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Six Sigma Concepts: a Complete Revolution

Garima Chaudhary
Assistant Prof. Guru Gobind Singh College for women Sector-26
Chandigarh, India

Abstract:

Revolution is the key word for every organization these days. Six sigma is that key element which can help the organizations in ensuring to provide the output with the least possible errors or defects. In this competitive era, none of the companies can afford to provide the customers with a defective or below the required standard goods, so six sigma is the best possible action available with them. Six sigma is now no more an option but has become the requirement of every enterprise as this is the only option which is a step forward than the total quality management and a source of assurance of the product with regard to its quality and perfection.

Keywords:

I. Introduction

Six sigma terminology originated with statistical modelling of manufacturing processes. This term basically defines quality which is almost near the perfection limit. It is a data driven approach which helps in eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit). It is said that if there are not more than 3.4 defects per million units, then six sigma has been achieved. The ain idea behind the six sigma concept is process improvement and reduction of variation. The Six Sigma DMAIC process (define, measure, analyze, improve, control) is an improvement system for existing processes falling below specification and searching for incremental improvement. The Six Sigma DMADV process (define, measure, analyze, design, verify) is an improvement system which is used to develop new processes or products at Six Sigma quality levels. The Six Sigma Management System drives clarity around the business strategy and the metrics that most reflect success with that strategy. It is rightly said that "It provides the framework to prioritize resources for projects that will improve the metrics, and it leverages leaders who will manage the efforts for rapid, sustainable, and improved business results.." [3]

Review of literature

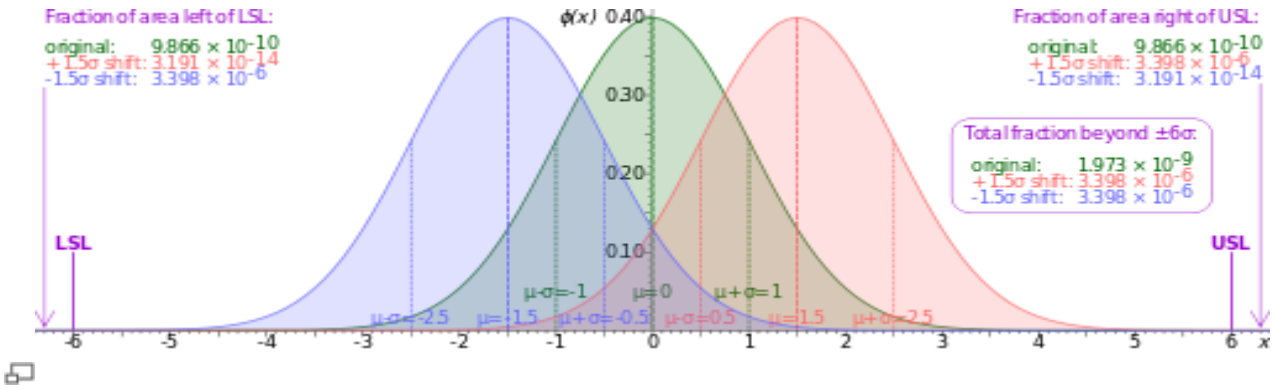
In 2006 Roy Andersen, Henrik Eriksson, and Hakan Tortensson studied the six sigma in ***Similarities and Differences between TQM, Six Sigma and Lean*** address unanswered questions about the similarities and differences of the application of the three quality concepts. The authors utilized data collected from a case study, a literature review and face-to-face interviews with existing users to provide guide to companies who want implement or apply the concepts of TQM, Six Sigma, or Lean.

II. History of six sigma

In early 1920's thew word sigma was used by the mathematicians and engineers as a symbol for measurement in product quality variation. Motorola Inc in USA started reducing defects in the production processes in 1980. With the advent of time, this concept became a formal improvement methodology which focussed far beyond defect reduction. With the beginning of 1991, Motorola was certified with its first 'black belt' followed by Allied Signal (a large avionics company which merged with Honeywell in 1999), adopted the Six Sigma methods and claimed significant improvements and cost savings within six months. GE adopted six sigma in 1995 and claimed that Six Sigma had generated over three-quarters of a billion dollars of cost savings. By the year 2000, Six Sigma was effectively established as an industry in its own right, involving the training, consultancy and implementation of Six Sigma methodology in all sorts of organisations around the world.

Six Sigma basically seeks to improve the quality of process outputs by identifying and removing the causes of defects or errors and minimizing variability in business process. It uses a set of quality management methods, including statistical methods and creates a special infrastructure of people within the organization ("Champions", "Black Belts", "Green Belts", "Yellow Belts", etc.) who are experts in the methods. Each Six Sigma project carried out within an organization follows a defined sequence of steps and has quantified value targets. The success 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 the products manufactured are statistically expected to be free of defects (3.4 defective parts/million), although this defect level corresponds to only a 4.5 sigma level.

As per Six sigma, if one has six standard deviations between the process mean and the nearest specification limit, as shown in the graph, no items will fail to meet specifications. Capability studies measure the number of standard deviations between the process mean and the nearest specification limit in sigma units. As standard deviation goes up, or the mean of the process moves away from the center of the tolerance, fewer standard deviations will fit between the mean and the nearest specification limit, decreasing the sigma number and increasing the likelihood of items outside specification.



The Greek letter σ (sigma) marks the distance on the horizontal axis between the mean, μ, and the curve's inflection point. The greater this distance, the greater is the spread of values encountered. For the green curve shown above, μ = 0 and σ = 1. The upper and lower specification limits (USL and LSL, respectively) are at a distance of 6σ from the mean. Because of the properties of the normal distribution, values lying that far away from the mean are extremely unlikely. Even if the mean were to move right or left by 1.5σ at some point in the future (1.5 sigma shift, coloured red and blue), there is still a good safety cushion. This is why Six Sigma aims to have processes where the mean is at most 6σ away from the nearest specification limit.

Main focus:

Six Sigma asserts that:

- It is important for a successful business to maintain continuous efforts to achieve stable and predictable process results (reduce process variation).
- Manufacturing and business processes have characteristics that can be measured, analyzed, controlled and improved.
- Entire organization requires commitment specifically from the top level management in order to achieve sustained quality improvement.

Unique features:

Features that set Six Sigma apart from previous quality improvement initiatives include:

- A clear focus on achieving measurable and quantifiable financial returns.
- An increased emphasis on strong and passionate management leadership and support.
- A clear commitment to making decisions on the basis of verifiable data and statistical methods, rather than assumptions and guesswork.

Processes that operate with "six sigma quality" over the short term are assumed to produce long-term defect levels below 3.4 defects per million opportunities. Organizations need to determine an appropriate sigma level for each of their most important processes and strive to achieve these. As a result of this goal, it is incumbent on management of the organisation to prioritize areas of improvement.

DMAIC [5]

The DMAIC project methodology has five phases:

- ***D**efine* the system, the voice of the customer and their requirements, and the project goals.
- ***M**easure* key aspects of the current process and collect relevant data.
- ***A**nalyze* the data to investigate and verify cause-and-effect relationships. Determine what the relationships are and attempt to ensure that all factors have been considered. Seek out root cause of the defect under investigation.
- ***I**mprove* or optimize the current process based upon data analysis using techniques such as design of experiments, mistake proofing, and standard work to create a new, future state process.
- ***C**ontrol* the future state process to ensure that any deviations from target are corrected before they result in defects. Implement control systems such as statistical process control, production boards, visual workplaces, and continuously monitor the process.

Some organizations add a ***R**ecognize* step at the beginning, which is to recognize the right problem to work on, thus yielding an RDMAIC methodology.

DMADV or DFSS

The DMADV project methodology, known as DFSS ("**D**esign **F**or **S**ix **S**igma"),features five phases:

- ***D**efine* design goals that are consistent with customer demands and the enterprise strategy.
- ***M**easure* and identify CTQs (characteristics that are **C**ritical **T**o **Q**uality), product capabilities, production process capability and risks.
- ***A**nalyze* to develop and design alternatives
- ***D**esign* an improved alternative, best suited per analysis in the previous step

- *Verify* the design, set up pilot runs, implement the production process and hand it over to the process owner(s).

Implementation roles

Executive leadership from the top level management is the main requirement to ensure the successful implementation of the six sigma concept in any organization. There aare different categories in six sigma:

Master Black Belts: They are identified by champions, act as in-house coaches on Six Sigma. They devote 100% of their time to Six Sigma. They assist champions and guide Black Belts and Green Belts. Apart from statistical tasks, they spend their time on ensuring consistent application of Six Sigma across various functions and departments.

Black Belts: They operate under Master Black Belts to apply Six Sigma methodology to specific projects. They primarily focus on Six Sigma project execution and special leadership with special tasks, whereas Champions and Master Black Belts focus on identifying projects/functions for Six Sigma.

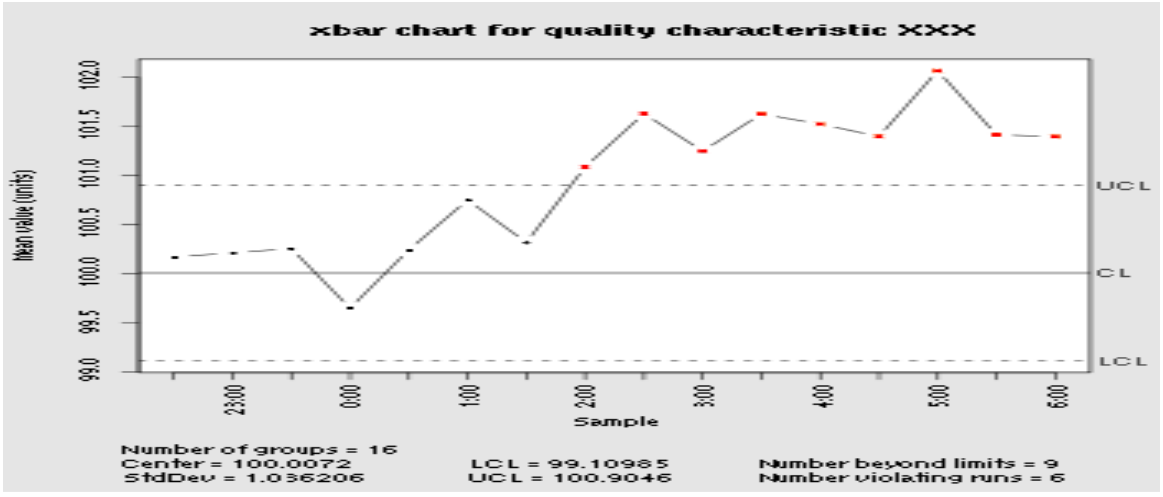
Green Belts: They are the employees who take up Six Sigma implementation along with their other job responsibilities, operating under the guidance of Black Belts.

Some organizations use additional belt colours, such as **Yellow Belts,** for employees who have basic training in Six Sigma tools and generally participate in projects and "**White belts**" for those locally trained in the concepts but do not participate in the project team. "**Orange belts**" are also mentioned to be used for special cases.

Role of the 1.5 sigma shift [5]

But processes usually do not perform as well in the long term as they do in the short term. As a result, the number of sigmas that will fit between the process mean and the nearest specification limit may well drop over time. This is based on the fact that a process that is normally distributed will have 3.4 parts per million beyond a point that is 4.5 standard deviations above or below the mean. So the 3.4 DPMO of a six sigma process in fact corresponds to 4.5 sigma, namely 6 sigma minus the 1.5-sigma shift introduced to account for long-term variations. This allows for the fact that special causes may result in a deterioration in process performance over time, and is designed to prevent underestimation of the defect levels likely to be encountered in real-life operation. The role of the sigma shift is mainly academic. The purpose of the sigma value is as a comparative figure to determine whether a process is improving, deteriorating, stagnant or non-competitive with others in the same business. Six sigma (3.4 DPMO) is not the goal of all processes.

Sigma levels



Control charts are used to maintain 6 sigma quality by signaling when quality professionals should investigate a process to find and eliminate special-cause variation.

The table below gives long-term DPMO values corresponding to various short-term sigma levels.[5]

The figures below assume that the process mean will shift by 1.5 sigma toward the side with the critical specification limit. In other words, they assume that after the initial study determining the short-term sigma level, the long-term C_{pk} value will turn out to be 0.5 less than the short-term C_{pk} value. So, for example, the DPMO figure given for 1 sigma assumes that the long-term process mean will be 0.5 sigma *beyond* the specification limit (C_{pk} = –0.17), rather than 1 sigma within it, as it was in the short-term study (C_{pk} = 0.33). Note that the defect percentages indicate only defects exceeding the specification limit to which the process mean is nearest. Defects beyond the far specification limit are not included in the percentages.

Sigma level	Sigma (with 1.5σ shift)	DPMO	Percent defective	Percentage yield	Short-term C_{pk}	Long-term C_{pk}
1	-0.5	691,462	69%	31%	0.33	–0.17
2	0.5	308,538	31%	69%	0.67	0.17
3	1.5	66,807	6.7%	93.3%	1.00	0.5
4	2.5	6,210	0.62%	99.38%	1.33	0.83

5	3.5	233	0.023%	99.977%	1.67	1.17
6	**4.5**	**3.4**	**0.00034%**	**99.99966%**	**2.00**	**1.5**
7	5.5	0.019	0.0000019%	99.9999981%	2.33	1.83

III. Criticism

a) **Lack of originality:** The six sigma concept is not a new concept, its ust the same wine in the new bottle. It includes what we used to call facilitators.

b) Role of consultants: Critics argue there is overselling of Six Sigma by too great a number of consulting firms, many of which claim expertise in Six Sigma when they have only a rudimentary understanding of the tools and techniques involved .

c) **Potential negative effects:** It has been observed that the claims given by the six sigma concept are in error and are ill informed.

d) **Over-reliance on (statistical) tools:** Six sigma is also found to be a rigid technique and there is an over reliance on the methods and tools given by it.In most cases, more attention is paid to reducing variation and searching for any significant factors and less attention is paid to developing robustness in the first place (which can altogether eliminate the need for reducing variation). The extensive reliance on significance testing and use of multiple regression techniques increases the risk of making commonly-unknown types of statistical errors or mistakes.

e) False beliefs: A possible consequence of Six Sigma's array of P-value misconceptions is the false belief that the probability of a conclusion being in error can be calculated from the data in a single experiment without reference to external evidence or the plausibility of the underlying mechanism.

f) **Lack of systematic documentation:** The experience of leading organizations like GE and Motorola has been evident that most cases are not documented in a systemic or academic manner. They provide no mention of any specific Six Sigma methods that were used to resolve the problems.

Six Sigma has now turned out to be a very big industry in its own right and has become an enormous 'brand' in the world of corporate development. Six Sigma began in 1986 but today, twenty-something years on, it is used as an all-encompassing business performance methodology, all over the world, in organizations as diverse as local government departments, prisons, hospitals, the armed forces, banks, and multi-nationals corporations.

It is said that many ordinary businesses actually operate at between three and two and sigma performance. This equates to between approximately 66,800 and 308,500 defects per million operations, (which incidentally is also generally considered to be an unsustainable level of customer satisfaction - ie., the business is likely to be in decline, or about to head that way. An 'operation' is not limited to the manufacturing processes - an 'operation' can be any process critical to customer satisfaction. It is not restricted to engineering and production - Six Sigma potentially covers all sorts of service-related activities. What matters is that the operation is identified as being strategically critical and relevant to strategy and customer satisfaction.

A measurement of four sigma equates to approximately 6,200 DPMO, or around 99.4% perfection. This would arguably be an acceptable level of quality in certain types of business, for instance a roadside cafe, but a 99.4% success rate is obviously an unacceptable level of quality in other types of business, for example, passenger aircraft maintenance.

A measurement of five sigma equates to just 233 defects per million opportunities, equivalent to a 99.98% perfection rate, and arguably acceptable to many businesses, although absolutely still not good enough for the aircraft industry.

Here's a simplified one-to-six sigma conversion scale:

one to six sigma conversion table[5]

'Long Term Yield' (basically the percentage of successful outputs or operations) %	**Defects Per Million Opportunities (DPMO)**	**'Processs Sigma'**
99.99966	3.4	6
99.98	233	5
99.4	6,210	4
93.3	66,807	3
69.1	308,538	2
30.9	691,462	1

, 'seven sigma' would equate to about 2 defects per 100 million.

Six Sigma is very flexible and it continues to evolve and is difficult to describe. Perhaps the most objective way of looking at Six Sigma is to recognise that the Six Sigma methodology essentially provides a framework, and importantly a strongly branded corporate initiative, for an organization to:

- Train its people to focus on key performance areas
- Understand where the organization wants to go (its strategy, related to its market-place)
- Understand the services that the organization's customers need most
- Understand and better organize main business processes that deliver these customer requirements
- Measure (in considerable detail) and improve the effectiveness of these processes.

IV. large organizations that have adopted six sigma

Now with the revolutionary evolution, many organizations have started using six sigma concept. The following companies claim to have successfully implemented Six Sigma in some form or another:

Apple Computer, Bank of USA, Boeing, Sony, US Army, US Air Force, United Technologies, Microsoft, NASA, Pentagon, Amazon.com, Bank of America, Bank of Montreal, Caterpillar Inc. , Convergys, Dell, Delphi Corporation, DHL, Deutsche Telekom, DuPont, Eastman Kodak Company, Ford Motor Company, LG Group, Merrill Lynch, Motorola, PepsiCo, Samsung Group, Siemens AG, The McGraw-Hill Companies, Toshiba, United States Army, United States Marine Corps, United States Navy, Vodafone, Whirlpool, Wipro, General Electric, Genpact, GlaxoSmithKline, HCL Technologies, Heinz Co. , HSBC Group, Intel .

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