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Authors: Joseph A. De Feo

15.0. CHAPTER PRELIMINARIES

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15.1. High Points of This Chapter

1. Six Sigma and Lean Six Sigma have developed into one of the most widely recognized and effective methods for creating breakthrough improvement. Both have evolved from the basis of Juran's Universal on Quality Improvement.
2. Six Sigma methods focus on identifying and meeting the needs of customers first and the business second. In this way, revenues increase and costs decrease, improving results.
3. Many large organizations like Samsung Electronics, General Electric, and Honeywell have experienced great success employing Six Sigma and Lean Six Sigma methods since its inception at Motorola in the 1980s. Today, organizations like Naples Community Hospital Florida, The Mayo Clinic, Bank of America, Telefónica in Spain, and hundreds of others have adopted Lean Six Sigma as their improvement method of choice.
4. Six Sigma and Lean Six Sigma methods help both traditional manufacturers of goods as well as producers of services and information to improve their bottom line and increase customer satisfaction.
5. The two primary Six Sigma methods are DMAIC (define, measure, analyze, improve, control) to improve processes and products (the focus of this chapter) and DMADV (define, measure, analyze, design, verify: Design for Six Sigma) to help ensure that products and processes function well from the voice of the customer (VOC) through the delivery of goods.
6. The five steps to carry out a Six Sigma DMAIC project are discussed in detail.
7. A successful Six Sigma deployment depends on a clear understanding of roles, responsibilities, structures, and training requirements of the employee.

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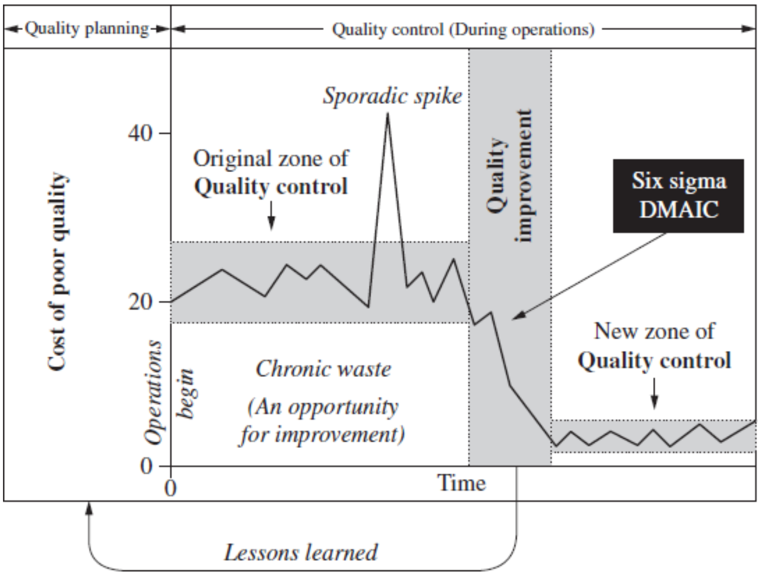
15.2. Six Sigma: A New Global Standard for Improvement

Six Sigma and Lean Six Sigma (which adds Lean tools to the basic methodology) are quality improvement methods with value-added enhancements of computers and an increasing array of statistical and other software packages. For simplicity, we will refer to the full range of quality improvement methods and tools simply as Six Sigma for this chapter (**Fig. 15.1**).

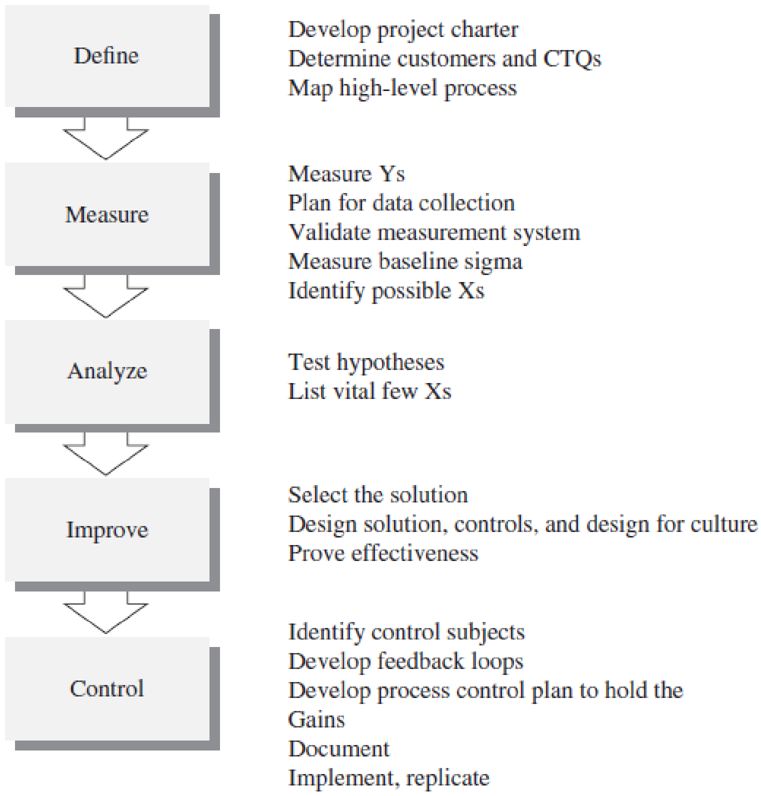
Figure 15.1 *Six Sigma and the Juran Trilogy. (Juran Institute, Inc., Southington, CT.)*



If solutions to your problems are elusive, or if you must attain quality levels measured in parts per million or approaching perfection, Six Sigma will place your ailing process under a microscope to find solutions. **Figure 15.2** presents the Six Sigma or DMAIC steps and tools most often used with it. The DMAIC steps are

1. *Define* the problem as clearly as one can in words.
2. *Measure* the current level of performance and voice of the customers.
3. *Analyze* collected data to determine the cause(s) of the problem.
4. *Improve* by selecting the right solutions to solve the problem.
5. *Control* to hold the gains.

Figure 15.2 *Six Sigma phases and steps.*

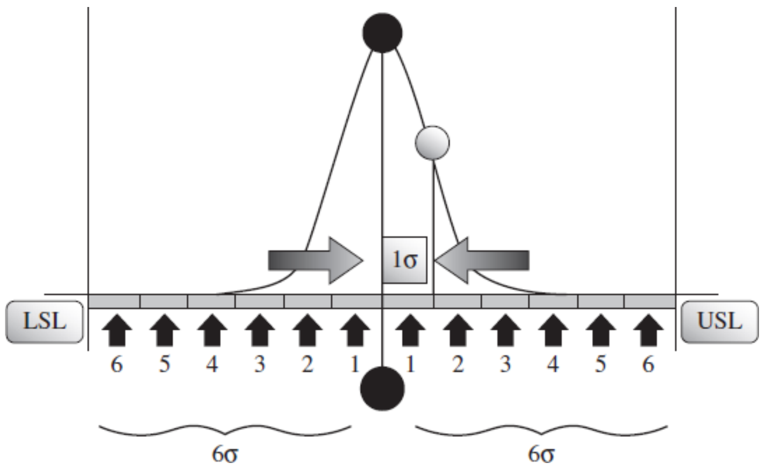


With these fundamental steps, Six Sigma is enabling many organizations around the world to succeed in achieving performance breakthroughs where they had failed before. The smart companies recognize this as not simply a "fix" to one-time problems, but truly a new way of doing business. Business challenges do not go away in a free marketplace; rather, they continually change in degree and form. Organizations worldwide are under continuing pressure to control costs, maintain high levels of safety and quality, and meet growing customer expectations. This breakthrough improvement process of Six Sigma has been adopted by many companies, including Samsung Electronics, General Electric, Honeywell, and other organizations, as the most effective method for achieving these and other goals.

More than just a formal program or discipline, Six Sigma is an operating philosophy that can be shared beneficially by everyone: customers, shareholders, employees, and suppliers. Fundamentally, it is also a customer-focused methodology that drives out waste, raises levels of quality, and improves the financial and time performance of organizations to breakthrough levels. Six Sigma's target for perfection is to achieve no more than 3.4 defects, errors, or mistakes per million opportunities, whether it involves the design and production of a product or a customer-oriented service process.

It is from this target that the "Six Sigma" name originated. Usually written as a small sigma in the Greek alphabet, sigma (σ) is the symbol used to denote the standard deviation or measure of variation in a process. A process with less variation will be able to fit more standard deviations, or "sigmas," between the process center and the nearest specification limit than a process that is highly variable. The greater the number of sigmas within the specifications, the fewer the defects. The smaller the variation, the lower the cost. A higher sigma level means the process of delivering a good, product, or customer service has greater consistency. Figure 15.3 demonstrates a Six Sigma level of performance. This means that one can fit in six standard deviations, or six sigmas, between the process center and the nearest specification limit.

Figure 15.3 *Six Sigma level of performance.*



Most organizations operate at the Three Sigma level, or about 66,800 defects per million opportunities (DPMO) for most of their processes and at a Four or Five Sigma level in some of the mission-critical processes. Comparisons of Sigma levels, yields, and the corresponding defect rates are shown in **Table 15.1**. It would be foolish, however, to try to achieve Six Sigma levels of performance for every process in the organization. This is because not all processes are equally important. For example, the process for requesting time off for vacation is not as critical as the order fulfillment process. What really counts is significant improvement in the mission-critical areas—that is, critical as defined by the customer.

Table 15.1 *Sigma Level, Yield, and Defect Level*

Process Sigma (Short Term)	Long-Term Yield	Defects Per Million
6	99.99966%	3.4
5.5	99.9968%	32
5	99.9767%	230
4.5	99.8650%	1340
4	99.3790%	6200
3.5	97.725%	22,700
3	93.319%	66,800
2.5	84.13%	158,000
2	69.15%	308,000
1.5	50%	499,000
1	31%	691,000
0.5	16%	841,000

15.2.1. Six Sigma Is Customer Focused—Organization Examples of Success

Why does Six Sigma work as well as it does? In large part, it is because of a strong emphasis on the customer. While the saying "the customer is always right" is not literally true, customers hold the key that can unlock unrealized potential in your business. Basically, the DMAIC process translates a customer's needs into actionable, operational terms and defines the critical processes and tasks that must be done well to meet the customer needs. Although the details vary, depending on the analysis and improvement interventions that follow. Six Sigma consistently will drive the performance of products, services, and processes to breakthrough levels, that is, to new and sustained levels of performance. Breakthroughs are achieved not by massive teams or flashy initiatives, but by using a steady and concerted project-by-project approach. In this manner, the Six Sigma approach will help organizations:

- Improve cycle times, quality, and cost
- Improve effectiveness and efficiency of processes, including e-commerce
- Design products and services that will sell well
- Reduce chronic waste, or the cost of poor quality (COPQ)
- Grow profits by improving revenue and reducing costs

In short, Six Sigma is financially rewarding. Our experience indicates returns on investment (ROI) are achievable ranging from 10:1 to more than 100:1.

15.2.2. Samsung Electronics

When the decision was made by Samsung Electronics Company, Ltd., Vice Chairman and CEO Jong-Yong Yun to position the company for the future, the catalyst was Six Sigma. Samsung Electronics began its journey with training as the first essential step to prepare for implementing the methodology. Starting initially in manufacturing operations and R&D in 2000, the company expanded to transactional business processes and the entire supply chain, ultimately obtaining significant savings and financial benefits in all 16 of its business units in South Korea and internationally. The methodology's philosophy and methods continue to be integrated still more deeply throughout the company by developing the internal specialists needed to teach, implement, maintain, and grow this competence in the future. No single person, nor any operation in Samsung Electronics, is exempted from the process, and the company is not looking back.

15.2.3. General Electric

Mr. Jack Welch, General Electric's retired CEO, was one of the first high visibility executives who became a Six Sigma leader and advocate. As an international business role model, he was vocal in expressing his views as to what leaders must do to achieve superior results. GE became an early adopter of Six Sigma, and through its demonstrated success and bottom-line results, enabled Mr. Welch to vault Six Sigma from the mailroom to the boardroom. In his book *Winning*, he said "Six Sigma, originally focused on reducing waste and elevating the quality in our products and processes, has delivered billions of dollars to GE's bottom line in savings. Six Sigma has grown from an internally focused activity to an outside focus—also improving the productivity and efficiency of our customers' operations. Increasing the intimacy between GE and its customer base is making everyone more productive and helps all of us grow through tough economic environments." "Today," Mr. Welch explained, "Six Sigma has evolved to an even larger role in GE. Its rigorous process discipline and relentless customer focus has made it the perfect training ground and vehicle for the future leadership of GE. Our best and brightest employees are moving into Six Sigma assignments. I'm confident that when the board picks a successor to Jeffrey Immelt 20 years from now, the man or woman chosen will be someone with Six Sigma in his or her blood. Six Sigma has become the language of leadership in our company in GE. Its rigorous process discipline and relentless customer focus has made it the perfect training ground and vehicle for the future leadership of GE."

15.2.4. Six Sigma Works for Production, Service, and Transactional Processes

The Six Sigma movement gained interest in health care, financial services, legal services, engineering, consulting, and almost all organizations. In addition to achieving major improvement in manufacturing goods, managing inventory, delivering products, and managing repetitive processes, the Six Sigma methods have migrated to transactional processes. Processes that avoided continuous improvement because, as many stated, "the tools did not apply to us" have joined the Six Sigma bandwagon. Processes like completing an invoice, writing a contract, and boarding passengers on an airline, banking, hospitals, insurance, government, and other service organizations have tried Six Sigma. Most succeeded in

- Optimizing equipment usage
- Experiencing fewer rejects or errors
- Cutting response times to customer inquiries
- Reducing inspection, maintenance, inventory, and supply chain costs
- Creating more satisfied customers, external as well as internal

When implemented strategically, Six Sigma also

- Helps turn over working capital faster
- Reduces capital spending
- Makes existing capacity available and new capacity unnecessary
- Fosters an environment that motivates employees
- Improves morale, teamwork, and career potential

15.2.5. Telefónica

One of the biggest names in business in Spain and in the Spanish- and Portuguese-speaking world has a long tradition of quality management practices and achievements. So when the company embarked on a pilot Six Sigma program toward the end of 2000, the scale and ambition of the effort reflected the company's experience of business improvement initiatives. Between March and July 2001, some 21 first-phase projects were completed. Efficiency savings from these projects amounted to more than 22 million euros; customer satisfaction levels were at all-time highs. Telefónica committed itself to 300 Six Sigma projects for the following year and estimated that it will have conducted 3000 projects during the next 3 years after that (European Quality, 2002).

The Six Sigma Model for Improvement has been widely used to address repetitive production-like processes and ones that address repetitive transactional processes.

We need to clearly establish the difference between production (aka, manufacturing) and service or transactional processes. All processes are transformations that result in the change of state of one or more things that can be physical objects or services. *Production processes* directly transform raw materials or semi-finished goods into a final physical product (aka, goods). The output of production processes is a transformed physical product; these processes are deterministic, workflow-oriented, highly procedural, and, therefore, highly repeatable. Because of this, production processes are well suited for representation by the traditional, workflow-based triple role of input-process-output (IPO) or supplier-input-process-output-customer (SIPOC) models.

A process to produce goods is a series of work activities performed by people and other resource-consuming assets in order to transform given input(s) into output(s).

A service process or transactional process (sometimes also called people or paper processes) directly transforms one state or condition of one or more things (objects, abstractions such as information, data, symbolic representations, etc.) into another. One execution of a transactional process results in a transformation, the outcome of which, in turn, may be a change of state in a number of things (physical objects such as inventories, data and information, people, etc.). Examples of transactional processes include

- Value-added service processes related to production (transporting, installing, storing, repairing, maintaining, etc.)
- Support or back-office processes in manufacturing and service organizations (selling, purchasing, subcontracting, warehousing, billing, human resources, etc.)
- Value-added processes in service industries (banking, insurance, transportation, health care, hospitality, education, etc.)
- Value-added processes in the public sector (including the military) and the not-for-profit sector (legislative and administrative processes, planning, command and control, fundraising, etc.)

The output of transactional processes is a change of state or condition, defined by the transaction. These processes are information (communication)-driven in that successive executions of a transactional process depend on the informational inputs (requests, offers, etc.) received at the outset of each execution. Accordingly, successive executions may be different with different results. Therefore, these processes are not always repeatable in the same sense as stamping out millions of identical parts, but are self-regulating and highly adaptable. A transactional process is a logical set of customer-supplier tasks that drive work activities performed by people.

Transactional process characteristics that differentiate them from production processes may include

- Scarcity of measurement data; available measurements are primarily discrete (attribute)
- Measurement system is partially or entirely I/T defined (e.g., reporting)
- The definition of quality includes information quality
- Dominant variables: people and information
- High-cost labor
- Disproportionately large financial leverage

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15.3. DMADV (Design) versus DMAIC (Improvement)

As stated in the "High Points of This Chapter" section, there is another Six Sigma methodology fo*designing and developing* a new product, service, or process with no defects.

Design for Six Sigma, DFSS for short, follows the DMADV steps. DMADV is different from DMAIC as follows:

1. *Define*. Provides the goals and direction to design a new product or service with development of a team charter.
2. *Measure*. Collects and translates customer needs into CTQs. A CTQ is what is critical to quality in the eyes of the customer. DMADV may deal with many CTQs in one design project. Six Sigma DMAIC typically focuses on only one CTQ that is creating customer dissatisfaction or related to the problem at hand.
3. *Analyze*. Understand the information collected from the voice of the customers and define the design features that collectively will be developed into a concept and then into one or more high-level designs. DMAIC focuses on identifying the root causes of the customer dissatisfaction and the problem at hand.
4. *Design*. In this step, the final product or service design is developed. A detailed design with associated design elements is completed and the critical-to-process variables are identified, from which the process for creating and delivering the good or service is developed.
5. *Verify*. The new design plans are implemented and the organization prepares for full-scale rollout and puts control mechanisms in place. In DMAIC, we control the process to hold the gains. In DMADV, we verify that the project goals are met, that the customer receives the value expected, and assure that control is effective to deliver on the CTQs and product design.

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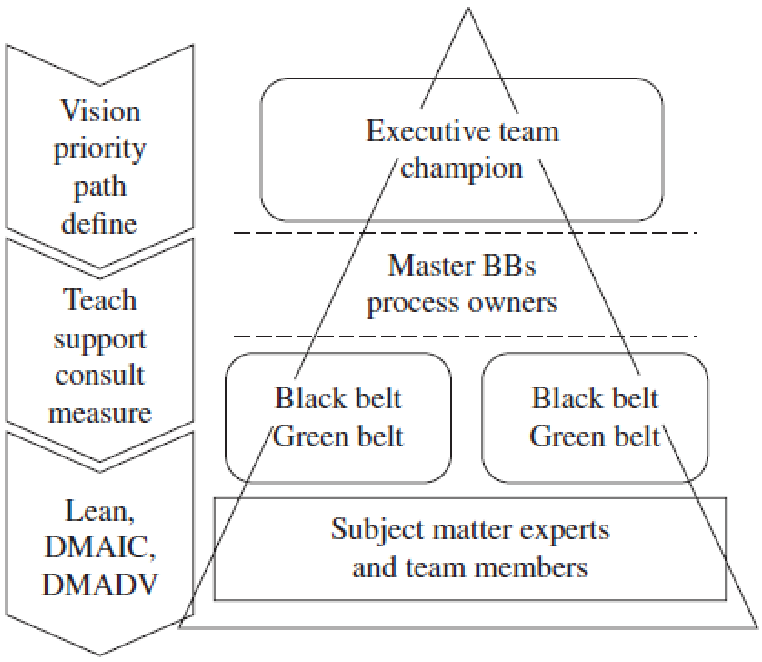
15.4. Key Roles to Deploying Six Sigma Successfully

Deploying a Six Sigma program requires building a suitable infrastructure, as described in Chap. 5, Quality Improvement Breakthrough Performance. A number of key roles are important, as shown in Fig. 15.4. Each role is essential, yet, by itself, insufficient to produce the improvement an organization expects from Six Sigma. Each role requires knowledge of the methods and tools. In addition, the Six Sigma community led by the American Society for Quality has established a standard curriculum and certification process for the roles of Green, Black, and Master Black Belts. Certification is granted upon completing subject matter training, carrying out a number of significant projects, and passing written and oral reviews.

Figure 15.4 *Key roles for Six Sigma. (Juran Institute, Inc.)*



The key roles to drive Six Sigma are

- Leadership
- Champion
- Master Black Belt
- Black Belt
- Green Belt
- Project Team and Subject Matter Experts (SMEs)
- Process Owner

15.4.1. Leadership's Role

The roles of *all* the members of the organization leadership team to create annual breakthrough when acting as a steering team are

- *Setting improvement goals*. Identify the best opportunities to improve performance and set strategic and annual goals for the organization. Establish accountability for meeting goals.
- *Establish infrastructure to enable Six Sigma Projects to happen*. Establish or revise management systems for selecting and assigning projects, organizational reporting of project progress, and accountability of the various roles, performance appraisal, reward, and recognition.
- *Appoint Champions*. They can sponsor projects and ask the right questions at each phase of DMAIC of the Six Sigma project.
- *Support projects and monitor progress*. Enable project teams to carry out their project goals. Provide the necessary training, resources, facilities, budgets, time, and most importantly, management support. Monitor progress of projects and keep them on track.
- *Provide organizational support to deal with resistance to change that occurs when implementing breakthroughs*.
- *Become educated and receive training in the methods of Six Sigma to be able to support and evaluate the work of all the other roles*.

All members of the executive team and managers at all levels should be committed to the Six Sigma effort, agree to support it, and act with unified focus and consistency to facilitate the gradual cultural changes that will inevitably be required. A fractured executive and management team can, and usually does, wreak havoc and confusion on a Six Sigma effort, drains the energy out of those trying to make it succeed, and leaves in its wake disillusionment and meager results. If the executive team fails to maintain unified focus and transform the culture, it loses its credibility and ability to lead.

15.4.2. Role of Champions

Champions are usually members of management (or at least folks with organizational clout). The ideal Champion is one who wants to sponsor a project and likes change.

The Champion

- Identifies improvement projects that meet strategic goals
- Is responsible for creating a project charter
- Identifies and selects competent Belts and team members
- Mentors and advises on prioritizing, planning, and launching Six Sigma projects
- Removes organizational obstacles that may impede the work of the Belts or project teams
- Provides approval and support to implement improvements designed by the project teams
- Provides recognition and rewards to the Black Belts and teams upon successful completion of their projects
- Communicates with executive management and peers as to the progress and results associated with the Six Sigma efforts
- Removes barriers the teams encounter
- Understands and upholds the Six Sigma methodology

In general, Champions manage, support, defend, protect, fight for, maintain, uphold, and function as an advocate for Six Sigma. Usually, a strong Champion can be found behind every successful project. Weaker Champions are usually associated with weaker results.

After helping the steering team select projects, the Champions mentor and support the overall process. Once criteria are established and business unit managers and Champions are identified, projects are selected for their potential in breakthrough improvement. This means evaluating opportunities for strategic relevance, operational efficiency, product and service quality related to customer satisfaction or dissatisfaction, and bottom-line savings.

The Champions and leadership of each business unit support Six Sigma project teams. As influential members of management, they are expected to promote the application, acceptance, and evolution of the process within their business units in the following ways:

- Project selection
- Leadership reviews
- Project support
- Resource allocation
- Career development

15.4.3. Role of Master Black Belts

A Master Black Belt receives training and coaching beyond that of a Black Belt. Master Black Belts are qualified to train Black Belts. The role of a Master Black Belt includes

- Acting as internal Six Sigma consultant, trainer, and expert on Six Sigma
- Managing and facilitating multiple projects—and their Black Belts
- Supporting and advising Champions and executive management
- Providing technical support and mentoring as needed

Everyone else in the organization—those who are not Champions, Master Black Belts, or Black Belts—becomes either a Green Belt or a team member (some organizations call them Yellow Belts). Suffice it to say that the different colored belts vary according to the amount of skill they will need, the formal training received, and the active roles each takes in participating in Six Sigma activities. In an ideal situation, all organization members receive training at some minimal level and are awarded the appropriate belt. Everyone feels included, and everyone understands what Six Sigma is all about, and just as important, what it is not about. No one is left to wonder what Six Sigma is all about or to resent or resist it. This unifies the organization behind the Six Sigma effort and significantly reduces pockets of resistance.

15.4.4. Role of Black Belts

Black Belts are on-site implementation experts with the ability to develop, coach, and lead cross-functional process improvement teams. They mentor and advise management on Six Sigma issues. Black Belts have an in-depth understanding of Six Sigma philosophy, theory, strategy, tactics, and Six Sigma tools. Each project is targeted to save at least $250,000 ROI per project. Black Belts are expected to guide three to six projects per year, which increases further the ROI of Six Sigma.

The training required to be certified as a Black Belt is rigorous and demanding. An illustrative list of topics would include

Critical team leadership and facilitation skills	Correlation and regression
Six Sigma methodology	Hypothesis testing using attribute and variables data
Core improvement tools	ANOVA: Analysis of variance
Use of an appropriate statistical software package	DOE: Design of experiments
Measurement system analysis	EVOP: Evolutionary operations
Determining process capability	Lean enterprise principles and tools
Process mapping	Mistake-proofing
Quality function deployment	SPC: Statistical process control
FMEA: Failure mode, effect, and criticality analysis	Process control plans
Basic statistical methods	Transfer to operations

Armed with this training—usually delivered in four weeklong sessions with 4- to 5-week intervening intervals—the Black Belt is full-time and devoted to carrying out real Six Sigma projects. When Black Belt training has been completed, employees are able to

- Develop, coach, and lead cross-functional teams
- Mentor and advise management on prioritizing, planning, and launching projects
- Disseminate tools and methods to team members
- Achieve results that match the company's business strategies with a positive benefit to financial performance

15.4.5. Role of Green Belts

Employees who become members of each project team often enter the process by becoming Green Belts. A Green Belt requires about 8 days of training in the overall Six Sigma improvement methods and tools. They become key team members on a Black Belt-level project or can be leaders of smaller-scope projects.

Each week in the classroom is followed by four to five weeks of practical application on the same projects back in their business units. If properly selected, these initial projects will produce significant bottom-line savings and, typically, return more than the entire training investment. Each project is targeted to save at least $100,000 to $250,000 ROI per project.

The total number of employees trained in Six Sigma throughout the world must be in the hundreds of thousands by now. More and more companies, like Samsung and GE, are planning for these employees to move up the ranks to top management levels. In the final analysis, success in achieving results with this process depends on whether top management, particularly CEOs, accept responsibility for their nondelegable roles.

Mr. Bob Galvin at Motorola, Mr. Larry Bossidy at AlliedSignal—now Honeywell—and Mr. Jack Welch at GE were role models for making Six Sigma and opportunities for Black Belt employees a vital part of the culture during their tenure as CEOs. Top management can overcome the powerful forces in any organization that may resist unity of direction. The answer is to find a universal improvement process like Six Sigma that fits all functions in an organization. Six Sigma is an extremely healthy and productive cultural change that takes time to complete. It is not free. It requires resources and training, but customer satisfaction, quality products and services, and a highly competitive organization produce a significant return on investment, satisfaction all employees have from being on a winning team, and pride in being part of such an organization.

15.4.6. Roles of Project Team Members and Subject Matter Experts

The members of the Six Sigma team can come from throughout the organization and are often subject matter experts from the various functional departments that are involved in the operation or maintenance of the process under study. Team members are expected to attend all team meetings, contribute to the work process, and complete assignments given to them by the project leader between meetings. Often, the subject matter experts (SMEs) are of greatest value assisting the team:

- When identifying key aspects of the problem and evaluating the appropriate goal for the project (define phase)
- During the process flow diagramming activity by contributing their expertise (measure phase)
- Collecting data about the parts of the process that they are most familiar with (measure and analyze phases)
- Identifying possible causes of the problem (measure phase)
- Identifying possible failure modes and ranking their severity, occurrence, and detection during completion of the PFMEA (measure phase)
- Developing possible solutions to the proven causes (improve phase)
- Identifying control subjects for ongoing measurements of the product and process (control phase)

15.4.7. Process Owners

Process owners are usually at the high supervisory or managerial level of the organization and are directly responsible for the successful creation of the product (goods, services, or information). They are typically not core team members, but may be called upon to assist the team with specific tasks as needed. Some of the most important needs for support from process owners occur during the Improve and Control phases when the team is

- Defining possible solutions to the proven causes of the problem
- Planning for dealing with cultural resistance
- Conducting pilot evaluations of possible solutions
- Implementing the selected improvements
- Designing the control plan and applying it to the everyday maintenance of the process performance
- Disbanding the teams after project completion and turning full responsibility back to the operating forces

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15.5. Lean Six Sigma Deployment Roadmap

Any deployment of quality improvement methods, whether it is called Lean Six Sigma, Performance Excellence, Lean or by some other nomenclature, requires a methodical approach to be successful. A phased approach that starts small and then expands has been shown to be the most effective. See Fig. 15.5 for a description of such an approach using the Juran Transformation Roadmap.

Figure 15.5 The Juran transformation roadmap. (Juran Institute, Inc.)

Decide	Prepare	Launch	Expand	Sustain
Learn about Lean and Six Sigma. Assess organization status-identify strategies, goals, and projects. Determine if Lean Six Sigma is to become part of the strategy. Decide on a “roadmap” to follow. Select external training/consulting partner. Attend an executive briefing. Discuss other initiatives and their impact on resources.	Organize the steering team to manage the process. Nominate and appoint champions. Nominate and select pilot projects. Train the Champions and Black Belts. Decide on the use of Green Belts and train them. Develop first wave plan. Select projects for first wave.	Support and mentor black and Green Belts. Support pilot project teams. Allow time to work on projects. Develop a project nomination process. Develop on-going cost of poor quality metric. Integrate participation reward and recognition. Establish assessments/meas-urements for on-going project selection.	Support infrastructure and review progress. Support expansion of all types and number of teams to other business units. Mandate improvement to all levels: other Belts. Begin product development and design teams. Create key macro-business process teams. Identify benchmarking opportunities.	Integrate process measures and move toward process owners. Fully Integrate Lean Six Sigma goals into next year’s business plan. Deploy Lean Six Sigma to all business units. Enable employee participation with training and resources. Act on audits of business systems to drive new projects. Continue to assess culture and act on gaps. Sustain breakthrough performance.

15.5.1. Decide

During the decide phase of deployment, upper management is becoming familiar with the Six Sigma methodology (or whatever methodology is being considered) and evaluating how well the approach fits with their organization's strategies and goals, particularly those related to performance excellence. A decision must be made whether Six Sigma, or some other approach, best fits the organization's needs.

The upper managers must then decide what roadmap to follow. The one recommended here is an option, but variations on this could work as well. The important thing is that the managers have a roadmap to follow so that the deployment will be done in a methodical way.

A decision must be made at this point whom to select as a training partner. It would be quite rare for an organization to have qualified internal resources to train, consult with, and mentor the resources being developed during the deployment, so it is almost always necessary to contract outside resources. It's important to select a partner that fits well with the organization's culture, business style, and desires for implementation flexibility. The first training delivered by the partner selected should be an executive briefing, which is attended by the entire upper management team. For more on the importance of leading change from the highest levels of the organization.

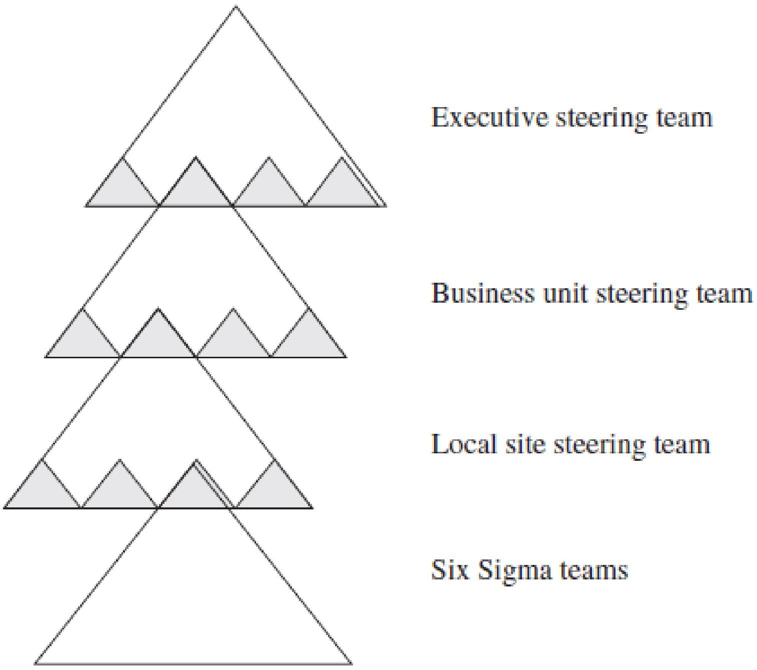
Finally and very importantly, management must decide what they will stop doing. Resources in any organization are finite, and laying a Six Sigma deployment over lots of other projects that are underway is a recipe for failure. The current initiatives should be evaluated and prioritized, and only the vital few continued. For the organization to successfully weave Six Sigma into its culture, it must become the method of choice for creating breakthrough improvement. Launching Six Sigma projects that mirror others already underway will lead to confusion over ownership of the problem and, likely, failure to effectively solve it.

Consider the following case in point: A Juran client that has undertaken a Lean Six Sigma (LSS) deployment failed to do this "stop doing" exercise as fully as they should have. As a result, a couple of the first-wave projects devolved into turf battles over whose solution to or analysis of the problem was best. Since the other "non–Six Sigma" projects were initiated by the process owners before the LSS deployment, the Six Sigma teams ultimately had to abandon their projects for lack of implementation support and be assigned another project to complete their training requirements. These events led to tarnishing the reputation of the LSS deployment and reduced its chances for ultimate success. One key factor leading to this outcome was lack of involvement and buy-in at the highest levels of the organization.

15.5.2. Prepare

During this second phase of the deployment, upper management begins to define the support infrastructure. The steering team or teams are established. A team should be designated at the corporate level to oversee the wide deployment, and ultimately at divisional and even unit levels to oversee the deployment regionally and locally. For a graphic depiction of this arrangement, see Fig. 15.6.

Figure 15.6 Linking steering teams together. (Juran Institute, Inc.)



In addition to the steering teams being developed, this is the time to select and train the initial group of project Champions. These people then can participate with the steering team in nominating the initial projects to be undertaken (see the discussion on nominating projects in the "Select the Problem" section later in the chapter).

The next step in this phase is very important: training the initial wave of Belts. There are a number of ways to approach this, including

- Only a Green Belt workshop at this phase and then Black Belt training during the expand phase.
- A combined Green Belt and Black Belt workshop with the whole class attending 10 days of training over a 4-week period and the Black Belt participants attending the full 20 days over that period. See Fig. 15.7 for a sample schedule for this method.
- Two workshops: a 10-day Green Belt and a 20-day Black Belt. This method is preferable if there are sufficient candidates to fill both workshops.

Figure 15.7 Combined GB/BB training schedule. (Juran Institute, Inc.)

	Week 1 define and team skills	Week 2 measure	Week 3 analyze	Week 4 improve/ control
Day 1	GB/BB	GB/BB	GB/BB	GB/BB
Day 2	GB/BB	GB/BB	GB/BB	GB/BB
Day 3	BB Only	GB/BB	GB/BB	BB Only
Day 4	BB Only	BB Only	BB Only	BB Only
Day 5	BB Only	BB Only	BB Only	BB Only

In any case, there should be 4 to 5 weeks between training weeks for the students to complete project work. By using this approach, within 1 month or 2 months of the completion of training, the first projects should be complete.

15.5.3. Launch

Due to the practicum period between weeks of training noted above, the launch phase overlaps the prepare phase in some aspects. The primary effort during this phase is the execution of the first wave of projects, including mentoring of the Green Belts and Black Belts by the designated coaches. Those coaches should ideally come from the designated training partner identified during the decide phase.

Also during this phase, the ongoing project selection method should be institutionalized and the ongoing COPQ metric should be developed as a data source to help with future project selections.

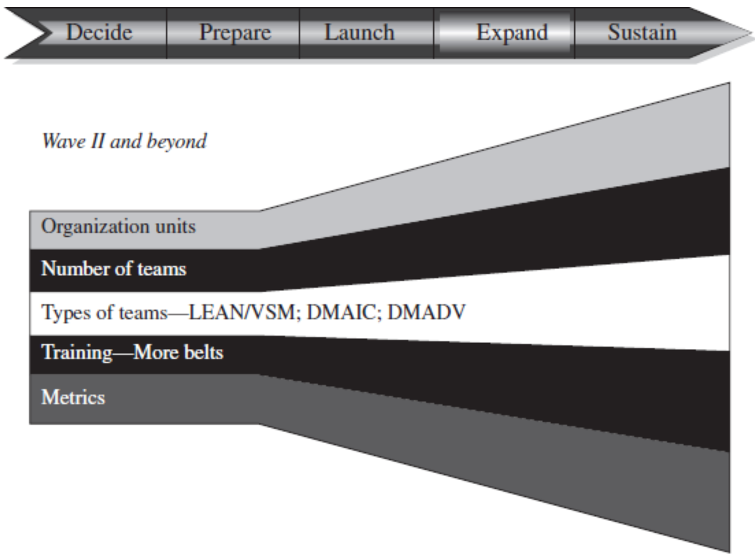
A reward and recognition program should be established at this time as well. Monetary rewards, sometimes a share of the savings from a project, are often but not universally used. Intangible rewards, such as desirable career pathing, recognition, and pride in a job well done, can be effective instead of or in addition to any monetary rewards.

This is the time the organization should also decide how the improvement projects would be tracked and measured. There are a number of commercially available products, such as Power Steering, Minitab's Quality Companion, and i-nexus, which are widely used to track Six Sigma deployments. Internally developed solutions based on Microsoft Access or SharePoint are also widely used. Effective applications include a project "hopper" or "pipeline" for nominating future projects to be considered by the steering teams for execution.

15.5.4. Expand

This phase includes what the name implies: expansion of the methodology to other divisions, additional (often deeper) levels of the organization, and additional project methodologies (e.g., value stream improvement, DFSS). Expansion to different types of processes that may not have been considered during the initial wave of projects will also begin during this phase. This would include key macro business processes, for example, order processing, strategic planning, and price setting (see Fig. 15.8).

Figure 15.8 Areas of expansion. (Juran Institute, Inc.)



Benchmarking other divisions, companies, and industries for best practices in Six Sigma implementation is also a key activity of this deployment phase. This is aimed at bringing your deployment to a world-class level.

During this phase, companies will often decide to begin developing their own internal resources to conduct the workshops and coach projects going forward. The same training partner the organization has employed thus far usually facilitates the development of Master Black Belts and Lean Masters during this phase.

15.5.5. Sustain

The sustain phase is intended to solidify the results and methods implemented during the prior phases of deployment. This is the time when the deployment becomes ingrained in the corporate culture. The Six Sigma goals are integral to the organization's yearly strategy deployment and are widely deployed to all business units.

All employees should now have access to training in at least basic Six Sigma principles and tools and be empowered to improve quality in the workplace every day. Six Sigma should be a way of corporate life.

A key sustaining feature is the conducting of audits on a regular basis. Management should review the audit results and take action on any gaps identified. Often, these gaps will point to additional projects that should be undertaken. The audits may also point to gaps in adoption of the process by the corporate culture. The best way to address these remaining gaps is to up the level of involvement and extend it to all levels (if it hasn't already been) from the top of the organization to the bottom. Ultimately, there may be some who just refuse to get on board. In these cases, the ultimate decision may be that they should find employment elsewhere.

Source: Juran's Quality Handbook: The Complete Guide to Performance Excellence, 7th Edition
ISBN: 9781259643613
Authors: Joseph A. De Feo

15.6. The Six Sigma DMAIC Steps

Experience with applying the five DMAIC steps shows that the team's DMAIC journey needs to be preceded by management selecting the project. The DMAIC journey with its five steps and some of the critical activities in each step are shown in **Fig. 15.2**. Here is a brief explanation of each step.

15.6.1. Select the Opportunity

In the select phase, potential projects are identified. Nominations can come from various sources, including customers, reports, and employees. To avoid suboptimization, management has to evaluate and select the projects. While evaluation criteria for project selection are many, the most frequent basis should be the COPQ at the organization or division level. Other criteria include impact on customer loyalty, employee effectiveness, and conformance with regulatory or other requirements. The project problem and goal statements are prepared and included in a team charter, which is confirmed by management. Management selects the most appropriate personnel for the project, assures that they are properly trained, and assigns the necessary priority. Project progress is monitored to ensure success.

15.6.2. Select: Deliverables

- List of potential projects
- ROI and contribution to strategic business objective(s) for each potential project
- List of potential projects
- Evaluation of projects
- Selected projects
- Project problem, goal statements, and a team charter for each project
- Formal project team(s) headed by Black Belt

15.6.2.1. Select: Questions to Be Answered

1. What customer-related issues confront us?
2. What mysterious, costly quality problems do we have that should be solved?
3. What are the likely benefits to be reaped by solving each of these problems?
4. Which of problems deserves to be tackled first, second, etc.?
5. What formal problem statement and goal statement should we assign to each project team?
6. Who should be the project team members and leader (Black Belt) for each project?

15.6.3. Define Phase

The define phase completes the project definition begun with the charter developed during selection. The team confirms the problem, goal, and scope of the project. The completed definition includes the following:

- Identify key customers related to the project
- Determine customer needs with respect to the project in the voice of the customer (VOC)
- Translate the VOC into CTQ requirement statements
- Define a high-level process flow to define the project limits

15.6.4. Define: Deliverables

- Confirmed project charter
- Voice of the customer
- CTQ statements
- A high-level flow, usually in the form of a supplier-input-process-output-customer (SIPOC) diagram

15.6.4.1. Define: Questions to Be Answered

1. Exactly what is the problem, in measurable terms?
2. What is the team's measurable goal?
3. What are the limits of the project? What is in and what is out of scope?
4. What resources are available—team members, time, finances—to accomplish the project?
5. Who are the customers related to this project?
6. What are their needs and how do we measure them in practical terms?

15.6.5. Measure Phase

The project team begins process characterization by measuring baseline performance (and problems) and documenting the process as follows:

- Understand and map the process in detail
- Measure baseline performance
- Map and measure the process creating the problem
- Plan for data collection
- Measure key product characteristics (outputs; Ys) and process parameters (inputs; Xs)
- Measure key customer requirements (CTQs)
- Measure potential failure modes
- Measure the capability of the measurement system
- Measure the short-term capability of the process

15.6.6. Map the Process

Focusing on the vital one (or few) outputs (Ys) identified by the Pareto analysis, graphically depict the process that creates it (them) by mapping the process with a flow diagram in order to understand the process anatomy.

15.6.7. Determine Baseline Performance

Measure the actual performance (outputs; Ys), such as costs of poor quality, number of defects, and cycle times of the process(es), which creates the problem to discover—by Pareto analysis—which vital outputs (Ys) make the greatest contribution to the problem.

15.6.8. Measure Potential Failure Modes

Referring to the analyzed process flow diagram for each process step, perform a failure mode and effect analysis (FMEA) by listing potential process defects (Ys) that could occur, their effects and their potential causes (Xs). (An additional source of ideas of possible Xs is the cause-effect diagram, which displays brainstormed possible causes for a given effect.) In addition, rate the severity of each effect, the likelihood of its occurrence, and the likelihood of its being detected should it occur. Upon completing the analysis, you will be able to identify those potential process failures that have the most risk associated with them. These results are used to further focus the project on those variables most in need of improvement.

15.6.9. Plan Data Collection for Short-Term Capability Study

- In preparation for determining the capability of the measurement system (which measures the Xs and Ys upon which the project team has focused) and the short-term capability of the process, create a sampling and data collection plan.
- In preparation for determining the short-term capability of the process, determine the capability of the measurement system to provide consistently accurate and precise data upon which the project team can depend to "tell the truth" about the process.
- If the measurement system is found to be not capable, take corrective action to make it so.
- If the measurement system is found to be capable, proceed with the next step—determining if the process is in statistical control with respect to given variables (Ys).

15.6.10. Measure the Short-Term Capability of the Process

- In preparation for measuring short-term capability of the process to meet given specifications (Ys), ascertain whether the process is in statistical control with respect to the given output (Y) of interest. A good way to measure process stability is to use a control chart to plot the process data and discover any indications of instability.
- If the process is not in statistical control—that is, if control charts detect special causes of variation in the process—take action to remove the special causes of variation before proceeding with the process baseline performance measurement.
- If the process is in statistical control—that is, the control charts do not detect special causes of variation in the process—perform a short-term capability study to provide baseline data of the ability of the process to consistently produce a given output (Y).

15.6.11. Confirm or Modify the Goal

In light of discoveries made during measurement of the current process performance, determine if the problem and goal statements are still appropriate for this project.

- Evaluate the project's problem statement and goal statement.
  - Does the problem statement and the goal statement meet the criteria of an effective problem and goal statement with clearly defined boundaries?
  - Are the same variables and units of measure found in the problem statement also found in the goal statement?
  - Can the project be handled by a single team?
  - Does it avoid unnecessary constraints but still specify clearly any necessary global constraints, such as organizational strategy?
  - Are there any points that need clarification or modification?
  - Are the team members representative of departments, divisions, or work units affected by the project? The detailed process flow diagram, particularly if it is constructed in "swim lane" fashion, can help with this.
- Verify that the problem truly exists. If the problem has not been accurately measured, the team must do so at this point.
- Validate project goal(s). Verify that the basis for the project goal(s) is (are) one or more of the following:
  - Technology
  - Market
  - Benchmarking
  - History
- Modify the problem statement and goal statement if either does not meet the criteria above.
- Obtain confirmation from the leadership team, Champion, Black Belt, or quality council on any necessary changes to the project goal or to team membership.
- Create a glossary (list of operational definitions) for your project that will serve as a "dictionary" for important terms relating to your project. Select a team member to act as glossary chief with the responsibility of maintaining the project glossary.

15.6.12. List Theories of Root Cause Based on the Process Flows and Measures

The team needs to develop a comprehensive and creative list of theories of root cause. A root cause is a factor that affects the outcome, would eliminate or reduce the problem if it were removed or mitigated. Tools typically used include Cause-Effect (fish bone or Ishikawa) diagrams, FMEA, and fault tree analysis.

15.6.13. Measure: Deliverables

- Baseline performance metrics describing outputs (Ys)
- Process flow diagram; key process input variables; key process output variables; cause-effect diagram; potential failure mode and effect analysis (FMEA) (to get clues to possible causes [Xs] of the defective outputs [Ys])
- Data collection plan, including sampling plan
- Gage reproducibility and repeatability or attribute measurement system analysis (to measure the capability of the measurement system itself)
- Capability measurement in terms of defect rates, capability indexes, and/or Sigma levels
- Confirmed or modified project goal
- Prioritized list of theories of cause based on cause-effect analysis, FMEA, or similar tools

15.6.13.1. Measure: Questions to Be Answered

1. How well is the current process performing with respect to the specific Ys (outputs) identified to Pareto analyses?
2. What data do we need to obtain in order to assess the capability of (a) the measurement system(s) and (b) the production process(es)?
3. What is the capability of the measurement system(s)?
4. Is the process in statistical control?
5. What is the capability of the process(es)?
6. Does the project goal need to be modified?
7. What are all the possible root causes for the problem?

15.6.14. Analyze Phase

In the analyze phase, the project team analyzes past and current performance data. Key information questions are answered through this analysis. Hypotheses on possible cause-effect relationships are developed and tested. Appropriate statistical tools and techniques are used: histograms, box plots, other exploratory graphical analysis, correlation and regression, hypothesis testing, contingency tables, analysis of variance (ANOVA), and other graphical and statistical tests may be used. In this way, the team confirms the determinants of process performance (i.e., the key or "vital few" inputs that affect response variable[s] of interest are identified). It is possible that the team may not have to carry out designed experiments (DOEs) in the next (Improve) phase if the exact cause-effect relationships can be established by analyzing past and current performance data.

Procedure to analyze response variables (outputs, Ys) and input variables (Xs):

- Perform graphical analysis using tools such as histograms, box plots, and Pareto analysis.
- Visually narrow the list of important categorically discrete input variables (Xs).

- Learn the effects of categorically discrete inputs (Xs) on variable outputs (Ys) and display the effects graphically.
- Perform correlation and regression to
  - Narrow the list of important continuous input variables (Xs) specifically to learn the "strength of association" between a specific variable input (Xs) and a specific variable output (Ys).
- Calculate confidence intervals to
  - Learn the range of values that, with a given probability, include the true value of our estimated population's parameter, which has been calculated from a sample (e.g., the population's center and/or spread).
  - Analyze relationships between specific Ys and Xs, to prove cause-effect relationships.
  - Confirm the vital few determinants (Xs) of process performance (Ys).
- Perform hypothesis testing using continuous variables data to
  - Answer the question, Is our population actual standard deviation the same as or different from its target standard deviation? Perform 1 variance test.
  - Answer the question, Is our population actual mean the same as or different from its target mean? Perform 1-sample *t*-tests.
  - Answer the questions, Is our population mean the same or different after a given treatment as it was before the treatment? or Is the average response at level 1 of the X factor the same or different as it is at level 2 of that factor? Perform 2 sample *t*-tests, or if there is a natural pairing of the response variable, paired *t*-tests.
  - Answer the question, Are several (>2) means the same or different? Perform analysis of variance.

Note: The above tests are referred to as parametric tests because they assume normally distributed response data and, in the case of ANOVA, equality of variances across all levels of the factor. For a discussion of nonparametric (also referred to as "distribution free") tests to use when assumptions of normality and or equality of variances are violated.

Perform hypothesis testing using attribute data to

- Answer the question, Is the proportion of some factor (e.g., defectives) in our sample the same or different from the target proportion? Perform a Minitab test and calculation of confidence interval for one proportion.
- Answer the question, Is proportion 1 the same or different from proportion 2? Perform the binomial proportions test and calculation of confidence interval for two proportions.
- Answer the question, Is a given output (Y) independent of or dependent on a particular input (X)? (This involves testing the theory that a given X is an important causal factor that should be included in our list of vital few Xs.) Perform a chi-squared test of independence (also called a contingency table).

15.6.15. Analyze: Deliverables

- Histograms, box plots, scatter diagrams, Pareto analysis, correlation and regression analyses (to analyze relationships between response variables [Ys] and potential causes [Xs])
- Results of hypothesis testing (to establish relationships between response variables [Ys] and input variables [Xs])
- List of vital few process inputs (Xs) that are proven root causes of the observed problem

15.6.15.1. Analyze: Questions to Be Answered

1. What patterns, if any, are demonstrated by current process outputs (Ys) of interest to the project team?
    - Analyze response variables (outputs; Ys).
    - Analyze input variables (Xs).
    - Analyze relationships between specific Ys and Xs, identifying cause-effect relationships.
2. What are the key determinants of process performance (vital few Xs)?
3. What process inputs (Xs) seem to determine each of the outputs (Ys)?
4. What are the vital few Xs on which the project team should focus?

15.6.16. Improve Phase

In the improve phase, the project team seeks to quantify the cause-effect relationship (mathematical relationship between input variables and the response variable of interest) so that process performance can be predicted, improved, and optimized. The team may utilize DOEs if applicable to the particular project. Screening experiments (fractional factorial designs) are used to identify the critical or "vital few" causes or determinants. A mathematical model of process performance is then established using 2k factorial experiments. If necessary, full factorial experiments are carried out. The operational range of input or process parameter settings is then determined. The team can further fine-tune or optimize process performance by using such techniques as response surface methods (RSM) and evolutionary operation (EVOP). Procedures to define, design, and implement improvements include

1. Plan designed experiments
2. Conduct screening experiments to identify the critical, vital few process determinants (Xs)
3. Conduct designed experiments to establish a mathematic model of process performance
4. Optimize process performance
5. Evaluate alternative improvements
6. Design the improvement

15.6.17. Plan Designed Experiments

- Learn about DOEs in preparation for planning and carrying out experiments to improve the "problem" process.
- Design in detail the experiments required by the project.

15.6.18. Conduct Fractional Factorial Screening Experiments

- Perform fractional factorial screening experiments to reduce even further the list of input variables to the vital few that strongly contribute to the outputs of interest. (A relatively large number of factors [Xs] are examined at only two levels in a relatively small number of runs.)

15.6.19. Conduct Further Experiments, If Necessary, to Develop Mathematical Model and Optimize Performance

- Perform 2k factorial experiments. Multiple factors (Xs, identified by screening experiments) are examined at only two levels to obtain information economically with relatively few experimental runs. Constructing equations that predict the effect on output Y of a given causal factor X discovers precise mathematical relationships between Xs and Ys. In addition, not only are the critical factors (X) identified, but also the level at which each factor performs the best and any significant interactions among the factors.
- If necessary, perform full factorial experiments. More information than is provided by 2k factorial experiments may be required. A full factorial experiment produces the same type of information as a 2k factorial does, but does so by examining multiple factors (Xs) at multiple levels.
- If necessary, and in addition, utilize RSM and/or EVOPs techniques to further assist in determining optimal process parameters.
- Using results of experiments derive mathematical models of the process and establish optimal settings for process parameters (Xs) to achieve desired (Ys).

15.6.20. Evaluate Alternatives and Choose Optimal Improvements

- Identify a broad range of possible improvements.
- Agree on criteria against which to evaluate the improvements and on the relative weight each criterion will have. The following criteria are commonly used:
  - Total cost
  - Impact on the problem
  - Benefit-cost relationship
  - Cultural impact or resistance to change
  - Implementation time
  - Risk
  - Health, safety, and the environment
- Evaluate the improvements using agreed-upon criteria
- Agree on the most suitable improvements

15.6.21. Design the Improvements

- Evaluate the improvements against the project goal.
- Verify that it will meet project goals.
- Identify the following customers:
  - Those who will create part of the improvements
  - Those who will operate the revised process
  - Those served by the improvements
- Determine customer needs with respect to the improvements.
- Determine the following required resources: people, money, time, and materials.
- Specify the procedures and other changes required.
- Assess human resource requirements, especially training.
- Verify that the design of the improvement meets customer needs.
- Plan to deal with any cultural resistance to change.

15.6.22. Improve: Deliverables

- Plan for designed experiments
- Reduced list of vital few inputs (Xs)
- Mathematical prediction model(s)
- Established process parameter settings
- Designed improvements
- Implementation plan
- Plans to deal with cultural resistance

15.6.22.1. Improve: Questions to Be Answered

1. What specific experiments should be conducted to arrive ultimately at the discovery of what the optional process parameter settings should be?
2. What are the vital few inputs (Xs, narrowed down still further by experimentation) that have the greatest impact on the outputs (Ys) of interest?
3. What is the mathematical model that describes and predicts relationships between specific Xs and Ys?
4. What are the ideal (optimal) process parameter settings for the process to produce output(s) at Six Sigma levels?
5. Have improvements been considered and selected that will address each of the vital few Xs proven during the analyze phase?
6. Has expected cultural resistance to change been evaluated and plans made to overcome it?
7. Has a pilot plan been developed and executed and the solutions appropriately adjusted based on the results?
8. Have all solutions been fully implemented along with required training, procedural changes, and revisions to tools and processes?

15.6.23. Control Phase

The project team designs and documents the necessary controls to ensure that gains from the improvement effort can be sustained once the changes are implemented. Sound quality principles and techniques are used, including the concepts of self-control and dominance, the feedback loop, mistake proofing, and statistical process control. Process documentations are updated (e.g., the failure mode and effects analysis), and process control plans are developed. Standard operating procedures (SOP) and work instructions are revised accordingly. The measurement system is validated, and the improved process capability is established. Implementation is monitored, and process performance is audited over a period to ensure that the gains are held. The project team reports the goal accomplished to management, and upon approval, turns the process totally over to the operating forces and disbands.

The activities required to complete the control step include

1. Design controls and document the improved process
2. Design for culture
3. Validate the measurement system
4. Establish the process capability
5. Implement and monitor

15.6.24. Design Controls and Document Improved Process

- Update FMEA to ensure that no necessary controls have been overlooked.
- Mistake-proof the improvement(s), if possible.
  - Identify the kind(s) of tactic(s) that can be incorporated into the improvements to make it mistake proof. Some options include
    - Designing systems to reduce the likelihood of error
    - Using technology rather than human sensing
    - Using active rather than passive checking
    - Keeping feedback loops as short as possible
    - Designing and incorporating the specific steps to mistake-proof as part of the improvements
- Design process quality controls to ensure that your improved levels of inputs (Xs) and outputs (Ys) are achieved continuously. Place all persons who will have roles in your improved process into a state of self-control to ensure that they have all the means necessary to be continuously successful.
- Provide the means to measure the results of the new process
  - Control subjects
  - Output measures (Ys)
  - Input measures and process variables (Xs)
  - Establish the control standard for each control subject
  - Base each control standard on the actual performance of the new process
- Determine how actual performance will be compared to the standard.
  - Statistical process control
- Design actions to regulate performance if it does not meet the standard. Use a control spreadsheet to develop an action plan for each control subject.
- Establish self-control for individuals so
  - They know exactly what is expected (product standards and process standards).
  - They know their actual performance (timely feedback).
  - They are able to regulate the process because they have
    - A capable process.
    - The necessary materials, tools, skills, and knowledge.
    - The authority to adjust the process.

15.6.25. Design for Culture to Minimize or Overcome Resistance

- Identify the likely sources of resistance (barriers) and supports (aids). Resistance typically arises because of
  - Fear of the unknown
  - Unwillingness to change customary routines
  - The need to acquire new skills
  - Unwillingness to adopt a remedy "not invented here"
  - Failure to recognize that a problem exists
  - Failure of previous solutions
  - Expense
- Rate the barriers and aids according to their perceived strengths
- Identify the countermeasures needed to overcome the barriers. Consider
  - Providing participation
  - Providing enough time
  - Keeping proposals free of excess baggage
  - Treating employees with dignity
  - Reversing positions to better understand the impact on the culture
  - Dealing with resistance seriously and directly
- Install statistical process control (SPC) where necessary to ensure that your process remains stable and predictable, and runs in the most economic manner.
- Consider introducing 6s standards to make the workplace function smoothly with maximum value-added activity and minimum non-value-added activity.

15.6.26. Validate Measurement System

Utilize commercially available software such as Minitab to evaluate measurement system capability (as in the measure phase) to ensure that the measurements utilized to evaluate control subjects can be depended on to tell the truth.

15.6.27. Establish Process Capability

- Prove the effectiveness of the new, improved process to ensure that the new controls work and to discover if your original problem has improved, and ensure that no new problems have inadvertently been created by your improvement(s).
- Decide how the improvements will be tested
    - Agree on the type of test(s)
    - Decide when, how long, and who will conduct the test(s)
    - Prepare a test plan for each improvement
    - Identify limitations of the test(s)
        - Develop an approach to deal with limitations.
        - Conduct the test.
        - Measure results.
        - Adjust the improvements if results are not satisfactory.
        - Retest, measure, and adjust until satisfied that the improved process will work under operating conditions.
- Utilizing control charts, ensure that the new process is in statistical control with respect to each individual control subject. If not, improve the process further until it is.
- When, and only when, the process is in statistical control, utilize Capability Analysis—as in the measure phase—to determine process capability for each individual control subject.

15.6.28. Implement the Controls and Monitor

- Transfer to the operating forces all the updated control plans, etc., and train the people involved in the process in the new procedure.
- Develop a plan for transferring the control plan to the operating forces. The plan for transferring should indicate:
    - How, when, and where the improvements will be implemented?
    - Why the changes are necessary and what they will achieve?
    - The detailed steps to be followed in the implementation.
- Involve those affected by the change in the planning and implementation.
- Coordinate changes with the leadership team, Black Belt, Champion, executive council, and the affected managers.
- Ensure preparations are completed before implementation, including
    - Written procedures

    - Training
    - Equipment, materials, and supplies
    - Staffing changes
    - Changes in assignments and responsibilities
    - Monitoring the results
- Periodically audit the process, and also the new controls, to ensure that the gains are being held
- Integrate controls with a balanced scorecard
- Develop systems for reporting results
- When developing systems for reporting results, determine
- What measures will be reported?
- How frequently?
- To whom (should be a level of management prepared to monitor progress and respond if gains are not held)?
- Document the controls

When documenting the controls, indicate

- The control standard
- Measurements of the process
- Feedback loop responsibilities (who does what if controls are defective)
- After a suitable period, transfer the audit function to the operating forces and disband the team (with appropriate celebrations and recognition)

15.6.29. Control: Deliverables

- Updated FMEA, process control plans, and standard operating procedures
- Validated capable measurement system(s)
- Production process in statistical control and able to get as close to Six Sigma levels as is optimally achievable, at a minimum accomplishing the project goal
- Updated project documentation, final project reports, and periodic audits to monitor success and hold the gains

15.6.29.1. Control: Questions to Be Answered

- What should be the plan to ensure the process remains in statistical control and produces defects only at or near Six Sigma levels?
- Is our measurement system capable of providing accurate and precise data with which to manage the process?
- Is our new process capable of meeting the established process performance goal?
- How do we ensure that all people who have a role in the process are in a state of self-control (have all the means to be successful on the job)?
- What standard procedures should be in place, and followed, to hold the gains?

15.6.30. Training and Certification of Belts

The introduction of Six Sigma in the past decade led to a surge in the certification of Belts. This was largely due to a lesson learned from the Total Quality Management (TQM) era. During TQM, many so-called experts were trained in the "methods of TQM." Unfortunately, few were trained in the tools to collect and analyze data. As a result, numerous organizations did not benefit from the TQM program.

Motorola introduced a core curriculum that all Six Sigma practitioners needed to learn. That evolved into a certification program that went beyond the borders of Motorola. As a result, there are many "certifiers" that will provide a certification as a Master Black Belt, Black Belt, Green Belt, and so on. Most certifications state that the person certified is an "expert" in the skills of Six Sigma or Lean or both. Certification did lead to improved performance, but also to some weak experts due to no oversight of the certifiers, many of which were consulting companies or universities not well versed in the methods or tools of Six Sigma and Lean.

The American Society for Quality (ASQ) for many years offered certification for quality technicians, quality auditors, quality engineers, and quality managers. As the Six Sigma movement grew, the ASQ and its affiliates around the world prepare a minimum body of knowledge for various belt levels. The ASQ provides a widely-accepted standard that any practitioner should at a minimum master. Certification must be based on legitimacy to be effective.

ASQ's Certified Quality Engineer (CQE) program is for people who want to understand the principles of product and service quality evaluation and control (ASQ, 2009). For a detailed list of the CQE body of knowledge, the reader is referred to the certification requirements for Certified Quality Engineer at **www.asq.org**.

ASQ also offers a certification for quality officers at the quality management level, called Certified Manager of Quality/Organizational Excellence. ASQ views the Certified Manager of Quality/Organizational Excellence as "a professional who leads and champions process-improvement initiatives—everywhere from small businesses to multinational corporations—that can have regional or global focus in a variety of service and industrial settings. A Certified Manager of Quality/Organizational Excellence facilitates and leads team efforts to establish and monitor customer/supplier relations, supports strategic planning and deployment initiatives, and helps develop measurement systems to determine organizational improvement. The Certified Manager of Quality/Organizational Excellence should be able to motivate and evaluate staff, manage projects and human resources, analyze financial situations, determine and evaluate risk, and employ knowledge management tools and techniques in resolving organizational challenges" (ASQ, 2009).

Note: No matter what organization you use to certify your experts, here are some lessons learned about certification:

- One project is not enough to make someone an expert
- Passing a written test that is not proctored is no guarantee the person who is supposed to be taking the test is actually taking it
- If you get someone in your organization to sign off on the success of the Belt project, you need independent evidence that the person is knowledgeable about the methods of Six Sigma
- Select a reputable certifying body