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Six Sigma Beyond Quality: A Concept of Management

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ABSTRACT

Six Sigma was developed by Motorola in the mid-1980s. The essence of Six Sigma is to stop variations in quality at the earliest possible point by attacking variation during design of products and processes and to create a culture that demands perfection.

The concept of Six Sigma is as a much-needed management program that has the highest impact on the bottom-line financials. The key focus of all Six Sigma programs is to optimize overall results at the business, operations, and process level within a company. The Six Sigma Breakthrough Strategy provides the tools to achieve the goal – 3.4 defects per million opportunities, through a highly focused system of problem solving. Six Sigma has a disciplined approach covering five phases: define, measure, analyze, improve, and control. The work of Six Sigma is led by the right people selected and trained in the Six Sigma methodology and establishes infrastructure – Master Black Belts, Black Belts, and Green Belts. The object of these training efforts is to have every employee make improvements in their work processes. What distinguishes Six Sigma from TQM is that each Six Sigma's work team with solving a specific problem has a clear goal tied a financial incentive.

When companies embark on Six Sigma quality programs, the object of technical viewpoint is to reduce the process variance and the objective of managerial or customer viewpoint being cost-effective is to adjust the process to the target value such as employee training in statistical problem-solving methods and techniques. That is why the Six Sigma long-term process is allowed to be off centering with 1.5 sigma shift to minimize the number of setups or tool changeovers.

Keywords: Six Sigma, off-centering, quality management.

1. Introduction

Quality engineers had advocated statistical process control, process capability and meeting requirements for years. They might conclude that the Six Sigma methodology is nothing new in quality. Six Sigma is neither new nor rocket science. It is a collection of tools for problem solving that will lead to economic benefits, value added to business, and globally competitive positions. Six Sigma is not just a modification of the old engineering idea of three sigma quality levels; it is entirely new way to manage an organization. Thus, Six Sigma is not primarily a technical program; it is a much-needed management program that has the highest impact on the bottom-line financials and customer satisfaction.

2. What Is Six Sigma

Six Sigma is not only a business improvement approach, but also a comprehensive quality and management program. It analyzes the root causes of business problems and solving them in delivering product, service, and relationship quality that customers value and reward. It is designed to achieve different yet complementary results at the business, operations, and process level within a company[1]. Success at each level associated with short-term and long-term performance goals is defined as the extent of improvement in the organization's quality and profitability as Table 1[4].

2.1. The basic concept of Six Sigma

The concept of Six Sigma is a disciplined, quantitative approach for improvement of defined metrics in manufacturing, service or financial processes. The Six Sigma approach drives the overall processes of selecting the right projects based on their potential to improve performance metrics. This also drives processes that identify and train the right people to get the business results. The heart of the Six Sigma approach is a method summarized by a disciplined process of five-phase improvement cycle: Define, Measure, Analyze, Improve, and Control(DMAIC)[3][6][7].

Define–Clearly define problems related to the business or critical to customer satisfaction and the metrics with their baseline and entitlement levels. Critical to quality(CTQ) factors essential for customer satisfaction are correlated with the overall business process at issue. Establish the project charters, identify the required resources, and obtain the leadership approvals to maximize project. In preparation for this phase, the training consists of a review of process mapping techniques and orientation to online tools available to support teams.

Table 1: A View of Six Sigma From an Organizational Perspective

Organization					
Strata	Goals		Vision		
	Long-term	Short-term	Strategy	Tactics	Tools
Business	Benchmark as best in class within five years from baseline period	Attain entitlement performance within two years from baseline period	Utilize Six Sigma to achieve business goals	Develop deployment and compensation plan	Metrics tracking and reporting system
Operations	Improve at 78% per year for all Six Sigma metrics	Attain entitlement rate of improvement for key metrics	Acquire Six Sigma human resource capacity	Define Six Sigma project selection criteria	Six Sigma project tracking and reporting system
Process	3.4 DPMO for the CTQs related to all processes	Attain entitlement capability for the CTQs related to key processes	Build Six Sigma human resource capability	Apply Six Sigma breakthrough strategy to all projects	Six Sigma breakthrough technologies and software

Source: Mikel J. Harry, "Abatement Of Business Risk IS Key To Six Sigma" Quality Progress, July 2000.

Measure–Establish base level measures of defects inherent in the existing process and define customer expectations to determine "out of specification" conditions or unacceptable performance. Gather preliminary data to evaluate current performance. Training for this phase includes basic probability and statistics, statistical analysis software, and measurement analysis.

Analyze–Analyze the preliminary data to document current performance or baseline process capability. Examine potential variables affecting the outcome and identify the most significant root causes. Develop a prioritized list of factors influencing the desired outcome. Tools used for this phase include multivariate analysis, test for normality, ANOVA, correlation, and regression.

Improve–Seek the optimal solution. Develop and test a plan of action for implementing and confirming the solution. Modify the process to significant reduce the defect levels or variability. Measure outcome to determine whether the revised method produces results within customer expectations. Additional statistical methods include design of experiments and multiple linear regression to support the final analysis of the problem and to test the proposed solutions.

Control–Once the desired improvements have been made, implement the ongoing measures to keep the problem from recurring and to ensure the improvements are sustained. Control charting techniques are used as the basis for developing these measures.

When these five steps are completely for all key processes within a company, breakthrough improvement occurs in economics and customer satisfaction. Although improved quality and efficiency are immediately by-products of Six Sigma, the purpose of Six Sigma is about improving profitability. Six Sigma leads to long-term payoffs both in quality and financial terms[8].

2.2. Origin of Six Sigma

In the mid-1980s, Motorola was being consistently beaten in the competitive marketplace by foreign firms. Motorola observed that Japanese products were of much higher quality at a lower cost than was supposed by traditional optimal quality level curves. Bill Smith, a reliability engineer at Motorola, was studying the correlation between a product's life and the frequencies of repair during the manufacturing process. He concluded that a much higher level of internal quality was required. His holistic view is "reliability" measured by mean time of failure and "quality" measured by process variability and defect rates. It was the Six Sigma quality objective. Bob Galvin, chairman of Motorola, agreed with his new supposition of the importance of setting Six Sigma as a quality goal.

The initial Six Sigma umbrella consists of statistical process control(SPC), advanced diagnostic tools(ADT), planned experimentation(PE), and design for manufacture (product capability and product complexity) as quality was linked to business performance, accomplishing quality through projects. While Motorola's design margin had been 25 percent(4σ), the disparity between actual reliability and the expected reliability at final test could be indicated by increased product complexity and deviations of the process mean from the target value, arriving at a value of 1.5 sigma. When a process mean that could not be maintained exactly on target deviated from target, the traditional three-sigma process produced large numbers of parts that exceed specifications. It was major contribution to break the three-sigma quality tradition. This breaking with the old idea of statistical control was the recognition of the role of complexity which dramatically increases the number of opportunities for defects.

With absorbing the Japanese optimal quality level, Motorola recognized that

–the costs of poor quality were far larger than was predicted;

–focusing on quality improvement of performance measures as a companywide effort;

–establishing a both moving toward quality improvement and low-cost solutions simultaneous system;

–shifting the focus of quality improvement from product attributes to operational procedures;

–developing a dynamic model in which customer needs for quality depends on their willingness to pay for these improvement;

–focusing on preventing error at the source, thereby dramatically reducing appraisal costs.

If the product was assembled error free, the product rarely failed during the early use by the consumer. Thus, Motorola was finding that best-in-class manufacturers were making products that required no repair or rework during the manufacturing process[11, p.30].

In 1988, Motorola won the Malcolm Baldrige National Quality Award. As other companies studied its success, Motorola was learning to create a deeper strategy with specific tactics and tools to accelerate Six Sigma and to achieve total customer satisfaction. It included a description of different competence levels in the Six Sigma methods. Motorola adopted the terms "Green Belts, Black Belts and Master Black Belts."

Green Belts(GB) are employee with some training in Six Sigma techniques. They must complete the required training and two projects to achieve certification. They must also complete one additional project and eight hours of post-certification training each year. Black Belts(BB) are team leader to implement the Six Sigma methodology in projects of business related. They act as technical and cultural change agents for quality and responsible for applying leadership skills in Six Sigma projects. They coach Green Belts on their projects. Master Black Belts(MBB) train, mentor and develop Six Sigma tools and are full-time teachers of the Six Sigma process. They help with the most difficult projects and problem. The object of these training efforts is to have every employee make improvements in their work processes[3].

2.3. Why Six Sigma is not TQM

Six Sigma performance metrics established directly measure the improvement in cost, quality, yield, and capacity. Contrary to some total quality management(TQM) initiatives, there is no difference between Six Sigma and TQM. Six Sigma does employ some of tools and techniques of improvement achieved through the many TQM efforts. Both Six Sigma and TQM focus on the importance of top down leadership and continuous quality improvement that is critical to long-term business success. The TQM plan-do-study-act cycle is not fundamentally different than the Six Sigma define-measure-analyze- improve-control cycle[10].

But there are critical differences that explain why Six Sigma is succeeding where TQM failed. The primary difference is management. TQM produced only broad guidelines for management to follow but Six Sigma was created by some of America's most gifted CEOs like Motorola's Bob Galvin, AlliedSignal's Larry Bossidy, and GE's Jack Welch. Six Sigma is based on designated teams(people power) that focus solely on solving a specific problem(process power). What distinguishes Six Sigma from TQM is that each team has a clear goal. Employees benefit because companies usually tie a financial incentive to a team's goal. There exists a single goal kept by these people that made their business successful.

The following is a number of shortcomings for quality specialty of TQM.

–They emphasized quality but ignored other critical business issues.

–They tended to lack of integration. A "quality council" made up of delegates rather than of the core management team.

–They suffered from all of suboptimization problems within the organization.

–They required no financial figures both to select projects and to evaluate success and tracked performance metrics rigorously.

–They focused on minimum acceptance requirements and standards rather than striving for ever-increasing levels of performance.

–They developed no infrastructure for releasing resources to improve business processes.

The CEOs could realize what the problems were and create an approach that fixed them. Six Sigma addresses them all[12, p.101].

–Bottom-line results created.
–Senior management leadership is active.
–A disciplined approach(DMAIC) is used.
–Rapid project completion(3-6 months).
–Clearly defines success.
–Infrastructure(MBB,BB,GB) established.
–Customers and processes are the focus.
–A sound statistical approach is used.

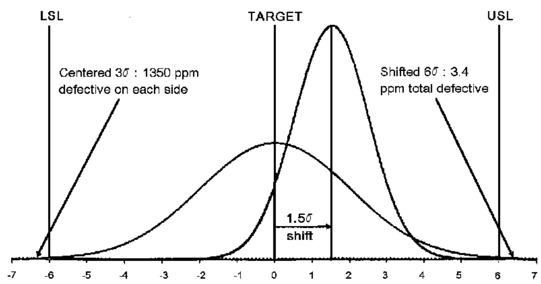
3. The Economics of Six Sigma Quality

When companies launched Six Sigma quality projects, is their object to reduce the process variance or to have very few defects? From technical viewpoint, it is in terms of the process variance so that the half tolerance of the product characteristic is equal to six times the standard deviation. From the managerial or customer viewpoint, the quality standards can be described in terms of defects per million. If the goal is to reduce the number of defects, it does not center the process[13].

3.1. The 1.5 Sigma shift

The short-term understanding of Six Sigma is for a single CTQ characteristic; in other words, when the process is centered. The long-term perspective after the influence of process factors such as material change, tool wear, and machine setup, is discovered that the 3.4 ppm(errors or defects per million opportunity) in terms of a defect rate is due to a 1.5 sigma shift for the process mean. In other words, the process is allowed to be off-centered to minimize the number of setups or tool changeovers. Stated differently, until Six Sigma became popular, all quality calculations were based on the standard normal distribution without any "adjustment"[5][9]. Six Sigma modifies the short-term performance by "adjusting" the process mean by 1.5 standard deviation before making a rational estimate of the long-term process capability. In addition, adjusting the process to move the process mean closer to the target value is relatively easier than improving the process to reduce the variance[13]. That is, if the capability of a CTQ characteristic is $\pm 6.0\sigma$ in the short-term, the long-term capability may be approximated as 4.5σ as Figure 1[11].

Fingure 1 : Six-Sigma Process with +1.5σ Shift vs. Centered Three-Sigma Process



Source : Ramberg , J.S., "Six Sigma : Fad or Fundamental ? " Quality Digest, May 2000

While the traditional normal model oversimplifies reality, it makes things look much better to the business than they look to customers. For example, in a production, oversimplifications include estimating sigma based on short-term variation, making measurement on new product, not considering shipping and handling effects, failing to consider environment to which product will be exposed, and incomplete understanding of the customers' requirements. The 1.5 sigma shift is simply a correction that illustrates factors not included in the model of reality.

3.2. Achievement of quality level

The idea of "opportunities for defects" is referred to the sum of all CTQs. It is to reduce quality problems to a metric called defects per opportunities(DPO), which is called to defects per million opportunities(DPMO). The DPMO metric can be transformed into an equivalent Z value, alsoknown as sigma capability. The desired quality level expressed by DPMO might be achieved through several combinations of off-centering and process standard deviations. Table 2 provides an comparison between off-centering quality levels, sigma capability, and the resulting DPMO[2][13].

Table 2: Number of Defectives (Parts per Million) For Specified Off-Centering of the Process And Quality Levels

Off-centering quality level	3 σ	3.5 σ	4 σ	4.5 σ	5 σ	5.5 σ	6 σ
0	2,700	465	63	6.8	0.57	0.034	0.002
0.25 σ	3,577	666	99	12.8	1.02	0.1056	0.0063
0.5 σ	6,440	1,382	236	32	**3.4**	0.71	0.019
0.75 σ	12,288	3,011	665	88.5	11	1.02	0.1
1 σ	22,832	6,433	1,350	233	32	**3.4**	0.39
1.25 σ	40,111	12,201	3,000	577	88.5	10.7	1
1.5 σ	66,803	22,800	6,200	1,350	233	32	**3.4**
1.75 σ	105,601	40,100	12,200	3,000	577	88.4	11
2 σ	158,700	66,800	22,800	6,200	1,300	233	32

Source: Pandu R. Tadikamalla, "The Confusion Over Six Sigma Quality," *Quality Progress*, November 1994

In his article "Six Sigma's Missing Link," author Robert J. Gnibus offers two excel spreadsheets for the positive and negative side of normal distribution curve. He calculated the Z value or sigma capability directly using NORMSINV(probability). His calculation for examining the examples assumes long-term data, which results in a shift from long-term to short-term of +1.5 sigma for the final answer.

For example, from Table 2, a four-sigma quality program with 1.5 sigma off-centering results in only 6200 defects per million.

6,200/1,000,000 defects, or
993,800/1,000,000 defect free, or
NORMSINV(9,938/10,000)

The sigma rating would equal NORMSINV(0.9938)+1.5 = 2.5+1.5 = 4.

In addition, a quality level of 3.4 DPMO can be achieved in at least three different ways as Table 2 shown:

–a five sigma quality program with 0.5 sigma off-centering.
–a 5.5 sigma quality program with 1 sigma off-centering.
–a six sigma quality program with 1.5 sigma off-centering.

The costs associated with adjusting the process mean determine how to achieve a specified quality level or a given number of DPMO. Being cost-effective is essential.

The process sigma calculation complicated depends on many factors: multiple customer requirements, multiple opportunities for defects within one product or service, multiple process levels, and non-normal data distributions. If the process centering can be not effectively controlled, it is allowed on each side of the specification to make process shifts. Six Sigma methods provide just as this way to deal with each of these complications.

4. Conclusion

While the essence of Six Sigma quality is the reduction of variability, management must get involved in the inevitability of variability in all kinds of business processes, set achievable measures on a good target to track a long-term commitment to attain the Six Sigma quality. Quality progress on a breakthrough project is in cost reductions, reduced scrap, increased production capacity, faster turnaround, quicker time to market, more profitable sales, faster delivery, and increased customer loyalty. As these accomplishments realized, the company grows closer to its customers and shift customer needs to develop the marketing mechanisms. Six Sigma quality system positions the company for greater customer satisfaction, profitability, and competitiveness.

As CEOs of leading U.S. firms praise the accomplishments of their Six Sigma initiatives, it is not a series of brilliant insights or bold gambles, but a fanatical attention to detail. Six Sigma will have a lasting impact on quality management because it has focused much-needed management attention on quality.

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