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SIX SIGMA CERTIFICATION

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TRAINING MANUAL

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Unit 1: Introduction to Six Sigma

Chapter 1: What is Six Sigma?

Six Sigma, or 6σ, is both a methodology for process improvement and a statistical concept that seeks to define the variation inherent in any process. The overarching premise of Six Sigma is that variation in a process leads to opportunities for error; opportunities for error then lead to risks for product defects. Product defects—whether in a tangible process or a service—lead to poor customer satisfaction. By working to reduce variation and opportunities for error, the Six Sigma method ultimately reduces process costs and increases customer satisfaction.

Data Driven Processes and Decisions

In applying Six Sigma, organizations, teams, and project managers seek to implement strategies that are based on measurement and metrics. Historically, many business leaders made decisions based on intuition or experience. Despite some common beliefs in various industries, Six Sigma doesn't remove the need for experienced leadership, and it doesn't negate the importance of intuition in any process. Instead, Six Sigma works alongside other skills, experience, and knowledge to provide a mathematical and statistical foundation for decision making. Experience might say a process isn't working; statistics prove that to be true. Intuition might guide a project manager to believe a certain change could improve output; Six Sigma tools help organizations validate those assumptions.

Decision Making Without Six Sigma

Without proper measurement and analysis, decision making processes in an organization might proceed as follows:

- Someone with clout in the organization has a good idea or takes interest in someone else's idea.
- Based on past experience or knowledge, decision makers within an organization believe the idea will be successful.
- The idea is implemented; sometimes it is implemented in beta mode so expenses and risks are minimized.
- The success of the idea is weighed after implementation; problems are addressed after they impact products or processes in some way in the present or the future.

What is beta testing?

Beta testing is the act of implementing a new idea, system, or product with a select group of people or processes in as controlled an environment as possible. After beta testers identify potential problems and those problems are corrected, the idea, system, or product can be rolled out to the entire population of customers, employees, or processes. The purpose of beta testing is to reduce the risks and costs inherent in launching an unproven product or system to a widespread audience.

Beta testing is sometimes used in a Six Sigma approach, but the idea or change in question goes through rigorous analysis and data testing first. The disadvantage of launching ideas into beta—or to an entire population--without going through a Six Sigma methodology is that organizations can experience unintended consequences from changes, spend money on ideas that don't end up working out as planned, and impact customer perceptions through trial-and-error periods rife with opportunities for error. In many cases, organizations that don't rely on data make improvements without first understanding the true gain or loss associated with the change. Some improvements may appear to work on the surface without actually impacting customer satisfaction or profit in a positive way.

Decision Making With Six Sigma

The Six Sigma method lets organizations identify problems, validate assumptions, brainstorm solutions, and plan for implementation to avoid unintended consequences. By applying tools such as statistical analysis and process mapping to problems and solutions, teams can visualize and predict outcomes with a high-level of accuracy, letting leadership make decisions with less financial risk.

Six Sigma methods don't offer a crystal ball for organizations, though. Even with expert use of the tools described in this book, problems can arise for teams as they implement and maintain solutions. That's why Six Sigma also provides for control methods: once teams implement changes, they can control processes for a fraction of the cost of traditional quality methods by continuing the use of Six Sigma tools and statistics.

Defining 6σ

Six Sigma as a methodology for process improvement involves a vast library of tools and knowledge, which will be covered throughout this book. In this section, we'll begin to define the statistical concept represented by 6σ.

At the most basic definition, 6σ is a statistical representation for what many experts call a "perfect" process. Technically, in a Six Sigma process, there are only 3.4 defects per million opportunities. In percentages, that means 99.99966 percent of the products from a Six Sigma process are without defect. At just one sigma level below—5σ, or 99.97 percent accuracy--processes experience 233 errors per million opportunities. In simpler terms, there are going to be many more unsatisfied customers.

Real World Examples

According to the National Oceanic and Atmospheric Administration, air traffic controllers in the United States handle 28,537 commercial flights daily.[1] In a year, that is approximately 10.416 million flights. Based on a Five Sigma air traffic control process, errors of some type occur in the process for handling approximately 2,426 flights every year. With a Six Sigma process, that risk drops to 35.41 errors.

The CDC reports that approximately 51.4 million surgeries are performed in the United States in a given year.[2] Based on a 99.97 accuracy rate, doctors would make errors in 11,976 surgeries each year, or 230 surgeries a week. At Six Sigma, that drops to approximately 174 errors a year for the entire country, or

[1] "Air Traffic," Science on a Sphere, National Oceanic and Atmospheric Administration. http://sos.noaa.gov/Datasets/dataset.php?id=44

[2] "Inpatient Surgery," FastStats, Centers for Disease Control and Prevention. http://www.cdc.gov/nchs/fastats/inpatient-surgery.htm

just over 3 errors each week. At Five Sigma, patients are 68 times more likely to experience an error at the hands of medical providers.

While most people accept a 99.9 percent accuracy rate in even the most critical services on a daily basis, the above examples highlight how wide the gap between Six Sigma and Five Sigma really is. For organizations, it's not just about the error rate—it's also about the costs associated with each error.

Consider an example based on Amazon shipments. On Cyber Monday in 2013, Amazon processed a whopping 36.8 million orders.[3] Let's assume that each order error costs the company an average of $35 (a very conservative number, considering that costs might include return shipping, labor to answer customer phone calls or emails, and labor and shipping to right a wrong order).

Cost of Amazon Order Errors, 5σ			
Total Orders	**Errors**	**Average Cost per Error**	**Total Cost of Errors**
36.8 million	8574.4	$35	$300,104.00

Cost of Amazon Order Errors, 6σ			
Total Orders	**Errors**	**Average Cost per Error**	**Total Cost of Errors**
36.8 million	125.12	$35	$4,379.20

For this example, the cost difference in sigma levels is still over $295,000 for the Cyber Monday business.

For most organizations, Six Sigma processes are a constant target. Achieving and maintaining Six Sigma "perfection" is difficult and requires continuous process improvement. But even advancing from lower levels of sigma to a Four or Five Sigma process has a drastic impact on costs and customer satisfaction. Let's look at the Amazon Cyber Monday example at other levels of sigma.

Sigma Level	Defects per Million Opportunities	Estimated Cyber Monday Defects	Total Cost (at $35 estimate per error)
One Sigma	690,000	25,392,000	$888,720,000
Two Sigma	308,000	11,334,400	$396,704,000
Three Sigma	66,800	2,458,240	$86,038,400
Four Sigma	6,200	228,160	$7,985,600
Five Sigma	233	8,574.4	$300,104

[3] Siegel, Jacob, "Amazon sold 426 items per second during its 'best ever' holiday season," Boy Genius Reports, Dec. 26, 2013. http://bgr.com/2013/12/26/amazon-holiday-season-sales-2013/

Six Sigma	3.4	125.12	$4,379

At very low levels of sigma, any process is unlikely to be profitable. The higher the sigma level, the better the bottom line is likely to be.

Calculating Sigma Level

Organizations and teams can calculate the sigma level of a product or process using the equation below:

$$\left(\frac{\text{\# of opportunities - \# of defects)}}{\text{\# of opportunities}} \right) \text{X } 100 = \text{Yield}$$

Consider a process in a marketing department that distributes letters to customers or prospects. For the purposes of the example, imagine that the process inserts 30,000 letters in preaddressed envelopes each day. In a given business week, the process outputs 150,000 letters.

The marketing department begins receiving complaints that people are receiving letters in envelopes that are addressed to them, but the letters inside are addressed to or relevant to someone else. The marketing department randomly selects 1,000 letters from the next week's batch and finds that 5 of them have errors. Applying that to the total amount, they estimate that as many as 750 letters could have errors. (Sampling and extrapolation are covered in depth in the advanced chapters on statistics.)

The letter process has 150,000 opportunities for error each week and an estimated 750 defects.

((150,000 – 750) / 150,000) * 100 = a yield of 99.5

Look up a yield of 99.5 in the abridged Sigma table below and you'll see the process described above is currently between 4 and 4.1 sigma.

Yield %	DPMO	Sigma Level
99.7450	2,550	4.3
99.6540	3,460	4.2
99.5340	4,550	4.1
99.3790	6,210	4.0
99.1810	8,190	3.9

Sigma Level Is Not a Final Indicator

Sigma levels provide organization with a high-level look at how a process is performing, but comparing sigma levels between multiple processes doesn't always point to the particular process an organization should improve first. Leadership should also consider costs, resources, and the estimated impact of improvements.

For example, consider these processes that might be found in a food processing plant:

Process	**Performance Metric(s)**	**Current Sigma Level**
Attaching a decorative element to food item	Decorative touch is centered on food product and stable so it won't fall off in transit	2.2
Packing product	Product is sealed for freshness	3.1
Shipping of product	Product reaches the right customer in a timely manner	4.3

A glance at sigma levels indicates that the process that attaches the decorative element is in most need of improvement. While that process has the highest rate of defects, leadership within the plant would have to ask themselves: How much does that matter to the customer, and what is the hit to the bottom line?

It's likely that most customers will notice most that the product is sealed for freshness and reaches the right location. Since bad product has to be thrown away, the most expensive errors might be associated with improper sealing during packing. The plant is likely to use resources to improve the packing process before addressing the decorative element issue.

After the packing process is improved, the plant might then consider whether to improve the decorating process or the shipping process. As part of that consideration, the company might conduct customer surveys to reveal that some customers have stopped buying the product because of the decorative element issue. An analyst estimates that the loss of sales related to that issue are costing the company $1,000 a week. Shipping issues are costing the company $500 a week.

Should the company address the costlier issue first? What if you were told that the shipping process could be improved with staff training sessions, while the decorative element issue required an expensive machinery update? Sometimes, organizations have to consider the expense of an improvement. Applying a Six Sigma project to all situations isn't financially lucrative since those improvements take time and money. A Six Sigma culture is about continuous improvement, which means teams consider all options before embarking on the most lucrative improvement measures.

Common Six Sigma Principles

Organizations can impact their sigma level by integrating core principles from the Six Sigma methodology into leadership styles, process management, and improvement endeavors. The principles of Six Sigma, and the tools used to achieve them, are covered in detail in various sections of this book, but some common ideas are introduced below.

Customer-Focused Improvement

In the illustration about the food plant, we saw that the Six Sigma process doesn't just make improvements for the sake of driving up sigma levels. A primary principle of the methodology is a focus on the customer. In Chapter 5, we'll look at the Voice of the Customer (VoC) and ways for establishing what the customer really wants from a product or process. By combining that knowledge with measurements, statistics, and process improvement methods, organizations increase customer satisfaction, ultimately bolstering profits, customer retention, and loyalty.

A detailed understanding of the customer and customer desires not only lets businesses customize product offerings and services, but it also lets organizations:

- Offer additional features customers want and are willing to pay for
- Prioritize product development to meet current needs
- Develop new ideas based on customer feedback
- Understand changing trends in the market
- Identify areas of concern
- Prioritize work on challenges based on how customers perceive various problems or issues
- Test solutions and ideas before investing time and money in them

Value Streams The value stream is the sequence of all items, events, and people required to produce an end result. For example, the value stream for serving a hotdog with ketchup to someone would include:

- A hotdog supplier
- A bun supplier
- A ketchup supplier
- Hotdogs
- Buns
- Ketchup
- A cooking procedure for the hotdog
- A pot
- Tongs
- Someone to do the cooking
- A plate
- Someone to put the hotdog into the bun
- Someone to put the ketchup on the hotdog
- Someone to put the completed hotdog onto a plate
- Someone to serve the hotdog to another

If you combine all of the above processes into a pictorial representation of exactly how these elements become the served hotdog, then you have a value stream map.

The purpose for determining a value stream for a process is that you can identify areas of concern, waste, and improvement. In the above process, are there four different people putting the hotdog together and serving it, or is one person doing all four of those tasks? Is the supplier a single grocery store, or are you shopping for items at various stores and why? Do you get savings benefits to offset the added time spent working with multiple suppliers? These are some examples of the questions you can reveal and answer during value stream mapping.

Continuous Process Improvement

Inherent in the Six Sigma method is *continuous* process improvement. An organization that completely adopts a Six Sigma methodology never stops improving. It identifies and prioritizes areas of opportunity on a continuous basis. Once one area is improved upon, the organization moves on to improving another area. If a process is improved from 4 Sigma to 4.4 Sigma, the organization considers ways to move the sigma level up further. The goal is to move ever closer to the "perfect" level of 99.99966 accuracy for all processes within an organization while maintaining other goals and requirements, such as financial stability, as quickly as possible.

Variation

One of the ways to continuously improve a process is to reduce the variation in the process. Every process contains inherent variation: in a call center with 20 employees, variation will exist in each phone call even if the calls are scripted. Inflection, accents, environmental concerns, and caller moods are just some things that lead to variation in this circumstance. By providing employees with a script or suggested comments for common scenarios, the call center reduces variation to some degree.

Consider another example: A pizzeria. The employees are instructed to use certain amounts of ingredients for each size of pizza. A small gets one cup of cheese; a large gets two cups. The pizzeria owner notes a great deal of variation in how much cheese is on each pizza, and he fears it will lead to inconsistent customer experiences. To reduce variation, he provides employees with two measuring cups: a 1-cup container for small pizzas and a 2-cup container for large pizzas.

The variation is reduced, but it is still present. Some employees pour cheese into the cups and some scoop it. Some fill the cups just to the rim; others let the cheese create a mound above the rim. The owner acts to reduce variation again: he trains all employees to fill the cup over the rim and use a flat spatula to scrape excess cheese off. While variation will still exist due to factors such as air pockets or how cheese settles in the cup, it is greatly reduced, and customers experience more consistent pizzas.

Removing Waste

Remember the hotdog example for value streams? We asked the question: do four different people act to place the hotdog in the bun, put the ketchup on the hotdog, plate the hotdog, and serve it? If so, does the process take more time because the product has to be transferred between four people? Would it be faster to have one person perform all those actions? If so, then we've identified some waste in the process—in this case, waste of conveyance.

Removing waste—items, actions, or people that are unnecessary to the outcome of a process—reduces processing time, opportunities for errors, and overall costs. While waste is a major concern in the Six Sigma methodology, the concept of waste comes from a methodology known as Lean Process Management..

Equipping People

Implementing improved processes is a temporary measure unless organizations equip their employees working with processes to monitor and maintain improvements. In most organizations, process improvement includes a two-pronged approach. First, a process improvement team comprised of project management, methodology experts, and subject-matter experts define, plan, and implement an improvement. That team then equips the employees who work directly with the process daily to control and manage the process in its improved state.

Controlling the Process

Often, Six Sigma improvements address processes that are out of control. Out of control processes meet specific statistical requirements. The goal of improvement is to bring a process back within a state of statistical control. Then, after improvements are implemented, measurements, statistics, and other Six Sigma tools are used to ensure the process remains in control. Part of any continuous improvement process is ensuring such controls are put in place and that the employees who are hands-on with the process on a regular basis know how to use the controls.

Challenges of Six Sigma

Six Sigma is not without its own challenges. As an expansive method that requires commitment to continuous improvement, Six Sigma is often viewed as an expensive or unnecessary process, especially for small or mid-sized organizations. Leadership at Ideal Aerosmith, a manufacturing and engineering company in Minnesota, was skeptical of Six Sigma ideas and the costs associated with implementing them. Despite reservations, the company waded into Six Sigma implementations, eventually seeing worthwhile results after only 18 months. Those results included a production improvement of 25 percent, a 5 percent improvement in profits within the first year, and a 30 percent improvement in timely deliverables.[4]

Some obstacles and challenges that often stand in the way of positive results from Six Sigma include lack of support, resources, or knowledge, poor execution of projects, inconsistent access to valid statistical data, and concerns about using the methodology in new industries.

Lack of Support

Six Sigma requires support and buy-in at all levels of an organization. Leaders and executives must be willing to back initiatives with resources—financial and labor related. Subject-matter experts must be open to sharing information about their processes with project teams, and employees at all levels must embrace the idea of change and improvement and participate in training. Common barriers to support include:

- Leaders that are unfamiliar with or don’t understand the Six Sigma process
- Leaders willing to pursue improvements initially but who lose interest in overseeing and championing projects before they are completed
- Staff that is fearful of change, especially in an environment when change has historically caused negative consequences for employees
- Employees who are resistant to change because they believe improvements might make them obsolete, drastically change their jobs, or make their jobs harder
- Department heads or employees who constantly champion their own processes and needs and are unwilling to enter into big-picture thinking

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[4] Gupta, Praveen and Schultz, Barb, “Six Sigma Success in Small Business,” Quality Digest. http://www.qualitydigest.com/april05/articles/02_article.shtml

Lack of Resources or Knowledge

Lack of resources can be a challenge to Six Sigma initiatives, but they don't have to be a barrier. Lack of knowledge about how to use and implement Six Sigma is one of the first issues small- and mid-sized companies face. Smaller businesses can't always afford to hire dedicated resources to handle continuous process improvement, but the availability of resources and Six Sigma training makes it increasingly possible for organizations to use some of the tools without an expert or to send in-house staff to be certified in Six Sigma.

Poor Project Execution

Companies implementing Six Sigma for the first time, especially in a project environment, often turn away from the entire methodology if the first project or improvement falls flat. Proponents of Six Sigma within any organization really have to hit it out of the ballpark with the first project if leadership and others are on the fence about the methodology. Teams can help avoid poor project performance by taking extreme care to execute every phase of the project correctly. By choosing low-risk, high-reward improvements, teams can also stack the deck in their favor with first-time projects. The only disadvantage with such a tactic is that it can be hard to duplicate the wow factor with subsequent improvements, making it important to remember that long-term implementation and commitment is vital in Six Sigma.

Data Access Issues

Data and analytics issues are a common challenge for organizations of all sizes. Gaining access to consistent and accurate data streams—and applying statistical analysis to that data in an appropriate manner—is difficult. Some data-related challenges include:

- Discovering that an important process metric is not being captured
- The use of manual data processes in many processes
- Automated data processes that capture enormous amounts and create scope challenges
- Data that is skewed due to assumptions, human interaction in the process, or incorrect capture
- Lengthy times between raw data capture and access
- Industry or company compliance rules that make it difficult to gain access to necessary data

Concerns about Using Six Sigma in a Specific Industry

Six Sigma originated in the manufacturing industry and many of the concepts and tools of the methodology are still taught in the context of a factory or industrial environment. Because of this, organizations often discount the methods or believe they will be too difficult to implement in other industries. In reality, Six Sigma can be customized to any industry.

Chapter 2: Six Sigma History and Application

While the roots of Six Sigma are commonly attributed to companies such as Toyota and Motorola, the methodology is actually grounded in concepts that date as far back as the 19^{th} century. Before delving into the history of Six Sigma, it's important to understand the difference between traditional quality programs, such as Total Quality Management, and continuous process improvement methods, such as Six Sigma.

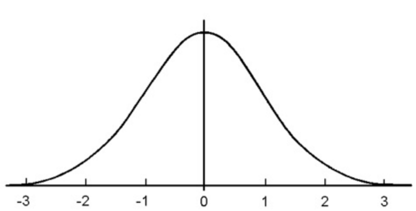
Most modern quality and improvement programs can be traced back to the same roots. Both quality programs and continuous process improvement methods look to achieve goals such as reducing errors and defects, making processes more efficient, improving customer satisfaction, and boosting profits. But quality programs are concerned with achieving a specific goal. The program either runs forever, constantly working toward the same goal, or it achieves the end goal and must be reset for a new goal.

Six Sigma seeks to instill a culture of *continuous* improvement and quality that optimizes performance of an organization from the inside out. It's the cultural element inherent in Six Sigma that lets organizations enact both small and sweeping improvements that drastically impact efficiencies and costs. Six Sigma does work toward individual goals with regard to each project, but the projects are part of the overall culture of improvement that, in practice, is never done. Six Sigma creates safeguards and tactics so that, even after a project is considered complete, controls are in place to ensure progress continues and it is impossible to revert to old ways.

The Development of Statistical Process Control

Six Sigma applies statistics to define, measure, analyze, verify, and control processes. In fact, Six Sigma teams usually use methodologies known as DMAIC or DMADV to accomplish improvements and develop controls for processes. DMAIC stands for Define, Measure, Analyze, Improve, and Control. These are the five phases of a Six Sigma project to improve a process that already exists. When developing a new process, teams use DMADV, which stands for Define, Measure, Analyze, Design, and Verify. Both methods are discussed in Chapter 11, and Unit 3 provides in-depth information about each phase of DMAIC.

The roots of statistical process control, which provide a backbone for Six Sigma methods, began with the development of the normal curve by Carl Friedrich Gauss in the 19th century. We know today that the normal curve is just one of several possible probability distribution models. It is perhaps the most widely used model, and the other models developed from the normal curve. Probability distribution models are discussed in later chapters on statistics



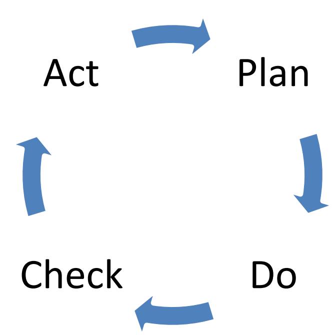
The Normal Curve

In the early part of the 20th century, statistical process control received another big boost thanks to contributions from an engineer and scholar named Walter Shewhart. Shewhart's contributions to quality are many, but two specific ideas stand out. First, Shewhart was the first person to closely relate sigma level and quality. He defined a process in need of correction as one that is performing at three sigma. If you look back to Chapter 1 and the theoretical Amazon example, the cost difference between four sigma and three sigma is over $78 million; in comparison, the difference between five and four sigma is only approximately $7.6 million. Because errors and costs exponentially increase as sigma level decreases, Shewhart's definition has very practical applications in business. While Six Sigma as a method seeks to move ever toward less than 3.4 defects per million opportunities (dpmo), it is also true that if the quality of a process decreases, as it approaches three sigma, the costs associated with errors increase substantially.

Second, Shewhart is considered the father of control charts. Control charts, which are covered in depth in the chapters on advanced statistics, are a critical component of statistical process control that lets organizations maintain improved performance after a Six Sigma initiative. At a time when scholars were writing about the theoretical application of statistics in a growing number of fields, Shewhart developed ways to apply these concepts to manufacturing and industrial processes specifically.

During the same time period, W. Edwards Deming was working for the U.S. Department of Agriculture. A physicist and mathematician, Deming was in charge of teaching courses at the agency's graduate school and he arranged for Shewhart to come and speak there. Later, Deming brought Shewhart's statistical concepts to the United States Census Bureau, applying his theories outside of an industrial or manufacturing environment for possibly the first time.

One of Deming's ideas is called the PDCA cycle, or plan-do-check-act cycle. The idea is that improvement comes when you recognize there is a need for change and make a plan to create improvement. Next, you do something by testing your ideas. Using the results of the test, you check or verify that your improvements are working. Then you act, bringing your improvements to a production environment or scaling improvements outside of the test environment. The fact that PDCA is a cycle means it never ends; there are always improvements to be made. This is a core tenet of Six Sigma.



Following World War II, Deming worked in Japan on behalf of the United States government in several capacities. While in post-war Japan, Deming befriended statisticians and convinced at least one notable engineer that statistical process control was relevant to Japan's need to drastically drive economic and production performance to overcome damage from the war. In the end, Deming became a valued teacher and consultant to manufacturing companies in Japan, planting the ideas and concepts that would soon become the Toyota Production System, or Lean Six Sigma.

Continuous Process Improvement: Toyota and Lean

Deming's teachings and the need for Japanese industry to make a successful comeback following a catastrophic war combined to bear fruit for Toyota. Toyota's leadership had visited the concepts of quality prior to WWII, but improved performance and efficiency became a more critical goal given the nature of Japan's economy and resources in the 1940s and 50s. Taking manufacturing ideas attributed to Henry Ford, Toyota leaders applied statistics and new quality concepts to create a system they felt would increase production and allow for variable products while reducing costs and ensuring quality.

> What is Jidoka?
>
> Jidoka is a principle that creates control of defects inside a business process. Instead of identifying defects at the end of the production line and attempting to trace errors back to a source, jidoka demands that a process stop as soon as errors are detected so improvements or troubleshooting can happen immediately.
>
> For jidoka to work properly, machines are often equipped to recognize bad outputs from good outputs; the machines are also equipped with a notification of some type to spark human interaction in the process when things go awry.

Several individuals were instrumental in the ultimate development of the Toyota Production System. They infused the process with automated machinery, quality controls to keep defects from occurring, and efficiency tools that had not yet been applied with such detail and consistency. One man, Kiichiro Toyoda, had previous factory experience. In his previous jobs, he added efficiencies to processes in textile mills through conveyor and other automated systems. Toyoda introduced the same concepts on certain lines in the Toyota manufacturing process. Later, Eiji Toyoda and Taiichi Ohno introduced concepts known as Just-in-Time and jidoka, which are the pillars of the Toyota Production System.

The principles driving Toyota's system, and later, the foundation of Lean Process Management or Lean Six Sigma, include:

- Defining customer values
- Identifying the value stream for customer needs and desires
- Identifying waste in the process
- Creation of a continuous process flow
- Continually working to reduce the number of steps and time it takes to reach customer satisfaction

Lean management is highly concerned with removing waste from any process. Waste increases costs and time spent on a process, making it undesirable in any form.

Motorola's Focus on Defects

Though the basis for Six Sigma was laid in the late 19th and early 20th centuries, it wasn't until the mid-1980s that these concepts saw large-scale success in the United States. Decades after Toyota developed its system, engineers at Motorola began to question how effective their quality management programs were. Those questions first arose after a Japanese company took over a Motorola television manufacturing plant. By applying Lean concepts, the new company began creating televisions that demonstrated 1/20th the amount of defects as Motorola's own television sets.

At the time, departments across Motorola measured defects as a ratio of a thousand opportunities. Bob Galvin, the CEO of Motorola, issued a challenge to his team. He wanted to see an improvement in quality and production—not just any improvement; he wanted a ten-fold improvement in half a decade. Engineer Bill Smith and a new addition to the Motorola team – Dr. Mikel Harry – began to work on the problem.

The team realized that measuring errors against a thousand opportunities didn't provide the level of detail needed for true statistical process control. Instead, the engineers wanted to measure defects against a million opportunities. We know that sigma levels were already defined and the idea of using sigma levels as a measure of quality began with Shewhart. It wasn't a long jump for the Motorola engineers to make from their desire for more accurate data to the basic concepts of Six Sigma as both a goal and a methodology.

Throughout the next two decades, Motorola worked to perfect its Six Sigma methodology, seeing positive results along the way. In addition to statistical tools, the team created a step-by-step process by which any team--in almost any industry--could make gains and improvements. For the first time, this type of statistical process control was taken out of the manufacturing environment on a large scale company-wide. Motorola applied the method to customer service, engineering, and technical support. It used the process to create a collaborative environment between stakeholders inside and outside of the organization. It was highly successful; according to Motorola, the company saved more than $16 billion as a result of continuous process improvement initiatives within 12 years.[5]

Motorola did more than improve its own systems and products, though. Galvin directed his team to share Six Sigma with the world. Motorola and its team published articles and books on the Six Sigma method and implemented efforts to train others. In this way, they created a methodology based on statistics that could be taught and implemented within any organization or industry.

ABB, Allied Signal, and General Electric

After leaving Motorola, Dr. Harry joined Asea Brown Boveri. At ABB, Harry worked with Richard Schroeder, who would also become a champion for Six Sigma. In fact, the two men later cofounded the Six Sigma Academy. At ABB, Harry came to realize a key idea in the evolution of Six Sigma: business, or profits, in some ways came before quality. Quality, in fact, was a driving factor of business. Customers didn't make purchases if quality was poor. Because the individuals with the ability to decide in favor of Six Sigma initiatives were highly motivated by dollars, Harry incorporated financial tactics into the Six Sigma methodology. For the first time, the method was focused on the bottom-line as a primary goal with other concerns and goals stemming from financially-led goals.

In 1993, both Schroeder and Harry changed jobs, joining the team at Allied Signal. Allied Signal's CEO at the time was Larry Bossidy. He was interested in Six Sigma but realized that executives and other high-level leaders experienced knowledge barriers while attempting to interact and collaborate with analysts, process engineers, and Six Sigma experts. Bossidy suggested that leadership at a company had to be

[5] "The History of Six Sigma," iSixSigma. http://www.isixsigma.com/new-to-six-sigma/history/history-six-sigma/

well-versed in Six Sigma to pick the right projects for success and support those projects on a company-wide basis to ensure success.

Harry, who is sometimes referred to as the father of Six Sigma, created a system for educating executive leaders. In conjunction with others at Allied Signal, he developed systems that allowed Six Sigma to be effectively deployed by leadership throughout an organization in its entirety.

Around the same time, GE CEO Jack Welch entered into the Six Sigma arena. Prior to learning about Six Sigma, Welch had stated he was not a proponent of quality measures. He'd previously criticized quality programs as heavy-handed approaches that did little to deliver results. Welch invited Larry Bossidy to speak at a GE corporate meeting in 1995. He also requested an analysis regarding the benefits of implementing Six Sigma at GE. At that time, GE was performing at between three and four sigma. The potential savings should the company rise to six sigma were enormous; estimates were $7 to $10 billion.[6]

Welch is known as a champion of Six Sigma not because he contributed in major ways to the development of statistical process controls or the Six Sigma toolsets, but because he demonstrated exactly how leaders should approach Six Sigma. He also made GE a historically successful Six Sigma organization by tying Six Sigma goals to employee reward structures. Employees were no longer only compensated based on financial performance factors; they were also evaluated based on Six Sigma performance. Suddenly, employees at every level had a personal reason to become involved in continuous process improvement, and employees and managers were supplied with the Six Sigma training to succeed.

Continued Growth of Six Sigma

Following the success of corporations such as GE and Motorola, companies across the country rushed to implement Six Sigma. Unfortunately, in the rush to implement the process, many organizations executed improvements poorly or failed to gain an adequate understanding of statistical process control before moving forward with improvements. Although Six Sigma methods have been used by organizations to gain millions—even billions—in savings and efficiencies, some companies walked away with a bad taste for the process. That bad taste has resulted in the following misconceptions and myths that are still prevalent today in many industries:

- *Six Sigma is solely concerned with metrics and ignores common sense.* The opposite is actually true: Six Sigma often starts with traditional common sense ideas, often arrived at through brainstorming, and validates those assumptions with data. The reason for this myth is twofold. First, managers and others who are used to making calls without being questioned are suddenly questioned in a Six Sigma environment. Not only are they questioned, but hard data sometimes proves them wrong. Second, in some cases data is improperly used to support conclusions that are against common sense or tradition. When those conclusions turn out to be faulty, it's easy to blame the process of Six Sigma there is a lack of adequate understanding of the statistical theories involved.
- *Six Sigma is too expensive*. While enterprise-wide adoption of Six Sigma can be costly at first, due in part to training needs, slowly integrating the concepts into a company often costs very

[6] "The Evolution of Six Sigma," PQA.net. http://www.pqa.net/ProdServices/sixsigma/W06002009.html

little in the long run. Organizations have to balance how they adopt Six Sigma with budgetary concerns—but when implemented correctly, Six Sigma generally leads to savings that more than cover its initial investment.

- *Six Sigma can fix anything.* Opposite the nay-sayers are Six Sigma cheerleaders who believe they can apply the method like a salve to any problem. While Six Sigma can be applied to any problem of process, it's not always relevant to problems of culture or people. If morale or other human resource problems are at the root of an issue, statistics can't help. However, if morale is low because a process is difficult to work with or is performing poorly, Six Sigma can be used to improve the process, thereby improving morale.

Applying Six Sigma Knowledge

Six Sigma is applied via a controlled project selection and management process. Once areas of concern are identified, leaders usually turn to analysts, Six Sigma experts, and subject-matter-experts for cost-benefit analyses. Six Sigma teams attempt to quantify how broken a process is (by calculating sigma level, costs of defects, downtime, and other metrics) and how much it might cost to address the problem. Problems are then prioritized according to severity as well as an organization's ability to address the issue. Teams begin working through the priority list, returning to the analysis from time to time to ensure the list has not changed. The majority of this book covers the methods by which teams identify and address problems using Six Sigma.

The Levels of Six Sigma Certification

Possessing a Six Sigma certification proves that an individual has demonstrated practical applications and knowledge of Six Sigma. Some organizations offer in-house certification processes. Most people seek certification by enrolling in online or onsite Six Sigma training course. Most organizations that offer Six Sigma education also offer a path to certification. You can take courses for certification at various levels; Six Sigma levels are differentiated by belt level.

White Belt

A certified Six Sigma White belt is familiar with the basic tenets of the Six Sigma methodology, though they aren't often regular members of process improvement teams. White belt training is a good introduction to Six Sigma for auxiliary staff members within an organization and can provide the information necessary for understanding why project teams do what they do. The training lets employees review project processes, understand information presented in milestone meetings, and better participate in project selection processes. White belt training can also be used across all levels of employees when organizations are attempting to implement a Six Sigma culture. It is worth noting that White Belt training usually only provides a very basic introduction and overview of Six Sigma, so much so that not all Six Sigma professionals recognize it as a true Six Sigma certification.

Yellow Belt

A yellow belt certification is a step above white belt: it is still considered a basic introduction to the concepts of Six Sigma, but a yellow belt learns basic information about the DMAIC method often used to improve processes. The following concepts are often included in Six Sigma yellow belt training:

- Six Sigma roles

- Team development and management
- Basic quality tools such as Pareto charts, run charts, scatter diagrams and histograms
- Common Six Sigma metrics
- Data collection
- Measurement system analysis
- Root cause analysis
- An introduction to hypothesis testing

At the yellow belt level, training is often geared toward understanding of the overall methodology and basic data collection. Yellow belts don't need to know how to conduct hypothesis testing, but they must understand the language of hypothesis testing and the conclusions that are drawn from such tests. Yellow belts are often employees who need to know about the overall process and why it is being implemented.

Green Belt

Certified green belts work within Six Sigma teams, usually under the supervision of a black belt or master black belt. In some cases, green belts might lead or handle smaller projects on their own. Green belts are generally equipped with intermediate statistical analysis capabilities; they might address data and analysis concerns, help Black Belts apply Six Sigma tools to a project, or teach others within an organization about the overall Six Sigma methodology.

Green Belts can be middle managers, business analysts, project managers, and others who have a reason to be involved regularly with process improvement initiatives but who might not be a full-time Six Sigma expert within an organization. Sometimes, Green Belts are considered the worker bees of the Six Sigma methodology because they undertake most of the statistical data collection and analysis under the supervision of certified Black Belts.

The following concepts are often included in Green Belt training:

- All of the information listed for yellow belt certification
- Failure mode and effects analysis
- Project and team management
- Probability and the Central Limit Theorem
- Statistical distributions
- Descriptive statistics
- How to perform basic hypothesis testing
- Waste elimination and Kaizen
- Basic control charts

Black Belt

A certified Six Sigma Black Belt usually works as the project leader on process improvement projects. They might also work within management, analyst, or planning roles throughout a company. Common minimum requirements for black belt certification include everything listed for yellow and green belts in addition to:

- Advanced project and team management skills

- Knowledge of the expansive list of Six Sigma brainstorming and project tools
- Intermediate to advanced statistics
- An understanding of other process improvement and quality programs, including Lean and Total Quality Management
- An ability to design processes
- Advanced capabilities for diagraming processes, including flow charts and value stream maps
- Use of software to conduct analysis, such as Excel or Minitab

Master Black Belt

A Master Black Belt is the highest certification level achievable for Six Sigma. Within a business organization, Master Black Belts usually manage Black Belts and Green Belts, consult on especially difficult project concerns, offer advice and education about challenging statistical concepts, and train others in Six Sigma methodology.

Certification Exams

Most certification programs require individuals to pass an exam for certification; some require that green and black belt candidates also demonstrate their knowledge in the form of Six Sigma project experience.

If an exam is required for white or yellow belt certification, it is usually fairly short and covers basic concepts about the methodology. Green belt exams are longer and might include questions about statistics and some basic calculations. Black belt exams often take up to four hours to complete; they test for understanding and application. Exams might include difficult statistical problems or questions about how a project leader might handle various situations. While exams differ by organization, this book is designed based on The Council for Six Sigma Certification’s (CSSC) published body-of-knowledge requirements.

Chapter 3: Other Process Improvement and Quality Methods

By studying the history of Six Sigma, you've already realized that the methodology is closely related to a number of other quality-driven initiatives developed over the past century. This is true in part because all successful businesses ultimately seek to do the same thing: serve a customer a product or service they need while making as much profit as possible.

While Six Sigma encompasses all the tools you need to approach virtually any problem of process, familiarity with other types of process improvement and quality methods is important. Some of these methods, such as Lean and JumpStart, add value within a Six Sigma approach. Others might be used by outside resources alongside a Six Sigma project. Even if you don't use or work with some of these programs, you will need to communicate with leadership and business partners who are more familiar with other methods. The ability to frame Six Sigma concepts in a more global quality management approach can help you win support for your own projects.

Other Formal Quality or Process Improvement Programs

Lean Process Management

Lean principles often go hand-in-hand with Six Sigma principles. While Lean originally developed as a concept for reducing waste in a manufacturing environment, the ideas of Lean Process Management can be applied to any process that involves the movement or creation of goods or services. This is true even if those services are virtual or digital, such as in a computerized workflow process.

One of the ways that Lean is similar to Six Sigma is that it is concerned with continuous improvements; like Six Sigma, Lean provides waste-removal tools so daily control and improvements can be made to processes. In fact, one of Lean's continuous improvement tools is called Kaizen, a Japanese word that translates loosely to "change for the better." The purpose of every change in a Kaizen environment is to eliminate waste and/or create more value for the customer on a continuous basis.

Lean Process Management can be deployed within a project environment or in daily production. Like Six Sigma, Lean is more about an overall culture of quality than a single quality event. Many organizations use Lean principles to make improvements in processes. By simply instituting some of the Lean principles, managers can drastically increase production and reduce costs for their departments.

Because Lean principles are so effective and fit so well with Six Sigma principles, for the purpose of this book, we will often treat Lean as a part of the Six Sigma methodology.

Total Quality Management

Total Quality Management, or TQM, is a phrase well-known by anyone who worked in business in the last quarter of the 20^{th} century. The TQM approach to quality is one of the first formal methods enacted in business environments in the United States. Originally developed in the 1950s, Total Quality

Management didn't become popular with companies across the country until the 80s. At one point, TQM was so popular with executives and other leaders that it actually became something of a joke among certain workforces who believed that much effort and expense was expended on quality without an equal resulting benefit. In fact, if you remember from the last chapter, Jack Welch at GE felt this way.

While Total Quality Management programs were often somewhat lackluster when it came to results, the method was an essential stepping point to current improvement and quality methods such as Six Sigma. TQM was not without its results: as with any method, results depended highly on the way the program was implemented and the culture of the organization. For this reason, TQM and its variations are still in play in many industries today. Some requirements for a successful TQM program include:

- A strict quality commitment at all levels of the organization, especially among leaders
- Empowered employees who can make quality decisions while working within the process without constantly seeking leadership approval for those decisions
- A reward and recognition structure to promote quality work so that employees have a reason to make quality-making decisions
- Strategic planning that takes quality and quality improvement goals into account when making long-term decisions
- Systems that let organizations make improvements and monitor quality

Successful TQM initiatives require eight key elements: ethics, integrity, trust, training, teamwork, leadership, recognition, and communication. You can view these elements as if they were part of the components needed to build a high-quality, lasting building. Ethics, integrity, and trust become the foundation for quality. Training, teamwork, and leadership are the bricks by which quality organizations are built. Honest, open, and concise communication is the mortar that binds everything else together, and recognition is the roof that covers everything, providing employees with a reason to seek and maintain quality.

One of the biggest advantages of the TQM mentality is that it began to force organizations to see themselves as one entity rather than a number of loosely related entities or departments. Prior to the quality methods developed in the last half of the 20th century, many organizations were run via heavily siloed departments. One department often did not understand what another was doing, which caused a great deal of rework and waste. Each department might seek higher quality levels or process improvements, but in the end, the organization was only as strong as the weakest element.

TQM began to change departmental thinking on a massive scale: organizations began to take enterprise approaches to decision making, quality, and customer service. Business leaders started to look at companies as a series of linked processes operating toward a single end goal. Within the bounds of TQM, the ideas for business process reengineering began to develop.

Organizations using TQM often experienced benefits such as:

- Improved employee engagement and morale
- A reduction in production or product costs
- Decreased cycle times
- More satisfied customers

Business Process Reengineering

Six Sigma, Lean and TQM are all concerned with making *continuous* changes on both a large and small scale that bring an organization ever closer to a model of perfection. In the case of Lean, that model is a process that has zero waste; in Six Sigma, the model is statistically 6 sigma. In TQM, organizations often define their own version of perfection before working toward it. Business Process Reengineering, or BPR, is less concerned with incremental quality wins and more concerned with a radical change across an entire organization or process architecture.

Business process reengineering, which is also called business process redesign, is most often concerned with the technical processes that occur throughout an organization. Those processes might include systems, software, data storage, cloud and web processes, and computer-based workflows operated and maintained by human users. Because of the intense integration of automation and computer elements into processes with BPR, organizations that enter BPR endeavors have to rely heavily on both inside and outside technical resources. Inside resources provide programming, integration, and troubleshooting services as processes are developed or redesigned. Outside resources can be BPR consultants, contracted programmers and developers, or vendors bringing new software products to the table.

As you can probably imagine, BPR initiatives can be costly, which is why they are often deployed only when an organization expects exponential gain or has determined that current processes are obsolete or badly broken.

BPR projects tend to follow a common map, though there isn't a defined set of principles as there is with Six Sigma. Most projects go through planning, design, and implementation phases. During planning, teams use process mapping and process architecture principles to define enterprise-wide processes in their current state. Teams look for opportunities for improvement and brainstorm new architectures for processes throughout the organization.

During the design phase, BPR teams use validation techniques 3 to ensure solutions they are planning will work within the enterprise structure. They also begin to build tools and programs to integrate the changes; technical teams might use the Scrum methods described later in this chapter at this point in the process.

Finally, organizations implement the changes they have made. Since changes are often programmatic in nature, implementation usually includes a rigorous change management and testing procedure. Testing in technical environments includes steps such as:

- Sandbox testing of basic functionality
- Quality assurance testing by trained technical resources
- Beta testing during which experienced subject matter experts vet all aspects of a program in a limited live environment
- A rollout of the program to the enterprise, often conducted in a phased approach during which technical resources are on call to immediately resolve troubleshooting issues
- A conversion to regular function where technical resources are available in a normal capacity to deal with occasional issues

Rummler-Brache
As process improvement methods became increasingly popular in the 1980s and later, individuals often took portions of one method or another and integrated it into new improvement or quality programs. In this manner, companies outside of the manufacturing industry began implementing bits and pieces of methods that incorporated Lean and Six Sigma elements. One such program is known as Rummler-Brache.

Rummler-Brache was pioneered in the 80s by Geary Rummler and Alan Brache. They developed what remains a proprietary program used by their own consulting firm, but details of the method have been published and used by others. The method seeks to affect positive change in processes and organizations by using a set of practical tools to address business issues and process problems.

One of the foundational components of Rummler-Brache is known as the Nine Boxes Model. The model is created by a matrix of three performance levels and three performance dimensions. Performance levels are the performer, the process, and the organization. Dimensions are management, design, and goal. When placed on a grid, the levels and dimensions form nine boxes, as seen below.

	Management	Design	Goals
Performer	Concerned with feedback, consequences, and rewards	Concerned with the tools and training needed to do the job as well as job documentation	Concerned with performance metrics and requirements at an individual level
Process	Concerned with who owns the process and how they might improve it	Concerned with the design of the process, work space, or system	Concerned with the requirements of the business and the customer
Organization	Concerned with overall leadership culture and the requirements of performance evaluation	Concerned with overall org charts and process architecture	Concerned with operating plans and top-level metrics

Rummler-Brache approaches improvement in six phases:

- **Improvement planning.** During the first phase, leadership and subject-matter-experts commit to making improvements and begin to identify opportunities for change.
- **Definition**. During the second phase, project goals and scopes are defined and teams are formed to create improvements.
- **Analysis and Design**. Teams use analysis to understand the current problem and to define and validate workable solutions.

- **Implementation**. Teams implement process changes. Depending on the type of change, this might include programming changes, retraining staff, changes in machinery or equipment, or policy changes.
- **Management of process**. Teams monitor the process during and immediately following the change to ensure improvements function as planned.
- **Processes are turned over to daily teams**. Management of the process is turned over to daily teams, often with some type of control in place to ensure continued success.

Scrum

Scrum is a project development method specific to Agile programming endeavors in technical departments. Scrum is used when teams want to create new technical products or integrate new developments on existing products within a short time frame. Commonly, Scrum projects last between two and four weeks, which is traditionally a very tight timeline for programming projects. Scrum was developed as programming and development teams needed a way to meet continuous technical design and improvement needs from other departments without substantially increasing programming, testing employee hours, or hiring more technical staff. Scrum can also be used to drive faster times to production or market for software and application products.

Scrum is a related concept to other process improvement initiatives discussed in the book because many projects today call for some type of technical resource or change. While project teams are working to validate and measure, technical departments often simultaneously deploy Scrum concepts to meet development needs for the improvement project by deadline.

Scrum projects feature three main phases:

- **The pregame**. Development teams analyze available data and business requirements. They use this information to come up with the concept for the new product or upgrade. Often, this involves translating business and process concepts into computer and technical concepts.
- **The game**. Teams begin to develop the product via programming sprints. Sprints are smaller phases of development that are completed in sequence, usually with a review and validation of the work before moving on to the next sprint. By validating work during development, teams are able to create working products faster.
- **The postgame**. Even though validation occurs during development, teams still have to follow quality assurance, testing, and change management procedures. Quality preparation for product release is handled in the final phase.

The Customer Experience Management Method (CEM)

Like Rummler-Brache, the Customer Experience Management Method, or CEM Method, was created by process improvement consultants to address needs in organizations outside of manufacturing. CEM combines some process improvement tools with customer relations management. It was developed in the 1990s by the Virgin Group and became popular throughout the 90s and early part of the 21st century.

The CEM Method takes an outside-in approach to process improvement, focusing on what the customer wants or needs and how each process in an organization serves that need. The primary purpose of CEM is to align processes throughout an organization with customer satisfaction goals. As such, even processes without a direct relation to customers are defined in terms of customers.

For example, shipping processes are obviously directly related to end customers, so it's easy to define how those processes can best serve customers. Shipments should arrive on time, be accurate to orders, and shipping costs should be affordable.

In-house human resource processes are harder to link to customer-facing goals. However, the morale and functionality of employees *is* directly related to how those employees can serve customers. You can make a customer-facing statement about almost any process in an organization in this manner. If organizations cannot link a process to the customer, then they must ask whether the process is necessary or broken.

Like Six Sigma, CEM relies heavily on data. Organizations can't make determinations about customer goals and the success of processes without collecting and analyzing customer feedback. The advantage of CEM is that organizations are able to deploy customer-facing tactics across the enterprise, which often results in enormous gains in customer satisfaction, loyalty, and spending. A disadvantage of this method is that traditionally inward-facing departments, such as human resources, legal, and accounting, often have a difficult time implementing customer-focused cultural change.

JumpStart

JumpStart differs from the other programs and methods described in this chapter in that it is a fast-paced method for identifying problems and solutions in a single session. JumpStart can be used within almost all of the other methods described in this book as a way to spark discussion regarding processes or to identify possible solutions. It can also be used as a management tool for helping teams come to tenable solutions outside of project environments or in the absence of project resources.

Because JumpStart doesn't take the time for rigorous verification or statistical analysis on its own, teams should not use this method to enact sweeping changes or attempt to improve processes that could seriously impact customer experience or the bottom line. One disadvantage of using JumpStart alone is that changes are sometimes made on a wait-and-see mentality, which is safe for many inner-team changes but often dangerous for department or enterprise-wide processes, or for making changes to processes that are closely tied to regulatory or compliance rules.

JumpStart usually begins when leaders at some level identify an area of concern or opportunity. The manager, supervisor, or other delegate identifies a team of employees who they believe would offer appropriate insight on the issue at hand. In most cases, JumpStart doesn't work to define the problem: the group is close enough to the issue that they already know what is wrong. Instead, the group spends several hours brainstorming root causes for the problem and coming up with possible solutions.

Six Sigma and other process improvement tools can be deployed during JumpStart sessions. Fishbone diagrams and solutions selections matrixes, both covered in later chapters, can be used to validate assumptions using only the knowledge of the people in the room and some quick research.

The benefit of JumpStart is that it lets teams create and implement small-scale solutions quickly, often providing problem resolution the same day. It also lets teams identify issues that need to be addressed in a more comprehensive project environment.

When to Use Six Sigma

Some organizations make use of various project improvement methods. As a Six Sigma expert, you might have to champion your own method on occasion. Here are some reasons to choose Six Sigma over other methods described in this chapter.

When facing the unknown

Six Sigma is designed so you can begin a project even when you don't know the cause of the problem. In some cases, teams aren't even sure what the exact problem is – they only know some metric is not performing as desired. For example, an organization might experience a drop in profits that doesn't correct itself in several consecutive quarters. Six Sigma methods can begin to seek the causes of the problem, prioritize them, and work toward solutions.

When problems are widespread and not defined

Even when a problem is understood, if it is wide in scope and not well defined, improvement projects that are not tightly managed can escalate in scope to a point that they become unmanageable. In this situation, teams attempt to solve increasingly bigger issues. As a result, no problem is ever completely solved. Six Sigma includes controls for avoiding such scope creep so teams can make incremental improvements that steadily improve a process over time. We'll talk about scope creep more in later chapters.

When solving complex problems

If processes are complex and feature many variables, it is difficult to determine how to approach a solution, much less define and measure success. Knowledge of statistical analysis and process control lets teams approach problems that involve enormous amounts of data and many variables. Through analysis and graphical representation, complex ideas can be distilled to specific hypotheses, premises, and conclusions.

When costs are closely tied to processes

Because Six Sigma's statistical process control component lets teams make more accurate assumptions than almost any other method, it is very appropriate for situations that are closely tied to revenue or cost. When a single tiny change can result in millions of dollars in gains or losses, teams must validate assumptions with an extremely small margin of error. Guesswork, basic research, and even years of experience cannot do that as accurately as properly implemented Six Sigma methods.