Six Sigma can be used in all sectors. Lean can reduce waste and improve process efficiency and Six Sigma can reduce variation and improve performance. Savings can be doubled when Lean and Six Sigma are used in a coordinated manner. Both can be used in non manufacturing environments. This is supported by O'Rouke [14] the intended outcome of Lean Six Sigma projects is that the combination of both the discipline of Six Sigma and the speed of Lean implementations will produce business and operational excellence.

Every organization strives to optimize its operations, further based on the type of problems, combining Lean and/or Six Sigma tools with traditional project management techniques can be a powerful combination as shown below in Figure 2 [15]:

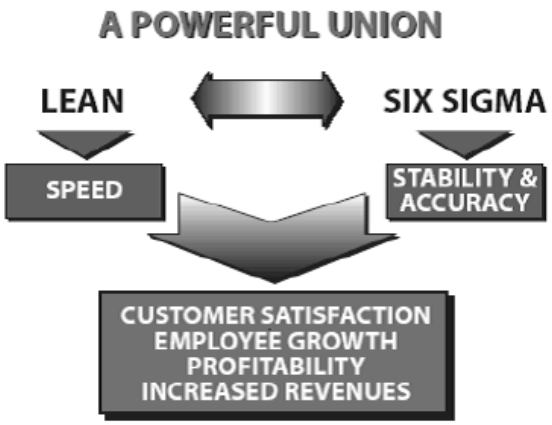

Fig. 2: Lean Six Sigma Process, Tools and Business Results

This section briefly discussed the similarities and differences between the approaches, Lean and Six Sigma, before stating their combined approach.

Ferguson [16] states that recognising the differences between Lean or Six Sigma means that returns can be maximised by knowing when to use which in the right context and environment. Ferguson [16] outlines that:

i) Lean is a philosophy, while Six Sigma is a programme.
ii) Six Sigma project teams exclude those not involved and the benefits occurred from projects are specific to departments. Lean is inclusive and involves the whole of the organisation.
iii) Six Sigma focuses on cost and quality. Lean focuses on business strategy, organisational design/structure, culture and processes of the whole value stream.
iv) Six Sigma focuses on specific goals and objectives, identifies route causes, tests hypotheses, validates the analysis and suggests recommendations. On completion of projects Six Sigma teams disband.
v) Lean is about continuous improvement as there will always be waste in the process. Lean is ongoing and in the new learning organisation, employees are continually building their skills and improving. Lean becomes part of their daily working lives.

Proudlove et al. [17] explain that in practice Lean appears to be a more participative, bottom-up approach than Six Sigma. One reason for this might be that Lean is characterised as relying more on intuition and deep insight for example when producing future state value stream maps. Proudlove et al. [17] point out that:

a) Six Sigma is a generic, root-cause and solution unknown problem-solving approach. Precisely what components of the process to change and what to change them to should emerge from the rigorous, analytical, data-driven methodology with potential over-emphasis on being data-driven, rather than problem-driven.
b) Lean, in contrast, brings principles for improving flow and some tried-and-tested solutions. These may be used at an early stage to construct a vision of the future configuration of the value stream, which may be used to guide and co-ordinate improvements.

Arhneiter and Maleyeff [18] suggest that Lean and Six Sigma can be integrated together in order to complement implementations. They [18] said that Lean organisations should make more use of data in decision making and use methodologies that promote a more scientific approach to quality. In turn, Six Sigma organisations can gain from training in Lean management methods to eliminate all forms of waste.

Dedhia supports the use of Lean Six Sigma in order to achieve positive financial impacts. Lean can reduce waste and improve process efficiency and Six Sigma can reduce variation and improve performance. Savings can be doubled when Lean and Six Sigma are used in a coordinated manner. Both can be used in non manufacturing environments but both require management's active support.

Both six sigma and lean have at heart the business process and the process improvement approaches. An holistic

model and methodology should thus retain this at its heart (Figure 3). The route through their approaches should depend primarily upon the issues that the organisation is facing and its nature, as well as being influenced by the organisation's and individual's aspirations and perceptions [19].

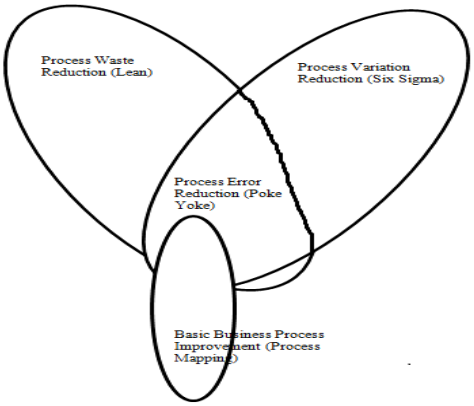

Fig. 3: A holistic model for business process improvement

V. CONCLUSION

Lean Six Sigma is a disciplined methodology which is rigorous, data driven, result-oriented approach to process improvement. It combines two industry recognized methodologies evolved at Motorola, GE, Toyota, and Xerox to name a few. By integrating tools and processes of Lean and Six Sigma, we're creating a powerful engine for improving quality, efficiency, and speed in every aspect of business. Lean and Six Sigma are initiatives that were born from the pursuit of operational excellence within manufacturing companies. While Lean serves to eliminate waste, Six Sigma reduces process variability in striving for perfection. When combined, the result is a methodology that serves to improve processes, eliminate product or process defects and to reduce cycle times and accelerate processes.

Lean and Six Sigma are conceptually sound technically fool proof methodologies and is here to stay and deliver break through results for a long time to come.

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