The SIX SIGMA HANDBOOK

THIRD EDITION

A Complete Guide for Green Belts, Black Belts, and Managers at All Levels

- *Full coverage of the management systems and statistical tools essential to Six Sigma implementation*
- *Expanded information on Lean Six Sigma integrated throughout*
- *Real-world Excel and Minitab examples*

THOMAS PYZDEK & PAUL KELLER

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Preface

The Six Sigma approach has been adopted by a growing majority of the Fortune 500 companies, as well as many small and mid-sized organizations. Its application in both for-profit and non-profit organizations is a reflection of its broad objectives in improving processes at the core of an organization's mission. While initial perceptions often focus on quality improvements, successful deployments look beyond to profitability, sustainability, and long term growth.

As these words are written, what is now the longest and deepest recession since the Great Depression has upset a record period of global growth and expansion. During the expansion, Six Sigma proved a valuable strategy to meet the strong market demand for products and services through capacity and productivity improvements and focus on reduced time to market. Where competitive pressures from emerging global markets were especially strong, service improvement, cost of delivery and cost to manufacture strategies proved successful. This recession has been labeled a "game changer" by more than a few economists, upsetting supply chains and forcing entire industries to rethink their business model. There will certainly be many organizational casualties of this recession in a wide array of industries. Yet, there will undoubtedly be survivors, who will gain market share and become the pillars of this new century. Those organizations will focus first on core businesses, ensuring continued market share and profitability. They will apply structured Six Sigma efforts directed at key cost, quality and service objectives. This will demand a fresh look at their internal processes, from the eyes of their customer base, to maximize value and reduce cost. They will then seize new opportunities, left open by the weakened competition. Their ability to expand into these markets will depend on diligent planning and successful execution, hallmarks of a Six Sigma approach. The simplicity and adaptability of the DMAIC approach will provide the means towards achieving a strengthened competitive advantage.

The key benefits we sought to achieve in this third revision include:

- Clearly define the management responsibilities and actions necessary for successful deployment.
- Fully incorporate Lean, Problem Solving and Statistical techniques within the Six Sigma methodology.
- Create an easy to use reference guide written in easy-to-understand language.

- Provide examples using Minitab, Excel and other software to demonstrate application of problem-solving and statistical techniques in a variety of settings.
- Emphasize service applications of Six Sigma, since all organizations are at their core a service organization.

We direct this revision toward executive-level management, or those who aspire to those positions, as a means to discover the potential of a properly designed and deployed Lean Six Sigma effort. Operational-level practitioners will also value the detailed deployment plans, and structured approach to the tools and methods used by project teams. The core principles and tools of Lean, with the statistical validation, root-cause analysis and DMAIC problem-solving methodology, are integrated throughout this handbook. The presentation of this third edition is based on the implementation strategy for Six Sigma: initial topics cover the management responsibilities, with subsequent topics addressing the details of the Lean Six Sigma DMAIC problem solving methodology.

We hope you enjoy it.

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CHAPTER 1

Building the Responsive Six Sigma Organization

What Is Six Sigma?

Six Sigma is a rigorous, focused, and highly effective implementation of proven quality principles and techniques. Incorporating elements from the work of many quality pioneers, Six Sigma aims for virtually error-free business performance. Sigma, σ, is a letter in the Greek alphabet used by statisticians to measure the variability in any process. A company's performance is measured by the sigma level of their business processes. Traditionally companies accepted three or four sigma performance levels as the norm, despite the fact that these processes created between 6,200 and 67,000 problems per million opportunities! The Six Sigma standard of 3.4 problems-per-million opportunities* is a response to the increasing expectations of customers and the increased complexity of modern products and processes.

Despite its name, Six Sigma's magic isn't in statistical or high-tech razzle-dazzle. Six Sigma relies on tried and true methods that have been used for decades. By some measures, Six Sigma discards a great deal of the complexity that characterized Total Quality Management (TQM). Six Sigma takes a handful of proven methods and trains a small cadre of in-house technical leaders, known as Six Sigma Black Belts, to a high level of proficiency in the application of these techniques. To be sure, some of the methods Black Belts use are highly advanced, including up-to-date computer technology. But the tools are applied within a simple performance improvement model known as Define-Measure-Analyze-Improve-Control, or DMAIC. DMAIC is described briefly as follows:

- *D* Define the goals of the improvement activity.
- *M* Measure the existing system.
- *A* Analyze the system to identify ways to eliminate the gap between the current performance of the system or process and the desired goal.
- *I* Improve the system.
- *C* Control the new system.

*Statisticians note: The area under the normal curve beyond Six Sigma is 2 parts-per-billion. In calculating failure rates for Six Sigma purposes we assume that performance experienced by customers over the life of the product or process will be much worse than internal short-term estimates predict. To compensate, a "shift" of 1.5 sigma from the mean is added before calculating estimated long-term failures. Thus, you will find 3.4 parts-per-million as the area beyond 4.5 sigma on the normal curve.

Why Six Sigma?

When a Japanese firm took over a Motorola factory that manufactured Quasar television sets in the United States in the 1970s, they promptly set about making drastic changes in the way the factory operated. Under Japanese management, the factory was soon producing TV sets with 1/20th as many defects as they had produced under Motorola's management. They did this using the same workforce, technology, and designs, and did it while lowering costs, making it clear that the problem was Motorola's management. It took a while but, eventually, even Motorola's own executives finally admitted "Our quality stinks" (Main, 1994).

It took until nearly the mid-1980s before Motorola figured out what to do about it. Bob Galvin, Motorola's CEO at the time, started the company on the quality path known as Six Sigma and became a business icon largely as a result of what he accomplished in quality at Motorola. Using Six Sigma Motorola became known as a quality leader and a profit leader. After Motorola won the Malcolm Baldrige National Quality Award in 1988 the secret of their success became public knowledge and the Six Sigma revolution was on. Today it's hotter than ever. Even though Motorola has been struggling for the past few years, companies such as GE and AlliedSignal have taken up the Six Sigma banner and used it to lead themselves to new levels of customer service and productivity.

It would be a mistake to think that Six Sigma is about quality in the traditional sense. Quality, defined traditionally as conformance to internal requirements, has little to do with Six Sigma. Six Sigma focuses on helping the organization make more money by improving customer value and efficiency. To link this objective of Six Sigma with quality requires a new definition of quality: the value added by a productive endeavor. This quality may be expressed as potential quality and actual quality. Potential quality is the known maximum possible value added per unit of input. Actual quality is the current value added per unit of input. The difference between potential and actual quality is waste. Six Sigma focuses on improving quality (i.e., reducing waste) by helping organizations produce products and services better, faster, and cheaper. There is a direct correspondence between quality levels and "sigma levels" of performance. For example, a process operating at Six Sigma will fail to meet requirements about 3 times per million transactions. The typical company operates at roughly four sigma, equivalent to approximately 6,210 errors per million transactions. Six Sigma focuses on customer requirements, defect prevention, cycle time reduction, and cost savings. Thus, the benefits from Six Sigma go straight to the bottom line. Unlike mindless cost-cutting programs which also reduce value and quality, Six Sigma identifies and eliminates costs which provide no value to customers: waste costs.

For non-Six Sigma companies, these costs are often extremely high. Companies operating at three or four sigma typically spend between 25 and 40 percent of their revenues fixing problems. This is known as the cost of quality, or more accurately the cost of poor quality. Companies operating at Six Sigma typically spend less than 5 percent of their revenues fixing problems (Fig. 1.1). COPQ values shown in Fig. 1.1 are at the lower end of the range of results reported in various studies. The dollar cost of this gap can be huge. General Electric estimated that the gap between three or four sigma and Six Sigma was costing them between $8 billion and $12 billion per year.

One reason why costs are directly related to sigma levels is very simple: sigma levels are a measure of error rates, and it costs money to correct errors. Figure 1.2 shows the relationship between errors and sigma levels. Note that the error rate drops exponentially as the sigma level goes up, and that this correlates well to the empirical cost data shown in Fig. 1.1. Also note that the errors are shown as errors per million opportunities, not as