

Certified Lean Six Sigma Green Belt Book

LEAN SIX SIGMA BELT SERIES

Fourth Edition - SigmaXL



OPEN SOURCE **SIX SIGMA**

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Lean Six Sigma Green Belt Training

Define Phase Understanding Six Sigma

Welcome to the Lean Six Sigma Green Belt Training Course.

This course has been designed to build your knowledge and capability to improve the performance of processes and subsequently the performance of the business of which you are a part. The focus of the course is process centric. Your role in process performance improvement is to be through the use of the methodologies of Six Sigma, Lean and Process Management.

By taking this course you will have a well rounded and firm grasp of many of the tools of these methodologies. We firmly believe this is one of the most effective classes you will ever take and it is our commitment to assure this is the case.

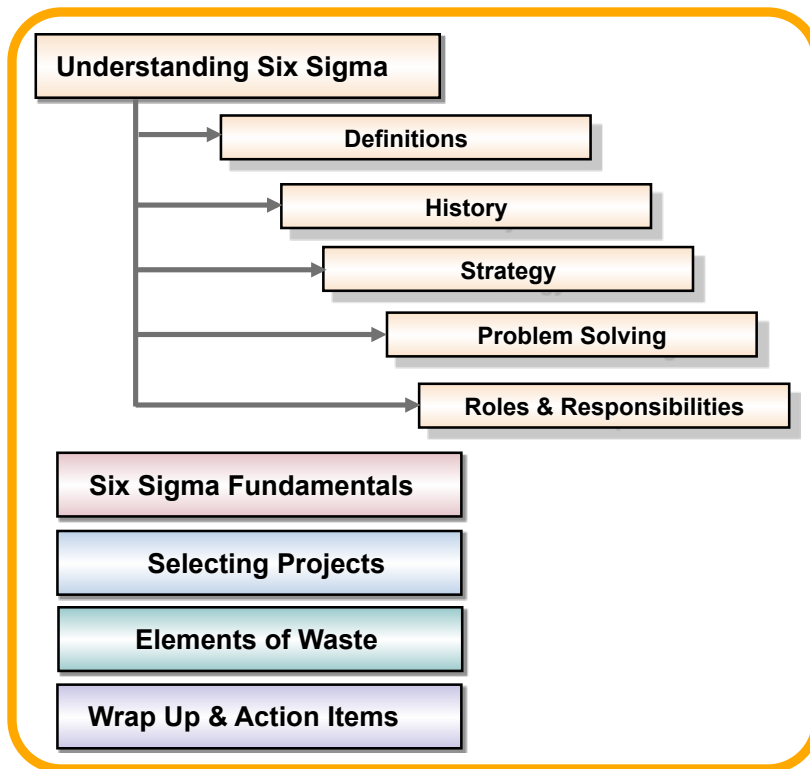
We begin in the Define Phase with “Understanding Six Sigma”.

Understanding Six Sigma

Overview

The fundamentals of this phase are Definitions, History, Strategy, Problem Solving and Roles and Responsibilities.

We will examine the meaning of each of these and show you how to apply them.



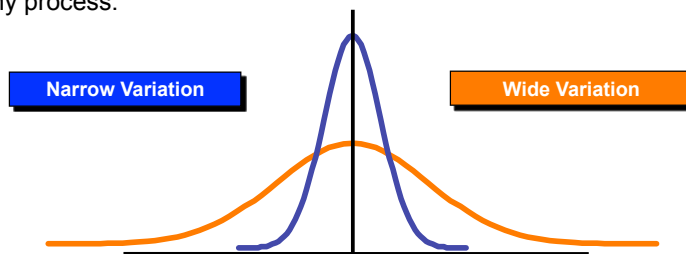
What is Six Sigma...as a Symbol?

Variation is our enemy. Our customers, both internal and external, have expectations relative to the deliverables from our processes. Variation from those expectations are likely dissatisfiers to them. Much of this course is devoted to identifying, analyzing and eliminating variation. So let's begin to understand it.

The Blue Line designates narrow variation while the Orange Line designates wide variation.

σ , sigma, is a letter of the Greek alphabet.

- Mathematicians use this symbol to signify Standard Deviation, an important measure of variation.
- Variation designates the distribution or spread about the average of any process.



The **variation in a process** refers to how tightly the various outcomes are clustered around the average. No process will produce the EXACT same output each time.

Obviously the less variation within a process the more **predictable** the process is, assuming the Mean is not moving all over the place. If you took the height of everyone in the class would you expect a large variation or narrow variation?

What if you had a few professional basketball players in the room, would that widen or narrow the variation?

Understanding Six Sigma

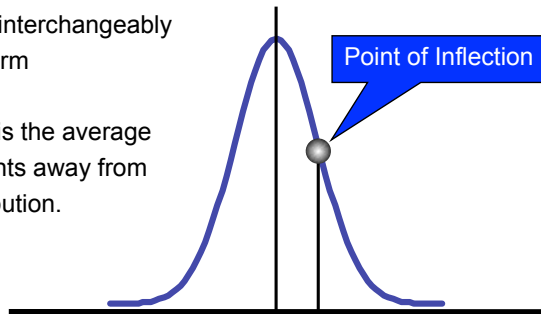
What is Six Sigma...as a Value?

Sigma is a measure of deviation. The mathematical calculation for the Standard Deviation of a population is:

$$\sigma = \sqrt{\frac{\sum_{i=1}^N (X_i - \mu)^2}{N}}$$

By definition the Standard Deviation is the distance between the Mean and the point of inflection on the Normal curve.

- Sigma can be used interchangeably with the statistical term Standard Deviation.
- Standard Deviation is the average distance of data points away from the Mean in a distribution.



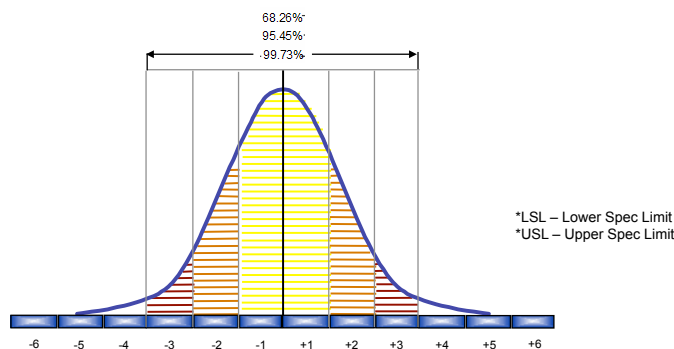
When measuring the sigma value of a process we want to obtain the distance from the Mean to the closest specification limit in order to determine how many Standard Deviations we are from the Mean....our Sigma Level! The Mean being our optimal or desired level of performance.

What is Six Sigma...as a Measure?

This pictorial depicts the percentage of data which falls between Standard Deviations within a Normal Distribution.

Those data points at the outer edge of the bell curve represent the greatest variation in our process. They are the ones causing customer dissatisfaction and we want to eliminate them.

The probability of creating a defect can be estimated and *translated* into a “Sigma” level.



The higher the sigma level the better the performance. Six Sigma refers to a process having 6 Standard Deviations between the average of the process center and the closest specification limit or service level.

Understanding Six Sigma

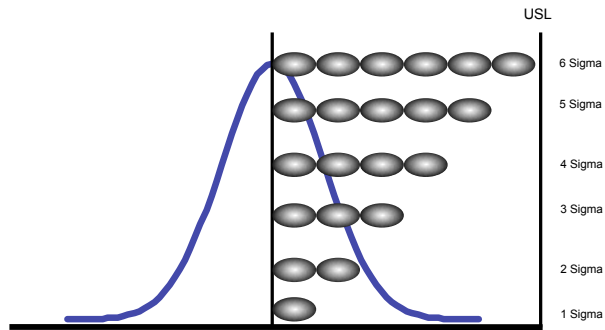
A Measure

Each gray dot represents one Standard Deviation. As you can see the Normal Distribution is tight.

Said differently, if all the outputs of our process fall within six Standard Deviations from the Mean we will have satisfied our customers nearly all the time. In fact, out of one million customer experiences only 3.4 will have experienced a defect.

“Sigma Level” is:

- A statistic used to describe the performance of a process relative to the specification limits
- The number of Standard Deviations from the Mean to the closest specification limit of the process



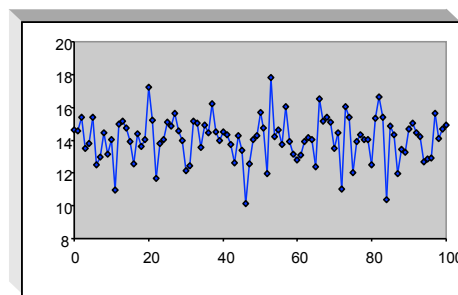
The likelihood of a defect decreases as the number of Standard Deviations that can be fit between the Mean and the nearest spec limit increases.

What is Six Sigma...as a Metric?

Here are some key metrics used in Six Sigma. We will discuss each in detail as we go through the course.

Each of these metrics serves a different purpose and may be used at different levels in the organization to express the performance of a process in meeting the organization's or customer's requirements.

- Defects
- Defects per unit (DPU)
- Parts per million (PPM)
- Defects per million opportunities (DPMO)
- Rolled Throughput Yield (RTY)
- First Time Yield (FTY)
- Sigma (s)



These metrics are used in Six Sigma. You will learn more about them through the course of your study.

Understanding Six Sigma

What is Six Sigma...as a Benchmark?

The data here represents the sigma level of companies. As you can see fewer than 10% of companies are at a 6 sigma level!

<u>Yield</u>	<u>PPMO</u>	<u>COPQ</u>	<u>Sigma</u>	
99.9997%	3.4	<10%	6	World Class Benchmarks
99.976%	233	10-15%	5	↑ 10% GAP
99.4%	6,210	15-20%	4	Industry Average
93%	66,807	20-30%	3	↑ 10% GAP
65%	308,537	30-40%	2	Non Competitive
50%	500,000	>40%	1	

Source: Journal for Quality and Participation, Strategy and Planning Analysis

What does 20 - 40% of Sales represent to your Organization?

What is Six Sigma...as a Method?

The Six Sigma Methodology is made up of five stages: Define, Measure, Analyze, Improve and Control. Each has highly defined steps to assure a level of discipline in seeking a solution to any variation or defect present in a process.

DMAIC provides the method for applying the Six Sigma philosophy in order to improve processes.

- **Define** - the business opportunity
- **Measure** - the process current state
- **Analyze** - determine Root Cause or $Y = f(x)$
- **Improve** - eliminate waste and variation
- **Control** - sustain the results



Understanding Six Sigma

What is Six Sigma...as a Tool?

Six Sigma has not created new tools. It is the use and flow of the tools that is important. How they are applied makes all the difference.

Six Sigma is also a business strategy that provides new knowledge and capability to employees so they can better organize the process activity of the business, solve business problems and make better decisions. Using Six Sigma is now a common way to solve business problems and remove waste resulting in significant profitability improvements. In addition to improving profitability, customer and employee satisfaction are also improved.

Six Sigma is a process measurement and management system that enables employees and companies to take a process oriented view of the entire business. Using the various concepts embedded in Six Sigma, key processes are identified, the outputs of these processes are prioritized, the capability is determined, improvements are made, if necessary and a management structure is put in place to assure the ongoing success of the business.

People interested in truly learning Six Sigma should be mentored and supported by seasoned Belts who truly understand how Six Sigma works.

Six Sigma contains a broad set of tools interwoven in a business problem-solving methodology. Six Sigma tools are used to scope and choose projects, design new products and processes, improve current processes, decrease downtime and improve customer response time.

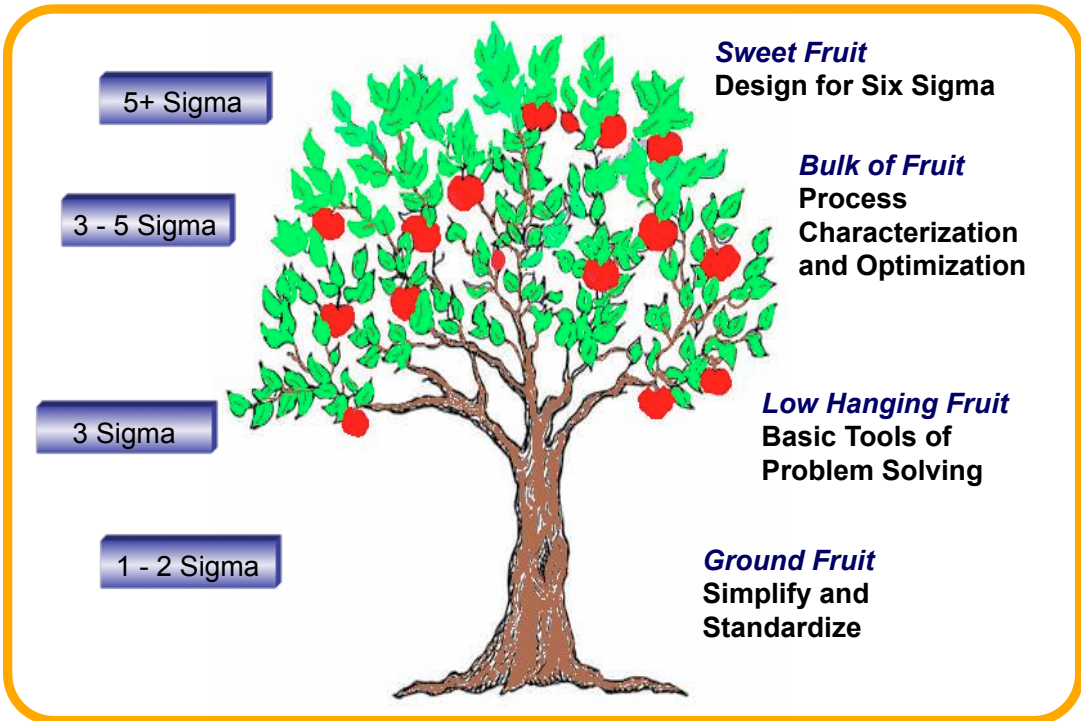
Six Sigma has not created new tools, it has simply organized a variety of existing tools to create flow.

Customer Value Responsiveness, Cost, Quality, Delivery	=	EBIT,	Management (Enabler)	, Product Design	, Process Yield	, Process Speed	, System Uptime	, Functional Support
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Understanding Six Sigma

What is Six Sigma...as a Goal?

To give you a better example the concept of the sigma level can be related to hanging fruit. The higher the fruit, the more challenging it is to obtain. And the more sophisticated the tools necessary to obtain them.



What is Six Sigma...as a Philosophy?

General Electric: First what it is not. **It is not a secret society, a slogan or a cliché.** Six Sigma is a **highly disciplined process** that helps us focus on developing and delivering near-perfect products and services. The central idea behind Six Sigma is if you can measure how many "defects" you have in a process, you can systematically determine how to eliminate them and get as close to "zero defects" as possible. Six Sigma has changed the DNA of GE — **it is now the way we work — in everything we do and in every product we design.**

Honeywell: Six Sigma refers to our **overall strategy to improve growth and productivity** as well as a measurement of quality. As a strategy, Six Sigma is a way for us to achieve performance breakthroughs. It **applies to every function** in our company, not just those on the factory floor. That means Marketing, Finance, Product Development, Business Services, Engineering and all the other functions in our businesses are included.

Lockheed Martin: We have just begun to scratch the surface with the **cost-saving initiative** called Six Sigma and already we have generated \$64 million in savings with just the first 40 projects. Six Sigma uses data gathering and statistical analysis to pinpoint sources of error in the organization or products and determines precise ways to reduce the error.

Understanding Six Sigma

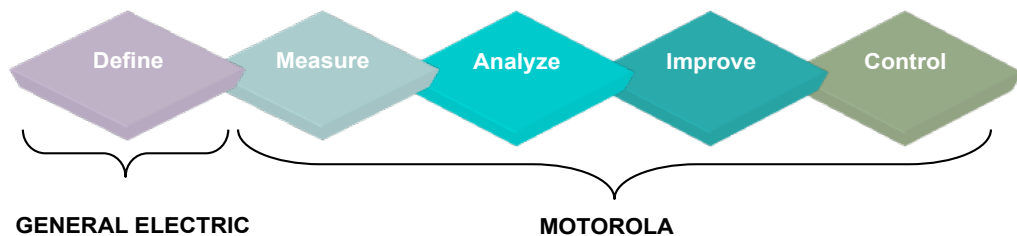
History of Six Sigma (cont.)

- **1984 Bob Galvin of Motorola edicted the first objectives of Six Sigma**
 - 10x levels of improvement in service and quality by 1989
 - 100x improvement by 1991
 - Six Sigma capability by 1992
 - Bill Smith, an engineer from Motorola, is credited as the father of Six Sigma
- **1984 Texas Instruments and ABB Work closely with Motorola to further develop Six Sigma**
- **1994 Application experts leave Motorola**
- **1995 AlliedSignal begins Six Sigma initiative as directed by Larry Bossidy**
 - Captured the interest of Wall Street
- **1995 General Electric, led by Jack Welch, began the most widespread undertaking of Six Sigma even attempted**
- **1997 To present Six Sigma spans industries worldwide**

Simplistically Six Sigma was a program initiated around targeting a process Mean (average) six Standard Deviations away from the closest specification limit. By using the process Standard Deviation to determine the location of the Mean the results could be predicted at 3.4 defects per million by the use of statistics. There is an allowance for the process Mean to shift 1.5 Standard Deviations. This number is another academic and esoteric controversial issue not worth debating. We will get into a discussion of this number later in the course.

The Phase Approach of Six Sigma

- Six Sigma created a realistic and quantifiable goal in terms of its target of 3.4 defects per million operations. **It was also accompanied by a methodology to attain that goal.**
- That methodology was a problem solving strategy made up of four steps: measure, analyze, improve and control.
- When GE launched Six Sigma they improved the methodology to include the Define Phase.

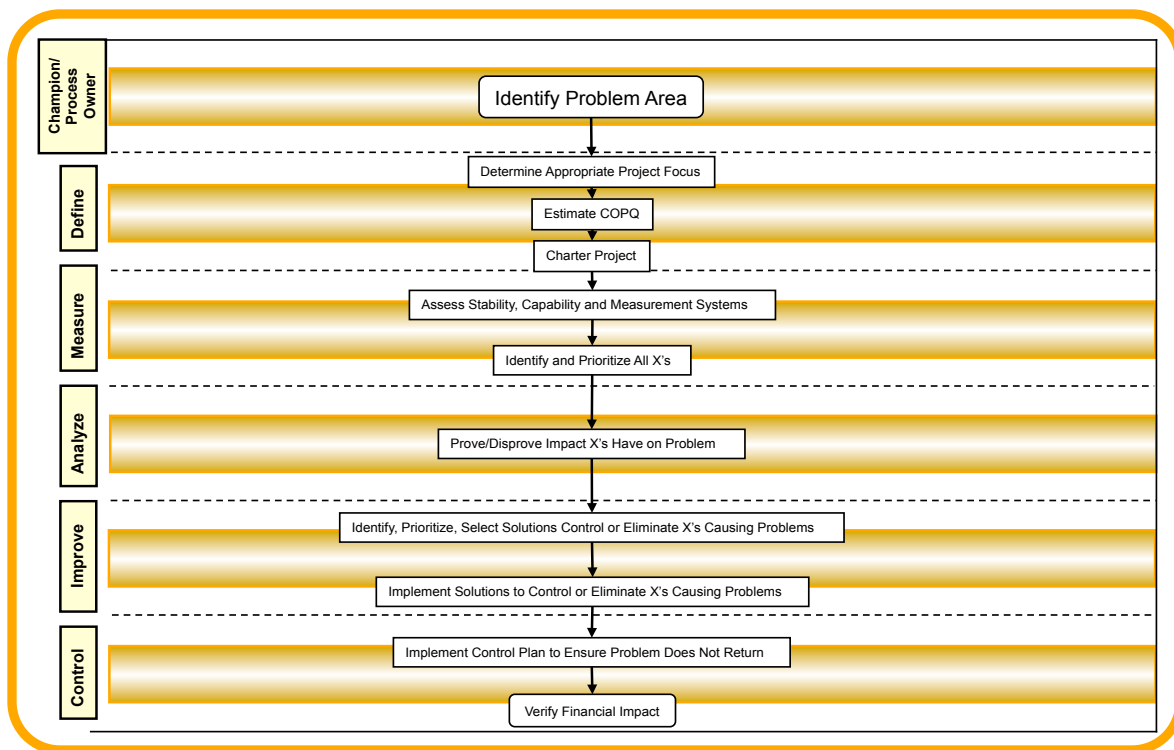


Today the Define Phase is an important aspect to the methodology. Motorola was a mature culture from a process perspective and did not necessarily have a need for the Define Phase. Most organizations today DEFINITELY need it to properly approach improvement projects.

As you will learn, properly defining a problem or an opportunity is key to putting you on the right track to solve it or take advantage of it.

Understanding Six Sigma

DMAIC Phases Roadmap

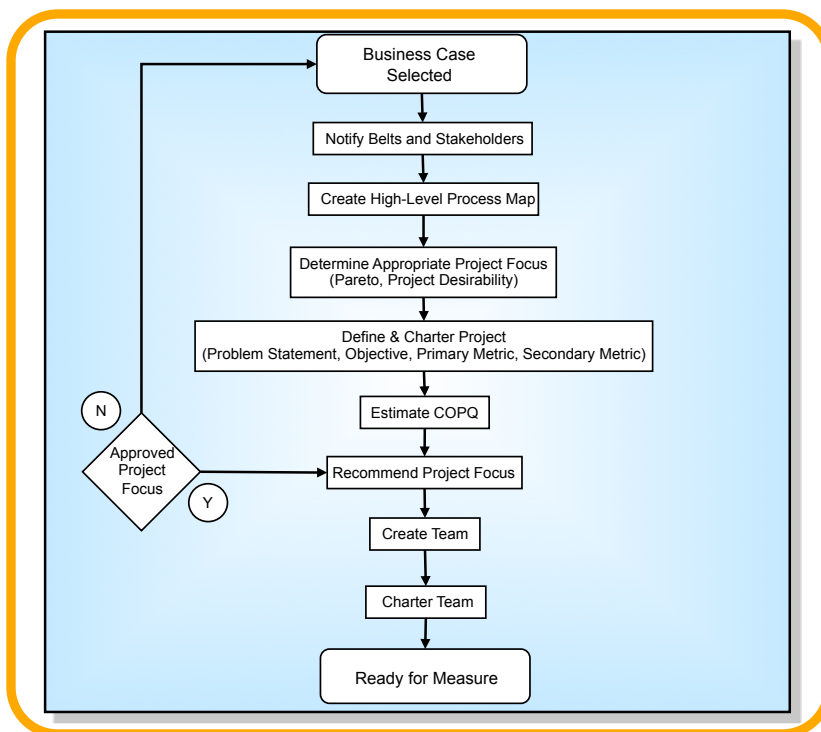


This roadmap provides an overview of the DMAIC approach.

Define Phase Deployment

Here is a more granular look of the Define Phase.

This is what you will later learn to be a Level 2 Process Map.



Understanding Six Sigma

Define Phase Deliverables

The Define Phase deliverables listed here are discussed throughout the Define course.

Listed here are the type of Define Phase deliverables that will be reviewed by this course.

By the end of this course you should understand what would be necessary to provide these deliverables in a presentation.

- Charter Benefits Analysis
- Team Members (Team Meeting Attendance)
- Process Map – high level
- Primary Metric
- Secondary Metric(s)
- Lean Opportunities
- Stakeholder Analysis
- Project Plan
- Issues and Barriers



Six Sigma Strategy

Six Sigma places the emphasis on the *Process*

- Using a structured, data driven approach centered on the customer Six Sigma can resolve business problems where they are rooted, for example:
 - Month end reports
 - Capital expenditure approval
 - New hire recruiting

Six Sigma is a *Breakthrough Strategy*

- Widening the scope of the definition of quality
 - Includes the value and the utility of the product/service to both the company and the customer

Success of Six Sigma depends on the extent of transformation achieved in each of these levels.

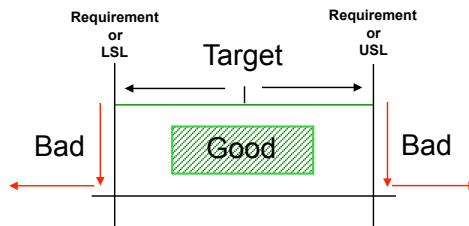
Six Sigma as a breakthrough strategy to process improvement. Many people mistakenly assume Six Sigma only works in manufacturing type operations. That is categorically untrue. It applies to all aspects of either a product or service based business.

Wherever there are processes Six Sigma can improve their performance.

Understanding Six Sigma

Conventional Strategy

Conventional definitions of quality focused on conformance to standards.



Conventional strategy was to create a product or service that met certain specifications.

- Assumed if products and services were of good quality then their performance standards were correct.
- Rework was required to ensure final quality.
- Efforts were overlooked and unquantified (time, money, equipment usage, etc.).

Using this strategy often required rework to ensure final quality or the rejection and trashing of some products and the cost of the efforts to accomplish this “inspect in quality” were largely overlooked and un-quantified.

You will see more about these issues when we investigate the Hidden Factory.

Problem Solving Strategy

The Problem Solving Methodology focuses on:

- Understanding the relationship between independent variables and the dependent variable.
- Identifying the vital few independent variables that effect the dependent variable.
- Optimizing the independent variables so as to control our dependent variable(s).
- Monitoring the optimized independent variable(s).

There are many examples to describe dependent and independent relationships.

- We describe this concept in terms of the equation:
 - Often referred to as a transfer function

$$Y = f(X_i)$$

This simply states that Y is a function of the X's. In other words Y is dictated by the X's.

Understanding Six Sigma

Problem Solving Strategy (contd)

$Y = f(x)$ is a key concept that you must fully understand and remember. It is a fundamental principle to the Six Sigma methodology. In its simplest form it is called “cause and effect”. In its more robust mathematical form it is called “Y is equal to a function of X”. In the mathematical sense it is data driven and precise, as you would expect in a Six Sigma approach. Six Sigma will always refer to an output or the result as a Y and will always refer to an input that is associated with or creates the output as an X.

Another way of saying this is the output is dependent on the inputs that create it through the blending that occurs from the activities in the process. Since the output is dependent on the inputs we cannot directly control it, we can only monitor it.

For example, you can only measure or monitor the temperature of an oven. If you want to affect it or control it you must adjust the amount of heat coming into the oven by adjusting the flow of gas or electricity by using the temperature control knob. Here you can begin to see that the temperature control knob is an input; that it is an independent action. If the temperature was too high and your food burned, it would be the cause of the problem and next time you would set the temperature control knob, an input, to a lower temperature.

Example

$$Y = f(X_i)$$

Which process variables (causes) have critical impact on the output (effect)?

$$\text{Crusher Yield} = f(\text{Feed, Speed, Material Type, Tool Wear, Lubricant})$$

$$\text{Time to Close} = f(\text{Trial Balance, Correct Accounts Applied, Sub Accounts, Credit Memos, Entry Mistakes, } X_n)$$

If we are so good at the X's why are we constantly testing and inspecting the Y?

$Y = f(x)$ is a transfer function tool to determine what input variables (X's) affect the output responses (Y's). The observed output is a function of the inputs. The difficulty lies in determining which X's are critical to describe the behavior of the Y's.

The X's determine how the Y performs.

In the Measure Phase we will introduce a tool to manage the long list of input variable and their relationship to the output responses. It is the X-Y Matrix or Input-Output Matrix.

Understanding Six Sigma

$Y=f(X)$ Exercise



Exercise: Consider establishing a $Y = f(X)$ equation for a simple everyday activity such as producing a cup of espresso. In this case our output, or Y , is espresso.

$$\text{Espresso} = f(x_1, x_2, x_3, x_4, x_n)$$

Notes

Understanding Six Sigma

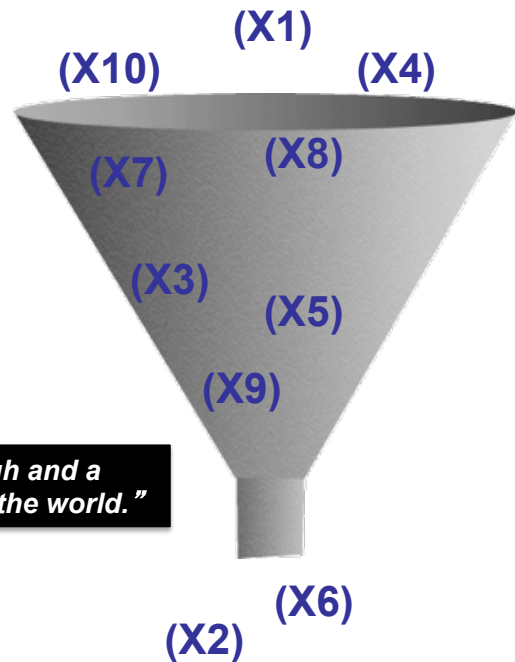
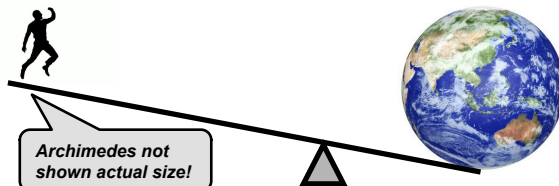
Six Sigma Strategy

We use a variety of Six Sigma tools to help separate the “vital few” variables effecting our Y from the “trivial many”.

Some processes contain many, many variables. However, our Y is not effected equally by all of them.

By focusing on the vital few we instantly gain leverage.

Archimedes said: “Give me a lever big enough and a fulcrum on which to place it and I shall move the world.”



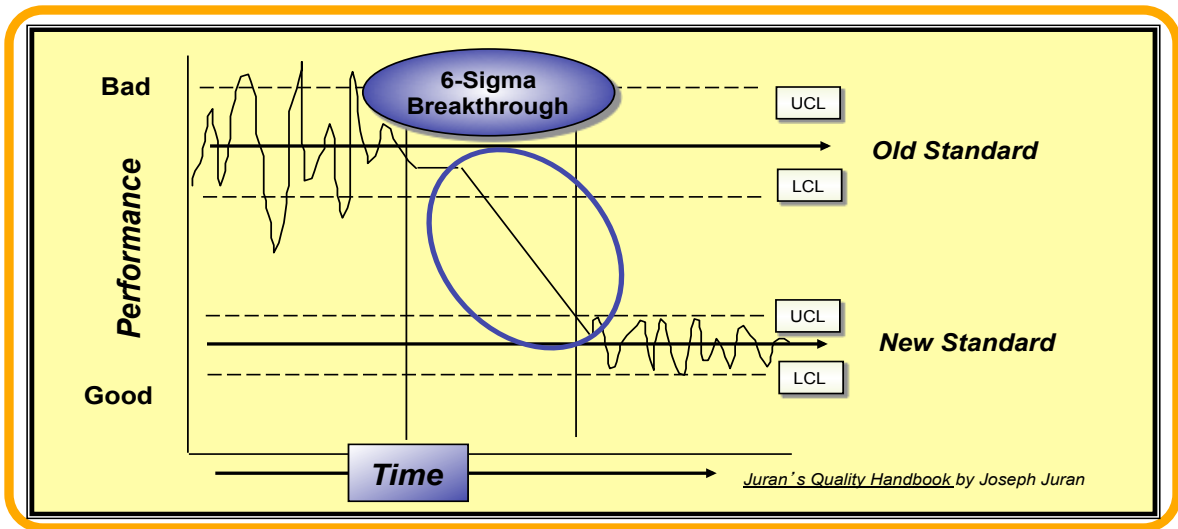
As you go through the application of DMAIC you will have a goal to find the Root Causes to the problem you are solving. Remember that a vital component of problem solving is cause and effect thinking or $Y = f(X)$. To aid you in doing so, you should create a visual model of this goal as a funnel - a funnel that takes in a large number of the “trivial many contributors” and narrows them to the “vital few contributors” by the time they leave the bottom.

At the top of the funnel you are faced with all possible causes - the “vital few” mixed in with the “trivial many.” When you work an improvement effort or project, you must start with this type of thinking. You will use various tools and techniques to brainstorm possible causes of performance problems and operational issues based on data from the process. In summary, you will be applying an appropriate set of “analytical methods” and the “Y is a function of X” thinking, to transform data into the useful knowledge needed to find the solution to the problem.

It is a mathematical fact 80 percent of a problem is related to six or less causes, the X's. In most cases it is between one and three. The goal is to find the one to three Critical X's from the many potential causes when we start an improvement project. In a nutshell this is how the Six Sigma methodology works.

Understanding Six Sigma

Breakthrough Strategy



By utilizing the DMAIC problem solving methodology to identify and optimize the vital few variables we will realize sustainable breakthrough performance as opposed to incremental improvements or, even worse, temporary and non-sustainable improvement.

The image above shows how after applying the Six Sigma tools, variation stays within the specification limits.

VOC, VOB, VOE

The foundation of Six Sigma requires Focus on the Voices of the Customer, the Business, and the Employee providing:

VOC is Customer Driven

VOB is Profit Driven

VOE is Process Driven

- Awareness of the needs are critical to the quality (CTQ) of our products and services
- Identification of the gaps between “what is” and “what should be”
- Identification of the process defects that contribute to the “gap”
- Knowledge of which processes are “most broken”
- Enlightenment as to the unacceptable Costs of Poor Quality (COPQ)

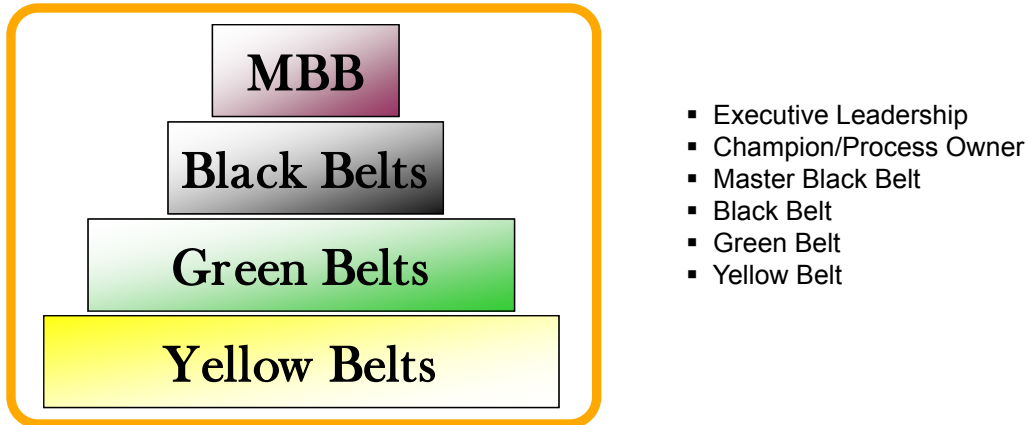
Six Sigma puts strong emphasis on the customer because they are the ones assessing our performance and they respond by either continuing to purchase our products and services or.... NOT!

So while the customer is the primary concern we must keep in mind the Voice of the Business – how do we meet the business’s needs so we stay in business? And we must keep in mind the Voice of the Employee - how do we meet employees needs such that they remain employed by our firm and remain inspired and productive?

Understanding Six Sigma

Six Sigma Roles and Responsibilities

There are many roles and responsibilities for successful implementation of Six Sigma.



Just like a winning sports team various people who have specific positions or roles have defined responsibilities. Six Sigma is similar - each person is trained to be able to understand and perform the responsibilities of their role. The end result is a knowledgeable and well coordinated winning business team.

The division of training and skill will be delivered across the organization in such a way as to provide a specialist: it is based on an assistant structure much as you would find in the medical field between a doctor, first year intern, nurse, etc. The following slides discuss these roles in more detail.

In addition to the roles described herein, all other employees are expected to have essential Six Sigma skills for process improvement and to provide assistance and support for the goals of Six Sigma and the company.

Six Sigma has been designed to provide a structure with various skill levels and knowledge for all members of the organization. Each group has well defined roles and responsibilities and communication links. When all participants are actively applying Six Sigma principles the company operates and performs at a higher level. This leads to increased profitability and greater employee and customer satisfaction.

Executive Leadership

Not all Six Sigma deployments are driven from the top by executive leadership. The data is clear however that those deployments are driven by executive management are much more successful than those that are not.

- Makes decision to implement the Six Sigma initiative and develop accountability method
- Sets meaningful goals and objectives for the corporation
- Sets performance expectations for the corporation
- Ensures continuous improvement in the process
- Eliminates barriers

The executive leadership owns the vision for the business, they provide sponsorship and set expectations for the results from Six Sigma. They enable the organization to apply Six Sigma then monitor the progress against expectations.

Understanding Six Sigma

Champion/Process Owner

Champions identify and select the most meaningful projects to work on, they provide guidance to the Six Sigma Belt and open the doors for the belts to apply the process improvement technologies.

- Own project selection, execution control, implementation and realization of gains
- Own Project selection
- Obtain needed project resources and eliminates roadblocks
- Participate in all project reviews
- Ask good questions...
- One to three hours per week commitment

Champions are responsible for functional business activities and to provide business deliverables to either internal or external customers. They are in a position to be able to recognize problem areas of the business, define improvement projects, assign projects to appropriate individuals, review projects and support their completion. They are also responsible for a business roadmap and employee training plan to achieve the goals and objectives of Six Sigma within their area of accountability.

Master Black Belt

MBB should be well versed with all aspects of Six Sigma, from technical applications to Project Management. MBBs need to have the ability to influence change and motivate others.



- Provide advice and counsel to Executive Staff
- Provide training and support
 - In class training
 - On site mentoring
- Develop sustainability for the business
- Facilitate cultural change

A Master Black Belt is a technical expert, a “go to” person for the Six Sigma methodology. Master Black Belts mentor Black Belts and Green Belts through their projects and support Champions. In addition to applying Six Sigma, Master Black Belts are capable of teaching others in the practices and tools.

Being a Master Black Belt is a full time position.

Understanding Six Sigma

Black Belt

Black Belts are application experts and work projects within the business. They should be well versed with The Six Sigma Technologies and have the ability to drive results.

Black Belts

- Project team leader
- Facilitates DMAIC teams in applying Six Sigma methods to solve problems
- Works cross-functionally
- Contributes to the accomplishment of organizational goals
- Provides technical support to improvement efforts

A Black Belt is a project team leader, working full time to solve problems under the direction of a Champion, and with technical support from the Master Black Belt. Black Belts work on projects that are relatively complex and require significant focus to resolve. Most Black Belts conduct an average of 4 to 6 projects a year -- projects that usually have a high financial return for the company.

Green Belt

Green Belts are practitioners of Six Sigma Methodology and typically work within their functional areas or support larger Black Belt Projects.

Green Belts

- Well versed in the definition & measurement of critical processes
 - Creating Process Control Systems
- Typically works project in existing functional area
- Involved in identifying improvement opportunities
- Involved in continuous improvement efforts
 - Applying basic tools and PDCA
- Team members on DMAIC teams
 - Supporting projects with process knowledge & data collection

Green Belts are capable of solving problems within their local span of control. Green Belts remain in their current positions, but apply the concepts and principles of Six Sigma to their job environment. Green Belts usually address less complex problems than Black Belts and perform at least two projects per year. They may also be a part of a Black Belt's team, helping to complete the Black Belt project.

Understanding Six Sigma

Yellow Belt

Yellow Belts

- Provide support to Black Belts and Green Belts as needed
- May be team members on DMAIC teams
 - Supporting projects with process knowledge and data collection

Yellow Belts participate in process management activities. They fully understand the principles of Six Sigma and are capable of characterizing processes, solving problems associated with their work responsibilities and implementing and maintaining the gains from improvements. They apply Six Sigma concepts to their work assignments. They may also participate on Green and Black Belt projects.

The Life of a Six Sigma Belt

Training as a Six Sigma Belt can be one of the most rewarding undertakings of your career and one of the most difficult.

You can expect to experience:

- Hard work (becoming a Six Sigma Belt is not easy)
- Long hours of training
- Be a change agent for your organization
- Work effectively as a team leader
- Prepare and present reports on progress
- Receive mentoring from your Master Black Belt
- Perform mentoring for your team members
- ACHIEVE RESULTS!

You are going places!



Understanding Six Sigma

Black & Green Belt Certification

To achieve certification Belts typically must::

- Complete all course work:
 - Be familiar with tools and their application
 - Practice using tools in theoretical situations
 - Discuss how tools will apply to actual projects
- Demonstrate application of learning to training project:
 - Use the tools to effect a financially measurable and significant business impact through their projects
 - Show ability to use tools beyond the training environment
- Must complete two projects within one year from beginning of training
- Achieve results and make a difference
- Submit a final report which documents tool understanding and application as well as process changes and financial impact for each project



We'll be watching!

Organizational Behaviors

All players in the Six Sigma process must be willing to step up and act according to the Six Sigma set of behaviors.

- Leadership by example: “walk the talk”
- Encourage and reward individual initiative
- Align incentive systems to support desired behaviors
- Eliminate functional barriers
- Embrace “systems” thinking
- Balance standardization with flexibility

Six Sigma is a system of improvement. It develops people skills and capability for the participants. It consists of proven set of analytical tools, project-management techniques, reporting methods and management methods combined to form a powerful problem-solving and business-improvement methodology. It solves problems, resulting in increased revenue and profit, and business growth.

The strategy of Six Sigma is a data-driven, structured approach to managing processes, quantifying problems, and removing waste by reducing variation and eliminating defects.

The tactics of Six Sigma are the use of process exploration and analysis tools to solve the equation of $Y = f(X)$ and to translate this into a controllable practical solution.

As a performance goal, a Six Sigma process produces less than 3.4 defects per million opportunities. As a business goal, Six Sigma can achieve 40% or more improvement in the profitability of a company. It is a philosophy that every process can be improved, at breakthrough levels.

Understanding Six Sigma

At this point you should be able to:

- Describe the objectives of Six Sigma
- Describe the relationship between variation and sigma
- Recognize some Six Sigma concepts
- Recognize the Six Sigma implementation model
- Describe the general roles and responsibilities in Six Sigma

You have now completed Define Phase – Understanding Six Sigma.

Notes

Lean Six Sigma Green Belt Training

Define Phase Six Sigma Fundamentals

Now we will continue in the Define Phase with the “Six Sigma Fundamentals”.

The output of the Define Phase is a well developed and articulated project. It has been correctly stated that 50% of the success of a project is dependent on how well the effort has been defined.

There's that $Y = f(X)$ thinking again.