Six Sigma

Writing Project—Spring 2007

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I. Introduction to Six Sigma

Six Sigma is a quality control initiative that uses statistical applications to reduce defects in all aspects of business processes. It is used in many corporations throughout the United States and world as a means to reduce costs and increase productivity, thus driving improvements in both revenues and profit. Six Sigma merges quantitative data and business process knowledge in a cohesive manner allowing for overall business improvement.

In 2003, Xerox's CEO and Chairman, Anne Mulcahy, implemented Lean Six Sigma business processes as a strategic plank in the company's "return to greatness," as a way to bring about major change to the company After four years, Ms. Mulcahy remains "convinced that Xerox Lean Six Sigma is a way to rebuild value in our company because it is about substance, not form; it's about discipline and infrastructure so projects can produce business results." (Xerox. 2005) This past summer, I had the opportunity to learn firsthand the importance of Six Sigma in a corporate environment as I interned at the Xerox Corporation in Rochester, NY. As part of the internship, I completed a 15-hour online course on the overall methodology and tools used in Six Sigma, and I was awarded my "Yellow Belt" at the completion of the course. Xerox's implementation combines two approaches: Lean and Six Sigma. Lean focuses on speed and lower costs, reducing waste (identifying non-value added steps and causes of delay) and increasing process speed. Six Sigma at Xerox focuses on improving performance to customer requirements and needs, utilizing the DMAIC (discussed in detail later) process combined with various tools to eliminate variation. My focus will be limited to Six Sigma; Lean concepts are not further investigated in depth.

Many of the tools used in the Six Sigma process are not new statistical concepts. The quality control methods are presented in a cohesive disciplined manner that enables adoption by company employees. It is not limited only to the manufacturing processes where its first implementation is often applied, but also is used for critical business processes as well. Corporation-wide deployment will often encompass processes, for example, within the areas of sales and marketing, operations, customer communications, information technologies, administration, and others.

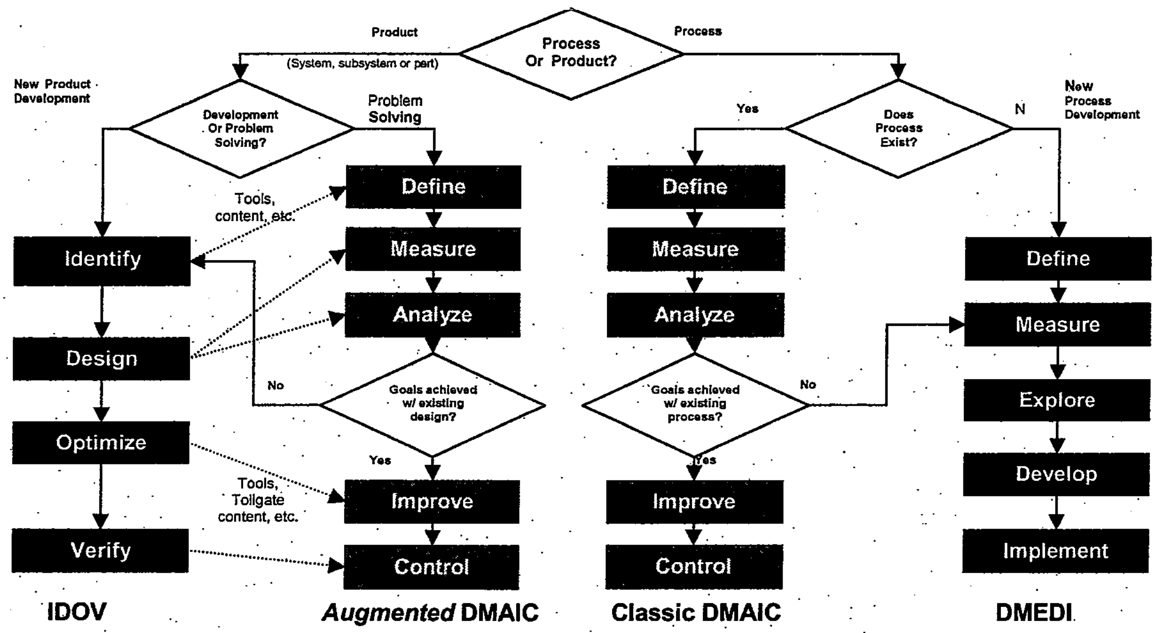
II. History of Six Sigma

Six Sigma was originally developed by Motorola in 1986 to improve business processes by reducing the number of nonconformities. Bill Smith, the father of Six Sigma, was a veteran engineer at Motorola who "introduced the concept of Six Sigma in response to increasing complaints from the field sales force about warranty claims. It was a new method for standardizing the way defects are counted, with Six Sigma being near perfection." (McCarty, 2004 p.1) Motorola merged together the concepts of process capability and product specifications. The measurement of defects per million opportunities (DPMO) was developed as a key metric in the Six Sigma process. Companies such as Xerox and Motorola strive for a 3.4 DPMO (or six sigma level) in their manufacturing and corporate-wide processes, although higher levels of defects are often acceptable as tradeoffs between benefits and costs are assessed for particular processes. (Folaron, 2003)

III. Methodology

The fundamental tool used for process improvement is the five-step DMAIC process. DMAIC stands for Define, Measure, Analyze, Improve and Control, and each step will be described more fully below. This is the preferred method used to identify and implement improvements to already existing processes. It may also be utilized to improvements in existing product design. In addition, the five-step DMEDI (Define, Measure, Explore, Develop and Implement) process is utilized when there is no existing process and a new process must be designed to meet customer requirements. In new product development, Design for Six Sigma (DFSS) or Identify-Define-Optimize-Verify

(IDOV) is used. The following chart is a decisioning tool utilized at Xerox to determine the appropriate approach to utilize at the onset of a project initiative. As noted above, it is important to first identify whether the focus is product or process improvement, followed by an assessment as to whether a product or process currently exists.



DMAIC: To initiate the DMAIC process, a first draft of the project charter must be received by the project team from the sponsor of the project. The project charter documents the problem to be addressed by the project team, identifies the anticipated goals and business impacts, and outlines the scope, timeline and resources (including team) required. At the end of each of the five steps of DMAIC, a "tollgate" is often held with the sponsor and team to ensure the project is advancing appropriately and alignment is maintained.

The first phase in Six Sigma methodology is the *define* phase. This is the critical phase where problems in the process are identified and agreement is reached as to the goals of the project. The process begins with the review of the initial project charter and adjustments are made to scope, timing and resources. Once this is completed, more research is needed to validate the problem statements and goals of the charter. This begins by focusing on the Voice of the Customer (VOC). One of the differences between

Six Sigma and other quality control initiatives is this focus on the customer. A great deal of time and money will be spent to determine what the cares and needs are of the customer upfront in the *define* phase; later improvement will be directly assessed against the customer needs. The VOC can be collected via multiple methods, including interviews, focus groups and by conducting surveys. The data collected should be used to determine what is critical to the customers. In many cases, Pareto charts are used to help and identify the central issues. Voice of Business (VOB) is also important and can be gathered through interviews with key internal stakeholders to determine internal considerations such as costs, timing, etc. Another critical tool utilized during this phase is a SIPOC (Suppliers/Inputs/Process/Outputs/Customers) diagram that provides an initial overview of the process being addressed, defining its scope from start to end of the process. Once the *define* phase has been finished, an updated project charter will be completed for management approval. Throughout the DMAIC process the project charter is constantly updated by the members of the team.

The second phase of DMAIC is the *measure* phase. This is where the company will work to fully understand the current state of the process and collect reliable data on key metrics such as process speed, quality and cost. Often, existing metrics are not sufficient for measurement of the process and plans must be made to find alternate ways of gathering data. Data collected during the *measure* phase provides an initial baselining of the process to assess improvements later in the DMAIC process. This data will help enable the company to determine the underlying areas within a specific process that are causing problems. Basic descriptive statistics such as histograms, scatterplots and measures of central tendency are used to examine the data. Critical at this point is detailing of a high level process map that ensures a common understanding of the current process.

A commonly used tool to analyze the data within the six sigma framework is the measurement system analysis (MSA) to assess repeatability and reproducibility (Gage R&R). MSA is used to make sure that differences in the data are due to actual differences in what is being measured and not due to variation in the method of measurement. It examines the contribution of the variation within the measurement process to the overall variability of the process. "Experience shows that 30% to 50% of measurement systems are not capable of accurately or precisely measuring the desired metric." (George, Rowlands, Price, and Maxey, 2005, p.87) Initial data is collected and analyzed to assess the variation in the measurement system by quantifying the total variability of the process using the following formula:

Total variation = repeatability + reproducibility + part variation + within-part variation

Or

$$TV = \sqrt{EV^2 + AV^2 + PV^2 + WIV^2}$$

$$R\&R = \sqrt{EV^2 + AV^2}$$

where EV = equipment variation or repeatability

AV = appraiser or operator variation or reproducibility

PV = part variation

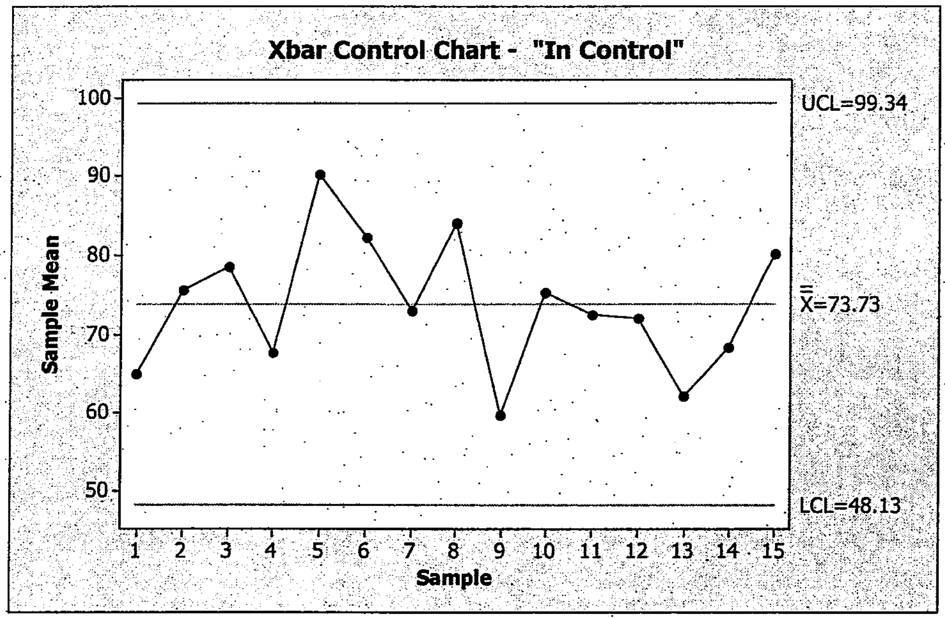
WIV = within-part variation

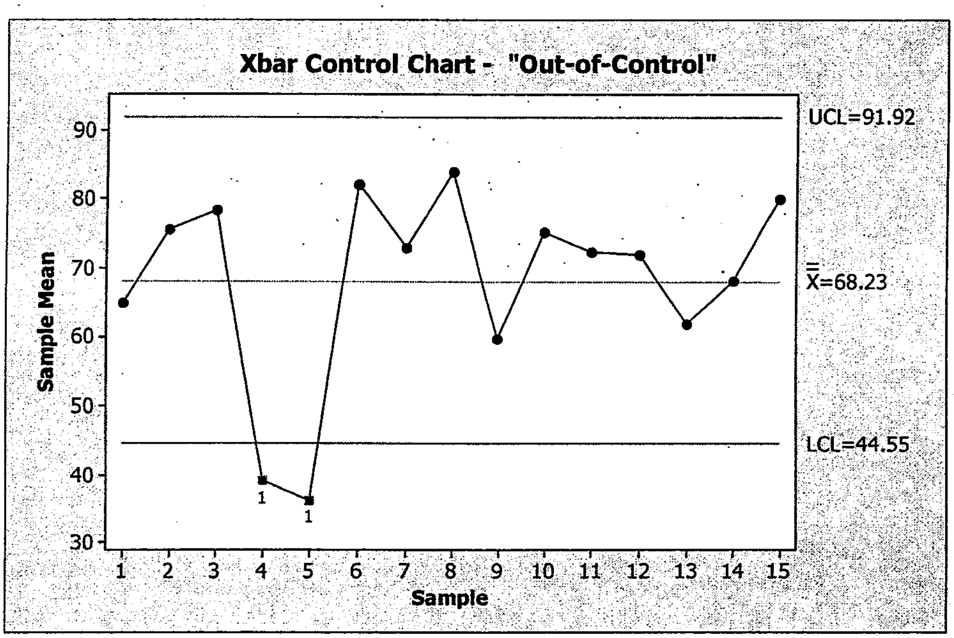
These four components of variation are then compared to the total variation to determine what is causing the underlying variation of the process. If R&R variation is less than 10% of total variation, then the measurement system is considered acceptable. If R&R variation is between 10% and 30% of total variation then it should only be used for non-critical applications. If, however, R&R variation is greater than 30% of total variation, then the measurement system must be corrected before it can used. (Gupta 2005, p.215).

Once the MSA has been completed and the measurement tools are considered to be statistically sound, then additional process data can be collected to determine the process capability. Both C_p and C_{pk} are used to measure the process capability.

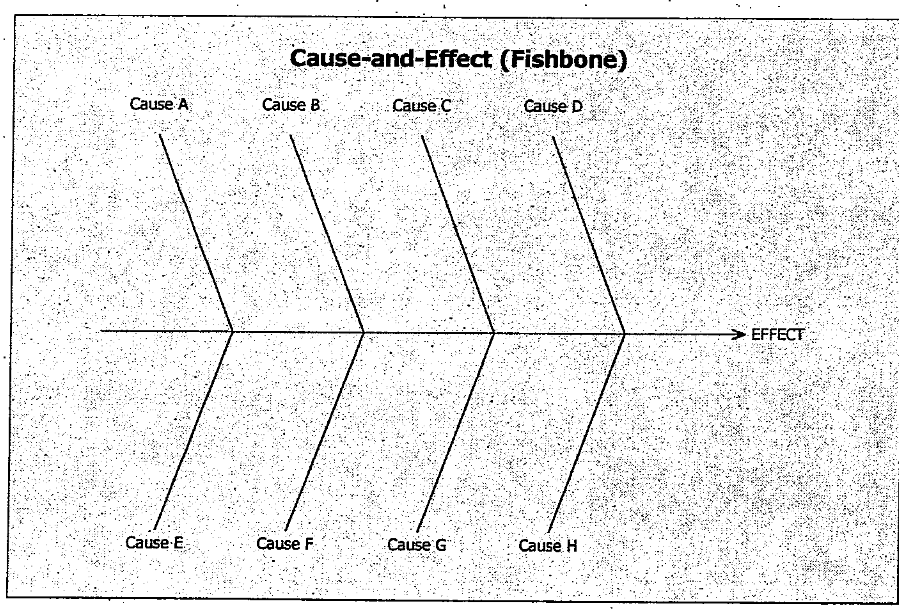
$C_p = \dfrac{USL - LSL}{6\sigma}$, where USL is the upper specification limit and LSL is the lower specification limit of the process. (Note: C_{pk} is similar but adjusted for process shifts.) C_p is useful in comparing the process outputs to what is actually desired by management and customers. It is desired that all of a company's needs are capable of satisfying the process specifications.

In a manufacturing process, this is the phase where control charting is very useful for determining where the process can be improved and how to minimize waste. Below are examples of both in-control and out-of-control processes based on x-bar control charts.





The *analyze* phase of Six Sigma is focused on finding root causes of the process that are directly tied to overall project goals using the data collected in the measure phase. This is defined as the transfer function Y = f(x, x, x...) where Y is the output (dependent) variable and the x's represents the input or process (independent) variables. The purpose of the *analyze* phase is to identify and validate the key critical x's that impact the ultimate output, and therefore, if addressed will yield the desired improvements in the process. A cause-and-effect analysis is run to determine the potential root causes of the problems of the associated process. Brainstorming sessions are often held to help provide a focus for management.



Additional data analysis must be undertaken to validate that a potential root cause indeed has a direct cause and effect. Often the variation in a process is very difficult to understand as there are many variables involved. Multivariable data analysis is a tool used to partition variation into smaller components so that the company can separately address each component of variation rather than attempt to address them all at once. Often charts are created so that managers can easily visualize the differing sources of variation.

Regression analysis is also performed during the *analyze* phase of Six Sigma when necessary. After root causes have been identified, a regression model can help quantify the cause-and-effect relationship among the indicator variables. Regression analysis can also be used for prediction based on the historical data collected. Additional tools utilized in the *analyze* phase include: hypothesis testing, ANOVA, and 5-Why analysis.

Once the sources of variation have been identified, analyzed and prioritized, the *improve* phase is begun to reduce variation. To begin the improve phase, managers must brainstorm potential solutions and determine what would be the best solutions to the problems within the process. After solutions have been identified and implemented, the new process must be tested to determine if statistically significant improvements have been achieved and if goals proposed in the *define* phase are attainable. Comparisons are made by using both parametric and nonparametric tests. In addition, process improvements often require small pilot experiments to test possible ideas for implementation. At the conclusion of this phase the process should be considered stable and also meet customer needs.

The fifth and final phase of the Six Sigma methodology is the *control* phase. Once the process has been improved and is able to meet the original specifications of the project charter, the process is ready for full implementation. A "process owner" who is accountable for implementation and ongoing assessment of the improved process must be identified at this point. Direct linkage to the process owner's performance assessment plan is key as well, as it must be important to the individual's success. A system for monitoring the implemented solution, called a process control plan, is created. The process control plan incorporates ways to monitor and control the new process. This is also a critical phase because it ensures that your newly redesigned process is actually being implemented correctly, and that sustainability of gains in improvement can be assured. A new data collection plan is also put into place so that a company can monitor the process in the future based on quantitative metrics.

IV. Implementation

The implementation of Six Sigma in a company is a huge undertaking. Six Sigma aims to increase the overall effectiveness of an organization by reducing both waste and costs. It is a complete business process focused on reinventing companies. In order for success, the company cannot solely rely on the statistics of the process, but rather a full understanding of the Six Sigma methodology. Culture change is often required, and therefore, a Six Sigma initiative must begin with the support of upper level management. In most of the successful companies, there must be pressure and support from the most senior individuals in order for middle management and all employees to believe in the process. In the article, "12 Requirements for Six Sigma Success," Sandholm states that "top management support has been noticeable in organizations that implemented Six Sigma with great success, such as Motorola and General Electric." (Sandholm and Sorqvist 2002, p.17). All employees must somehow be brought into the Six Sigma culture.

After a company decides to implement a Six Sigma strategy into their company, managers must decide who is going to initially deploy the process. Companies will often hire outside consultants to train their employees in the practices of Six Sigma. These outside consultants help to transition the corporation. Resources are identified within each company that are dedicated solely to focus on Six Sigma implementation, including: Deployment Managers, Master Black Belts and Black Belts. Deployment managers champion the overall deployment of Six Sigma within a division or business unit of the corporation, ensuring plans for project identification and selection, training, resources, and communications are in place. Master Black Belts are generally responsible for training delivery, coaching of other belts, and working on high-level, cross-functional projects. Black Belts are the primary resource for leading the DMAIC projects. Black Belts receive extensive training (which can last up to 12 weeks) in statistics, problem solving and project management. (Sheehy 2002, p.7-9)

In addition to the Black Belts, there are also Green Belts within the company. They are trained on a subset of the tools and are also critical to the Six Sigma process as they work on and lead smaller projects or are assigned to help Black Belts to work on larger projects addressing areas of concern within the company.

A case in study regarding resource implementation is Xerox. A critical plank to their success has been the commitment to resources. After four years (on a base of 58,000 employees worldwide), over 800 Black Belts have achieved certification or are in some phase of training or coaching, over 3700 Green Belts have been trained, 40,000 Yellow Belts have been trained, and 600 DFLSS (Design for Lean Six Sigma) Black Belts and Green Belts have been trained in first waves. Their target is to have 1-3% of all employees trained as Black Belts and/or Green Belts. New employees must complete their Yellow Belt training within 6 weeks of their hire. In addition, a team of roughly 30 full-time deployment managers is maintained.

V. Criticism

While Six Sigma is designed to improve overall quality within a company, as cited earlier, key strategic elements must be present to ensure its successful implementation. If not present, the expectation of significant gains in quality improvement is not always achievable. Issues with the implementation of the Six Sigma methodology often arise regarding how to incorporate the processes throughout the entire organization and its culture. Some companies are looking for a quick-fix to bigger issues and are not able to dedicate nor sustain the time and/or resources that are necessary for Six Sigma to be effectively implemented. As the definition of what Six Sigma is varies, individuals without full training and the reinforcement of management buy-in can get lost in the many terms and ideas that it encompasses. The many tools that are used in Six Sigma are not new to statistical quality control -- the process in which they are implemented is what makes Six Sigma unique. While there is a general roadmap for success, each company needs to vary implementation to meet its needs and requirements within their own culture. Companies who misunderstand this idea and expect miraculous results from a process that they do not fully understand, and without the surrounding strategic elements, will not be successful with the implementation of Six Sigma.

VI. Conclusions

Six Sigma methodology is a way for businesses to work toward an overall improved process through thoughtful deployment of common statistical practices that all employees will understand. It allows companies to address issues of quality ensuring a better overall experience for both its customers and employees. Critical to the successful implementation of Six Sigma within a company are key elements. Calcutt (2001 p.305) states that these key elements include:

(1) A focus on processes and, therefore, a focus on customers
(2) An interest in process performance, at all levels, and a company-wide measure of process capability (in many cases DPMO).
(3) Blackbelts, Master Blackbelts, and Greenbelts
(4) Blackbelt projects that focus on the reduction of defects and/or the reduction of variation
(5) Management by fact.
(6) Blackbelt projects are related to business objectives
(7) Senior management have clear vision, value and objectives
(8) Senior management objectives are deployed right down to the shop floor and the customer contact levels

Quality control initiatives have been implemented with demonstrated success in many companies. They are often used to foster growth and productivity while increasing revenue. Six Sigma uses many basic statistical tools to enable data driven decisions and drive process improvement within a company.

VII. References

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