Six Sigma Method and Its Applications in Project Management

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Introduction

This paper provides an overview of the Six Sigma management method and the integration of project management and Six Sigma strategies. Applications of Six Sigma in project management include effective management of Six Sigma projects, as well as using the disciplined Six Sigma method in managing projects in organizations. This important topic has not yet received the attention it deserves in project management conferences and publications.

The term Six Sigma was used originally used by Motorola in the early 1980s to describe the overall management approach summarized in this paper. The Six Sigma method has since been successfully used by many other organizations including General Electric, Boeing, DuPont, Toshiba, Seagate, and many others. It is rapidly becoming a major force driving the strategy of many leading organizations.

The Six Sigma method focuses on understanding customers' requirements better and eliminating defects and waste. These objectives are achieved through profound knowledge of statistics, engineering and project management, as well as the underlying processes and systems. Objective of Six Sigma projects are to improve the organization's products, services and processes across various disciplines, including production, marketing, finance, and administration.

The Benefits of Six Sigma include better understanding of changing customer requirements, improvement of quality and delivery, reduction of waste, reduction of cost, development of robust products and processes, continuous improvement, and enhancement of competitive position.

The paper presents the main elements of effective selection and management of Six Sigma projects, aimed at business systems improvement. It clarifies the roles of various participants in achieving the bottom-line financial and technical objectives of each Six Sigma project, and the importance of evaluating the success of these projects.

The paper presents applications of the disciplined Six Sigma method in project management. It proposes that projects are conducted under the quadruple constraints of scope, time, cost, and quality, and shows the implications of applying the Six Sigma method in each of these four areas. It also specifies potential pitfalls of careless application of the Six Sigma method in project management.

Involvement in Six Sigma projects is becoming an important career path requirement in many organizations. Understanding the Six Sigma management method and the integration of project management and Six Sigma strategies can provide project professionals important opportunities to support their organizations Six Sigma project leadership, mentoring, and training needs.

Overview of the Six Sigma Method

The Six Sigma management method philosophy focuses on better understanding of customer requirements, improving business systems throughout the organization, and enhancing the organization's financial performance. It is used to improve the organization's products, services and processes across various disciplines, including production, product development, marketing, sales, finance, and administration. It is achieved through understanding the underlying processes, and reducing or eliminating defects and waste. The Six Sigma management method integrates profound knowledge of statistics, engineering, process, and project management.

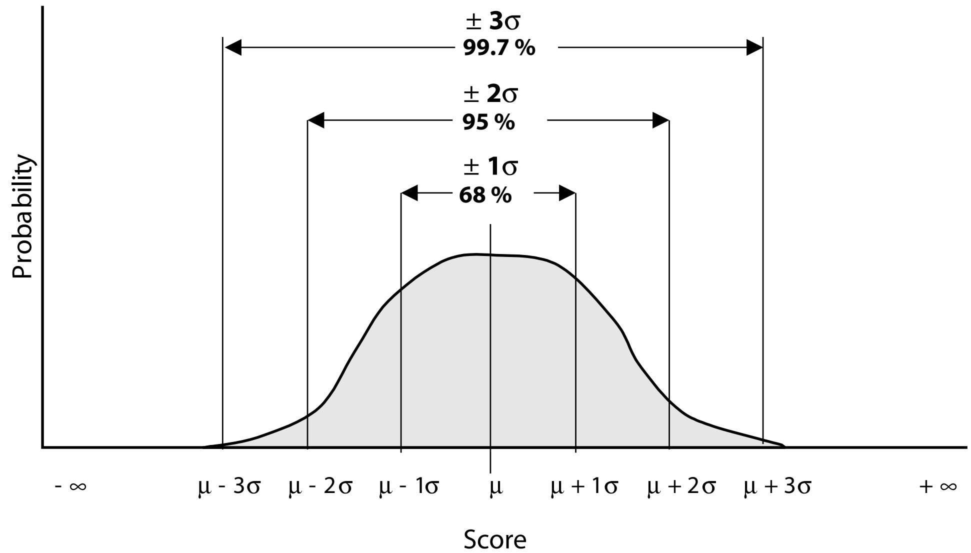
The term was coined by Motorola in the early 1980s and used by others since then: GE, Boeing, DuPont, Toshiba, Seagate, and many others. The results have been very impressive.

The benefits of Six Sigma include better understanding of changing customer requirements, improvement of quality and delivery, reduction of waste, reduction of cost, development of robust products and processes, enhancement of competitive position, and sustained competitive advantage through continuous improvement of all business systems in the organization.

Six Sigma and Other Quality Initiatives: The Six Sigma management method is more comprehensive than prior process improvement initiatives such as Total Quality Management (TQM) and Continuous Quality Improvement (CQI). The Six Sigma management method includes measured financial results, uses additional, more advanced data analysis tools, and uses project management methodology and tools.

TQM and CQI and their basic quality control tools were appropriate in the 1980s and early 1990s. As implemented, these initiatives aimed at what was often referred to as the "low hanging fruit." Many organizations had such improvement opportunities. The problems that were originally targeted had occurred as a result of historical developments in these organizations. Certain activities were performed in these organizations for specific reasons, and

Exhibit 1



continued to be performed well after their value diminished or disappeared completely. To improve these processes and eliminate these non value-added activities, TQM (or CQI) aimed primarily at empowering individuals and teams to discuss these issues within their own area or across organizational boundaries. The tools of TQM (or CQI) were heavily oriented toward brainstorming, communications and simple data analysis.

However, by the mid 1990s, most organizations that adopted TQM (or CQI) ran out of "low hanging fruit." The problems that needed to be tackled next, did not lend themselves easily to simple data analysis, and required more investment in resources and time than what was viewed as appropriate involvement in TQM (or CQI) process improvement activities. Significant business results were no longer achievable through TQM (or CQI) initiatives, and organizational commitment to these initiatives came to an end.

In the meantime, the Six Sigma management method continued to grow and thrive, from its initial development by Motorola in the mid 1980s, to its widely advertised adoption by GE in 1992, to its adoption by many other powerful organizations since that time. The Six Sigma method appeared to be the next logical step, since it cured the deficiencies of TQM (or CQI) by including measurements of financial results, using additional, more advanced data analysis tools, and using project selection, evaluation, and relevant project management methodology and tools.

The clearly measured financial results ensured sustained commitment to the initiative by senior executives. Application of advanced data analysis tools, such as quality function deployment (QFD), design of experiments (DOE), failure mode and effect analysis (FMEA), regression analysis, in addition to the basic analysis tools of TQM (or CQI), focused on customer concerns and ensured problems were properly analyzed. The Six Sigma project-driven organizational structure and the use of appropriate project selection, evaluation and project management tools, ensured that Six Sigma projects reached their objectives effectively.

As such, we can summarize the Six Sigma management method as follows:

Six Sigma = TQM (or CQI) + Stronger Customer Focus + Additional Data Analysis Tools + Financial Results + Project Management

Theoretical Basis of Six Sigma

The German mathematician Carl Friedrich Gauss (1777–1855) developed the normal distribution. This distribution was found to apply to many physical and process characteristics. It is often used as an underlying assumption for measurements on many processes.

The Normal Distribution indicates that a process has many observations around its mean (average) and fewer observations as we get further and further away from the mean. It indicates that about 68% of the observations in a process would be within one standard deviation (one sigma) in each direction from the mean, about 95% of the observations in a process would be within two standard deviation (two sigma) in each direction from the mean, about 99.7% of the observations in a process would be within three standard deviation (thee sigma) in each direction from the mean (Exhibit 1).

Statistical Quality Control Theory was developed by Dr. Walter A. Shewhart of Bell Labs. He published it in his 1931 book, *Economic Control of Quality of Manufactured Product,* and further elaborated on it in his book, *Statistical Method from the Viewpoint of Quality Control*, published in 1939, with the editorial assistance of W. Edwards Deming.

Quality control charts, developed by Dr. W. A. Shewhart, provide a view of the process characteristic of interest over time. Observations, or sample means are plotted on the chart. The Centerline (CL) of the chart is the mean of the data, the Upper Control Limit (UCL) is set three standard deviations above the mean, and the Lower Control Limit (LCL) is set three standard deviations below the mean. These values are calculated from observations on the process itself. Therefore, the quality control chart represents the voice of the process (Exhibit 2).

Exhibit 2

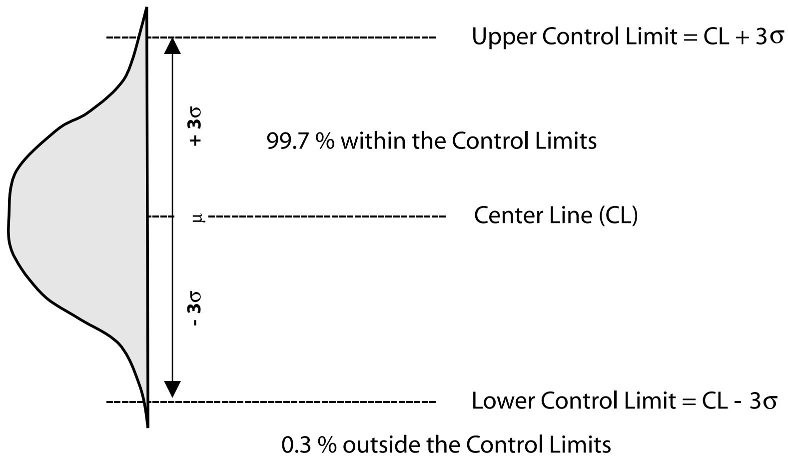
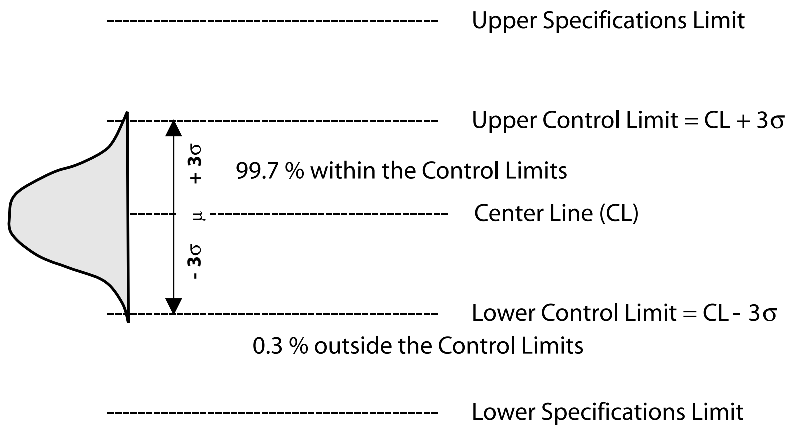


Exhibit 3



Since the Upper Control Limit (UCL) is set three standard deviations (three sigma) above the mean, and the Lower Control Limit (LCL) is set three standard deviations (three sigma) below the mean, the distance between UCL and LCL is six standard deviations. When the process is in statistical control, the process is said to be stable, predictable, consistent, or in control. In this case, approximately 99.7% of the plotted points will be within the control limits. The remaining 0.3% (or 0.003, or 3 per thousand) of the plotted points will be outside the control limits: 0.15% above the UCL and 0.15% below the LCL.

The quality control chart allows differentiation between common cause variation and special cause variation.

Common Cause variation is caused by the total system, including planning, design, equipment selection, maintenance, personnel selection, training, etc. It can be referred to as system, random, or normal variation. Since management designs the system and has the authority to change it, management is generally considered to be responsible for system variation. Common cause variation is indicated when all plotted points fall within the control limits, with no trends, runs, cycles, or special patterns.

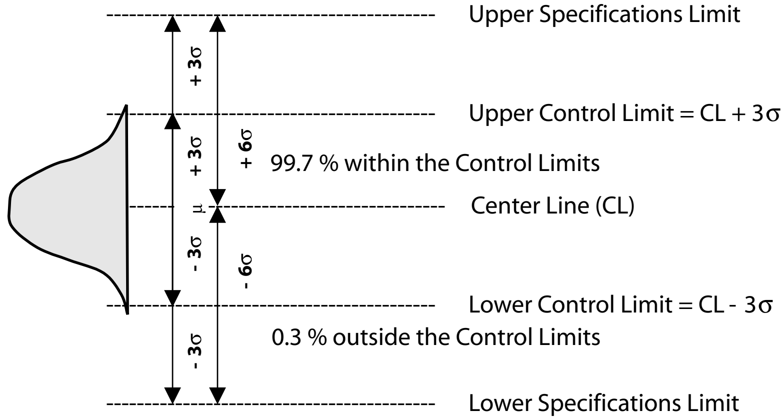
Special Cause variation is caused by causes outside the system, including human error, accidents, equipment breakdown, etc. It can be referred to as assignable variation. Since this variation indicates a condition different than the way the system or process operates normally, it is generally considered to be the responsibility of the individual worker. Special cause variation is indicated when a plotted point, or points, fall outside the control limits, or when all plotted points fall within the control limits but have trends, runs, cycles, and/or special patterns.

Dr. W. Edwards Deming (1900–1993) developed the management theory based on continuous quality improvement, popularized the use of Statistical Quality Control methods and had a great deal of impact on Japanese and American Quality and competitive position. The Deming Medal, given out annually by the Deming Prize Committee of the Japanese Union of Scientists and Engineers (JUSE) continues to be the highest honor in quality in Japan.

Dr. Genichi Taguchi developed the Loss Function, emphasizing the importance of having process output as close to the target (or nominal dimension) desired by the customer. He further stressed the importance of reduction in variation, and popularized the use of experimental design in manufacturing processes.

Certain customer requirements may be stated in terms of a Target Value (or Nominal Dimension), an Upper Specifications Limit, and a Lower Specifications Limit. These represent the voice of the

Exhibit 4



customer. Integrating the voice of the process with voice of the customer, we obtain the graph shown in Exhibit 3.

The control chart represents the voice of the process. It indicates whether the process is stable and predictable or not. However, it does not indicate whether the process is acceptable, adequate or capable of meeting specifications and customer requirements.

Process capability studies combine the voice of the process with the voice of the customer, engineer, designer or manager. Widely used measures of process capability include the Process Capability Index (C_p) and the Capability Index with Correction (k) for non-centrality (C_{pk})

If the Upper Specifications Limit, and the Lower Specifications Limit were six standard deviations (six sigma) each away from the mean, then pure six sigma would be achieved with a theoretical maximum of 2 defective parts per billion (Exhibit 4).

Six sigma practice convention is based on allowing the mean to move ±1.5 standard deviations (1.5 sigma), leaving 4.5 standard deviations (4.5 sigma) between the process mean and the closest Specifications Limit. This results in a maximum of 3.4 defective parts per million. Further, practice convention indicates that the maximum is 3.4 defects per million opportunities (DPMO). This provides less stringent requirement, since the same part (or component, or item) may have multiple defect opportunities. Thus, six sigma is achieved when the process generates no more than 3.4 defects per million opportunities. This is still a very heroic target for many organizations, processes and projects.

Six Sigma Projects

Quality Improvement Projects: Dr. J. M. Juran suggested that quality could be accomplished project by project and in no other way. He developed important quality management concepts, tools, and had a great deal of impact on Japanese and American Quality and competitive position.

Six Sigma Projects: The Six Sigma method adopted the idea of project-driven business system improvement. A Six Sigma project is targeted to have a duration of three to six months. The expected financial impact per Six Sigma project is $100,000 to $500,000 with a target of $175,000. If a business system improvement project exceeds these targets, it would be broken down to smaller projects to fit these criteria.

Six Sigma projects are elected carefully and evaluated rigorously to ensure that they achieve their financial objectives.

Six Sigma Project Management Tools include project identification and selection methods, basic team development approaches, basic project planning and control tools, and post project evaluation methods.

Organizational Structure

The Six Sigma Project Management Structure is centered on the Black Belt. This is the Six Sigma project leader.

The Black Belt works on Six Sigma projects full time, and may lead four to six projects per year. Black Belts are carefully selected and receive extensive training in Six Sigma methodology. In some organizations, this assignment lasts about two years and constitutes an important milestone in the career path of the individual assigned to that role.

Green Belts are specialized team members and work on Six Sigma projects on a part time basis. Green Belts receive training in Six Sigma methodology. Some organizations refer to all team members on a Six Sigma project as Green Belts and provide them with the relevant training in Six Sigma methodology.

Project Team Members work on Six Sigma projects on a part time basis.

Master Black Belts are experienced Black Belts and act as technical resources to Black Belts, Green Belts, and other tem members.

Champions are the organization's strategic and tactical business leaders. They approve Six Sigma project charters, review project progress, and ensure success of Six Sigma projects in their business units.

Six Sigma Project Methodology

The generally accepted methodology for managing Six Sigma projects includes the following phases:

Define: The objectives and scope of the project are defined. Relevant information about the process and customer are collected.

Measure: Data on the current situation and process metrics are collected.

Analyze: Collected data are analyzed to find the root cause(s) of the problem.

Improve: Solution(s) to the problem are developed and implemented.

Control: The implemented solution(s) are evaluated and the mechanisms are implemented to hold the gains, which may include standardization.

This methodology has often been referred to by its initials: DMAIC. Some are suggesting an additional initial phase that might be called Recognize. This would occur before the Define phase, and is intended to ensure that appropriate opportunities and problems are properly recognized.

Professionals in the project management field may find a valuable opportunity to contribute to enhancing the Six Sigma project management methodology.

Quadruple Constraints of Project Management

Each project has four general objectives, which are also the four constraints of the project:

Scope: Each project is undertaken to complete a certain scope of work.

Time: Each project needs to be completed in a given amount of time, or by a given target date.

Cost: Each project needs to be completed within a given cost or budget, in monetary or effort terms.

Quality: Each project needs to satisfy specified quality levels, or specifications.

There is a strong relationship between scope and quality. Similarly, there is a strong relationship between time and cost. A project can be completed faster for an additional cost. There is also a strong relationship between quality and cost. Poor quality increases total project cost due to rework and other failure costs. Indeed, there are strong relationships among various project parameters. We separate them to study and analyze each of them carefully, while recognizing that each project parameter is related to other project parameters.

Project Management Applications

The application of the Six Sigma method in project management may have the appearance of an impossible dream.

Scope: Applying Six Sigma in scope management would enforce clear definition of requirements and rigorous change management. The risk may be that this application could inhibit innovation.

Time: Applying Six Sigma in time management would require better scheduling, immovable deadlines, careful progress monitoring, risk management, and enforces better resource management. The risk may be that this application could encourage additional schedule padding and increase buffers.

Cost: Applying Six Sigma in cost management would imply absolute budgets, enforce careful cost controls, and effective forecasting. The risk may be that this application could encourage additional budget padding and increase reserves.

Quality: Applying Six Sigma in scope management would enforce unyielding quality targets, careful selection of standards, and realistic assessment of capabilities. The risk may be that this application could result in hiding problems and assigning blame for defects to others.

Can Six Sigma be achieved in project management? There is at least one example that it has already been achieved: Most organizations went through the Year 2000 remediation project (Y2K Project). Millions of projects were successfully accomplished with very few failures.

Imagine if we could approach each project as if it were a Y2K project: Clear objectives, immovable deadlines, unwavering support by senior executives, sufficient resources, strong desire to succeed in view of the high risk of failure, and overall organizational alignment to ensure success of each project. These almost sound as the critical success factors for project management. Perhaps we can dream a little!

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