WHITE PAPER:

“mini Sigma:” How To Achieve Six Sigma Benefits On A Tight Budget

How, why and when to apply basic analysis tools to boost the bottom line

Table of Contents

Introduction

Six-Sigma and Return On Investment (ROI) have become the Quality mantra of the 2000 decade. Virtually every large organization has a quality initiative that focuses on reducing scrap, increasing throughput and improving the bottom line. The Six-Sigma methodology and the associated promise of large ROIs have spread through boardrooms of large corporations at an amazing pace. But small- to medium-sized companies often have been slow to adopt Six-Sigma, because of the up-front investment in staff, training and tools.

If your company happens to fall within the small to medium category, or you're a larger organization with limited resources, you should not be discouraged by the substantial investment of time and money required to launch a Six Sigma program. Rather, as a cost-effective alternative, you might adopt a "mini-Sigma" approach to achieve substantial bottom-line benefits. What surprises many people is that the skills necessary and the tools used in mini-Sigma programs are many of the same skills and tools used in the past with TQM, ISO-9000, JIT and other Quality programs. You can leverage your existing staff and knowledge base—without incurring large costs.

To help you determine if a "mini-Sigma" program is right for you, you should first identify and define your skill sets, understand the basic Quality tools that are necessary to be successful, and then coordinate the activities of those involved. This paper discusses the process, people, and tools you can deploy for a mini-Sigma program.

The Difference Between Six Sigma and mini-Sigma

Six Sigma is an excellent discipline to help identify and solve costly saving. However, it is often best suited for larger, slow-moving organizations as a methodology to expedite solutions. The shorthand version or "mini-Sigma" is an ideal solution for small to medium size enterprises that can move quickly and need to conserve capital. The difference between a formal, costly Six Sigma program and a self-guided, less expensive mini-Sigma are summarized in the table below.

Although, both programs have proven successes, mini-Sigma programs are by far the easiest and least expensive to undertake.

Six Sigma compared to mini Sigma programs

	Six Sigma	mini Sigma
Process	• Formal DMAIC approach • Monthly, weekly, and daily meetings needed to co-ordinate activities. • Expensive and requires a large budget • Six months or more to achieve goal • Possible large return on investment (ROI)	• Informal DMAIC approach • Kick-off meeting with periodic status updates • Inexpensive and can be implemented on a modest budget • Typically less than three months to achieve goal • Realistic return on investment
People	• Black Belts, Green Belts and Statisticians required • Advanced statistical training needed • Involves teams and many other departments. • Requires in depth statistical knowledge	• Existing Staff • Basic SPC training is sufficient • Might be a team of one • Requires common sense and basic statistical knowledge
Tools	• 1000s of tools available • Specialized tools for every situation	• 15 Standard tools • Basic statistics recommended

Process – DMAIC versus dmaic

Six Sigma, at its core, is a highly structured methodology to improve performance. The formal approach to Six Sigma can be summarized with the acronym, "DMAIC", which stands for Define, Measure, Analyze, Improve, and Control. Each stage of the DMAIC cycle relies on a variety of tools to accomplish its objective and to lay the foundation for the next stage. Larger companies with complex infrastructures embrace the Six Sigma methodology because of its intensive project management methodology with emphasis on tightly defining and controlling a project from its inception to completion.

A mini Sigma program uses the same five 'dmaic' stages, but with less emphasis on project management and more emphasis on applying the common tools used within each of the stages. With mini Sigma, success is driven more by identifying when and why to use the basic tools rather than extensive project management practices. In short, smaller companies that have less-complex infrastructures and the ability to move faster can take advantage of mini Sigma programs by distilling the process and focusing more on applying the analytical tools that directly produce the bottom-line benefits. Unlike Six Sigma, mini Sigma programs can be kicked off with an initial planning meeting followed by several status meetings until the project is complete. Minimal training and a small cash investment are all that is required to start a mini Sigma program. And when the project is complete, you will see a ROI for your efforts.

In summary, the emphasis of a mini Sigma program is on:

- Solving the problems at hand rather than managing a project
- A self-guided approach to improving quality at your company rather than a managerial program that requires constant oversight
- Finding a better solution than your current system offers rather than finding the ultimate solution for the problem

Other benefits of a mini Sigma program are:

- Fewer meetings
- Smaller budgets
- Realistic ROIs—often in three months or less
- Significant bottom-line contributions

People—Creating the mini Sigma Team

Many organizations assume that they must have a Six Sigma Black Belt on staff to achieve any of the benefits of a Six Sigma project. Not true. Although large projects do need a knowledgeable statistician and project leader, it is not essential with mini Sigma projects. Most mini Sigma projects need only a person who is familiar with common statistics and the problem at hand.

In order for a mini Sigma project to be successful, first identify the people who have the traits listed below. In general, these are the people you should ask to coordinate the activities and direct the team to address the issue(s) at hand. If there isn't one person who exhibits all of the traits, then seek two or more individuals who complement each other. In many cases, this will be a Quality Manager, Quality Engineer, Process Engineer, Line Personnel, Production Manager or somebody with intimate knowledge of the problem.

Organization Skills

At minimum, someone needs to coordinate schedules and lead team meetings. This person also is responsible for: managing the project plan; tracking and reporting on milestones and tasks; and communicating the progress to the rest of the organization. The ability to take clear notes and identify project responsibilities is a core component of a mini Sigma project.

Statistical Process Control (SPC) Knowledge

The most common statistical process control (SPC) tools have been around since the early 1940s. A basic understanding of these tools and how to interpret them is crucial for any Six Sigma or mini Sigma project. Many Quality and Process engineers already have this knowledge and should have ample experience in applying the tools. It is important that the team work with facts and not with assumptions.

Problem Solving

Identifying the problem and the potential root causes are, in many cases, the hardest part of a mini Sigma project. There are many ways to clarify a problem and to address it, including: Brainstorming, Pareto Diagrams, Consensus, Process Flow Diagrams, Control Charts and Management Tools. Having someone who has had exposure to these tools is desired. Having someone who can think "outside of the box" is mandatory.

Team Building

The last, but certainly not the least important, trait is team building. You should have at least one person who understands the dynamics of a team. The phrase "Forming, Storming, Norming and Performing" should not be new to them. They should be familiar with these four development stages of team building and have experience with addressing the conflicts that will arise.

mini Sigma Tools, Analysis and Reports

A mini Sigma program begins with assessing your data collecting activities: • Are you collecting variable (discrete measurements) or attribute (defects) data? • Is the volume of data small (several samples a day), or large (multiple samples per hour, minute or second)? • Are there other sources of data that you haven't considered?

Depending on your answers, you'll need to decide if your current "quality system" is adequate. A quality system includes everything from the paper-and-pencil approach to "lights-out" automation. Typically, you'll fall somewhere in between with software that can collect the data, do the analysis and provide output for your customers or management.

dmaic Tool Set

The next step is to review the analytical tools you use to assess if:

- You currently use the tools correctly
- You might be able to refine how you use the tools

The mini Sigma tool set is listed in the following table. Although there are hundreds of specialized tools available, this basic selection should cover at least 80 percent of the mini Sigma projects you undertake. These tools were selected because they have been proven to produce bottom-line benefits. Review the tools, study the problem-solving flow chart on the next page and then read the tools definitions and application information that follow to determine which tools to select for your situation.

Phase of dmaic in which the tool is most commonly used

Tool Name	define	measure	analyze	improve	control
Brain Storming	x				
Flow Charts	x				
Xbar Charts		x	x	x	x
Range Charts		x	x	x	x
Individual (X) Charts		x	x	x	x
Moving Range Charts		x	x	x	x
P-Charts		x	x	x	x
Np-Charts		x	x	x	x
C-Charts		x	x	x	x
u-Charts		x	x	x	x
Histograms		x	x	x	x
Pareto Charts		x	x	x	
Check Sheets		x	x	x	x
Sampling		x	x	x	x
Cause & Effect Diagrams			x		
Scatter Diagrams			x		
Box & Whiskers			x		

Control Charts

The Xbar & Range, X & Moving Range, P, np, C, and U charts all belong to a family called "control charts". Although the reasons for using a control chart are usually the same for each of these charts; when to use them varies with the situation. Typical uses for a control chart include:

- Monitoring a process to identify shifts or changes quickly
- Monitoring a process to help hold onto the gains made from an improvement project
- Monitoring a process to see whether changes made to the process had the desired effect
- Identifying root causes of variation
- Identifying special causes versus common causes of variation
- To understand and predict process capability (expected output of future values)

There are generally two types of data that are captured and analyzed with control charts: Continuous and Discrete data. Continuous data is obtained by measuring. Some examples are Diameter, Length and Pressure. Discrete data is obtained by counting events that meet a certain criteria. Some examples include number of defects in a package, number of scrapped parts in production and number of customer complaints.

Why use control charts?

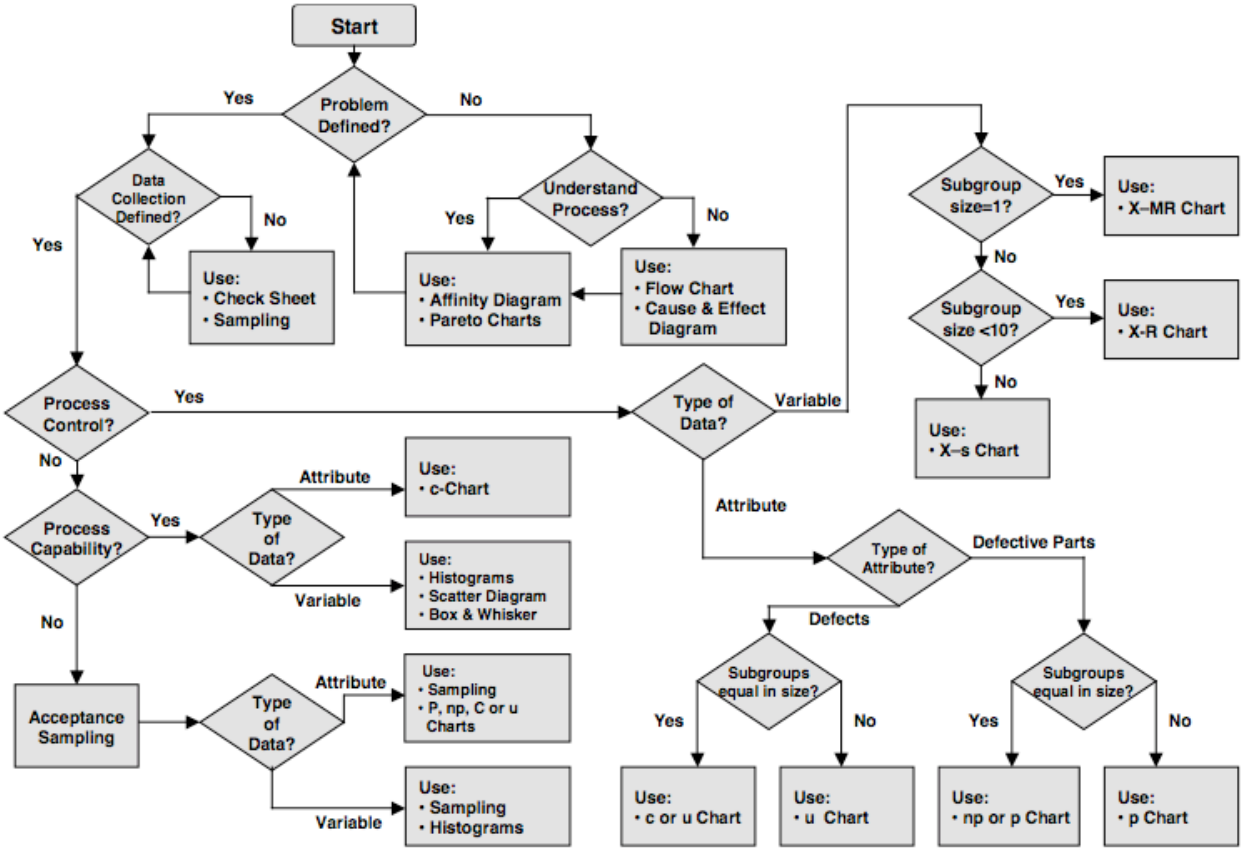
- Because they can be used for virtually any type of data collected over time
- Because they use statistical control limits to establish their capability
- Because control limits can be used to separate "common"
- causes from "special" causes

Insight:

A Baldrige Award winner, who experienced a more than 40% reduction in supplier PPMs, stated ,"they use control charts and other summary statistics to increase the visibility of key manufacturing metrics to their engineering and management groups. A simple graph conveys so much more than raw data."

mini Sigma Flow Chart for Analysis

The flow chart below depicts a standard mini Sigma analysis methodology with the recommend tools for each step. It's important to acknowledge that there are many other quality analysis tools in addition to those listed, and that there might be a specific statistic or report that is necessary for your unique project that is not listed here. The tools mentioned in this paper, however, are the most common and widely used mini Sigma tools. The tools and their applications are described in detail in the next section of this paper.



Defining mini Sigma Tools and When to Use Them

Affinity Diagrams

Affinity Diagrams help individuals or teams clarify unfamiliar problems. They use 'language data' to define the problem. Affinity diagrams encourage brainstorming and other creative thinking techniques to identify patterns within your data and to help you organize your thoughts into meaningful groups. The steps to using an Affinity diagram are to first, define your problem. Next write your ideas, thoughts, facts, etc. on individual 3x5 cards. Then you organize the cards into similar thought patterns or categories. The main category idea becomes the 'affinity' card. Once all of the cards have been placed in their proper groups, a diagram is drawn.

When to use Affinity Diagrams:

- Primarily used to organize ideas, data, facts, opinions and issues
- When the problem is complex
- When analyzing customer comments/data

Flow Charts

Flow Charts are often the starting point for process improvement. They are graphical displays that help create a common understanding of a process. A simple plot of the steps in a process can usually generate several improvement ideas.

When to use Flow Charts:

- Primarily used to clarify the steps of a process and to create a common understanding
- When the cause of a problem is unclear
- When i's unclear how a process actually operates and how it should operate

Xbar & Range Charts

Xbar & Range Charts are the most common control charts used in measuring continuous data. They are fundamental tools used to display the range of variability inherent to a process. By monitoring an Xbar and Range chart, you can determine whether a process is operating consistently or if a special cause has occurred that has changed the operating characteristics of your process. By identifying and eliminating these special causes, you can improve the overall process, which in turn will reduce your scrap and rework numbers, increasing yields.

When to use Xbar & Range Charts:

- When data is collected in rational subgroups
- When it is necessary to detect small shifts in process averages
- When it is necessary to detect changes in process variability

To interpret an Xbar & Range chart, you should first look at the Range Chart and note any special causes. If there are special causes in the Range chart, it is unwise to draw any conclusions about the Xbar chart. Also look for positive or negative correlations between the Xbar and Range charts. Either of these conditions may affect your conclusions. To help judge the effects of skewed data, it is common to use a Histogram (see below) in conjunction with the Xbar and Range charts.

Insight:

A $3.5 billion manufacturer of exhaust and suspension systems uses Xbar & Range charts for adjusting their processes to keep them in control and centered. Now, they are able to detect problems as they happen rather than waiting for the paper trail.

X & Moving Range Charts

X & Moving Range Charts are common in batch operations where it is unlikely or costly to take more than one sample at a time. Like Xbar & Range charts, they measure continuous data but they may require more data before identifiable patterns can be detected.

When to use X & Moving Range Charts:

- Primarily used to track performance over time
- When measurements are expensive (i.e. destructive testing)
- When the output is relatively homogeneous

Caution should be taken when using X & Moving Range charts because these charts are not as sensitive in detecting process changes as Xbar & Range charts. To interpret X & Moving Range charts, you should first confirm that the process is symmetrical and that you are not trying to isolate piece-

to-piece repeatability of a process. If this condition exists, it might be better to use an Xbar and Range chart with small sample sizes even if this requires a longer period between subgroups.

Insight:

A leader in the Pet Products industry uses X and Moving Range charts to monitor individual package fill volumes and to consistently fill to specifications. "The amounts that the company saved by controlling amounts as small as a teaspoon raised some eyebrows. Profit margins can be measured in very small amounts in a large-scale manufacturing setting."

P Charts

P Charts, or percent defective charts, measure discrete data. They are used to quantify defective units. The data is usually collected in samples that are not of constant sizes. Normally subgroup sizes should be larger than 50 and your average number of defects should be equal to or greater than 5. The p-chart chart measures the output of a process as a percentage of defective items. Each item is recorded as either pass or fail, even if the item has more than one defect. This is the most sensitive attribute chart.

When to use P Charts:

- Primarily used to follow trends and cycles over time
- Used when the subgroup size changes from sample to sample
- Used to evaluate progress after process changes and/or improvements
- Used in cases to quickly and inexpensively gather data
- When there are no specialized skills required to collect the data

The major assumptions in using P charts are that there are only 2 attributes (e.g. Pass/Fail) that you are measuring and the occurrence of an attribute is independent from item to item.

Insight:

A supplier of indoor comfort systems was having problems producing leak-free refrigerant coils. Their scrap rate was too high and was cutting in to their profit margin. By monitoring the defects, their locations and using P-and np-Charts, they were able to identify the source of their problems and significantly reduce their overall scrap.

np Charts

np Charts, or number of defectives chart, are similar to P charts with just a few exceptions. Np Charts are used in cases where the subgroup size remains constant. Np charts are generally easier to understand because they deal with the actual number of defects rather than percentages.

When to use np Charts :

- Primarily used to follow trends and cycles over time
- Used when the subgroup size is constant from sample to sample
- Used to evaluate progress after process changes and/or improvements
- Used in cases to quickly and inexpensively gather data
- When there are no specialized skills required to collect the data

The major assumptions in using np charts are identical to P charts. Except for plotting the actual number of defectives instead of the percentage of defects, the np chart is closely related to the P chart.

C Charts

C Charts also measure discrete data. They are used in cases where a single unit is likely to have many defects. The interest here is not only that the item is defective but also in how many defects it has.

When to use C Charts:

- Primarily used to follow trends and cycles over time
- When you can count occurrences, but cannot count non-occurrences.

- When the probability of an occurrence is less than 10%
- When occurrences are independent from one another

C charts are used when counting the number of occurrences of many defects.

Insight:

A leading motorcycle manufacturer tracks warranty claims using Pareto charts, to rank them from the most frequent offenders to the least, and then examines the top 20 using a C-chart. The Pareto chart gives them a snapshot of where they are today; the C-chart gives them a snapshot of where they might be in the future. By identifying problems that are trending upward and then focusing on their root causes, this motorcycle company has significantly reduced their warranty claims.

U Charts

U Charts also measure discrete data. They are similar to C charts in that they are used in cases where a single unit is likely to have many defects. The differences are in the calculation of control limits and that the plotted points represent the average number of nonconformities per unit. A U chart is used when the unit size of a subgroup varies from subgroup to subgroup.

When to use U Charts:

- Primarily used to follow trends and cycles over time
- When the subgroup size varies from subgroup to subgroup
- When the probability of an occurrence is less than 10 percent
- When occurrences are independent from one another

U charts are used when counting the number of occurrences of many defects across many items.

Histograms

Histograms, or frequency plots, show the distribution of the data by displaying how often different values occur. They are used to summarize data from a process in graphical form. The graph helps answer the question of whether the process is capable of meeting customer requirements.

When to use Histograms:

- Primarily used to display large amounts of data that are difficult to interpret in a spreadsheet format
- When you need to identify the centering, spread, and variation of the data in graphical form
- To quickly illustrate the underlying distribution of the data, usually a normal distribution

The Histogram is commonly used to answer questions such as: Is the process performing within the specification limits? Is there a wide variation in the process? If a change is required to the process, what change is appropriate? You can usually answer these questions by analyzing three key characteristics of the Histogram. 1) How well is the data centered? The centering of the data provides information about the process target. 2) How wide is the Histogram? The width of a Histogram defines its variability. 3) What is the shape of the Histogram? If the shape is not a bell-shaped curve, which is usually the shape you are looking for, there is something going on in the process, which is causing quality problems.

Insight:

A Quality Manager at a metal forming plant said, "We use Xbar & R charts and Histograms, together. The combination of the charts gives us a pretty good view of the trends and patterns in our process. I don't know what we would do without them."

Pareto Charts

Pareto Charts are used when analyzing data that can best be described by dividing the data into categories. A Pareto chart will help to understand the pattern of occurrences of a problem. It will also quantify the problem(s) and help track down the biggest contributors to a problem. If you are unclear on where to focus your efforts to achieve the most payback, start with a Pareto chart and rank your problems.

When to use Pareto Charts:

- When the problem under scrutiny can be broken down into categories
- When you need to identify the "vital few" categories versus the "trivial many"

When analyzing data using Pareto charts, it's important to know that the height of each bar represents the relative importance of that particular category. The relative importance could be the number of occurrences, the costs or time. Typically, you will identify and focus your efforts on the largest contributors to a problem. Only react to a Pareto chart when the Pareto Principle shows that a few categories are responsible for a majority of the problems.

Check Sheets

Check Sheets come in a variety of forms but all of them are used to reduce the likelihood of errors in recording data. They standardize data collection activities by providing specific locations where people record their data. When possible, using a computerized version of a Check Sheet is ideal because it can help eliminate other common mistakes such as missing decimal points, transposing of digits and erroneous values.

When to use Check Sheets:

- When collecting data results in numerous errors or missing values
- When there is a need to create a common procedure for data collection

Insight:

A high volume manufacturer of complex stampings and subassemblies commented "Before check sheets, we used to make a lot of mistakes. It's hard to analyze a problem when the data is bad or incomplete, to begin with. Now we have a computerized system that prompts you when it's time to collect data, verifies the data as it is being entered, and notifies you of any potential trends in real time. Talk about a time saver!"

Sampling

Sampling is more of a technique than a report. It is the act of collecting a portion of all data and using that portion to draw conclusions. A decision is then made to accept or reject the entire lot based on the results of the sample. The advantages of using sampling come from reducing the costs you would incur if you had to inspect 100% of your lot. But great care should be taken in order to assure you are collecting the appropriate amount of data. Sampling is recommended in situations where looking at all of the data is either too expensive, too time consuming or destructive.

When to use Sampling:

- When data is too expensive to gather or too time-consuming
- When the test is destructive
- When there is a need to improve inspection time
- When there is a need for greater accuracy

Some factors that you should identify in order to determine how many samples you need are: 1) What type of data are you handling: discrete or continuous? 2) The acceptance of good lots should be more likely than the acceptance of bad lots. 3) What level of "Producers Risk", the probability that a good lot will be rejected, do you desire. 4) What level of "Consumers Risk", the probability that a bad lot will be accepted, do you desire.

The most important aspect of sampling is that it requires randomness in the sample selection. The sample must be representative of the population and not just the product that is easiest to obtain. There are many industry standard sampling plans available. A good place to start would be with the U. S. Department of Defense.

Cause and Effect Diagrams

Cause and Effect Diagrams, or Fishbone Diagrams, graphically display potential causes of a problem. They are used to show a cause-and-effect relationship between the potential causes.

When to use Cause and Effect Diagrams:

- To stimulate thinking during a brain-storming session
- To understand relationships between potential causes
- To dissect problems into smaller pieces

A Fishbone Diagram is generally broken into six parts; Machine, Material, Method, Manpower, Measurement and Environment. If properly used, you should be able to circumvent the natural tendency of "jumping to conclusions" that are common amongst people working on an improvement project. Making a diagram is the most important "first step" that you can do before collecting data. The output of a Fishbone Diagram is a plan of attack.

Scatter Diagrams

Scatter Diagrams are graphical representations of the relationship that exists between two items. They can be used to check whether one variable is related to another and they are an effective way to communicate the relationships that you uncover. Scatter Diagrams are used to determine which causes are related to the effects you are seeing in your process.

When to use Scatter Diagrams:

- To discover whether two variables are related or not
- To test for cause and effect relationships

Some things to look for when interpreting a Scatter Diagram are the outliers and the patterns formed by the scatter of data points. The tighter the points are clustered together, the stronger the correlation. But beware of the fact that a strong correlation doesn't always mean causation or that the two variables are related.

Insight:
A producer of power tools and accessories uses scatter diagrams to understand the relationships of their curing & coating processes. This tool helped them discover the optimal curing time and coating thickness. By identifying key causes and effects, they were able to reduce scrap by more than 20%.

17) Box & Whiskers Charts

Box & Whiskers Charts give a quick and informal way to summarize the location, spread, and skewness of a distribution. An ideal Box & Whiskers chart would contain 50% of your data within the box and the whiskers on either side would extend about the same distance from the box, indicating a symmetrical distribution. It is easy to compare multiple variables on one chart using this tool.

When to use Box & Whiskers Charts:

- Primarily used to compare two or more sets of data
- Useful when dealing with large volumes of data
- When presenting graphic displays of median, range and inter-quartile ranges

Caution should be taken when using a Box & Whiskers chart that any conclusions drawn from the data are informal. To confirm your conclusions, you should use one of the other tools.

Insight:
A large producer of pudding and other snacks uses a Box & Whiskers chart to monitor the fill weights produced by each nozzle of a 48 nozzle machine. By identifying which nozzles were over-and under filling, they were able to save hundreds of thousands of dollars on raw material costs while meeting even tighter government regulations on package weights.

Reports: The Need for Real-Time Feedback

Collecting data, analyzing reports, and making timely decisions is an understated goal of the dmaic model. While it is possible to define, measure, analyze, improve and control a process using a paper-and-pencil system, it is desirable to do these activities as close to real-time as possible. Using a computerized system to gather data, monitor for problems, and distribute reports simplifies the work effort, streamlines the process, and documents improvements.

The benefit of an automated system is obvious: the sooner operators receive feedback from the process the quicker they will be able to react to correct any negative conditions to:

- Improve product quality
- Reduce scrap and rework
- Increase productivity

These types of improvements translate directly to bottom-line savings.

Getting Started

The key advantage of mini Sigma is that you can get started quickly. And the sooner you start, the sooner you will benefit from resulting cost savings.

- Choose your team
- Call the kick-of meeting
- Define areas for improvement
- Follow the simplified process in the flowchart
- Choose and apply the basic analytical tools
- Analyze and report the results
- Make the modifications required for improvement
- Continue to monitor the results

Conclusion

Six Sigma, although a valuable discipline, is not a monolithic solution for all quality problems. A mini Sigma approach lets you get in the cost-cutting and savings game with a minimum investment using your current staff and common tools. With mini Sigma you can eliminate defects, increase productivity and realize a substantial return on your investment.

Understanding your situation is important. If you're a small to medium size company or a larger organization with limited resources, mini Sigma is a cost-effective alternative. If you would like to see an ROI of 3 months or less, mini Sigma might be right for you.

In summary, through a mini Sigma program you will find that

1) The process is less formal resulting in quicker decisions
2) The process can be implemented on a modest budget
3) The people needed for this program come from your current staff
4) The people implementing the program have most of the skill sets already
5) There are common tools that everyone uses
6) There is little, if any, training needed to use the tools
7) There are many knowledgeable companies and consultants who can help you
8) A mini Sigma program takes you one step closer to an actual Six Sigma program in the future

The bottom line is that each organization should tailor its Quality programs to meet its particular needs. What works for one company might not work for you. Take the time to investigate your needs, identify your resources, and choose a solution that works for you--and then get started!

If you would like more assistance in developing a mini Sigma program, give DataNet a call. DataNet offers cost-effective mini Sigma program services in addition to its award -winning , real-time SPC software, WinSPC®.

To obtain more information about DataNet services or receive a free 60-day trial of WinSPC call 248.357.2200 or visit www.winspc.com

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DataNet Quality Systems

DataNet Quality Systems delivers continuous improvement software and services that empower manufacturers to improve their product and process quality through real-time Statistical Process Control (SPC). Our award-winning WinSPC and QualTrend software allow shop-floor personnel to identify, control and prevent manufacturing process and product defects in real-time, while providing manufacturing engineers and management with advanced statistical analysis and reporting tools. With over 2500 installed facilities worldwide and distributors throughout the world, DataNet is dedicated to delivering a high level of customer service and support, shop-floor expertise, and professional continuous improvement, Six Sigma, and lean Six Sigma services.