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Six Sigma for Managers

24 Lessons to Understand and Apply Six Sigma Principles in Any Organization

THE EMPLOYEE HANDBOOK FOR ENHANCING CORPORATE PERFORMANCE

Greg Brue

"Six Sigma is best described as a journey—a journey for business professionals who are truly committed to improving productivity and profitability."

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“The Six Sigma approach to managing is all about helping you identify what you don't know as well as emphasizing what you should know and taking action to reduce the errors and rework that cost you time, money, opportunities, and customers.”

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Contents

Six Sigma: A methodology for improvement

Six Sigma is a method for improving productivity and profitability. It's a disciplined application of statistical problem-solving tools to identify and quantify waste and indicate steps for improvement.

The Six Sigma story began in the 1980s at Motorola. In 1983, reliability engineer Bill Smith concluded that inspections and tests were not detecting all product defects, customers were finding defects, and defects were causing products to fail. Since process failure rates were much higher than indicated by final product tests, Smith decided that the best way to solve the problem of defects was to improve the processes to reduce or eliminate the possibility of defects in the first place. He set the standard of six sigma—nearly perfect, 99.9997%—and coined the term for the methodology.

Mikel Harry, a quality and reliability engineer at Motorola who founded the Motorola Six Sigma Research Institute, further refined the methodology beyond eliminating process waste. Bob Galvin, the CEO of Motorola at the time, promoted Six Sigma, and Motorola realized huge bottom-line results as a result of its Six Sigma efforts, documenting more than $16 billion in savings in 15 years.

Larry Bossidy of Allied Signal (now Honeywell) and Jack Welch of General Electric initiated Six Sigma programs in their companies. Allied Signal saved $500 million in one year, Honeywell saved $1.8 billion in three years, and GE saved $4.4 billion in four years. Other companies have also achieved impressive savings.

Those savings were possible because of the high levels of variation in business processes, variation that causes defects and wastes and keeps costs higher than necessary. Most companies function at four sigma—tolerating 6,210 defects per one million opportunities. Operating at six sigma creates an almost defect-free environment, allowing only 3.4 defects per one million opportunities: products and services are nearly perfect (99.9997%). Eliminating defects eliminates dissatisfaction.

Six Sigma asks hard questions about your processes and provides solutions. Six Sigma eliminates wasteful variation, changes business cultures, and creates the infrastructure you need to initiate and sustain greater productivity, profitability, and customer satisfaction rates.

Six Sigma statistically measures and reflects true process capability, correlating to such characteristics as number of defects per number of outputs, and probabilities of process success or failure. Its value is in transforming corporate culture from complacency to accomplishment.

For Six Sigma to work, managers at all levels, from top to bottom, must commit to investing the resources to initiate, promote, execute, and support a Six Sigma program. That means providing their employees with the training, resources, knowledge, and authority to solve problems and then trusting them to do so.

Finally, as you go through this book, remember that this is just an overview of Six Sigma and its tools and processes. There are many other books available to help you get into the subject in more depth, including two other books I wrote: *Six Sigma for Managers* (McGraw-Hill, 2002) and *Design for Six Sigma* (McGraw-Hill, 2003).

"Your employees are your greatest assets; Six Sigma knowledge and tools can give them almost limitless potential to transform your company—one project at a time."

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☐ Accept defects as inevitable

☑ Reduce defects, cut costs

In any organization, the hidden costs of defects are huge: the monetary impact on productivity, customer satisfaction, and profitability is dramatic! Many companies believe that dealing with defects is just a cost of doing business. But that way of thinking is just plain wrong.

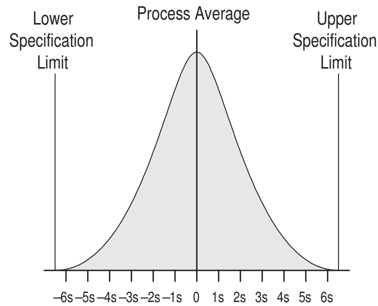
Six Sigma helps you identify the problems in your processes and reduce the defects that are costing you time, money, opportunities, and customers.

It's all about defects. The name "Six Sigma" derives from a level of quality: performing at the six sigma level means only 3.4 defects per million opportunities (DPMO). (The Greek letter sigma is the symbol in statistics for standard deviation, a measure of variation.)

Most organizations in the U.S. are operating at levels of three to four sigma. Defects in these organizations in terms of time, waste, and labor cost them as much as 25% of their total revenue.

How much are defects costing you? What's the cost of scrap and rework? What's the cost of excessive cycle times and delays? What's the cost of business lost because customers are dissatisfied? What's the cost of opportunities lost because you don't have the time or the resources to take advantage of them? What's your total cost of poor quality? Often there are certain factors (sometimes called the "vital few") you can identify that substantially affect these costs.

Can you answer the questions above? If so, then you know how much it's worth to reduce defects. If not, then you need to get some answers so you can begin to cut costs.



Even if a process has a variation of six sigmas above or below the ideal average, the outputs still fall within specification limits and be acceptable

Six Sigma helps you find out which characteristics are critical for your customers, identify the factors that most influence those characteristics, and reduce variations in those key factors.

It requires commitment from the top and throughout the organization. It requires questioning traditional beliefs and ways. It's no longer business as usual—for anyone on the organizational chart.

Implementing the Six Sigma methodology costs money, of course—for time, resources, consulting, training, and improvements. But the return is worth the investment. When you reduce defects and inefficiencies, costs decline naturally.

Six Sigma helps you do the following:

Know what your customers want: That's what matters, not what you *think* they want. What characteristics of your products or services are critical to quality (CTQ) for your customers?

Focus on the vital few factors: Understand the factors in your processes that most influence the CTQs. Then you can work most efficiently to improve your processes.

Control variation in the vital few factors: Less variation, fewer defects. Fewer defects, higher customer satisfaction and lower costs.

"Six Sigma is exciting. But it requires tenacity, mental toughness, and, above all, an unwavering dedication to the pursuit of perfection in every aspect of business operations."

Set business metrics

Metrics are essential to Six Sigma. If you can measure your processes, you can understand them. If you can understand them, you can improve them and reduce costs.

Many organizations *operate by axiom*—they accept certain beliefs as truths. For example, "We are committed to quality." But managers generally cannot justify their acceptance of these axioms. What does that mean exactly? Unless they have metrics to demonstrate the truth of this axiom, it will have little meaning.

How do you set appropriate metrics? Measure what's critical to your business.

Start with your customers. What things matter most to them?

Involve your leaders. Metrics should align with *company strategy*. When upper managers are engaged and committed to process improvement, then all employees will have the power to make changes based on what the metrics tell you.

All metrics should link to *bottom-line results*. With Six Sigma, this is a continual question, because Six Sigma focuses on tangible financial results.

Metrics should relate to *important, regular activities and processes*. Your metrics must enable you to reduce defects and correct the processes to reduce costs.

Ask questions. Why do we measure this? Why do we measure it in this way? What does this measurement mean? Why is this measurement important? Challenge answers. Test assumptions.

Six Sigma uses a universal metric—defects per million opportunities (DPMO). That metric makes it easier and more realistic to compare performances for products, services, or processes in any type of organization. Another key metric is the cost of poor quality (COPQ). To discover the COPQ, calculate the costs of inspections, rework, duplicate work, scrapping rejects, replacements and refunds, dealing with complaints, loss of customers, and other non-value-added activities in your organization.

Limit the number of metrics—generally, no more than 10. Your metrics must be simple; they must clearly communicate the information you need. They must also be clear: use units and terms that everybody understands.

Your measurement systems must provide feedback promptly, so you can identify problems and correct them as soon as possible. And finally, your metrics must be sensitive enough to reveal performance changes of any significance.

Here are the three most important points about metrics:

Start with your customers: What factors are critical to quality for them?

Measure what matters: Metrics must align with strategy, link to bottom-line results, and relate to important, regular activities and processes. Measure in order to determine where your defects are and what you need to do to improve your processes.

Question and challenge: Focus on *why* you're measuring so you can decide *what* to measure.

"Establishing metrics requires dedication, focus, and logic. It also requires leadership. As manager, you must be a model of critical thinking and courage to challenge the status quo and underlying assumptions."

☑ Use statistics

A basic principle of Six Sigma is reducing variation in the quality of outputs. To reduce it, we must be able to measure it.

Let's take a simple example—reducing variation in assembly times on three production lines. You clock the time per unit for 100 widgets on each of the lines. How much do those times vary?

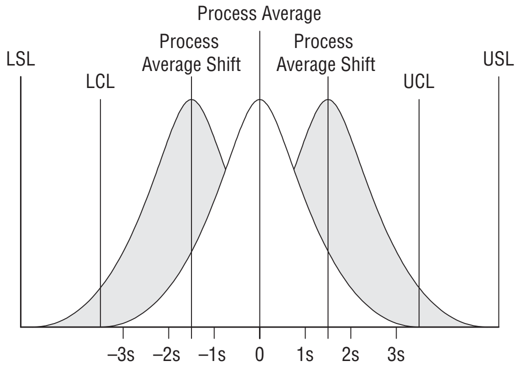
Six Sigma uses *standard deviation* (sigma) to measure the variation of values from the mean (average). You calculate the standard deviation for the times from each of the lines. (There are calculators and software applications that crunch these numbers.)

Then you plot the values on a distribution chart (histogram). With enough values, the distribution will likely form a bell-shaped curve. In a normal distribution, 68.2% of the values will be within one sigma of the mean, 95.5% will be within two sigma, and 99.7% will be within three sigma.

Then determine how much variation is acceptable to your customer. The widget packagers who must keep pace with the assemblers would be happy if the lines took between four and six minutes. Use those values to set the lower specification limit (LSL) and upper specification limit (USL) within which each line must operate.

Now, compare the standard deviation for each line with the interval between the mean for that line and the LSL or the USL. If it's less, congratulations! If not, you need to reduce the variation, the sigma level.

The goal of Six Sigma is to reduce the standard deviation of your process to the point that six standard deviations (six sigma) can fit within your specification limits. That means improving process capa-



What you look for with Six Sigma is a process where all inputs fall within the upper and lower specification limits, even if the process averages shifts 1.5 sigma

bility—a statistical measure of variation in a stable process, expressed as a capability index.

In addition to the LSL and USL, another pair of limits should be plotted for any process—the lower control limit (LCL) and the upper control limit (UCL). These values mark the minimum and maximum inherent limits of the process, based on data collected from the process. If the control limits are within the specification limits or align with them, the process is considered capable of meeting the specifications. If either or both of the control limits are outside the specification limits, the process is considered incapable of meeting the specifications.

In order to measure variation in a process, there are three basic steps:

Calculate the standard deviation for your data: This measure of process variation is central to Six Sigma.

Set the specification limits: Determine what your customers want. The variation in your outputs should not exceed these limits.

Plot the control limits (LCL and UCL): All variation must be between these limits for a process to be considered in control.

"Any process improvement should reduce variation, so we can more consistently meet customer expectations."

☑ Focus on results

From the start of a Six Sigma initiative, commitment and communication are crucial. To get results that count, the executive leaders must support and promote the initiative and provide information about Six Sigma and all developments. The initiative also depends on the people who play the primary roles, who are responsible for using the Six Sigma techniques and tools to achieve results. There are a number of roles different people take on when establishing the Six Sigma initiative in an organization.

Champions are generally upper managers. They serve as mentors and leaders; they support project teams, allocate resources, and remove barriers.

Black belts lead improvement projects full time, supported by project team members. Choose your candidates carefully. It takes certain qualities to be a black belt; training develops these qualities, but it can't create them.

Master black belts train black belts and project team members, and they provide guidance as needed.

Green belts assist black belts part time.

Finally, in the beginning, an implementation partner—an outside expert—helps structure, introduce, and support the Six Sigma initiative and provides training for master black belts.

Six Sigma requires training: up front and then throughout improvement projects for black belts and green belts.

Executive training should be offered to all senior managers. This should include an overview of Six Sigma, a review of case studies, deployment strategies, tools and methods, statistical analysis, improvement, measurements, and management controls.

Champion training should be offered to managers at all levels: the principles, tools, and applications of Six Sigma, including deployment tactics and strategies.

Black belt candidates should learn the Six Sigma philosophy, tactics, techniques, tools, and group dynamics. Much of the training is provided throughout the projects, as the need arises. Similar training is provided to the green belts who are working with them.

Here are three essentials for starting a Six Sigma initiative:

Focus on results: Top managers must commit and communicate, support and promote—actively. Training provided during the projects must be practical and based on the specific needs of the team members.

Choose the right implementation partner: Get an expert who will be dedicated to your bottom line. Use the expertise and experience of a master black belt wherever and whenever possible.

Define roles from the start: The key players should know their responsibilities and how all of the roles work together.

"Six Sigma provides some powerful techniques and tools, but success depends on the people who play the primary roles and assume the central responsibilities for putting those techniques and tools to work for your organization."

Choose projects carefully

The selection of Six Sigma projects is crucial, especially early in your initiative. Your implementation partner should review your financial statements and then help you find projects.

The cost of poor quality is the basic criterion for judging potential projects. A project must reduce costs or there's no point to doing it. In Six Sigma the only measure of success is dollars saved delivering outputs that customers value.

Two important considerations in project selection are the *resources and time required* and the *probability of success*.

Give priority to projects that address factors critical to your customers' expectations of quality, cost, and delivery and have a low effort-to-impact ratio. For each project, quantify the *impact* and the *effort* required. (You can also think of this as a kind of cost-benefit analysis.) Then, quantify the *probability of success*, assessing the risks, complexity, uncertainty, and barriers. Will the benefit of this project outweigh the cost and effort required?

Identify and prioritize the factors suspected of affecting your critical-to-quality metrics. Then identify the owners of the suspected sources, who then become the champions for those projects, and departments and people that you'll need for support. Next, establish parameters for each project, set a timeline boundary (usually six months at most), and start planning the tools and techniques to deploy.

Create a project problem statement. That's one of the hardest things to do in Six Sigma. It must be quantifiable and specific; it must attack the process at its core and look at the business metrics around it. A problem statement has two purposes: to focus the team and to present the problem and the benefit of fixing it to executives or others to whom you'll be reporting.

Create an objective statement. Quantify the expected performance, indicate the improvement target, and give the expected time frame.

Finally, present your potential projects for senior managers to review and approve. In this way, you get their buy-in and support of the project and they get a clear sense of the objective and the plan for pursuing it.

To make the best project choices:

Select judiciously: Not every problem is a project and not every project idea will generate the results you want. Use the expertise of your outside consultant.

Focus on the financial: Projects must reduce costs. Locate the cost of poor quality in your processes.

Develop good problem and objective statements: Be clear about what you're attacking and why. Keep your projects on track by focusing on their objectives and your plans for achieving them.

"The average Six Sigma project returns a minimum of $175,000 to the bottom line. The benefits of implementing the disciplined, data-driven methodology speak for themselves."

Plan implementation

The standard Six Sigma methodology consists of five phases: Define, Measure, Analyze, Improve, and Control (DMAIC). This methodology is not rigid, and approaches vary. Some practitioners do not include the Define phase, considering it as part of preparation.

The model, whether you use DMAIC or MAIC, is the key to Six Sigma. It sequences the steps that are essential to achieving results: *define* the projects, the goals, and the deliverables to customers (internal and external); *measure* the current performance of the process; *analyze* and determine the root cause(s) of the defects; *improve* the process to eliminate defects; and *control* the performance of the process. Each phase has key deliverables that are used as documentation and evaluation.

Here are the basic activities, showing the logic of the Six Sigma DMAIC model:

Define Phase

1. Identify the important problems in your processes.
2. Select a project to combat one or more of the problems and define the parameters of the project.
3. Determine the vital few factors to be measured, analyzed, improved, and controlled.

Measure Phase

4. Select critical-to-quality characteristics for your product or process (the CTQ Y's, where Y = CTQ characteristic).
5. Define performance standards for Y.

6. Validate the measurement system for Y.
7. Establish the process capability of achieving Y.

Analyze Phase

8. Define the improvement objectives for Y.
9. Identify the sources of variation in Y.
10. Screen potential causes for change in Y and identify vital few initial X's (where X = key variable in the process).

Improve Phase

11. Discover variable relationships among the vital few initial X's.
12. Establish operating tolerances on the vital few initial X's.
13. Validate the measurement system for the vital few initial X's.

Control Phase

14. Determine your ability to control the vital few initial X's.
15. Implement a process control system for the vital few initial X's.

To summarize:

Plan each Six Sigma project with the DMAIC/MAIC model: It sequences the steps essential to success. Follow each step in the proper order and complete the tasks for each.

Complete the key deliverables for each phase: They are documented, quantified evaluations of completion of the phase.

Understand and respect the logic of the model: Six Sigma is more than a statistics program; it shows how to use statistics and to understand their value, in order to make rational and measurable decisions about business processes.

"A step-by-step discipline that defines, measures, analyzes, improves, and controls, DMAIC/MAIC is the key that unlocks true Six Sigma success for your business."

Plunge into action

Plot the project

As outlined earlier, the Define phase of Six Sigma follows this logic:

- Identify the important problems in your processes.
- Select a project to combat one or more of the problems and define the parameters.
- Determine the vital few factors to be measured, analyzed, improved, and controlled.

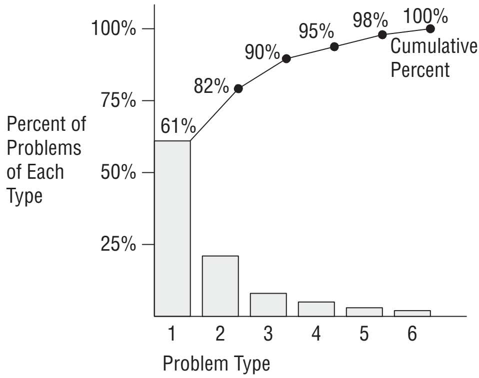
Let's examine the Define phase more closely.

First, define the chronic, big issues in your processes. It's often useful to map processes, in order to better understand them and locate the problems. This involves creating a diagram showing all the steps in the process and where the problem steps are.

Then, select a project to combat one or more of these process problems. It's essential to define the parameters and scope of the project and to understand what you want to accomplish. The scope and sequence exactly define rules for your project—how long it will run, what you're examining, your goals, and the tools and personnel you'll need to achieve them.

Next, hand over the project to your black belt and the team. They will further examine the elements that are critical to quality for your customers and start solving the problems.

Central to Six Sigma is the vital few equation, $Y = f(X)$. This simple transfer function shows that Y, the characteristic of quality you're targeting, is a function of X's, the key variables in the process. Funnel all process elements through the equation to get to the vital few factors that directly explain the cause-and-effect relationship of the process output being measured in relation to the inputs that



A Pareto chart for identifying the vital few

drive the process. Identify the X's so you can concentrate your efforts where the impact and return are greatest.

The key deliverables of the Define phase include the following:

1. project status form
2. metric graph
3. process map with tally points
4. Pareto charts (a tool for identifying the vital few X's)
5. improvement plans/next steps
6. local review

Once you've defined the project, you can now move on to start fixing the problems in the remaining four phases.

Three important points in the Define phase:

Identify the most serious problems in the processes: The first step is usually to map the processes.

Frame a project to work on the problems: State the problem. State the objective. Determine the scope.

Identify the vital few factors: These are the factors to measure, analyze, improve, and control.

"Central to the Six Sigma methodology is a key equation that defines which vital few factors need to be measured, analyzed, improved, and controlled for bottom-line results."

☑ Measure smart

As outlined earlier, the Measure phase of Six Sigma follows this logic:

- Select critical-to-quality (CTQ) characteristic(s) in the product or process.
- Define performance standards for Y, the CTQ characteristic.
- Validate the measurement system for Y.
- Establish the process capability of achieving Y.

Let's examine the Measure phase more closely.

First, identify the crucial internal processes that influence the CTQ measurements, the process outcomes. Then, measure the defects that profoundly affect the CTQ standard.

Next, calculate how much money you would save if they were eliminated.

Before measuring, the black belt must conduct a measurement systems analysis, which includes *gauge studies*. The purpose of a gauge (or gage) repeatability and reproducibility study is to ensure that the measurement systems are functioning properly. It measures how well you're measuring.

A gauge R&R can alert you to any discrepancy in measurements, so you can correct them as soon as possible, and validate that your metrics make good sense and will provide the information you need to reduce defects.

Gauge R&R repeats measurements under various conditions to test the systems for four essential criteria—*accuracy* (How precise is the measurement?), *repeatability* (If the same person and/or equipment measures the same item more than once, will the results be the same?), *reproducibility* (If other people and/or other equipment measure the same item, will the results be the same?), and *stability* (Will accuracy, repeatability, and/or reproducibility change over time?)

Finally, the black belt estimates the process baseline capability, defined as "a statistical measure of inherent variation for a given event in a stable process." Basically, how good is the process at this point?

The key deliverables of the Measure phase include the following:

1. project status form
2. metric graph
3. process map with tally points
4. Pareto charts
5. measurement tools, including gauge R&R studies
6. improvement plans/next steps
7. local review

This documentation shows exactly what and how you measured to identify the vital few factors that are central to the entire course of your project. Three important points in the Measure phase:

Select the critical-to-quality characteristic(s) in the process: What defects most significantly affect what matters most to your customers?

Validate the measurement systems: Four criteria are essential—accuracy, repeatability, reproducibility, and stability.

Establish the process capability: How much is variation affecting critical-to-quality characteristics?

"There is a direct and measurable relationship between defects and dollars. In the Measure phase, you can figure out that relationship exactly."

☑ Understand the process

As outlined earlier, the Analyze phase of Six Sigma follows this logic:

- Define improvement objectives for Y (CTQ characteristic).
- Identify variation sources in Y.
- Screen potential causes for change in Y and identify the vital few initial X's.

Let's examine the Analyze phase more closely.

At this point, you try to understand *why* defects happen and then break down the reasons identified. In other words, the team asks which *inputs* are affecting the *outputs*.

In mapping and measuring your process and identifying input variables that may affect the critical-to-quality attributes, you've probably come up with some assumptions about relationships between each critical-to-quality defect measurement (the Y) and the factors that would affect it (the X's). Now, you formulate hypotheses and statistically test them to determine which factors are critical to the outcomes.

Hypothesis testing is a series of cycles consisting of three steps. First, develop a hypothesis about the cause(s). Second, analyze the process and/or data. Third, if the hypothesis is correct, add the cause(s) to the list of vital few or, if the hypothesis is incorrect, refine it and analyze again or reject it and develop another hypothesis.

Hypothesis testing uses detailed analyses to calculate the probability that the factors identified as the vital few truly have the greatest impact on the critical-to-quality outcomes. You then start devising solutions and developing plans for taking corrective action.

The key deliverables of the Analyze phase include the following:

1. project status form
2. metric graph
3. tool use as required, to show competence—gauge R&R, Pareto charts, etc.
4. solution (root cause)
5. improvement plans/next steps
6. quantification of improvement plans
7. local project review
8. list of significant causal factors

This documentation shows that you have identified the vital few factors, determined the effect of each, and planned the next corrective actions. It's a disciplined approach to determining the course of your project.

Three important points in the Analyze phase:

Define your improvement objectives for Y: What are the critical-to-quality attributes to be improved?

Identify the sources of variation that affect Y: Which inputs are affecting the outputs?

Screen the potential causes and identify the vital few initial X's: Which factors are most influencing the outcomes?

"In the third phase, Analyze, you work with all the information gathered in the Measure phase to determine potential causes and to prepare for making key changes to positively alter each scenario."

☑ Test solutions

As outlined earlier, the Improve phase of Six Sigma follows this logic:

- Discover variable relationships among the vital few X_i (initial X's, the key variables that affect a CTQ characteristic).
- Establish operating tolerances on the vital few X_i.
- Validate the measurement system for the X_i.

Let's examine the Improve phase more closely.

In the Improve phase, you confirm key independent variables and quantify the effects of those variables on the dependent variables, the critical-to-quality outcomes (Y's). As a result, you can identify the maximum acceptable range of each independent variable to ensure that your measurement system can actually measure that variation.

The difference between independent and dependent variables is crucial. In the transfer function equation, $Y = f(X)$, you can't adjust the dependent variable Y (the outcome); you must adjust the independent variables, the X's, to effect change. Among these we identify the vital few factors that influence almost every aspect of a process. When you know the vital few X's in the $Y = f(X)$ equation, you can manipulate each X so that it stays within an acceptable range to achieve the Y's you want, within an acceptable range.

You generate possible solutions to the problems you've identified. Then you test those possibilities, using such tools as design of experiments (DOE) and failure modes and effects assessment (FMEA). Finally, you select the best solutions and you design an implementation plan.

The key deliverables of the Improve phase include the following:

1. project status form
2. metric graph
3. tool use as required, to show competence—hypothesis testing, gauge R&R, Pareto charts, etc.
4. list of significant causal factors
5. solution (containment action)
6. improvement plans/next steps
7. quantification of improvement plans
8. local project review

This documentation shows the vital few factors and the rate of the effect of each of them and it also outlines the actions you plan to take to improve them. It's a disciplined approach to reducing the damaging effects of variation.

Three important points in the Improve phase:

Discover the variable relationships among the vital few X's: How do the variables work together to result in the outcomes?

Establish operating tolerances for the vital few X's: How much variation is possible without causing the CTQs to exceed the limits acceptable to the customers?

Validate the measurement system for the X's: How accurately can the input variables be measured and controlled?

"After you've carefully (sometimes painstakingly!) measured and analyzed the situation, you arrive at the exciting point of actually testing your theory to find an equation to solve the problem."

☑ Monitor and maintain

As outlined earlier, the Control phase of Six Sigma follows this logic:

- Determine your ability to control the vital few initial X's (key variables that affect quality).
- Implement a process control system for the vital few initial X's.

Let's examine the Control phase more closely.

In the Control phase you maintain the changes you made in the X's in the equation in order to sustain the improvements in the resulting Y's. You continue to document and monitor the processes via your metrics to assess and ensure their capability over time. In some cases, you can skip much of the Control phase, because you eliminate the problem entirely.

Following the logical sequence of DMAIC enables you to maintain a level of higher quality and lower costs. By mapping the processes and then measuring and analyzing each factor, you know how to improve and control them, through mechanisms that can be both macro and micro in scope.

At this point, it's time for closure. You transfer ownership of the process and the knowledge acquired through the project to the process owner. Then, you report on lessons learned so that other project teams can benefit from your experiences. Finally, the team celebrates.

The key deliverables of the Control phase include the following:

1. project status form
2. metric graph
3. specific control/validation plans

4. verification of improvement/results in metrics and dollar savings
5. significant lessons learned
6. final report
7. local project review

Once you've completed this documentation, you have the critical information in hand that indicates exactly not only the vital few factors and the rate of the effect of each of them, but also what you're going to do specifically to sustain the gains you've made. It's a disciplined approach to staying the improvement course that's already under way.

Three important points in the Control phase:

Determine your ability to control the vital few initial X's: You should ensure that the team has succeeded, that you've reduced variation and stabilized the process.

Implement a process control system for the vital few initial X's: The owner of the process should be able to maintain the gains after the project is completed.

Hand over the process to the process owner: The project team has finished its work. It should report on lessons learned. Then, it's time to celebrate!

"You now know what you need to do to make lasting, profitable changes. You know what works and what doesn't. Now you have the roadmap for staying on course."

Open up, narrow down

When beginning a Six Sigma project, you need to open up the investigation before you can narrow down the focus. It's not who starts soonest, but who starts smartest.

Brainstorming is a method for generating ideas; you can use it to develop a list of possible causes in the Define phase, to probe during the Analyze phase, and to generate possible solutions in the Improve phase.

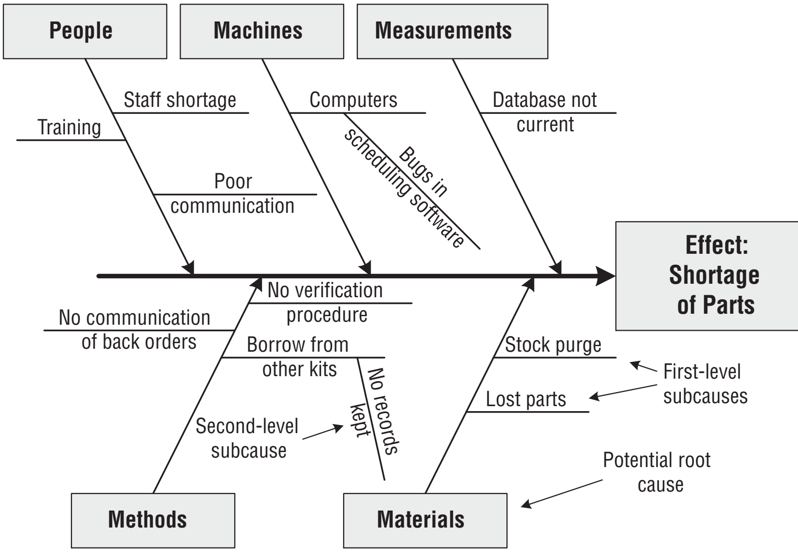
Team members focus on a problem or an opportunity and come up with as many ideas as possible. They do not criticize or discuss any ideas; the point is to open up thinking about the issue. Each idea is recorded on a board or a flipchart, so others can build on it.

After brainstorming, the team members analyze and explore the results.

The cause-and-effect diagram is a tool for showing relationships between a result and possible causes. The structure—a horizontal line with diagonal lines branching up and down from the main line—resembles a simplified fish skeleton, which is why it's also called a fishbone diagram.

The line (spine) represents the effect and is typically labeled on one end as the head of the fish. Each diagonal line (major bone) branching out from the spine corresponds to a major cause or group of causes. Minor bones branch off from major bones for contributing causes. This diagram is useful in any analysis of causes and effects.

A Pareto chart is a good way to show the relative importance of causes or solutions. It's a graphic application of the Pareto principle: 20% of factors account for 80% of results.



A cause-and-effect diagram for identifying causes of particular outcomes

Use a Pareto chart to identify the factors that have the greatest cumulative effect in a process. Plot each factor, from most important to least, and the cumulative effect of the factors. Then, you can determine how many factors together will provide the results you want.

Use these three tools to open up your investigation and narrow down the focus:

Use brainstorming to generate ideas: Use it to identify causes or solutions.

Use a cause-and-effect diagram to identify causes or solutions: It's a systematic way to explore causal relationships.

Use a Pareto chart to quantify the effects of the causes: Identify the factors that together have the greatest effect, so you can focus on the most important.

"You don't need to become a statistician or develop the expertise of a black belt, but you need to know the basics about the fundamental tools used in Six Sigma methodology."

☑ Discover patterns

If you trust in averages, a zebra is gray. However, for most people, a zebra is patterns of black and white.

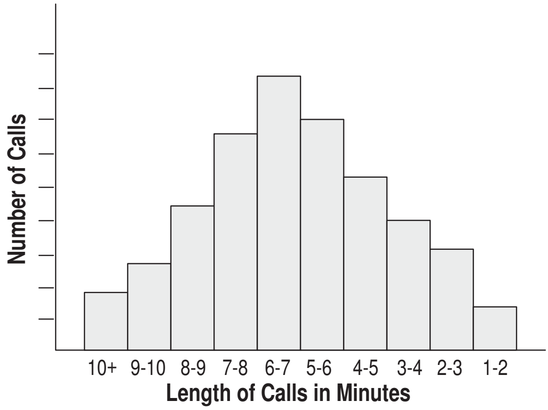
In Six Sigma, it's important to go beyond averages, to analyze the variations that averages hide. Graphical tools can show data in ways that patterns emerge.

A histogram is a group of vertical bar graphs that shows on a two-axis graph the distribution of points in a group of data. The histogram takes us beyond mean, mode, and median, which measure the central tendency of a group of data.

You create the histogram bars to group data into equal increments—bins, segments, groups, classes, or buckets—according to a metric, such as size, time, frequency, or dollars. Along the horizontal axis, you plot each bin: e.g., 26-30 seconds, 21-25 seconds, 16-20 seconds, and so on. Along the vertical axis, you plot the count (frequency): e.g., zero units, one unit, two units, and so on. Then, you make a bar to show the frequency for each bin: e.g., three units took 26-30 seconds, five took 21-25 seconds, eight took 16-20 seconds, and so on.

Bin width is an important consideration. Smaller bins might allow us to detect distribution patterns that are not evident with larger bins. You can make bins as small as the precision of your measurements allows: e.g., 30 minutes, 29 minutes, 28 minutes, and so on.

Data displayed on a histogram will often show what's considered a normal distribution, in the shape of a bell, with the highest point in the middle and sloping away from the center on both sides, smoothly and symmetrically.



A histogram plotting number of calls and length of calls. In this case the distribution conforms to a standard bell curve

Not all distributions are normal. In fact, most business processes don't produce normal distributions. Some curves are not symmetrical: a slope on one side is longer. Some curves are pointier or flatter than most. Some curves have two peaks: this pattern may mean that the data is reflecting two processes, so you would need to distinguish between the two to understand either.

When examining data:

Use a histogram to go beyond averages: Look for patterns that tell you about the process.

Size the bin widths to allow patterns to emerge: If the bins are too wide, patterns may remain hidden. If the bins are too narrow, there may not be enough points in each to indicate any pattern.

Investigate any patterns: Trust your data—but not your displays. Experiment with bin widths.

"The histogram adds a new aspect to your investigation—the distribution of elements in your process."

Study correlations

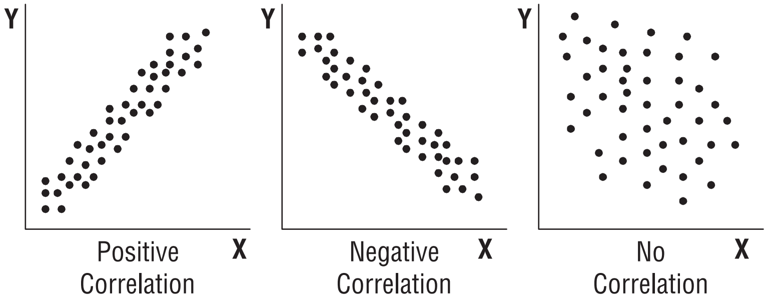
It's tempting to jump to conclusions about data and try to move ahead. However, it makes sense to verify any conclusions about cause-and-effect relationships. Correlation studies allow us to investigate them.

Correlation is a measure of the degree to which two variables are linearly related, expressed in terms of a correlation coefficient, which ranges between –1 and 1. If the value of one variable increases when the value of the other increases, they are positively correlated. If the value of one variable decreases when the value of the other variable increases, they are negatively correlated. If one variable does not affect the other, they are not correlated.

The typical graph used in a correlation study is a scatter plot. To create a scatter plot, mark the possible values for one data set along one axis and the possible values for the other data set along the other axis. Then, plot each pair of data points as a coordinate on the graph.

The closer the plotted points come to forming a straight line, the higher the correlation between the two variables. If that line goes from low X and Y values out to high X and Y values, the correlation is positive. If the line goes from high Y and low X values to high X and low Y values, the correlation is negative. If the plotted points do not form a line, there is no correlation. Perfect correlations are +1 or –1: the closer the number to either extreme, the stronger the relationship.

Scatter plots can also show more complex, nonlinear relationships in which the variables are positively correlated for some values and negatively correlated or unrelated for other values.



Correlation diagrams showing positive, negative, and no correlation

It's important to understand and remember that correlation does not necessarily mean causation. To examine how different X's might affect Y's in a process, the team can pair up data in different ways. For example, just because sales of ice cream and people drowning at the beach both go up in the summer, it doesn't mean there is a correlation between the two events. If scatter plots show correlation between two variables, it mainly suggests probable directions for further investigation.

Three points to remember about using correlation studies to investigate cause-and-effect relationships:

Correlation coefficients range from +1 to –1: The closer to +1, the stronger the positive relationship. The closer to -1, the stronger the negative relationship.

The correlation coefficient is a measure of linear relationships: A relationship between two variables may not be strictly linear.

Correlation does not mean causation: It can only suggest probable directions for further investigation.

"Correlation is an overworked and incorrectly used word that frequently gets tossed around in business."

Map the process

The first key Six Sigma tool is process mapping, used during the Define and Measure phases. The purpose is to develop an accurate, comprehensive picture of the entire process. Process mapping is an integrally important tool that helps you understand every aspect of every input and output. It helps you document the process so that you can understand it more thoroughly, maintain control over what you change, and reduce variations as they arise over time.

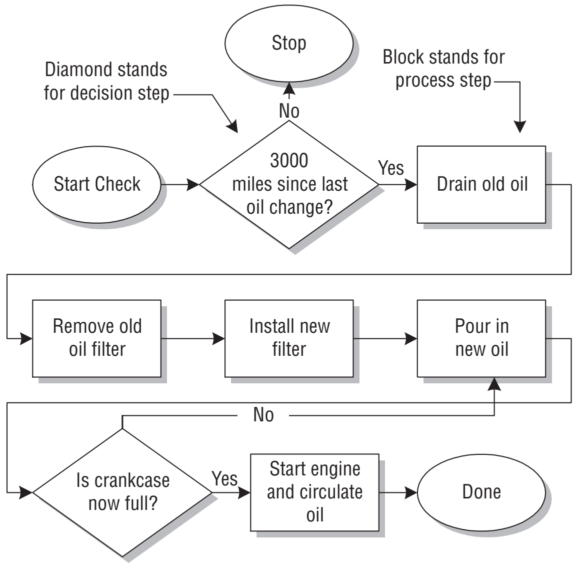
The procedure for mapping a process is very simple but extensive: list all the inputs and the outputs—all the steps, all the cycle times, and so on.

As you start mapping processes, identify the value-added and the non-value-added factors inside the steps. List and classify each step in this context—digging deeper and deeper to ensure that you've documented every factor affecting each step in the process.

Once you know all the inputs and factors, you can then designate them as external or internal and determine whether their effect is good or bad. You can then layer on operating specifications and ask about the targeted specs for the particular process.

The standard tool is a flowchart, a schema to show operations, decision points, delays, movements, handoffs, rework loops, and controls or inspections. By breaking down the process into steps, the flowchart makes it easier to analyze. As you map your process, ask two key questions: for every step, ask why you do it and how you know you're doing it right.

Process maps keep critical team members and resources focused and involved and help them identify the benefits and opportunities



A simple process map (or flowchart) showing the process for changing oil in a car

of attacking the bottlenecks, capital constraints, or other material problems.

Here are three basic rules for mapping processes:

List every step and every input and output: Consult with people close to the process. Break it down into all of its components—operations, decision points, delays, movements, handoffs, rework loops, and controls or inspections.

Identify every factor as value-added or non-value-added: What activities are essential to transforming inputs into outputs to meet customer requirements? What activities are not essential?

For every step, ask two key questions: Why do we do it? How do we know we're doing it right?

"A process map is a 'living' document: it helps you document the process so you can maintain control over what you change and be alert for variations as they start to pop up over time."

Focus on functions

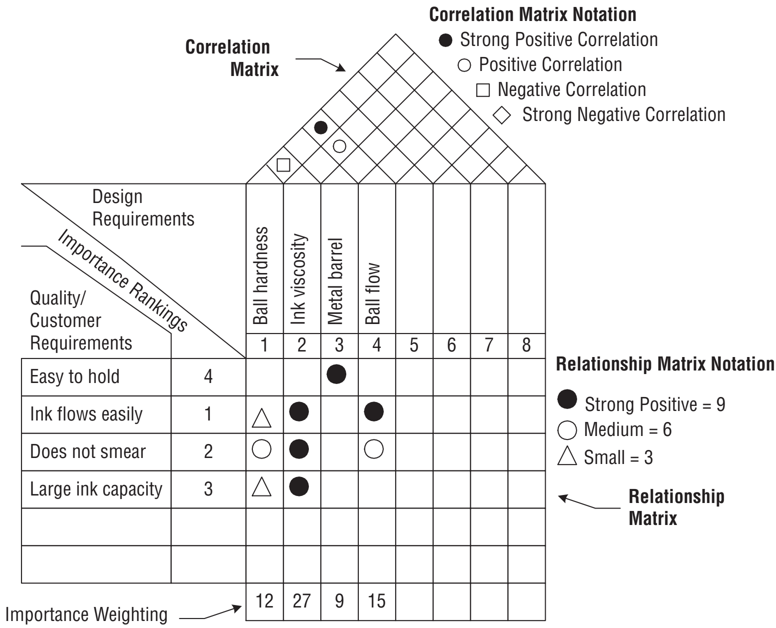
The XY matrix is used in the Measure phase to link your customers' critical-to-quality (CTQ) requirements to your process inputs, to ensure you have the right priorities for improving the process.

This matrix, also called a CTQ matrix, enables you and your project team to study and understand the relationship between what you're putting into a process and what your customers are getting out of it. It allows the team to identify gaps—areas for improvement.

Create a matrix with enough columns for the input variables (X's) and enough rows for the output variables that are functions of those inputs (Y's). Across the top, label a column for each X. Down the left side, label a row for each Y. Then have the team members, by consensus, rate each output on a scale of 1 to 10 in terms of its importance to customers, based on information from customers. Next, have them rate, by consensus, each of the input variables in terms of its effect on each of the output variables, using the same scale. Finally, they multiply the ratings to identify the input factors that most affect the outcomes that matter most to your customers.

The XY matrix enables you to prioritize input variables through disciplined thinking about customer priorities and the $Y = f(X)$ transfer function. The XY matrix is a directional tool; it shows which variables you think are the most important so you can measure them to confirm or refute your suspicions.

A variation of this XY matrix is the House of Quality, which adds a triangle to the top of the matrix, for correlating every input with every other input. Quality function deployment uses a series of these houses.



An XY or CTQ matrix, a simple example of a ballpoint pen and the connection between design and customer requirements

Here are three basic principles for using an XY matrix:

Emphasize disciplined thinking: The XY matrix works to the extent that team members focus on each of the variables and on the relationships among them.

Promote collaboration: The XY matrix works best when team members pool their knowledge and experiences to rate the variables.

Don't expect answers: The XY matrix is a directional tool. It doesn't provide answers. It points to suspect variables that you should measure to obtain answers.

"It may seem that the XY matrix is contradicting everything you've learned about Six Sigma, because it's based on opinion, not fact. But the opinions are informed: the matrix is based on expertise and thoughtful, constructive group analysis of the issues."

☑ Test the systems

Six Sigma depends on measurements. It's only logical, then, to ensure that your measurement systems are statistically sound—that they all function independently and correctly 100% of the time; otherwise, you risk flaws in your data. So, during the Measure phase, the black belt conducts a measurement systems analysis (MSA).

MSA is an experimental and mathematical method for determining how much of the variation in a process results from variation within the measurement system. Central to the MSA is the gauge (gage) repeatability and reproducibility (gauge R&R) study.

The gauge R&R study compares your measurement devices against others to ensure that you're measuring what you think you're measuring. It examines your units of measure and number of variables, calibrates the measurement gauge, randomly selects samples to measure against different operators, and assesses the data for statistical soundness. Once all the trials are completed, the study shows where the flaws are and takes corrective action.

Gauge R&R repeats each measurement under various conditions to test it against these four essential criteria:

- **Accuracy.** How precise is the measurement?
- **Repeatability.** If the same person or piece of equipment measures the same item more than once, will the results be the same?
- **Reproducibility.** If other people or other pieces of equipment measure the same item, will the results be the same?
- **Stability.** Will accuracy, repeatability, and/or reproducibility change over time?

Essentially, the study plays two roles: it can alert you to any discrepancy within defined measurements, so you can correct them at the beginning, and it can validate that you're using metrics that not only make good sense, but also will get you the information you need to reduce defects.

Three things to keep in mind about measurement systems:

Don't measure until you've completed an MSA: If you don't know if you're measuring correctly, how can you be sure about the problems and the solutions you discover?

Understand the factors in your measurement systems: How are you measuring? Who's measuring? What tools are they using? All factors should be considered in an MSA.

Correct any variations in your measurement systems: Don't simply try to accommodate variations and allow for inaccuracies.

"To maximize the investment of time and resources in a Six Sigma project, you've got to be sure that you're measuring the right stuff in the right way to get the right results."

☑ Make the fix last

In the lesson on statistics (pages 5 to 6), you learned about standard deviation, specification limits, and control limits. It stated that if the control limits for a process (the capabilities of the process) are within the specification limits (what will satisfy the customer) or align with them, the process is considered capable of meeting the specifications. That's process capability—the ability of the process to achieve certain results. Process capability is measured toward the end of the Measure phase.

Process capability is a statistical measure of inherent variation for a given event in a stable process. "Stable," in simple terms, means that all of the causes of variations in a process are known, that there is no significant variation due to special causes. Process capability indicates to what extent the process is able to meet specifications and customer critical-to-quality requirements in the long term. It's great that you can fix something, but to really reap the benefits you must make that fix last. That's why we use capability metrics.

Process capability analysis establishes short- and long-term deviation patterns and baseline performance for each process. The tools determine whether or not the process is performing within the specifications, show you how to decrease variation, and help you reach optimal, statistically proven capability.

Process capability is calculated as a capability index. There are two capability indices commonly used, Cp and Cpk.

Cp is calculated as the process width (the difference between the specification limits) divided by six times the standard deviation (6 sigma) of the process. Cp is a simple and straightforward measure of process capability. However, it measures only the spread of the distribution, the variation in a process; it tells us nothing about how the distribution is centered, how far the variation is from the target. That's why Cpk is necessary: in essence, it adjusts Cp for distributions that are not centered on the target value.

Cpk is calculated as the lesser of these two calculations: the upper specification limit minus the mean divided by 3 sigma or the mean minus the lower specification limit divided by 3 sigma.

Measure the capability of your processes: Reducing variation temporarily is only a start; what really matters is to ensure that the reduction lasts.

Ensure that a process is stable before measuring its capability: Measures of process capability are valid only for processes that are stable.

Calculate both Cp and Cpk: Knowing that the extent of variation is acceptable means little if the values are not close to your target value.

"Process capability answers the question, 'What can your process deliver?'"

☑ Identify vital few causes

As you begin the Analyze phase, you need to know how the inputs affect the output capabilities of the process. To do so, you use multivari analysis to identify the significant inputs and characterize the process.

A multivari study is an analysis of possible sources of variation in a process. You do this by graphing the interrelationship of multiple variables to learn which one contributes the most to that variation.

The multivari chart presents an analysis of variation as a process operates in its normal state by differentiating three main sources: intra-piece (variation within a piece, batch, or lot), inter-piece (variation from piece to piece), and temporal (variation related to time). By comparing input variables and output variables, the studies allow the project team to quantify basic correlation.

Regression—the relationship between the mean value of a random variable and the corresponding values of one or more independent variables—is used with the data from the multivari study to determine the formula that correlates input variables and output variables. Sometimes a multivari study will reveal the sources of problems; in other cases, the outputs of a multivari study become the inputs for a factorial experiment.

Multivari studies characterize the baseline capability of a process while it is in operation. Data is collected and analyzed to determine the capability, stability, and relationships between key inputs and outputs. Multivari studies compare how the same functions, performed by different people or in different shifts, perform over time.

There are three basic steps in conducting a multivari study:

Identify the sources of variation: There are three families—positional (variation within a specific product—intra-piece), cyclical (variation among products in a sequence or across a series of processes—inter-piece), and temporal (variation in a process over time).

Sample the families: Use one or more of several types of representative sampling—random, systematic, subgroup, and cluster or stratified sampling.

Use graphical analysis: Graph the results, using a multivari plot, a box plot, a main effects plot, or a regression plot.

"Multivari studies allow you to identify the inherent capabilities and limitations of a process."

Check hypotheses

The purpose of hypothesis testing is to investigate a theory about the suspected cause(s) of a particular effect in a process to determine if it is correct. Hypothesis testing is a key to the Analyze phase. It uses a series of detailed analyses to calculate the probability that the factors that you've identified as the vital few truly have the greatest impact on the critical-to-quality outcomes.

First, develop a hypothesis about the cause(s). In mapping and measuring the process and identifying input variables that may affect the critical-to-quality attributes, you've probably come up with some assumptions about relationships between your critical-to-quality characteristic (the Y) and the inputs (the X's) that would affect it. Now you shape them into a hypothesis to explain why defects are happening and identify and verify the causes.

Second, test the hypothesis statistically. Analyze the process and/or data through a logical sequence of steps, using one or more hypothesis tests (one sample, two independent samples, two dependent samples), correlation and regression, t-tests and paired t-tests, one-way analysis of variance (ANOVA), chi-square tests, and computer simulations using software that allows you to insert data and conduct what-if tests.

Third, if a hypothesis is correct, add the cause to your list of vital few causes; if not, refine it and test it again, try another hypothesis, or move on to the next step in the Analyze phase.

When you and your project teams are in the Analyze phase, you are continually brainstorming in a statistical sense—you are challenging the status quo and investigating the process and the data to identify the factors that are most influencing the outputs so you can generate solutions and develop plans for taking corrective action in the next phase, Improve.

There are three steps in hypothesis testing:

Develop a hypothesis about the cause(s): What assumptions have you been making about relationships between critical-to-quality characteristics and inputs?

Analyze the process and/or data: Hypothesis testing uses a logical sequence of steps to calculate the probability that factors identified as the vital few have the greatest impact on the critical-to-quality outcomes.

Accept, refine, reject, and/or move on: If the hypothesis is correct, add the cause(s) to the list of vital few. If the hypothesis is incorrect, refine it and analyze again or reject it and develop another hypothesis.

"Hypothesis testing is a compass that points you directly to the vital few factors that are most affecting your process."

☑ Know the risks

During the Analyze phase, the team conducts a failure modes and effects analysis (also known under similar names, but most generally by the acronym FMEA). Once you've collected the data, you must know how failure modes affect customer critical-to-quality characteristics.

There are risks associated with defects, and it's vital to know about those risks. FMEA is a disciplined procedure that enables you to anticipate failures, identify them, and prevent them. It's a method for making a process more reliable while minimizing causes of failure. For example, in an assembly line a higher number of defective products than is acceptable may occur while the process is still under statistical control. To figure out what is going on, you can conduct an FMEA. Here's how.

Define the processes to be analyzed; agree on the level of FMEA and the scope. Develop maps of the processes and do a SIPOC (suppliers, inputs, process, outputs, customers) analysis for each process. Define each function and goal of the processes.

Define every potential failure mode for each process step and the possible effects, both immediate and eventual. Evaluate each failure mode in terms of the worst potential results and rate it from 1 to 10 for severity (SEV). Evaluate each failure mode in terms of the likelihood of it occurring and rate it from 1 to 10 for occurrence (OCC). Evaluate each failure mode in terms of the detection methods and rate it from 1 to 10 for detectability (DET). Multiply the three ratings—SEV, OCC, and DET—to calculate the risk priority number (RPN).

Use the RPNs as a guide in determining how to correct failure modes or compensate for their effects. After taking measures to correct or compensate, rate severity, occurrence, and detectability again and calculate new RPNs. Document the FMEA and any problems that the team could not correct and any special controls necessary.

An FMEA can be divided into three stages:

Define the processes to be analyzed: Determine the level of FMEA and the scope. Map and analyze the processes. Define every function and goal.

Assess the failure modes and their effects: Rate each failure mode for severity, occurrence, and detectability. Multiply the three ratings to calculate the risk priority number (RPN).

Correct and compensate: Correct the failure modes or compensate for their effects. Evaluate the processes again. Document the analysis, any problems not corrected, and any special controls necessary.

"As the managing champion of a project, you can use the FMEA to correct each and every failure mode as you direct your team."

☑ Correct any problems

In the Improve phase, you adjust various aspects within the process to identify what's needed to change the outcomes, so you can start correcting the problems. The tool to use at this point is design of experiments (DOE). Also known as *multivariable testing*, DOE is a way of determining the significance of two or more factors on the outputs of a process, by experimenting with many factors simultaneously rather than only one at a time, and quantifying the values of the input variables to meet the output requirements.

A team can identify the most influential factors more efficiently with DOE than with traditional means. If, for example, there are just five interacting factors to be studied and only two levels, the traditional full-factorial experiment would require 2^5—32!—experiments to explore all potential effects and interactions. The traditional approach can take a lot of time and money, especially if you repeat each test to be sure of the results. And as the number of factors rises, the costs increase exponentially.

DOE enables a team to identify a smaller number of experiments that can measure the interactions more efficiently. From the results, it can build an empirical model to predict process behavior based on the results for the values of these factors.

Here is how DOE works.

Identify the input variables and the output response(s) to be measured. For each input, define a number of levels. Form an experimental plan that indicates where to set each test parameter for each run of the test. Run the test for each level of input variable and measure the response variable. Analyze the resulting data and attribute any differences in outputs either to single effects of inputs or to interactions among inputs.

DOE consists of three activities:

Identify the variables and set the levels: What are the input variables? What are the response variables? Which levels represent the range of values?

Form an experimental plan: Determine the value for each input variable for each test run. Plan properly: generally, as much as 50% of your DOE effort should go into planning.

Run the tests and analyze the results: Test for each level of input variable and measure the response variables. Analyze the results and determine whether any differences in outputs are due to single effects of inputs or to interactions among inputs.

"DOE requires planning to work properly. DOE saves time and resources—if you don't try to cut corners setting it up."

☑ Plan for control

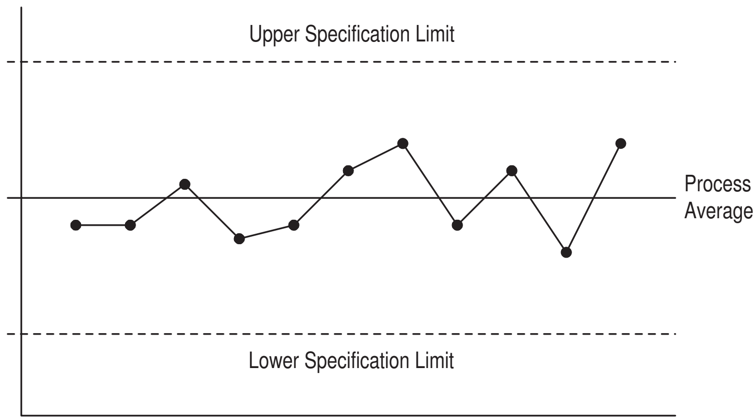
In the Control phase, the last tool is the control plan, a detailed assessment and guide for maintaining all the positive changes that the project team has made. It provides a written description of the system to control the process: it identifies and communicates changes in process characteristics, control methods, and measurement of characteristics. A control plan documents what has been done to prevent defects, how defects will be detected, and what to do if defects occur.

For Six Sigma to work, the process must be in control. If the process is out of control, measurements such as mean and process capability have little meaning.

What does it mean for a process to be "in control"? Ideas and rules differ. But the basis for any understanding of the concept of control is the control chart, the fundamental tool of statistical process control.

The control chart indicates the range of variability inherent in a process (known as *common cause variation*). Thus, it helps determine whether or not a process is operating in control or if the process mean or variance is changing because of a *special cause,* a source of variation that is both unpredictable and not due to normal causes.

The control chart shows the upper and lower control limits, which mark the minimum and maximum inherent limits of the process, based on data from the process. Data points that fall outside these bounds represent variations due to special causes; these causes can usually be identified and eliminated. In contrast, improvements



A simple control chart showing a process that is in control

in common cause variation require fundamental changes in the process.

A process is considered to be in control if all variation is random and if there are no data points outside the control limits, no runs of seven data points ascending or descending (evidence of a movement in the process), and no trends of seven data points above or below the mean (evidence of a shift in the process).

Here are three points for using control plans:

Make sure that the process is in control: All variation must be random. There can be no data points outside the control limits, no runs of seven data points ascending or descending, and no trends of seven data points above or below the mean.

Describe the system: Identify and communicate changes in characteristics, control methods, and measurement of characteristics.

Provide guidance for sustaining the gains: Document what has been done to prevent defects, how defects will be detected, and what to do if defects occur.

"A control plan ensures that you have the information to prevent a return to less than optimal performance standards."

☑ Sustain the gain

To get the best return on your investment in Six Sigma, you need to sustain the gain.

In the first year of Six Sigma ...

- Build and maintain a database of "lessons learned" so you can share your findings and techniques. Knowledge transfer needs to happen continually, both inside and outside of each project.
- Develop your ongoing project list that registers both projected and actual savings.
- Establish and maintain a good communication plan to keep everybody current on your Six Sigma initiative. With press releases, monthly newsletters, company intranet updates, and quarterly company meetings, get the message out regularly and conspicuously on the benefits of Six Sigma.
- Support continual training programs for Six Sigma, throughout the organization, formally and informally.
- Link all of your recognition of Six Sigma contributors to the structure of your compensation plans. Reward master black belts, black belts, and green belts for their efforts, to keep the skill and expertise you've invested so much to develop.
- Develop a common metric and reporting/review system that evaluates and updates the status of all projects monthly.
- Maintain a Six Sigma sustainability checklist, to ensure that you're sustaining Six Sigma properly.
- Keep executive managers committed and involved in the Six Sigma initiative with regular reviews.

In the second year …

- Involve your suppliers in your initiative. Train them in Six Sigma so they can reduce or eliminate defects in whatever they provide to you. Everybody benefits.
- Build Six Sigma into the business plan as an integral element of any strategic planning.
- Host certification events that reward and recognize black belt achievements.
- Develop compensation/incentive plans for black belts, team members, and upper management to ensure continued support.

There are three key points for sustaining Six Sigma:

Share and communicate: Spread the "lessons learned" from every project throughout the organization. Keep everybody current on the Six Sigma initiative.

Build a strong team: Support continual training of master black belts, black belts, and green belts, formally and informally. Reward Six Sigma contributors for their efforts.

Keep executive managers committed and involved: They should support and endorse the Six Sigma initiative with regular reviews.

"The proof that Six Sigma works is its financial impact on the bottom line. Sustaining Six Sigma takes commitment and leadership."

About the Author

Since 1994, Greg Brue, President and CEO of Six Sigma Consultants, Inc. and Senior Master Black Belt, has implemented Six Sigma methodologies for some of the world's most recognized companies. He was one of the original five consultants to pioneer the historical Six Sigma deployment at both Allied Signal and General Electric. SSC is one of the oldest and most experienced Six Sigma providers in existence today. Visit his Web site at www.sixsigmaco.com.

“The Six Sigma journey is a full-time trip and never, ever ends, as long as you want to attain the pinnacle of quality and grow the bottom line in your role as the highest-quality, lowest-cost producer of goods and services.”

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