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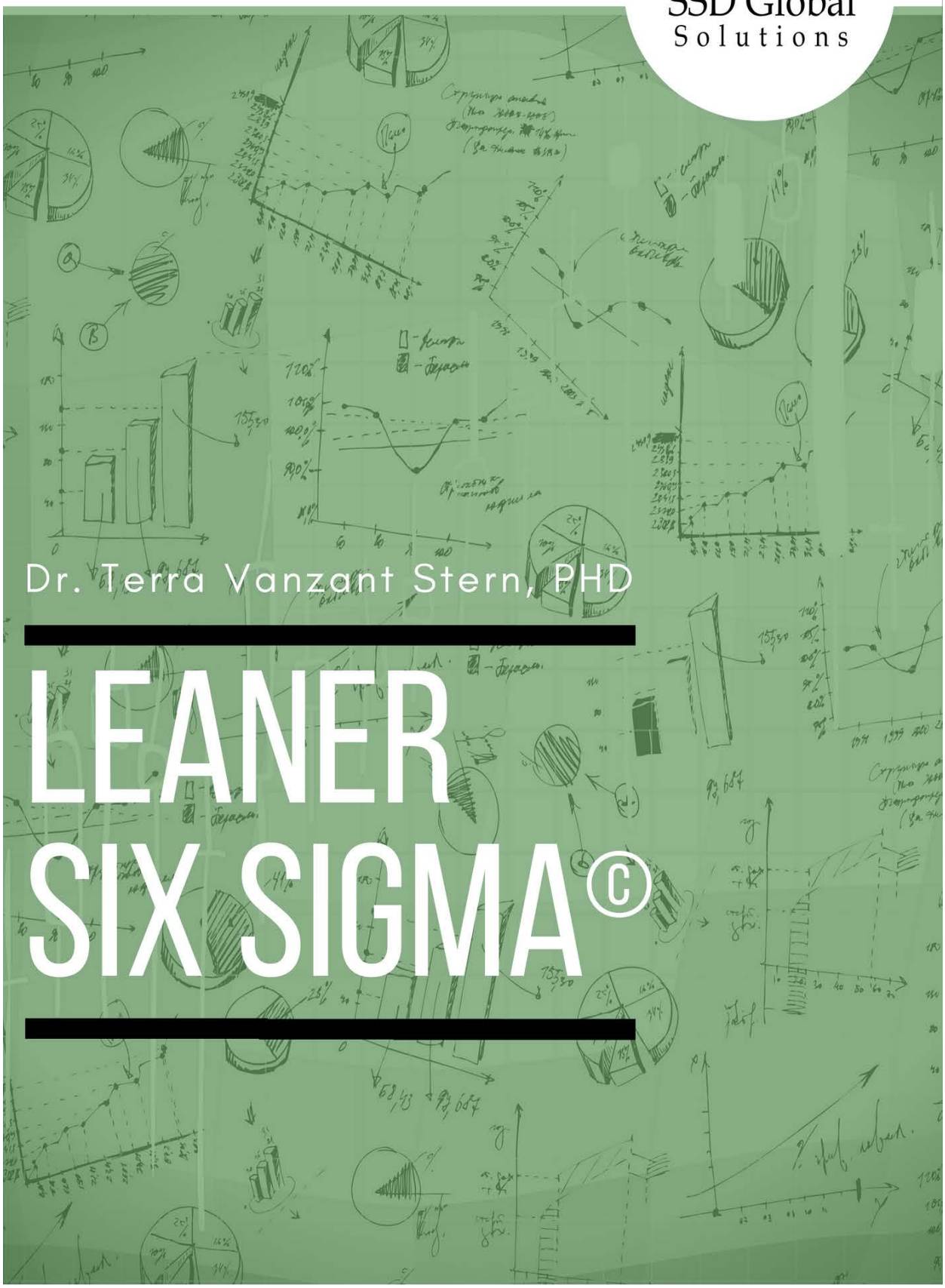

Dr. Terra Vanzant Stern, PHD

LEANER SIX SIGMA©

Leaner Six Sigma (L*r*SS©)

Terra Vanzant Stern, PhD

February 2018

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DEDICATIONS

This eBook is dedicated to the all the fine students at Tennessee Valley Authority (TVA), Southern California Edison (SCE), Ahold Holding Company, Fidelity, Jefferson and Arapahoe Counties in Colorado, State of Colorado, New Horizons, Blue Cross/Blue Shield, various U.S. Military Veterans and all the other wonderful independent students who have participated in making it a *Leaner* World.

Additionally, SSD Global Solutions dedicates this work to the many members of the ASQ Lean Enterprise Division community who contributed directly and indirectly to the construct that Lean could be made *Leaner*!

My sincere gratitude is also extended to my father, career military, and to the US Air Force who provided me the means to my core education through the GI Bill.

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Leaner Six Sigma© (L*r*SS)

Preface

Process improvement (PI) is a theory about how we can make existing activities better, faster or more cost-effective. In other words, how can we improve thing we already do and hopefully keep improving them? There are a number of PI theories. They all come with their own methodologies and tools and in many cases specific templates for purchase.

There are organizations and associations that specialize in sponsoring a specific PI program. These groups have long histories, politics and bodies of knowledge supporting that their way is the best way and these entities remain on-going.

Eventually, however, most business professionals and leaders agreed that there was not a one-size-fits-all plan. Not surprisingly it turns out that having a plan is almost always better than not having a plan. So the any PI programs can have great results. Six Sigma developed by Motorola and Lean who gives developmental credit to several people, including Henry Ford, are among the top choices.

Today a person may become certified in Six Sigma or Lean through a variety of vendors or universities. However, the trend is overwhelming to participate in training programs that combine both Lean and Six Sigma methodologies. Typically, this combined science is known as Lean Six Sigma (LSS).

Lean Six Sigma, sometimes called Lean and Six Sigma has done a tremendous job in increasing Return on Investment. But, almost two decades later it is time for the next generation. We've actually learned ways to make the core methodology and tools better, faster and more cost-effective. So we are past due for an upgrade.

SSD Global Solutions product, *Leaner* Six Sigma (L*r*SS©) is *that* next generation. L*r*SS© or, if you prefer, *Leaner*, simplifies the thoughts, concepts and the terms used in ordinary Lean Six Sigma programs. Using *Leaner*, students can apply models and theories, on the fly, without constantly consulting huge or complicated manuals. This is because the information is simplified in a way that it makes sense the first time it is heard. Then, immediately the notion is tied to an activity that is meaningful and easy to recall.

This abridged and accelerated approach allows the reader or student more time to work with the context of the issue as opposed to memorizing convoluted and sometimes outdated tools. With the new push, in our society, that less education may actually represent more time to reason things out by discussing issues, *Leaner* is a timely addition to the problem-solving and innovation arena.

Chapter One

1 LEAN SIX SIGMA AND DMAIC Overview

Although Six Sigma is a stand-alone methodology it is often partnered with Lean which is also an independent model. Both Six Sigma and Lean are problem-solving models that allow for maximum return-on-investment by making existing activities better, faster or more cost-effective by using methodologies and tools designed for those specific purposes.

It is important to note that many organizations informally embrace the basic concepts. Many Lean and Six Sigma tools are now integrated into day-to-day business activities. Used together Lean and Six Sigma increases the likelihood of success. Since Lean works to eliminate or reduce waste and Six Sigma works to eliminate or reduce mistakes, the methodologies are not mutually exclusive and work will together. This combined use in the industry is referred to as Lean Six Sigma (LSS).

The premise of this eBook is that LSS, although incredibly successful in its time, is ready for an upgrade. SSD Global Solutions *Leaner* Six Sigma (L*r*SS©) is *that* next generation. Similar to any software or game release *Leaner* allows the foundational knowledge to be used and applied more easily with less rules and instructions.

There are a number of models used in LSS but the Define-Measure-Analyze-Improve-Control (DMAIC) model is the most popular. These five phases, sometimes called steps, are the basis of most LSS training.

Each phase (or step) of this model supports tools, ideas and templates. After each phase of the model a tollgate review is performed. A tollgate is a check sheet to ensure activities have been completed. In *Leaner,* this has not changed. *Leaner* just made the steps easier to understand and the tools easier to use. The integrity of the program is still intact.

For example, in formal Six Sigma it is rare to start activities on a phase until the previous phase is completed. Lean Six Sigma is a little more flexible. In other words, if there is an opportunity in Define to satisfy some of the Measure requirements, those are taken into consideration. It isn't the goal to move to one phase before the previous phase is complete but it is allowed. Generally this is because a Lean Six Sigma project has the same manager from cradle to grave whereas the Six Sigma project has several owners and there may be a different resource for each phase due to the size of the project.

Leaner, goes a step further. Whereas LSS offered more flexibility in the model, *Leaner* supports the idea that, the model should be looked at as a guideline. Additionally, *Leaner* supports that handful of tools is often all that is needed to successfully complete a project.

Certainly it is nice to have additional tools but those can be added on an as-needed basis rather than using the time that should be devoted to fixing the problem at hand memorizing outdated or unnecessary tools.

There are only a few things written in stone as far as *Leaner* is concerned. For example, a WBS is an outline where tasks are numbered 1,2, 3 and so forth and tasks associated with each number are labeled 1.1, 1.2, etc. Tasks under 1.2 would be noted as1.2.1, 1.2.2. *Leaner* believes this to be an imperative as opposed to an option.

WBS is the preferred way in both Lean and Six Sigma to create a project plan. In *Leaner,* we believe it is an imperative and used properly negates the need to learn a bevy of other tools.

In *Leaner*, we also support that you have to fully understand the current state before you can make improvements. Both Lean and Six Sigma agree.

This chapter begins by summarizing the model and some of the more popular tools. The next chapters will discuss a little more in-depth about each phase.

DEFINE

Define is the first phase of the demand model. Examples of activities in this phase include:

- Identifying, prioritizing, and selecting the opportunities
- Defining the processes to be improved and preparing process maps
- Developing project team charters
- Building effective teams
- Identifying the customer segments and requirements

MEASURE

Examples of activities in the second phase of the DMAIC model include:

- Determining the parameters to be measured
- Managing the measure process
- Understanding variation
- Evaluating the measure system and selecting the measuring devices
- Determining the process performance

In the Measure Phase consideration is given to CTQ. This is Critical to Quality – the accepted term used to define customer requirements. However, we now use that term interchangeably with Critical to Satisfaction or Critical to Success. Although CTQs are relevant throughout the entire model this is the phase in which the CTQ is determined.

ANALYZE

Examples of activities in third phase of the DMAIC process include:

- Identifying potential root causes
- Implementing alternative methods
- Conducting sources of variation studies
- Conducting correlation analysis

The Analyze Phase is crucial to the final outcome. Many of the analytical problem-solving tools are utilized in this phase.

IMPROVE

Examples of fourth phase of the DMAIC model include:

- Generating solutions
- Identifying alternatives
- Ranking the alternatives
- Selecting the best solution
- Discussing the implementation aspects
- Implementing the final solution as per plan

In the Improve Phase, implementing the best solution usually involves more than one department. Discussing the implementation aspects of the best solution with everyone impacted is a necessity before finalizing and implementation of the plan.

CONTROL

Examples of activities in the final phase include:

- Develop a control plan (specify the check points & control points)
- Implement a suitable monitoring system for control
- Review and evaluate the impact of changes
- Update the documents, incorporating process changes
- Close the project, reward the team members, and disband the team.

In the Control Phase, there is a check regarding data integrity. This is where a control and transition plan is written. The idea behind the control plan, which can also be seen as a major deliverable, is that the control plan is written in a way that even those not exposed to Lean Six Sigma can review and understand it.

Success in Lean Six Sigma is not based on complicated or high-tech procedures. It relies wholly on tried and tested systems. It simplifies things by reducing the many complexities. One way to reduce complexity is to have everyone on the project team follow a basic roadmap.

There are several things a person may want to do before beginning the DMAIC process:

- PDCA/PDSA (Plan-Do-Check-Act) or (Plan-Do-Study-Act)
- SWOT (Strengths-Weaknesses-Opportunities-Threats) Analysis
- 5S (A physical organizational method that requires: Sort, Set in Order, Shine, Standardize and Sustain)

PDCA

PDCA (plan-do-check-act, sometimes seen as plan-do-check-adjust) is a repetitive four-stage model for continuous improvement (CI) in business process management. The **PDCA** model is also known as the Deming circle/cycle/wheel, Shewhart cycle, control circle/cycle, or plan–do–study–act (PDSA).

Plan–Do–Check–Act Procedure

1. Plan. Recognize an opportunity and plan a change.
2. Do. Test the change. Carry out a small-scale study.
3. Check. Review the test, analyze the results and identify what you've learned.
4. Act. Take action based on what you learned in the study step: If the change did not work, go through the cycle again with a different plan. If you were successful, incorporate what you learned from the test into wider changes. Use what you learned to plan new improvements, beginning the cycle again.

SWOT ANALYSIS

A SWOT Analysis is a study undertaken by an organization to identify its internal strengths and weaknesses, as well as its external opportunities and threats.

- Strengths: characteristics of the business or project that give it an advantage over others
- Weaknesses: characteristics of the business that place the business or project at a disadvantage relative to others
- Opportunities: elements in the environment that the business or project could exploit to its advantage
- Threats: elements in the environment that could cause trouble for the business or project

5S

One of the methods of determining an organizations approach to its business is to evaluate its workplace organization capability & visual management standards.

The 5 Steps are as follows:

- **Sort**: Sort out & separate that which is needed & not needed in the area.
- **Straighten** or **Set in Order:** Arrange items that are needed so that they are ready & easy to use. Clearly identify locations for all items so that anyone can find them & return them once the task is completed.
- **Shine**: Clean the workplace & equipment on a regular basis in order to maintain standards & identify defects.
- **Standardize**: Revisit the first three of the 5S on a frequent basis and confirm the condition of the Gemba using standard procedures.
- **Sustain**: Keep to the rules to maintain the standard & continue to improve every day.

Here's a quick overview of the two methodologies that impact Lean Six Sigma:

Six Sigma

- Emphasizes the need to recognize opportunities and eliminate defects as defined by customers
- Recognizes that variation hinders our ability to reliably deliver high quality services
- Requires data driven decisions and incorporates a comprehensive set of quality tools under a powerful framework for effective problem-solving

- Provides a highly prescriptive cultural infrastructure effective in obtaining sustainable results
- When implemented correctly, promises and delivers $500,000+ of improved operating profit per Black Belt per year (a hard dollar figure many companies consistently achieve)

Lean

- Focuses on maximizing process velocity
- Provides tools for analyzing process flow and delay times at each activity in a process
- Centers on the separation of "value-added" from "non-value-added" work with tools to eliminate the root causes of non-valued activities and their cost.
- Focuses on reducing and/or eliminating waste.

SUMMARY OVERVIEW

Lean Six Sigma is a methodology used to make things better, faster or more cost-effective. It combines the best ideas captured in Six Sigma methodology and Lean thinking. Although there are many models and tools available to accomplish process improvement, there is a great deal of emphasis on the DMAIC model.

The DMAIC model phases are:

1. Define
2. Measure
3. Analyze
4. Improve
5. Control

Each phase of the model has suggested tools and strategies to move the project manager from one phase to the next.

Sometimes, there are activities a project manager might want to perform before starting the DMAIC process. These include, but are not limited to, working with a smaller model such as PDCA which stands for Plan Do Check Act or organizing the work space by using a 5S model.

Chapter Two

2 DEFINE

DMAIC (<u>DEFINE</u>-Measure-Analyze-Improve-Control**)**

The DMAIC model is a structured and disciplined approach to process improvement. It consists of the five phases. Each phase is linked logically to the previous phase as well as to the next phase. This chapter covers the basics of DEFINE. Technically there are only two major rules in DEFINE. Rule One is that you should start with a Process Map outlining the actual current process. Rule Two is that you should not leave DEFINE without a project charter.

Albert Einstein said that if he had only an hour to solve a problem he would spend 55 minutes thinking about the problem and only five minutes on the solution. Whereas this is not the exact intention of the DEFINE portion of the DMAIC model is does represent the concept that a great deal time in problem-solving should be devoted to thinking about the problem itself. This may seem logical to the reader, however, we live in a reactive environment that often starts trying to solve the problem without truly understanding the problem statement.

Having a standard problem-solving model such as DMAIC (Define-Measure-Analyze-Improve- Control) is extremely helpful. It provides teams with a roadmap. But without first spending serious time understanding the problem and why it is important the DMAIC model doesn't work properly. In the words of Lewis Carroll paraphrased from Alice in Wonderland, if you don't know where you are going, any road will get you there.

Elements of Define (DMAIC)

The tools most commonly used in the *Define* phase are:

- Project Charter
- Stakeholder Analysis
- Suppliers, Inputs, Process, Output, and Customers (SIPOC) Process Map
- Voice of the Customer
- Affinity Diagram
- Kano Model
- Critical-To-Quality (CTQ) Tree

The first phase is *Define*. During the *Define* phase, a team and its sponsors reach agreement on what the project is and what it should accomplish. Presuming that a draft of the Project Charter is already in place, the main work in the *Define* phase is for the project team to complete an analysis of what the project should accomplish and confirm understanding with the sponsor(s). They should agree on the problem, which customers are affected, and how the current process or outcomes fail to meet their customers' needs through "Voice of the Customer or Critical-To- Quality (CTQ)." The outcome of the Define phase is:

- A clear statement of the intended improvement (Project Charter)
- A high-level map of the Processes (SIPOC)
- A list of what is important to the customer (CTQ)
- An understanding of the project's link to corporate strategy and its contribution to ROIC the following sections provide a brief description of the above tools and techniques.

Project Charter

The charter is a contract between the organization's leadership and the project team created at the outset of the project. Its purpose is:

- To set clear definition of what the project and is not
- To provide the parameters of the project
- A communication tool to align Sponsors, Champions, Project Manager, and Teams
- To keep the project and team aligned with organizational priorities

Stakeholder Analysis

A DMAIC project will require a fundamental change in the process. In an effort to mitigate the resistance to change when the improvement is implemented, it is crucial to identify the stakeholders early on, and to develop a communication plan for each of them. Typical stakeholders include managers, people who work in the process under study, upstream and downstream departments, customers, suppliers and finance. Regular communication can create more buy-in, identify better solutions, and avoid pitfalls.

SIPOC Process Map

A SIPOC is a high-level process map that includes Suppliers, Inputs, Process, Output, and Customers. Quality is judged based on the output of a process. The quality is improved by analyzing inputs and process variables. An example of a SIPOC Process Map is provided below.

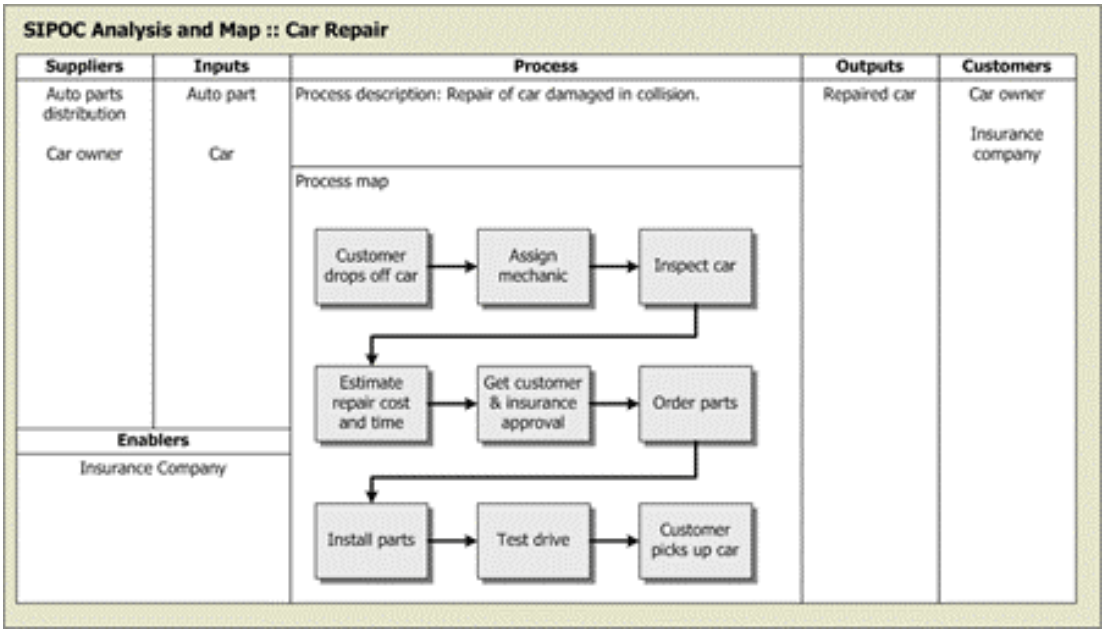


Figure 1: SIPOC Process Map example

Voice of the Customer

The "Voice of the Customer" is a process used to capture the requirements/feedback from the customer (internal or external) to provide them with best-in-class service/product quality. This process is all about responsiveness and constantly innovating to capture the changing requirements of the customers over time.

The "Voice of the Customer" is the term used to describe the stated and unstated needs or requirements of the customer. The “Voice of the Customer” can be captured in a variety of ways:

- Direct discussion or interviews, surveys, focus groups, customer specifications, observation, warranty data, field reports, complaint logs, etc.
- This data is used to identify the quality attributes needed for a supplied component or material to incorporate in the process or product. The VOC is critical for an organization to:
- Decide what products and services to offer
- Identify critical features and specifications for those products and services
- Decide where to focus improvement efforts
- Obtain a baseline measure of customer satisfaction against which improvement will be measured
- Identify key drivers of customer satisfaction

> *IMPORTANT: The larger the change the more methods and tools should be used to collect an accurate and full picture of the voice of the customer. Many insights can be gains from utilizing the VOE, VOB, and VOP.*

The following is a list of typical outputs of the VOC process:

- A list of customers and customer segments
- Identification of relevant reactive and proactive sources of data
- Verbal or numerical data that identify customer needs
- Defined Critical-To-Quality requirements (CTQs)
- Specifications for each CTQ requirement

Affinity Diagram

An Affinity Diagram (sometimes referred to as a "KJ", after the initials of the person who created this technique, Kawakita Jiro) is a special kind of brainstorming tool. You use an Affinity Diagram to:

- Gather large numbers of ideas, opinions, or issues and group those items that are naturally related
- Identify, for each grouping, a single concept that ties the group together

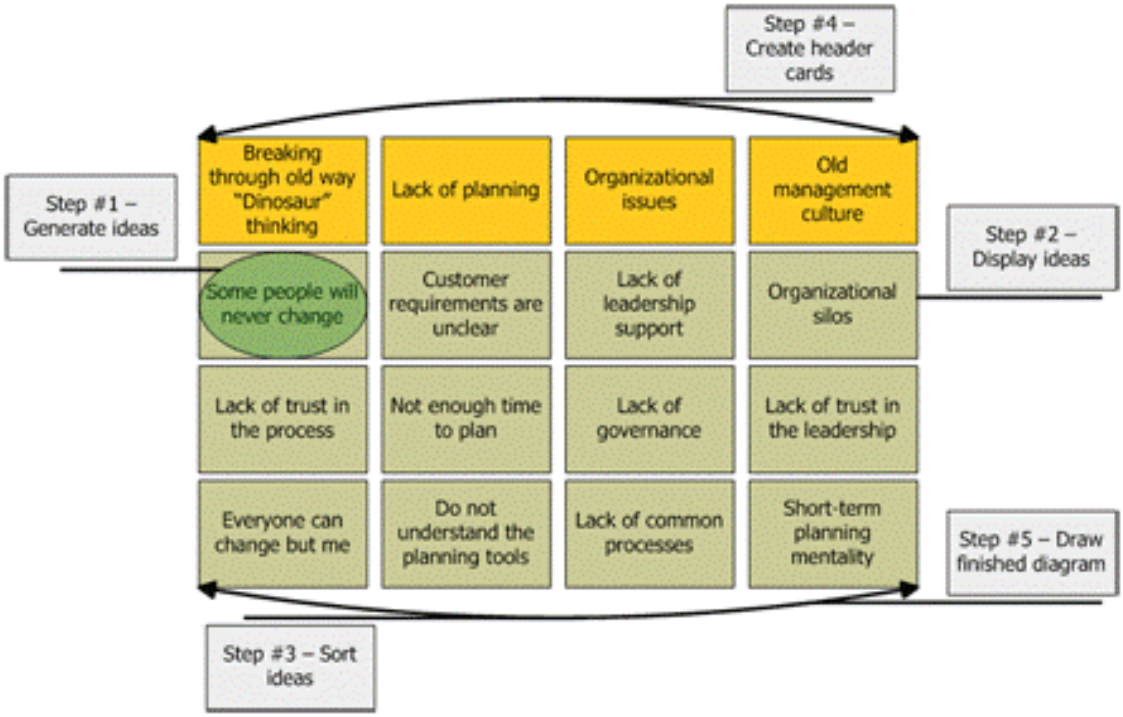


Figure 2: Affinity Diagram example

An Affinity Diagram is especially useful when:

- Chaos exists
- The team is drowning in a large volume of ideas
- Breakthrough thinking is required
- Broad issues or themes must be identified

Building an Affinity Diagram is a creative rather than a logical process.

Kano Model

Developed in the 80's by Professor Noriaki Kano, the Kano model is based on the concepts of customer quality and provides a simple ranking scheme which distinguishes between essential and differentiating attributes. The model is a powerful way of visualizing product characteristics and stimulating debate within the design team. Kano also produced a rigorous methodology for mapping consumer responses into the model. Product characteristics can be classified as:

- **Threshold / Basic attributes**
  - Attributes which must be present in order for the product to be successful, and can be viewed as a 'price of entry'. However, the customer will remain neutral towards the product even with improved execution of these threshold and basic attributes.
- **One dimensional attributes** (Performance / Linear)
  - These characteristics are directly correlated to customer satisfaction. Increased functionality or quality of execution will result in increased customer satisfaction. Conversely, decreased functionality results in greater dissatisfaction. Product price is often related to these attributes.
- **Attractive attributes** (Exciters / Delighters)
  - Customers receive great satisfaction from a feature and are willing to pay a price premium. However, satisfaction will not decrease (below neutral) if the product lacks the feature. These features are often unexpected by customers and can be difficult to establish as needs during initial design. They are sometimes called unknown or latent needs.

An example of Kano Model is provided below.

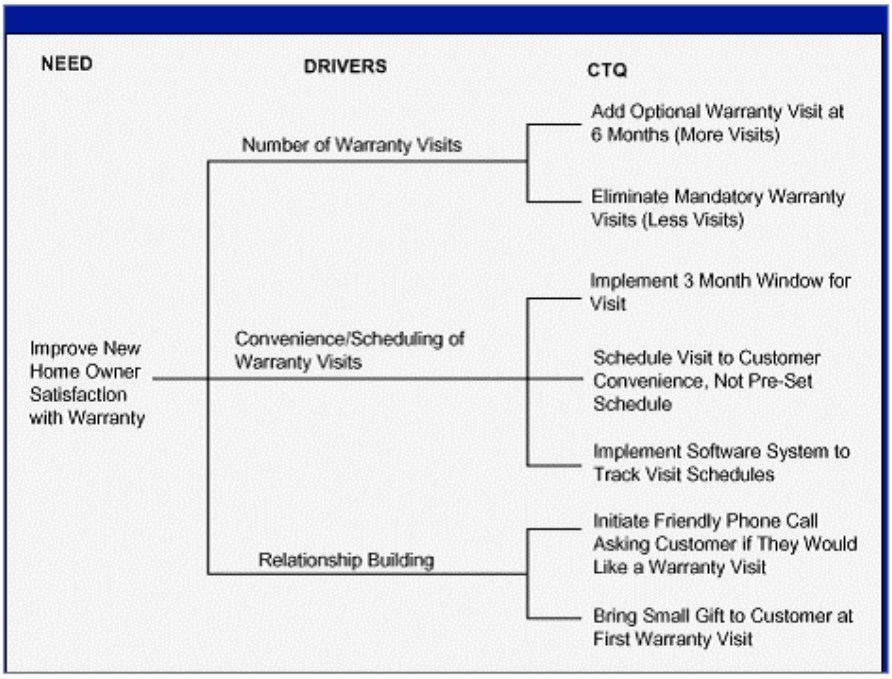
Figure 3: Kano Model example

Critical-To-Quality (CTQ) tree

The purpose of Critical-To-Quality trees is to convert customer needs/wants to measurable requirements for the business to implement.

For example: A retail merchant was receiving a significant number of complaints regarding their homeowner warranty policies from their customers. By analyzing customer survey data and developing the CTQ tree, the business was able to identify critical-to-satisfaction requirements. These requirements became the focus for improving customer satisfaction. The business eliminated mandatory warranty visits and made all warranty visits optional. Eliminating mandatory visits satisfied the customers who thought there were too many visits and adding an extra optional visit satisfied customers who thought there were too few visits. Expanding the time frame for scheduling warranty visits from two weeks to three months eliminated the inconvenience for customers who had busy schedules and found the time frame difficult to manage.

The business took a general, difficult-to-measure need (to improve homeowner warranty satisfaction) and developed specific, measurable, and actionable requirements to drive improvements in customer satisfaction.



Closing Thought

Malcom Forbes said that it was "… so much easier to suggest solutions if when you don't know too much about the problem". DEFINE forces the project manager not to make this mistake. The tools and exercises in this chapter encourage the project manager to truly understand the problem and to make sure the right problem is being considered.

Chapter Three

3 MEASURE

DMAIC (Define**-MEASURE** -Analyze-Improve-Control**)**

It is tempting not to pay attention to the current state of affairs and skip ahead to solving the problem. Although DEFINE offers the project manager a lot of information about what is happening now, the purpose of MEASURE is to take a more in-depth look. Albert Einstein said we cannot solve problems with the with the same level of thinking that created them. This is why, what is happening now, in real time, becomes very important. For example, what is working currently and what is not?

If it is possible to take a picture or a video, then do that! Before and after pictures are very powerful. A detailed process map may be just as good as taking a photograph. However, often a process map cannot accurately represent a picture. This is why the tools in MEASURE are so important. For example, a picture or a video clip of how you wash your clothes, now, might make a good reflection of what is happening, now, in current time. But, what if you wanted to explain your existing budgeting process? That might be more difficult. So remember, the purpose of the Measure Phase is to give a true and accurate picture of the current condition as it relates to the project.

How the data will be collected is also something that should be considered. In this heighten age of both confidentiality and cyber security a documented and endorsed plan should be in place before data is collected.

Most Lean Six Sigma professionals will agree that in order document and collect data the following things should be considered:

- Select the Critical to Quality characteristics in your process. These are the outcomes of the given process that are important to the customer.
- Define what that process output should be, which is done by looking at the customer requirements and the project goal.
- Define the defects in the process. Remember, a defect is an outcome that falls outside the limits of customer's requirements or expectations and must be measurable.
- Find the inputs to the process that contribute to defects.
- Define an accurate dollar impact of eliminating the defects in terms of increased profitability and/or cost savings.
- Measure the defects that affect the Critical to Quality characteristics as well as any related factors.
- Incorporate Measurement Systems Analysis - a method to make sure the defects are being measured properly.
- Refine data collection procedures, if needed.

Leaner would simply suggest that you start by seeing if any of this documentation is in place, even in draft form, and ask yourself which of the above-stated activities are essential to the

progress of accomplishing the goal of MEASURE. The Lean Six Sigma mindset often focuses more on the tools than the purpose.

The tools most commonly used in the *Measure* phase are:

- Prioritization Matrix
- Process Cycle Efficiency
- Time Value Analysis
- Pareto Charts
- Control Charts
- Run Charts
- Failure Modes and Effect Analysis (FMEA)

Supporters of Six Sigma will mention the methodology's *demand* for a fact-based and data-driven analytical approach. This is, indeed, important. And, the Lean influence certainly softened the requirements and made all of this easier.

Leaner simply states that <u>all</u> of the above-mentioned tools are not necessary for every project. In order to accomplish the mission quickly, the project manager should consider which tools are the most meaningful to the project. Consideration should also be given to which tools the project manager feels comfortable using and understands. If the project manager has to spend too much time learning the tool then it isn't particularly Lean.

Many improvement methodologies attempt process improvement without sufficient data to understand the underlying causes of the problem. Although ANALYZE is dedicated to a more thorough study as to why a condition is occurring, *Leaner* believes that thinking about why the problem is occurring just saves time down the line. Still, it is important not to develop a bias too early in the solution stage and to examine, or measure as the DMAIC model prefers to say, all the conditions that are meaningful to solving the problem.

One of the goals of MEASURE is to tag the location or source of a problem. This makes the job in ANALYZE a little easier. Another important part of MEASURE is to establish baseline capability levels. Some capability awareness should already have happened in DEFINE. This is because if the process isn't capable (or does not have the capacity) of handling the process improvement, the project manager needs to deal with that issue before moving forward. However baselines, standards and what is considered "the norm" are more aptly determined and documented in MEASURE.

This is a summary of how most LSS professionals will describe the core tools in MEASURE listed above.

Prioritization Matrix

The Prioritization Matrix provides a way of sorting a diverse set of items into an order of importance. This Matrix may also be used in other phases such as Analyze and Improve. It also enables their *relative* importance to be identified by deriving a numerical value of the importance of each item. Therefore an item with a score of 223 is clearly far more important

than one with a score of 23, but is not much more important than one with a score of 219. Items are compared, scored against a set of key criteria, and the scores for each item are then summed.

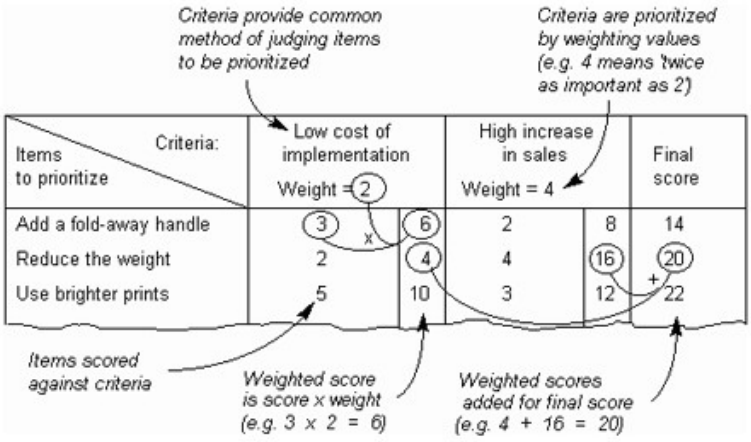


Figure 5: Prioritization Matrix

Process Cycle Efficiency

This is a calculation that relates the amount of value-added time to total cycle time in a process.

Time Value Analysis

This is a chart that visually separates value-added from non-value-added time in a process.

This technically something studied in the LSS Black Belt program but if you are interested these are great you tube videos:

Pareto Charts

Vilfredo Pareto, a turn-of-the-century Italian economist, studied the distributions of wealth in different countries, concluding that a fairly consistent minority – about 20% – of people controlled the large majority – about 80% – of a society's wealth. This same distribution has been observed in other areas and has been termed the Pareto effect.

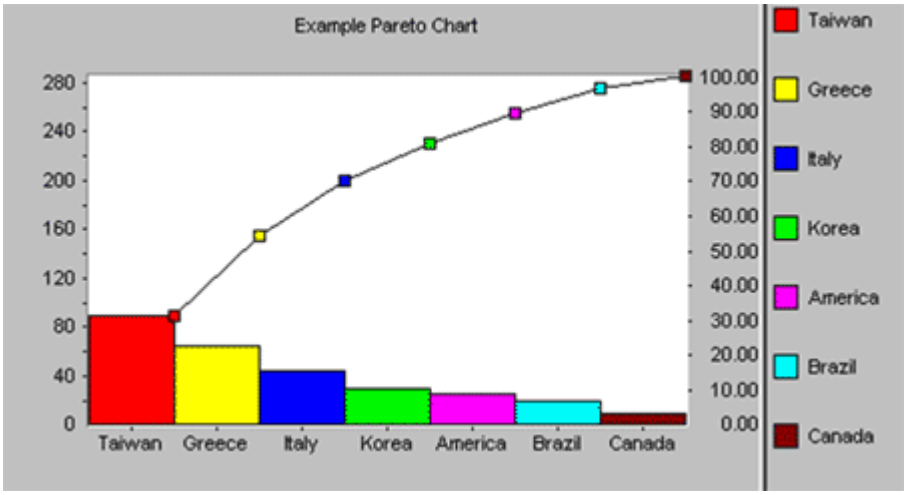


Figure 6: Example Pareto Chart

The Pareto effect even operates in quality improvement: 80% of problems usually stem from 20% of the causes. Pareto charts are used to display the Pareto principle in action, arranging data so that the few vital factors that are causing most of the problems reveal themselves. Concentrating improvement efforts on these few issues will have a greater impact and be more cost-effective than undirected efforts.

Measurement Systems Analysis

A Measurement System Analysis, abbreviated MSA, is a specially designed experiment that seeks to identify the components of variation in the measurement. Just as processes that produce a product may vary, the process of obtaining measurements and data may have variation and produce defects. A Measurement Systems Analysis evaluates the test method, measuring instruments, and the entire process of obtaining measurements to ensure the integrity of data used for analysis (usually quality analysis) and to understand the implications of measurement error for decisions made about a product or process.

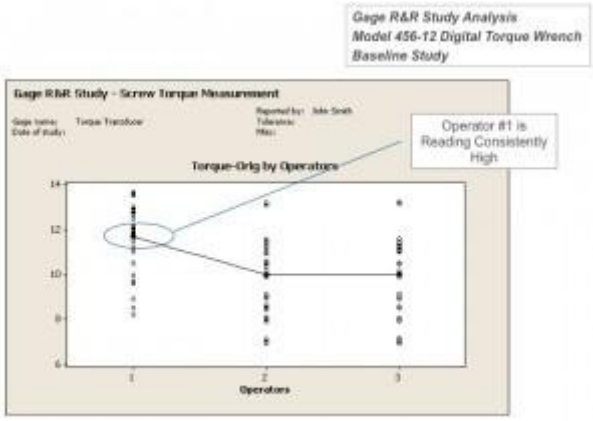
A Measurement Systems Analysis considers the following:

- Selecting the correct measurement and approach
- Assessing the measuring device
- Assessing procedures & operators
- Assessing any measurement interactions
- Calculating the measurement uncertainty of individual measurement devices and/or measurement systems

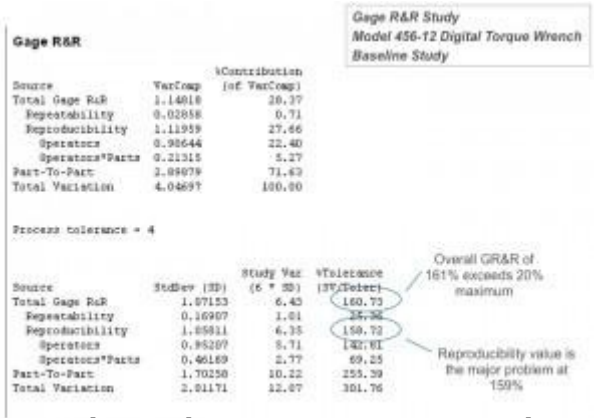
Common tools and techniques of Measurement Systems Analysis include: calibration studies, fixed effect ANOVA, components of variance, Attribute Gage Study, Gage R&R, ANOVA Gage R&R, Destructive Testing Analysis and others. The tool selected is usually determined by characteristics of the measurement system itself.

A very popular MSA is Gage R&R. Gage Repeatability and Reproducibility is the amount of measurement variation introduced by a measurement system, which consists of the measuring instrument itself and the individuals using the instrument. A Gage R&R study quantifies three things:

1. Repeatability – variation from the measurement instrument
2. Reproducibility – variation from the individuals using the instrument
3. Overall Gage R&R, which is the combined effect of (1) and (2)

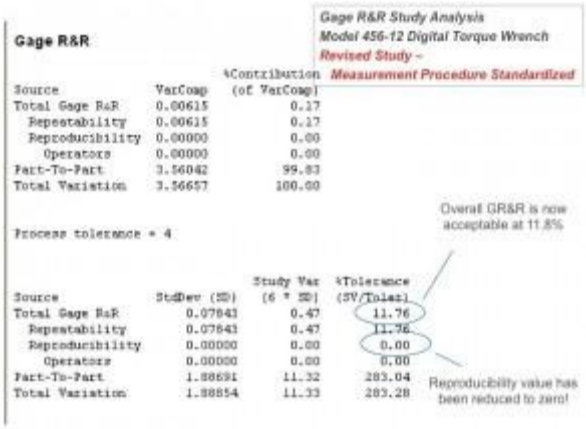


In the case of a furniture manufacturing company, the project team performs a Gage R & R (GR&R) study on a known critical measurement (screw torque) that affects a cracking condition on one of its chair lines – this will come in handy later in the project. The initial GR&R results show that the screw torque measurement method introduces far too much variation –



4. Using a graphical technique learned in Gage R & R training, the team finds that the first operator in the study is recording consistently higher readings than the other two operators.

5. Finally, after correcting operator #1's measurement technique and updating the measurement procedure, the team conducts a follow-up Gage R & R study with much-improved results –



Control Charts

Every process varies. If you write your name ten times, your signatures will all be similar, but no two signatures will be exactly alike. There is an inherent variation, but it varies between predictable limits. If, as you are signing your name, someone bumps your elbow, you get an unusual variation due to what is called a "special cause". If you are cutting diamonds, and someone bumps your elbow, the special cause can be expensive. For many processes, it is important to notice special causes of variation as soon as they occur.

There's also "common cause" variation. Consider a baseball pitcher. If he has good control, most of his pitches are going to be where he wants them. There will be some variation, but not too much. If he is "wild", his pitches aren't going where he wants them; there's more variation. There may not be any special causes - no wind, no change in the ball - just more "common cause" variation. The result: more walks are issued, and there are unintended pitches over the plate where batters can hit them. In baseball, control wins ballgames. Likewise, in most processes, reducing common cause variation saves money.

Happily, there are easy-to-use charts which make it easy see both special and common cause variation in a process. They are called control charts, or sometimes Shewhart charts, after their inventor, Walter Shewhart, of Bell Labs. There are many different subspecies of control charts which can be applied to the different types of process data which are typically available.

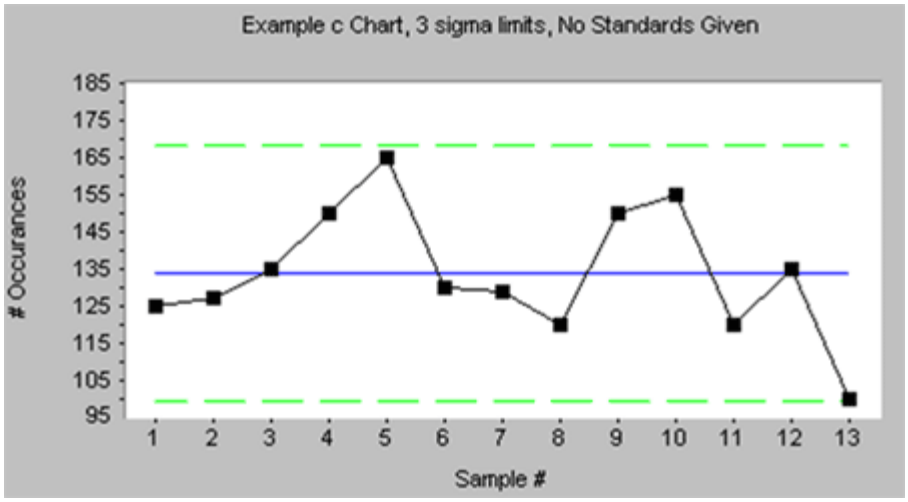


Figure 7: Example Control Chart

All control charts have three basic components:

- A centerline, usually the mathematical average of all the samples plotted.
- Upper and lower statistical control limits that define the constraints of common cause variations.
- Performance data plotted over time.

Run Charts

Run charts (often known as line graphs outside the quality management field) display process performance over time. Upward and downward trends, cycles, and large aberrations may be spotted and investigated further. In a run chart, events, shown on the y axis, are graphed against a time period on the x axis. For example, a run chart in a hospital might plot the number of patient transfer delays against the time of day or day of the week. The results might show that there are more delays at noon than at 3 p.m. investigating this phenomenon could unearth potential improvement needs. Run charts can also be used to track improvements that have been put into place, checking to determine their success. Also, an average line can be added to a run chart to clarify movement of the data away from the average.

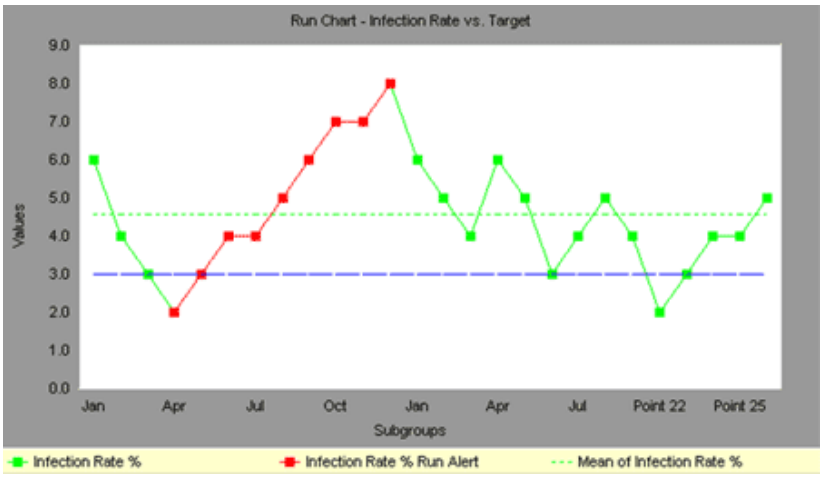


Figure 8: Example Run Chart

Failure Modes and Effect Analysis (FMEA)

Procedures and tools that help to identify every possible failure mode of a process or product, determine its effect on other sub-items and on the required function of the product or process. The FMEA is also used to rank & prioritize the possible causes of failure as well as develop and implement preventive actions, with responsible persons assigned to carry out these actions.

Closing Thought

The purpose of MEASURE is to get a clear as-is idea of what is happening now. Take a picture if you can. Try a detailed process map. If you still don't have a handle on what is going on in real time, try a simple tool, observation. It is always amazing how much you can learn by simply watching. The BEFORE picture is very important. Later, when you roll out your process improvement, it will be the AFTER picture. Before-and-After pictures are the way to document your improvement. The other tools covered in this chapter help you do that as well.

Chapter Four

4 ANALYZE

DMAIC (Define-Measure-**ANALYZE** -Improve-Control**)**

Performed correctly, MEASURE has identified and documented the current state of affairs. What is happening now, in relationship to, the activity that needs to be improved?

In the Analyze phase of the DMAIC model, the root cause of the current condition is explored along with correlation, impact and variation. This examination should lead to a list of possible solutions.

Sun Tzu, in The Art of War, makes an interesting observation. There are only a handful of musical notes. And, yet, the combinations, of these notes, produce more melodies than can ever be heard. This implies that there is an infinite amount of outcomes to any effort.

ANALYZE can be approached by using a series of questions:

1. What are the perceived causes of the process variability and which can we control?
2. What is of value to the customer?
3. What are the detail steps of the process?
4. Have you validated the “As-Is” causes?

The tools most commonly used in the Analyze phase are:

- Brainstorming
- Cause and Effect Diagram
- Affinity Diagrams (covered in the Define phase)
- Control Charts (covered in the Measure phase)
- Flow Diagram
- Pareto Charts (covered in the Measure phase)
- Regression Analysis
- Scatter Plots

This is a summary of how most professionals, if given only a short time to explain, would explain the above tools.

5 Whys Analysis

5 Whys Analysis is a problem-solving technique that allows you to get at the root cause of a problem fairly quickly. It was made popular as part of the Toyota Production System (1970’s). Application of the strategy involves taking any problem and asking "Why - what caused this problem?"

By repeatedly asking the question "Why" (five is a good rule), it is possible to peel away the layers of symptoms to identify the root cause of a problem. Very often the first reason for a problem will lead you to another question and then to another. Although this technique is called "5 Whys," you may find that you will need to ask the question fewer or more times than five before you find the issue related to a problem.

Key Concept

Benefits of the 5 Whys:

It helps to quickly identify the root cause of a problem

It helps determine the relationship between different root causes of a problem

It can be learned quickly and doesn't require statistical analysis to be used

5 Why Example:

1. Why is our largest customer unhappy? Because our deliveries of bicycles have been late for the last month.
2. Why have our bicycle deliveries been late for the last month? Because production has been behind schedule.
3. Why has production been behind schedule? Because there is a shortage of wheels.
4. Why are we having a shortage of wheels? Because incoming inspection has rejected a large number of wheels for not being round.
5. Why are we rejecting so many parts? Because purchasing switched to a cheaper wheel supplier that has inconsistent quality.

Brainstorming

Brainstorming is simply listing all ideas put forth by a group in response to a given problem or question. In 1939, a team led by advertising executive Alex Osborn coined the term "brainstorm." According to Osborn, "Brainstorm means using the brain to storm a creative problem and to do so "in commando fashion, each stormer audaciously attacking the same objective." Creativity is encouraged by not allowing ideas to be evaluated or discussed until everyone has run dry. Any and all ideas are considered legitimate and often the most far-fetched are the most fertile. Structured brainstorming produces numerous creative ideas about any given "central question". Done right, it taps the human brain's capacity for lateral thinking and free association.

Brainstorms help answer specific questions such as:

What opportunities face us this year?

What factors are constraining performances in Department X?

What could be causing problem Y?

What can we do to solve problem Z?

However, a brainstorm cannot help you positively identify causes of problems, rank ideas in a meaningful order, select important ideas, or check solutions.

Cause and Effect (C&E) Diagram

The Cause & Effect diagram is the brainchild of Kaoru Ishikawa, who pioneered quality management processes in the Kawasaki shipyards and in the process, became one of the founding fathers of modern management. C&E diagrams are also called Ishikawa Diagrams or Fishbone Diagrams. The C&E diagram is used to explore all the potential or real causes (or inputs) that result in a single effect (or output). Causes are arranged according to their level of importance or detail, resulting in a depiction of relationships and hierarchy of events. This can help you search for root causes, identify areas where there may be problems, and compare the relative importance of different causes.

Causes in a C&E diagram are frequently arranged into four major categories. While these categories can be anything, you will often see:

- Manpower, methods, materials, and machinery (recommended for manufacturing)
- Equipment, policies, procedures, and people (recommended for administration and service)

These guidelines can be helpful but should not be used if they limit the diagram or are inappropriate. The categories you use should suit your needs. Often we can create the branches of the cause and effect tree from the titles of the affinity sets in a preceding affinity diagram.

The C&E diagram is also known as the fishbone diagram because it is drawn to resemble the skeleton of a fish, with the main causal categories drawn as "bones" attached to the spine of the fish.

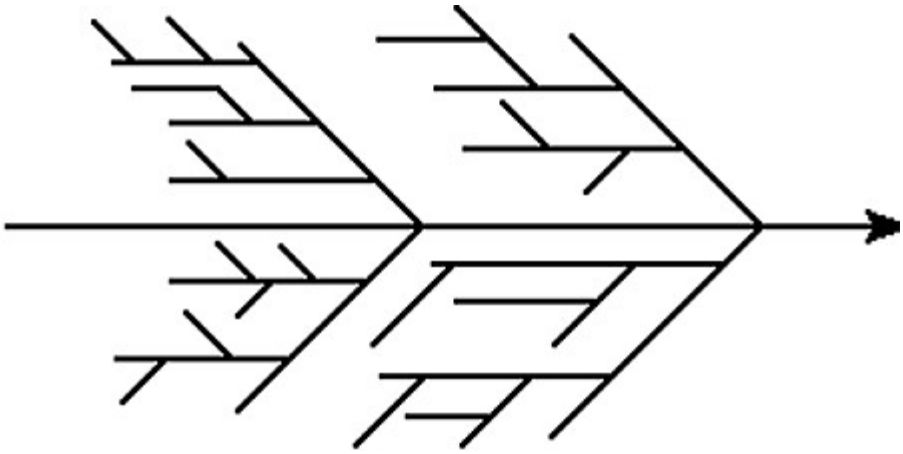


Figure 9: Example C&E diagram

Flow Diagrams

Flowcharts are maps or graphical representations of a process. Steps in a process are shown with symbolic shapes, and the flow of the process is indicated with arrows connecting the symbols. Computer programmers popularized flowcharts in the 1960's, using them to map the logic of programs. In quality improvement work, flowcharts are particularly useful for displaying how a process currently functions or could ideally function. Flowcharts can help you see whether the steps of a process are logical, uncover problems or miscommunications, define the boundaries of a process, and develop a common base of knowledge about a process. Flowcharting a process often brings to light redundancies, delays, dead ends, and indirect paths that would otherwise remain unnoticed or ignored. But flowcharts don't work if they aren't accurate, if team members are afraid to describe what actually happens, or if the team is too far removed from the actual workings of the process.

There are many varieties of flowcharts and scores of symbols that you can use. Experience has shown that there are three main types that work for almost all situations:

High-level flowcharts map only the major steps in a process and provide a good overview:

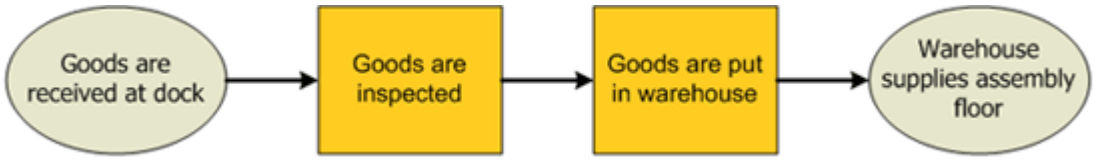


Figure 10: High-level flow diagram example

Detailed flowcharts show a step-by-step mapping of all events and decisions in a process:

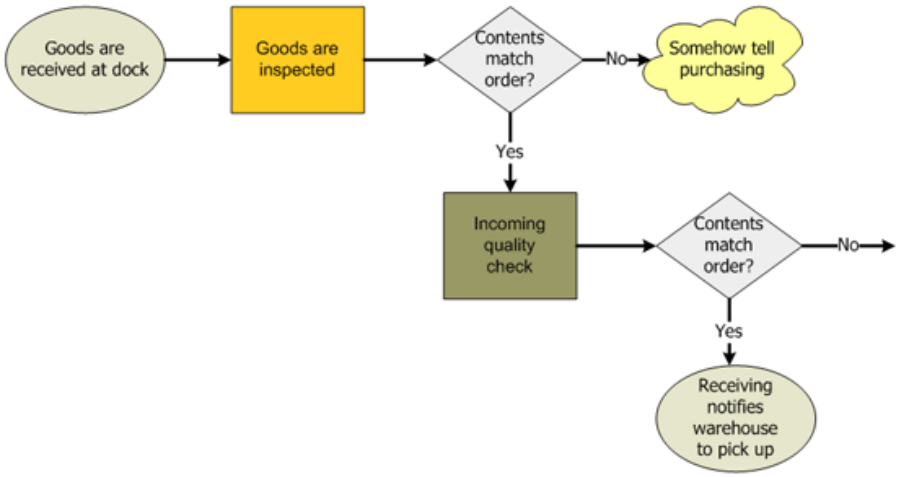


Figure 11: Detailed flow diagram example

Deployment flowcharts organize the flowchart by columns with each column representing a person or department involved in a process:

IMPORTANT: There are many examples of almost all tools in Lean Six Sigma. Flowcharts are no different, the key is to create a common and agreed upon method that will be used consistently throughout the teams/organization.

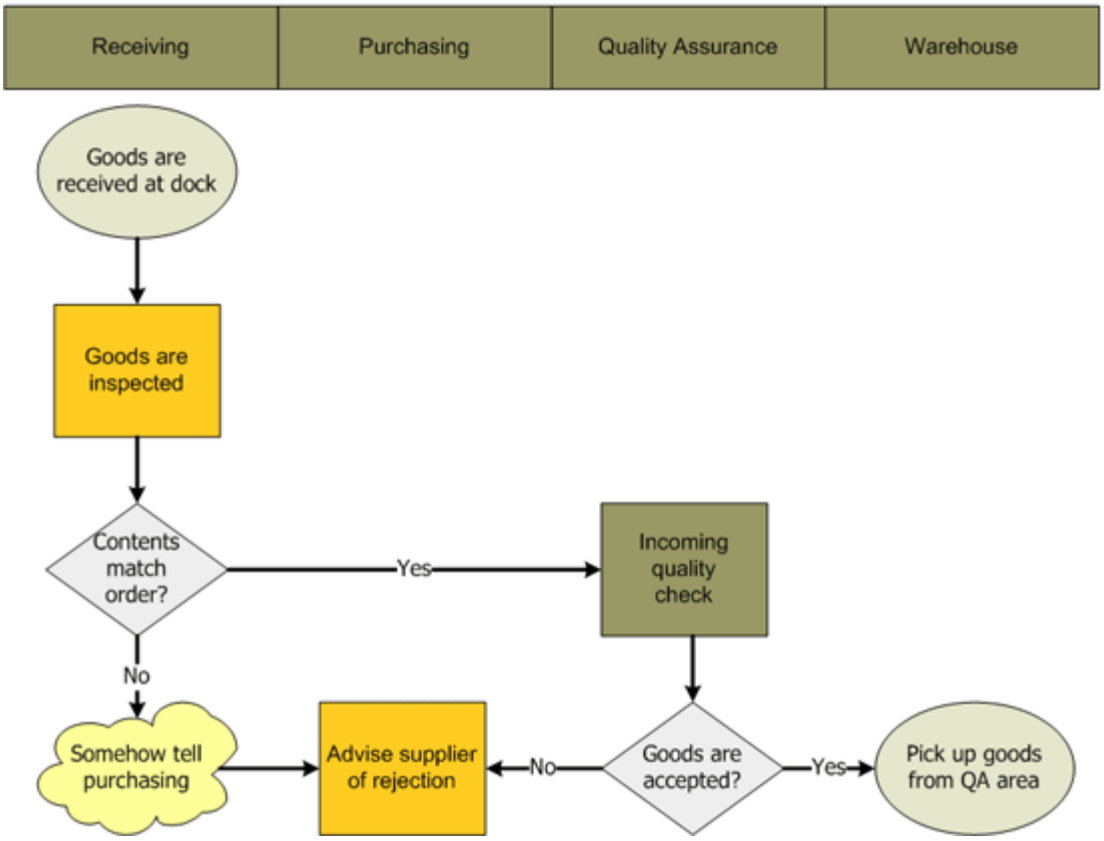


Figure 12: Deployment flow diagram example

Regression Analysis

Regression analysis is a statistical forecasting model that describes and evaluates the relationship between a given variable, usually called the dependent variable, and one or more other variables, usually known as the independent variables. Regression analysis models are used to help us predict the value of one variable compared to one or more other variables whose values can be predetermined.

Scatter Plots

Scatter Plots (also called scatter diagrams) are used to investigate the possible relationship between two variables that both relate to the same "event." A straight line of best fit, using the least squares method, is often included.

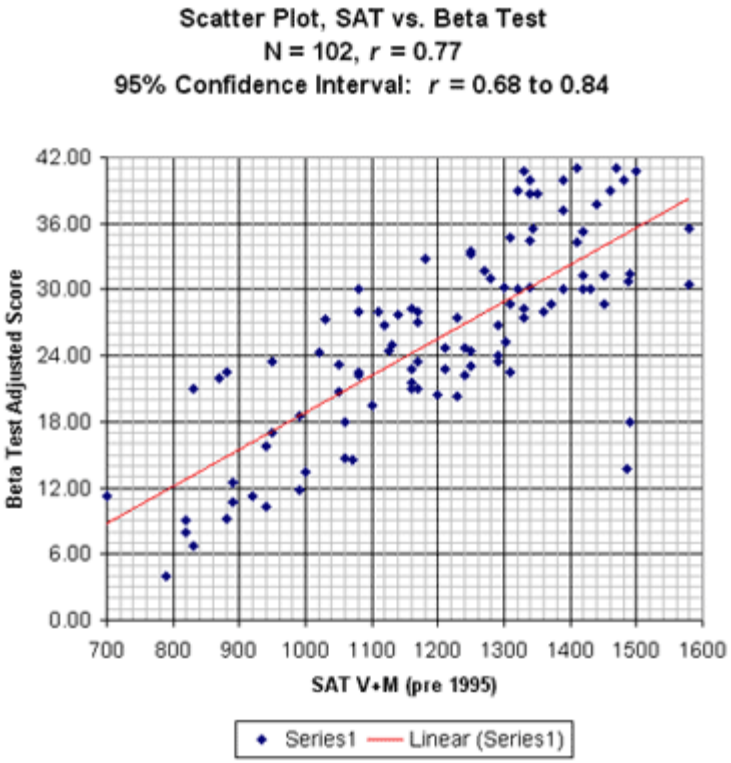
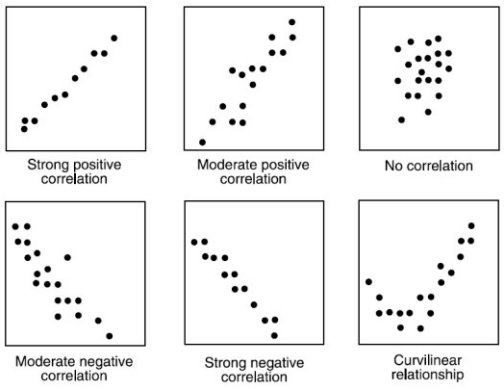


Figure 13: Scatter plot example

Things to look for in a scatter plot:

- If the points cluster in a band running from lower left to upper right, there is a positive correlation (if x increases, y increases).
- If the points cluster in a band from upper left to lower right, there is a negative correlation (if x increases, y decreases).
- Imagine drawing a straight line or curve through the data so that it "fits" as well as possible. The more the points cluster closely around the imaginary line of best fit, the stronger the relationship that exists between the two variables.

If it is hard to see where you would draw a line, and if the points show no significant clustering, there is probably no correlation.



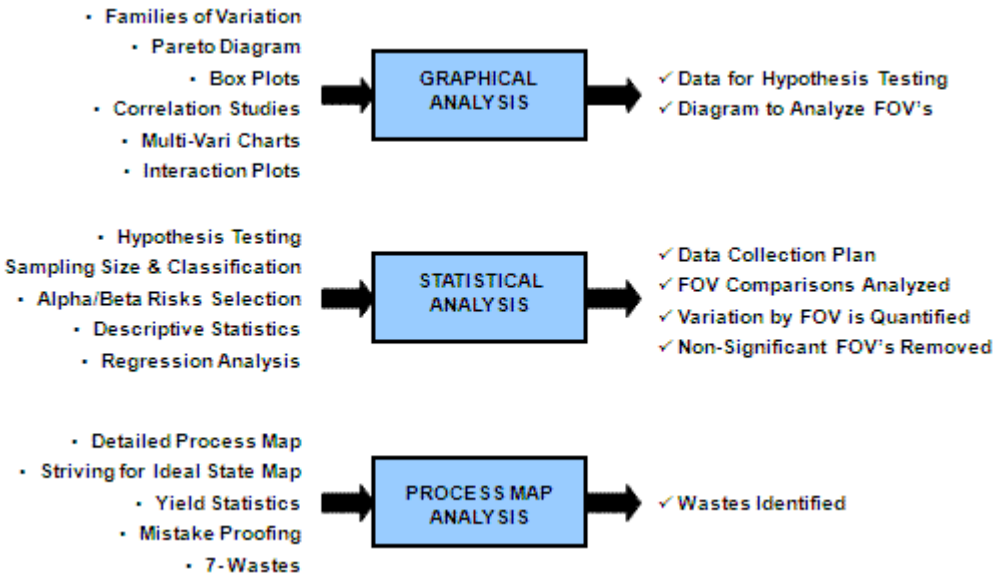
Please take a moment and review this video. It will help you understand the 7 Quality tools and provides for a great review! https://www.youtube.com/watch?v=LdhC4ziAhgY (Remember if the link doesn't work you can always cut and paste it into your browser).

When you analyze data you are looking for many things:

- Root Cause
- Correlation
- Variation

Variation

See the following model to get a better idea of Variation. These topics are covered in most LSS Black Belt programs. Here is a quick graphic to get a better understanding:



Closing Thought

This is where most traditional Lean Six Sigma and Six Sigma classes spend their time in instructing the student. In Six Sigma this is also where statistics are discussed. Often, especially in Lean Six Sigma projects, statistics are not useful because there are not enough data points. Using math and statistics can be useful in ANALYZE but not always necessary to the extent they are used.

Another thing to remember about this phase is that you don't want to end up with more than 3-5 solutions because too many or not enough choices can be confusing.

Chapter Five

5 Improve

DMAIC (Define**-**Measure-Analyze-**Improve**-Control**)**

IMPROVE has a number of facets and it is where most of the solution time will be spent in the DMAIC model. IMPROVE works first to gain consensus. Which of the three to five solutions from ANALYZE should be tried? How will the idea be piloted or tried out? Then after these questions are answered a project plan is created and rolled out.

Gaining consensus, as to which solution should be tried, creates buy-in. Alvin Toffler, an associate editor for Fortune magazine said "It is always easier to talk about change than to make it". Creating true buy-in helps with the impending change. Process improvement always represents changing something. Lean Six Sigma and to a greater extent *Leaner* supports the concept that people factors are the primary make-or-break considerations leading to a successful project.

There is a lot of information in this chapter and the project manager and/or reader is reminded that these are simply options and thoughts to be considered. IMPROVE is a roadmap. Whereas DEFINE, MEASURE and ANALYZE are creative in nature with many options IMPROVE is a roadmap. The major activities after a solution has been selected are:

- Try out the Solution – if it works move forward, it not choose another solution from the list
- Create the project plan
- Execute the project plan
- Move to CONTROL if an improvement can be documented

Much of this chapter is dedicated to project management (PM). Once a solution is selected, IMPROVE is mostly about basic PM. The basics of PM include defining the problem solution (which is what the DMAIC helps you do), building a project plan, executing that plan and managing your resources to meet your project baseline. Your project baseline is what you have determined your project will cost (cost baseline) and how long it will take (time baseline).

The tools most commonly used in the Improve phase are:

- Brainstorming
- Flow Charting
- FMEA
- Stakeholder Analysis
- Setup Reduction

- Queuing Methods for Reducing Congestion and Delays
- 5S's Method
- Kaizen

Setup Reduction

Key Concept

Benefits of Setup Reduction:

- Reduce lead time, resulting in improved delivery
- Improve documentation of setup processes, leading to improved processes
- Decreased inventory and costs, while increasing capacity

Setup reduction is the process of reducing changeover time (i.e., from the last good piece of the previous run to the first good piece of the next run). Since setup activities add no marketable form, fit, or function to the product, they are by definition non-value adding. The tool for tackling setup time is the Four-Step Rapid Setup method. The principle of this method is to eliminate anything that interrupts or hinders productivity. The following steps provide a high level description of the *Four-Step Rapid Setup method*:

Step # 1 – Identify and tabulate any process-related activity that fits into one or more of the following categories:

- Activity that delays the start of value-added work
- Activity that causes interruptions to value-added work
- Activity where it is similar or identical to another task in the process

Step #2 – See if any of the interruptive/delaying tasks can be offloaded: Our focus here is to move preparatory work outside of the main process flow so that information or material ends up waiting for you, not the other way around. The goal is to quickly complete value-added work without any non-value-added activity.

Step # 3 - Streamline or automate any interruptive/delaying tasks that cannot be offloaded.

Step # 4 – Bring the process under statistical control: The setup is not complete until the output of the process is "within specification" and under statistical control, meaning the amount of variation in lead time is within predictable limits of +/- 3 sigma.

Queuing Methods for Reducing Congestion and Delays

Often congestion occurs because of variation in demand, much like travel congestion and delays that we all witness during the holiday season. Once identified, there are two principal techniques for reducing congestion that arises from variation in the demand for service.

- **Pooling:** Cross training staff to step in during times of peak loads. One hotel chain, for example, trains office and other staff to help out with registration during unexpected and predictable peak times.
- **Triaging:** Sorting jobs into categories that reflect different levels of effort required.

Typical schemes include: fast service times versus slow service times; routine problems versus catastrophic problems. Once Triaging categories have been identified, you then develop different strategies to deal with each category.

Kaizen

Kaizen is often translated in the West as ongoing, continuous improvement. Some authors explain Japan's competitive success in the world market place as the result of the implementation of the Kaizen concept in Japanese corporations. In contrast to the usual emphasis on evolutionary, innovative change on an occasional basis, Kaizen looks for uninterrupted, ongoing incremental change. In other words, there is always room for improvement and continuously trying to become better.

In practice, Kaizen can be implemented in corporations by improving every aspect of a business process in a step-by-step approach, while gradually developing employee skills through training and increased involvement. Principles in Kaizen implementation are:

- Human resources are the most important company asset.
- Processes must evolve by gradual improvement rather than radical changes.

Improvement must be based on statistical/quantitative evaluation of process performance. Improve is a road map that you have to follow specifically:

- Choose the solution from the list you developed in Analyze
- Get consensus
- Try it out
- Create a project plan
- Roll it out and stay in Improve until you see an improvement has been accomplished

Remember that once the project reaches the plan development the role changes to that of project manager.

A project manager is the person who has the overall responsibility for the successful initiation, planning, design, execution, monitoring, controlling and closure of a project. The

job title is used in construction, petrochemical, architecture, information technology and many different industries that produce products and services.

The project manager must have a combination of skills including an ability to ask penetrating questions, detect unstated assumptions and resolve conflicts, as well as more general management skills.

Key among his or her duties is the recognition that risk directly impacts the likelihood of success and that this risk must be both formally and informally measured throughout the lifetime of the project.

Risks arise from uncertainty, and the successful project manager is the one who focuses on this as the main concern. Most of the issues that impact a project arise in one-way or another from risk. A good project manager can lessen risk significantly, often by adhering to a policy of open communication, ensuring every significant participant has an opportunity to express opinions and concerns.

It follows that a project manager is one who is responsible for making decisions both large and small, in such a way that risk is controlled and uncertainty minimized. Every decision taken by the project manager should be taken in such a way that it directly benefits the project.

Project managers use project management software, such as Microsoft Project, to organize their tasks and workforce. These software packages allow project managers to produce reports and charts in a few minutes, compared with the several hours it can take if they do it by hand.

Roles and Responsibilities

The role of the project manager encompasses many activities including:

- Planning and Defining Scope
- Activity Planning and Sequencing
- Resource Planning
- Developing Schedules
- Time Estimating
- Cost Estimating
- Developing a Budget
- Documentation
- Creating Charts and Schedules
- Risk Analysis
- Managing Risks and Issues
- Monitoring and Reporting Progress
- Team Leadership
- Strategic Influencing
- Business Partnering
- Working with Vendors
- Scalability, Interoperability and Portability Analysis

- Controlling Quality
- Benefits Realization

But what is Project Management? The DMAIC model can align with these steps or the steps can be used prior to developing the actual project plan. Remember this is where a person would start if they knew the solution to the problem or already had a project plan in mind. The DMAIC assumes you do not have the solution or that there are many solutions and one needs to be validated. But, once a solution is agreed upon and tested project management kicks into play.

Most agree that basic project management essentially has five steps.

5 Basic Phases of Project Management

Project Management Institute, Inc. (PMI) defines project management as "the application of knowledge, skills, tools and techniques to a broad range of activities in order to meet the requirements of a particular project." The process of directing and controlling a project from start to finish may be further divided into 5 basic phases:

1. Project conception and initiation

An idea for a project will be carefully examined to determine whether or not it benefits the organization. During this phase, a decision-making team will identify if the project can realistically be completed.

2. Project definition and planning

A project plan, project charter and/or project scope may be put in writing, outlining the work to be performed. During this phase, a team should prioritize the project, calculate a budget and schedule, and determine what resources are needed.

3. Project launch or execution

Resources' tasks are distributed and teams are informed of responsibilities. This is a good time to bring up important project related information.

4. Project performance and control

Project managers will compare project status and progress to the actual plan, as resources perform the scheduled work. During this phase, project managers may need to adjust schedules or do what is necessary to keep the project on track.

5. Project close

After project tasks are completed and the client has approved the outcome, an evaluation is necessary to highlight project success and/or learn from project history.

Projects and project management processes vary from industry to industry; however, these are more traditional elements of a project. The overarching goal is typically to offer a product, change a process or to solve a problem in order to benefit the organization.

Closing Thought

The key activities in IMPROVE are to choose a solution and implement via a solid project plan. The project manager can continue to the next phase by ensuring a process improvement has been made. The way the manager knows the improvement has been made is by comparing the Before Picture (MEASURE) to the After Picture (the project plan results in IMPROVE).

It is important to use the same tools in MEASURE as those used in IMPROVE. Again a Before-and-After picture is the best documentation.

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Chapter Six

6 CONTROL

DMAIC (Define-Measure-Analyze-Improve-**CONTROL)**

The primary objective of the DMAIC Control phase is to have simple documentation that keeps your process improvement in place. A common problem in business is that things revert back the previous state. Sometimes this happens because people are not aware of the change or the proper buy-in was not achieved in IMPROVE or earlier in the DMAIC model.

A lot of CONTROL has to do with the way the process improvement is documented. It is also about helping those involved in the process recognize red flags and letting them know the specific action that should be taken. Many times if the instructions or documentation is too complicated or not made readily available the best documentation won't be adopted. In order to sustain an improvement it is necessary sometimes to produce checklists and/or assign individual responsibility to certain tasks.

During the Improve phase, the solution is piloted, and plans are made for full scale implementation. Putting a solution in place can fix a problem temporarily. CONTROL is designed to keep the improvement in place and in the best case scenario continue to improve the overall situation. Sometimes there are ancillary benefits. These should also be documented.

The tools most commonly used in Control phase are:

- Control Charts
- FMEA forms
- Transition plans
- ROI formulas

Quality control:

The ultimate purpose in control is overall assurance that a high standard of quality is met. The customer's expectations depend on this, so control is inherently associated with quality.

Since the purpose to Six Sigma is to improve overall process by reducing defects, quality control is the essential method for keeping the whole process on track; for enabling us to spot trouble and fix it; and for judging how effectively the project was executed and implemented.

Quality is at the heart of the Six Sigma philosophy. Reducing defects has everything to do with striving for perfection. Whether we reach perfection or not, the effort defines our attitude toward quality itself.

Standardization:

One feature of smooth processing is to enable processes to go as smoothly as possible. This usually means standardization. In a manufacturing environment, the value of standardization has been proven over and over.

We need to devise a control feature to processes so that the majority of work is managed in a standardized manner.

Standardization enables high quality production of goods and services on a reliable, predictable, and sustainable basis. Standardization is making sure that important elements of a process are performed consistently in the most effective manner. Changes are made only when data shows that a new alternative is better. Use of standard practices will:

- Reduce variation among individuals or groups and make process output more predictable
- Provide "know-why" for operators and managers now on the job
- Provide a basis for training new people
- Provide a trail for tracing problems
- Provide a means to capture and retain knowledge
- Give direction in the case of unusual conditions

Control methods and alternatives:

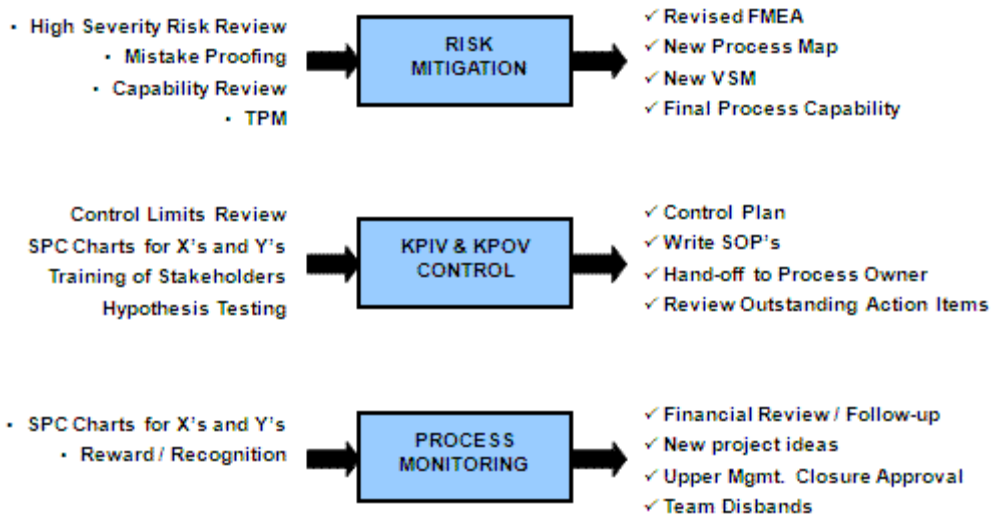
The development of a new process of any change to an existing process requires the development of procedures to control work flow.

When a process cannot be managed in the normal manner, we need to come up with alternatives short of forcing compliance to the standardized method.

Responding when defects occur:

The final step in a control process is knowing how to respond, once a defect is discovered. The weak links in the procedure, where defects are most likely to occur, should be monitored carefully.

Rewarding the team and stakeholders is important because they not only deserve it but to leave on a final positive note and grow credibility for the GB/BB and the company's Six Sigma program.



There cannot be enough emphasis placed on the importance of devoting the same high level of energy and commitment throughout this phase. Complacency and anxiety can set in for the sake of bringing closure and receiving some form of credit or bonus, etc.

Closing Thought

CONTROL is all about keeping the improvement in place. The opening statement in the control phase, regardless if you are doing a presentation or a written report, should reiterate what the problem was; what the solution was chosen and what did it make, save or avoid the company from spending (ROI).

The next set of information should be the sustainability plan. This plan should be geared to the entity that will now be managing the project. Then finally, close out activities that would occur with any project. This would include things such as updating documentation, celebrating the success, publishing results and letting those involved know that this part of the project has been completed.

7 Lean Six Sigma Key Terms

4 M's- 4 words categories used to provoke thought on an Ishikawa diagram (cause & effect diagram). Material, Method, Machine, Man.

5 Why's- The practice of asking why 5 times when presented with a problem to try to identify potential root causes.

5S- A process and method for creating and maintaining an organized, clean, safe, and high-performing workplace. The steps are Sort, Set, Shine and Standardize and Sustain. All

A3 Report- A Toyota developed standard report showing a problem, analysis and corrective action plan on a single piece of paper usually A3 size.

A-B Control- A method used to regulate working relationships between a pair of operations such that overproduction is minimized. Machine A cannot feed machine B until it is empty or waiting for work.

ABC Production Analysis- Volume based groupings used to segment part numbers in order to define the inventory policy that they fall within.

Abscissa- The horizontal axis of a graph.

Acceptance Criteria- These are specific criteria identified by the customer for each functional requirement. The acceptance criteria are written in simple terms and from a perspective of the customer.

Acceptance Testing- Acceptance testing is a validation activity conducted to determine whether or not a system satisfies its acceptance criteria. It is the last phase of the software testing process.

Acceptance Region- The region of values for which the null hypothesis is accepted.

Affinity Diagram- Organizes brainstorming ideas into categories or themes. Useful when there are large amounts of information collected during a brainstorming session. It is also called the KJ method, after Kawakita Jiro (a Japanese anthropologist) who first developed the idea.

Agile- A conceptual framework for undertaking software projects. Agile methods are a family of development processes, not a single approach to software development.

Alpha Risk- The probability of accepting the alternate hypothesis when, in reality, the null hypothesis is true.

Alternative Hypothesis- A tentative explanation which indicates that an event does not follow a chance distribution; a contrast to the null hypothesis.

Andon- the Japanese word for signal referring to a visual system that provides an indicator to supervision when abnormalities occur within processes.

Anova- Analysis of variance- This is a statistical test done by comparing the variances around the means of the condition being compared. In the simplest form Anova gives a statistical test of whether the means of several groups are all equal.

Anova Gauge R&R- Measures the amount of variability induced in measure by the measurement system itself, and compares it to the total variability observed to determine the viability of the measurement system.

Assemble to Order- An environment where a product or service can be assembled or provide upon receipt of a customer's order. The product will usually consist of a number of modules that are assembled to the highest level possible and stored such that when the order arrives, it can be assembled quickly and to the customer's specification.

Assignable Cause- A source of variation which is non-random; a change in the source ("Vital Few" variables) will produce a significant change of some magnitude in the response (dependent variable), e.g., a correlation exist; the change may be due to an intermittent in-phase effect or a constant cause system which may or may not be highly predictable; an assignable cause is often signaled by an excessive number of data points outside limits; an unnatural source of variation; most often economical to eliminate.

Assignable Variation- Variation in data which can be attributed to specific causes.

Assumption- There may be external circumstances or events that must occur for the project to be successful (or that should happen to increase your chances of success). If you believe that the probability of the event occurring is acceptable, you could list it as an assumption. An assumption has a probability between 0 and 100%. That is, it is not impossible that the event will occur (0%) and it is not a fact (100%). It is somewhere in between. Assumptions are important because they set the context in which the entire remainder of the project is defined. If an assumption doesn't come through, the estimate and the rest of the project definition may no longer be valid.

Attribute- A characteristic that may take on only one value, e.g.) or 1.

Attribute Data- Numerical information at the nominal level; subdivision is not conceptually meaningful; data which represents the frequency of occurrence within some discrete category, e.g., 42 solder shorts.

Automatic Line Stop- Ensuring that processes producing will stop whenever aa defect or problem occurs.

Autonomation- A term developed by Taiichi Ohno to describe "automation with human touch". Autonomated machine will stop when abnormalities occur so that they will not create large amounts of scrap and do not need an operator to watch the machine.

Average- Also called the mean, it is the arithmetic average of all the sample value. It is calculated by adding all of the sample values together and dividing by the number of elements(n) in the sample.

Background Variables- Variables that are of no experimental interest and are not held constant. Their effects are often assumed insignificant or negligible, or they are randomized to ensure that contamination of the primary response does not occur.

Balance Chart- A bar chart or histogram that illustrates work content per operator. Can be used to balance work for operators or machines in order to achieve improvements in flow.

Balanced Scorecard – is a performance management approach that focuses on customer perspective, internal-business processes, and learning and growth and financials. It was originated by Drs. Robert Kaplan (Harvard Business School) and David Norton as a performance measurement framework that added strategic non-financial performance measures to traditional financial metrics to give managers and executives a more 'balanced' view of organizational performance.

Batch and Queue- Typical mass production method such that a part going through a system will be produced in large batches to maximize "efficiency" and then sit in a queue waiting for the next operation.

Behavior Driven Development- Behavior driven development (or BDD) is an agile software development technique that encourages collaboration between developers, QA and non-technical or business participants in a software project. BDD focuses on obtaining a clear understanding of desired software behavior through discussion with stakeholders. It extends TDD by writing test cases in a natural language that non-programmers can read.

Benchmarking – a standard used to compare performance against best-in-class companies. It then uses the information gathered to improve its own performance. Subjects that can be benchmarked include strategies, products, programs, services, operations, processes, and procedures.

Beta Risk- The probability of accepting the null hypothesis when, in reality, the alternate hypothesis is true.

Blocking Variables- A relatively homogenous set of conditions within which different conditions of the primary variables are compared. Used to ensure that background variables do not contaminate the evaluation of primary variable.

Bottleneck- A bottleneck is a sort of congestion in a system that occurs when workload arrives at a given point more quickly than that point can handle it. It is metaphorically derived from the flowing of water through a narrow mouthed bottle where the flow of water is constrained by the size of its neck.

Breakthrough Improvement-a rate of improvement at or near 70% over baseline performance of the as-is process characteristics.

Brownfield- A brownfield site is an existing facility that is usually managed in line with mass production methods.

Bugs- A software bug is a problem causing a program to crash or produce invalid output. It is caused by insufficient or erroneous logic and can be an error, mistake, defect or fault.

Build to Order- A production environment when a product or service can be made and assembled after receipt of a customer's order.

Burndown Chart- A burndown chart is a visual tool for measuring and displaying progress. Visually, a burndown chart is simply a line chart representing remaining work over time. Burndown charts are used to measure the progress of an agile project at both an iteration and project level.

Capability - measurement index that expresses the capability of the process by suing a percentage.

Capital Linearity- A philosophy linked to capital expenditure on machinery such that a small amount of additional capacity can be added by using a number of smaller machines rather than one big and very expensive machine.

Cause and Effect Diagram – also called a fishbone diagram. This is a graph that places the issue being discussed in the head of the fish. The bones of the fish are categories of problems that could be a problem. The smaller bones are the possible root causes

Causalty- The principle that every change implies the operation of a cause.

Causative- Effective as a cause.

Cause- That which produces an effect or brings about change.

Cell- A cell is a group of people, machines, materials, and methods arranged so that processing steps are located adjacent to each other and in sequential order. This allows parts to be processed one at a time or, in some cases, in a constant small batch that is maintained through the process sequence. The purpose of a cell is to achieve and maintain an efficient, continuous flow of work.

Center Line- The line on a statistical process control chart which represents the characteristic's central tendency.

Central Tendency – data clustered around the middle. Mean, mode and median are all examples of central tendency; numerical average, e.g., mean, median, and mode; center line on a statistical process

Chaku-Chaku- One-piece flow ideal whereby machines automatically unload parts so that an operator can move a part from one machine to the next without stopping to unload parts.

Champion – a person who supports the successful completion of the project.

Characteristic - a process input or output which can be measured and monitored.

Chief Engineer- The Toyota term used to describe the person who is totally responsible for the successful development of a product line.

Classification- Differentiation of variables.

Client/Customers- The person or group that is the direct beneficiary of a project or service is the client / customer. These are the people for whom the project is being undertaken (indirect beneficiaries are stakeholders). In many organizations, internal beneficiaries are called "clients" and external beneficiaries are called "customers," but this is not a hard and fast rule.

Common Cause- SEE Random Cause.

Common Causes of Variation - sources of variability in a process which are truly random. These are generally inherent in the process itself and can be managed. This type of variation is usual, historical, quantifiable variation in a system.

Complexity -The level of difficulty to build, solve or understand something based on the number of inputs, interactions and uncertainty involved.

Confidence Level- The probability that a random variable x lies within a defined interval.

Confidence Limits- The two values that define the confidence level.

Confounding- Allowing two or more variables to vary together so that it is impossible to separate their unique effects.

Consumer Risk- Probability of accepting a lot when, in fact, the lot should have been rejected (see Beta Risk).

Continuous Data- A set of observations usually associated with physical measurement that can take on any mathematical value within specified parameters.

Continuous flow. Each process, whether in an office or plant setting, makes or completes only the one piece that the next process needs; the batch size is one. Single-piece flow, or one-piece flow, is the opposite of a batch-and-queue process.

Continuous Random Variable- A random variable which can assume any value continuously in some specified variable.

Constraints- Constraints are limitations that are outside the control of the project team and need to be managed around. They are not necessarily problems. However, the project manager should be aware of constraints because they represent limitations that the project must execute within. Date constraints, for instance, imply that certain events (perhaps the end of the project) must occur by certain dates. Resources are almost always a constraint, since they are not available in an unlimited supply.

Control Chart - The most powerful tool of statistical process control. It consists of a run chart, together with statistically determined upper and lower control limits and a centerline.

Control Limits - Upper and lower bounds in a control chart that are determined by the process itself. They can be used to detect special or common causes of variation.

Control Specifications- Specifications called for by the product being manufactured.

Cost of Poor Quality (COPQ) - The costs associated with any activity that is not doing the right thing right the first time.

Critical Path- The series of consecutive activities that represent the longest time path through the process; The critical path is the sequence of activities that must be completed on schedule for the entire project to be completed on schedule. It is the longest duration path through the work plan. If an activity on the critical path is delayed by one day, the entire project will be delayed by one day (unless another activity on the critical path can be accelerated by one day).

Cycle Efficiency (CE)- CE is a measure of the relative efficiency in a production system. Is represents the percentage of value added time of a product through the critical path vs. the total cycle time (TCT).

Cycle Time Interval- The frequency that a particular item is made during a set period of time (usually days).

Critical to Quality (CTQ) – Any activity or thought related to the successful outcomes of the project.

Cross Dock- A facility that gathers and recombines a variety of inbound materials and parts from multiple suppliers to forward on to multiple customers.

Cutoff Point- The point which partitions the acceptance region from the reject region.

Cycle Efficiency (CE)- CE is a measure of the relative efficiency in a production system. It represents the percentage of value added time of a product through the critical path vs. the total cycle time (TCT).

Cycle time. This is the time a person needs to complete an assigned task or activity before starting again.

Daily Standup/Scrum- A Daily Standup is a whole team meeting that happens at the same time every day that usually lasts 15 minutes or less. The meeting is designed to allow the entire team to synchronize with each other and to understand the flow and challenges of the development process. Each team member should provide the following information: what did I do yesterday, what am I planning to do today, and what impediments do I currently have?

Data- Factual information used as a basis for reasoning, discussion, or calculation; often refers to quantitative information.

Decrete Random Variable- A random variable which can assume values only from a definite number of discrete

Defect - An output of a process that does not meet a defined specification, requirement or desire such as time, length, color, finish, quantity, temperature etc.

Defective - A unit of product or service that contains at least one defect.

Degrees OF Freedom- The number of independent measurements available for estimating a population parameter.

Deliverable- A deliverable is any tangible outcome that is produced by the project. All projects create deliverables. These can be documents, plans, computer systems, buildings, aircraft, etc. Internal deliverables are produced as a consequence of executing the project and are usually needed only by the project team. External deliverables are those that are created for clients and stakeholders. Your project may create one or many deliverables.

Demand- The usage of an item over a period of time. This also includes an understanding of the customer requirements for quality, lead-time and price.

Density Function- The function which yields the probability that a particular random variable takes on any one of its possible values.

Dependent Variable- A response variable; e.g., y is the dependent or "Response" variable where Y=f (XI…Xn) variable.

Design of Experiments (DOE) - an efficient, structured, and proven approach to interrogating a process or system for the purpose of maximizing the gain in process or system knowledge.

Design for Six Sigma (DFSS) - The use of six sigma thinking, tools and methods applied to the design of products. Any Six Sigma model for managing a project, that is not DMAIC, is generally considered a DFSS.

Distributions- Tendency of large numbers of observations to group themselves around some central value with a certain amount of variation or "scatter" on either side.

Done- Also referred to as "Done-Done", this term is used to describe all the various tasks that need to happen before a story is considered potentially releasable.

DMAIC. This acronym stands for "define, measure, analyze, improve, and control. It is the heart of the Six Sigma process and refers to a data-driven quality strategy for improving processes. It is an integral part of any company's Six Sigma quality initiatives.

DPMO - Defects per million opportunities - The total number of defects observed divided by the total number of opportunities, expressed in parts per million.

DPU - Defects per unit - The total number of defects detected in some number of units divided by the total number of those units.

Effect- That which was produced by a cause.

Engineer to Order- Products whose customer's specifications are unique for each order therefore each product is engineered from scratch upon receipt of an order.

Epic- A very large user story that is eventually broken down into smaller stories.

Estimation- The process of agreeing on a size measurement for the stories, as well as the tasks required to implement those stories in a product backlog.

Exits- The amount of work completed over a given amount of time measured in £'s or Units.

Experiment- A test under defined conditions to determine an unknown effect; to illustrate or verify a known law; test or establish a hypothesis.

Experimental Error- Variation in observation made under identical test conditions. Also called residual error. The amount of variation which cannot be the variables included in the experiment.

Factors- Independent variables.

Failure Mode and Effects Analysis (FMEA) - A procedure used to identify, assess, and mitigate risks associated with potential product, system, or process failure modes.

Feature Creep- Feature creep occurs when a software becomes complicated and difficult to use as a result of too many features.

FIFO- A strategically sized inventory that keeps the sequence of the production uniform throughout the value Stream maintaining flow.

Finish to Order- An environment such that products are built to as higher level as is possible and then configured to customers' requirements upon receipt of order.

Fishbone Diagram - See cause and effect diagram.

Fixed Effects Model- Experimental treatments are specifically selected by the researcher. Conclusion only applies to the factor levels considered in the analysis. Inferences are restricted to the experimental levels.

Fixed-Position Stop System- A problem addressing method on continuously moving production lines such that if a problem is identified and not resolved before a fixed point, the production line will stop.

Flowchart - A graphic model of the flow of activities, material, and/or information that occurs during a process.

Fluctuations- Variances in data which are caused by a large number of minute variations or differences.

Frequency Distribution- The pattern or shape formed by the group of measurements in a distribution.

Functional Manager- The functional manager is the person you report to within your functional organization. Typically, this is the person who does your performance review. The project manager may also be a functional manager, but he or she does not have to be. If your project manager is different from your functional manager, your organization is probably utilizing matrix management.

Gage R&R – is used in Measurement Systems Analysis (MSA) Quantitative assessment of how much variation (repeatability and reproducibility) is in a measurement system compared to the total variation of the process or system.

Gemba- Japanese term used to describe the "actual place" where value is added or the shop floor.

Greenfield- A new production facility not restricted by practices of the past therefore having a culture of adapting change without resistance.

Gantt Chart- A Gantt chart is a bar chart that depicts activities as blocks over time. The beginning and end of the block correspond to the beginning and end-date of the activity.

Heijunka- Leveling the production by product and/or quantity over a fixed time period.

High-Level Value Stream Map- A visual representation of the aggregated material and information flows within a company or business unit.

Histogram - A bar chart that depicts the frequencies (by the height of the plotted bars) of numerical or measurement categories.

Homogeneity of Variance- The variances of the groups being contrasted are equal (as defined by statistical test of significant differences).

Hoshin- the Japanese work for planning and used throughout operational, financial, strategic, and project based scenarios.

Independent Variable- A controlled variable; a variable whose value is independent of the value of another variable.

Input - A resource consumed, utilized, or added to a process or system. Synonymous with X, characteristic, and input variable.

Inspection- Mass production would use inspectors outside of a process. Lean producers assign the responsibility of quality to the areas where the processes are performed. Inspections are performed within the areas that own the assembly process.

Issue- An issue is a major problem that will impede the progress of the project and that can't be resolved by the project manager and project team without outside help. Project managers should proactively deal with issues through a defined issues management process.

Instability- Unnaturally large fluctuations in a pattern.

Interaction- The combined effect of two factors observed over and above the singular effect of each factor against the level the other factor. A significant interaction indicates that the effect of each factor on the response changes depending on the value of the other factor.

Interval- Numeric categories with equal units of measure but no absolute zero point, i.e., quality scale or index.

Inventory Turns- A measure to quantify the pace at which inventory rotates throughout a company. Inventory turns = annual cost of goods sold / average value of inventory during year.

Jidoka- Quality built into processes such that if a process is not capable of creating the required output then it will not operate until it can.

Jishuken- a Japanese word used to describe a "hands-on learning workshop".

Just in Time (JIT)- stands for "just in time." This means producing or conveying only the items that are needed by the next process when they are needed and in the quantity needed. This process can even be used between facilities or companies.

Kaikaku- Radical improvement designed to quickly eliminate and/ or add value to a value stream. Also described as Breakthrough Kaizen.

Kaizen Event – A rapid improvement event**;** part of a continuous improvement program. A focused, dedicated and well defined event that is used to get quick hit value by implementing "do-now" solutions leading to waste elimination.

Kaizen- Incremental change for the better. The organized use of common sense to improve cost, quality, delivery, safety and responsiveness to customer needs.

Kanban- Kanban, pronounced /'kɑn'bɑn/, is a method for developing products with an emphasis on just-in-time delivery and the optimization of flow of work on the team. It emphasizes that developers pull work from a queue, and the process, from definition of a task to its delivery to the customer, is displayed for participants to see.

Kanban Post- A storage container for Kanban cards pulling deliveries.

Labor Linearity- A manning philosophy such that as demand increases or reduces manpower is added one at a time as such manpower requirements are linear to production volume.

Lead-Time- The total time from the beginning of the supply chain to the time something needs to ship. The sum of the VA/NVA time for a product to move through the entire value stream.

Lean – Lean software development is a translation of Lean manufacturing and Lean IT principles and practices to the software development domain. Adapted from the Toyota Production System and is a set of techniques and principles for delivering more values with the same or less resources by eliminating waste across organizations and business processes

Lean Transactional- The application of lean to business processes such as paperwork flow through an office in accounts or marketing.

Level Selling- The eliminating of sales spikes generated by end of month sales targets at dealers and so forth. This allows for improved flow of demand from the customer and improvements in anticipated demand.

Lifecycle- Lifecycle refers to the process used to build the deliverables produced by the project. There are many models for a project lifecycle. For software development, the entire lifecycle might consist of planning, analysis, design, construct/test, implementation, and support. This is an example of a "waterfall" lifecycle. Other lifecycles include iterative development, package implementation, and research and development. Each of these lifecycle models represents an approach to building the deliverables on your project.

Line Charts- Charts used to track the performance without relationship to process capability of control limits.

Linear regression- Analyzes the relationship between two variables, X and Y.

Long-term Variation - The observed variation of an input or output characteristic which has had the opportunity to be observed over time.

Lower Control Limit (LCL) - Used in control charts to show the lower limit. Typically, three standard deviations below the central tendency.

Machine Cycle Time- The amount of time unit spends in the operational cycle of a machine.

Mean- The statistical measure on a sample that is used as an estimate of the mean of the population from which the sample was drawn. Numerically equals the sum of scores divided by the number of samples.

Measurement Accuracy - For a repeated measurement, it is a comparison of the average of the measurements compare to some known standard.

Measurement Precision - For a repeated measurement, it is the amount of variation that exists in the measured values.

Median - The middle value of a data set when the values are arranged in either ascending or descending order.

Metric - A measure that is considered to be a key indicator of performance. It should be linked to goals or objectives and carefully monitored.

Milestone- A milestone is a scheduling event that signifies the completion of a major deliverable or a set of related deliverables. A milestone, by definition, has duration of zero and no effort. There is no work associated with a milestone. It is a flag in the work plan to signify that some other work has completed. Usually, a milestone is used as a project checkpoint to validate how the project is progressing. In many cases there is a decision, such as validating that the project is ready to proceed further, that needs to be made at a milestone.

Milk Run- Reducing transport costs and batch sizes by performing multiple pick up and drops at multiple suppliers using one truck.

Mixed Effects Model- Contain elements of both the fixed and random effects models.

Muda- the Japanese word for waste or Non-Value Added activity.

Mura- the Japanese word used to describe variation or fluctuation.

Muri- the Japanese word used to describe overburdening or strain/stress.

Nemawashi- a Japanese expression used to describe the practice of obtaining support and buy-in for change by firstly the idea and then the plan with upper management and stakeholders. Directly translated means "preparing" the ground for planting.

Nominal- Unordered categories which indicate membership or non-membership with no implication of quantity, i.e., assembly area number one, part numbers, etc.

Nonconforming Unit- A unit which does not conform to one more specifications, standards, and/or requirements.

Nonconformity- A condition within a unit which does not conform to some specific specification, standard, and/or requirement; often referred to as a defect; any given nonconforming unit can have the potential for more than one nonconformity.

Non-Value Added (NVA) - Any activity performed in producing a product or delivering a service that does not add value.

Normal Distribution - The distribution characterized by the smooth, bell- shaped curve.

Null Hypothesis- A tentative explanation which indicated that a chance distribution is operating; a contrast to the null hypothesis.

Obeya- Translated as "Big Room" this is the expression used by the Japanese to describe the powerful project room concept also known as a "war room".

Objective- An objective is a concrete statement that describes what the project is trying to achieve. The objective should be written at a low level, so that it can be evaluated at the conclusion of a project to see whether it was achieved. Project success is determined based on whether the project objectives were achieved. A technique for writing an objective is to make sure it is **S**pecific, **M**easurable, **A**ttainable/Achievable, **R**ealistic, and **T**ime bound (SMART).

One Piece Flow- Making and moving only one piece or part at a time. See Continuous Flow.

One-sided Alternative- The value of a parameter which has an upper bound and a lower bound, but not both.

Operator Cycle Time- The time it takes an operator to go through all of his or her work elements before repeating them.

Order Interval- Represents the frequency (days) that a part is ordered.

Ordinal- Ordered categories (ranking) with no information about distance between each category, i.e., rank ordering of several measurements of an output parameter.

Ordinate- The vertical axis of a graph.

Overall Equipment Effectiveness (OEE)- A total productive maintenance (TPM) measures of how effectively equipment is being used. OEE= availability rate x performance rate x quality rate.

Overproduction – The process of producing more, sooner, or faster than is required by the next process or customer.

P Charts- Charts used to plot percent defectives in a sample.

Pacemaker- The only point in the production process that is scheduled and therefore dictates the pace of production for a whole system of processes.

Pacesetter- The point in the process that limits the output of the total process.

Pair Programming- is an agile software development technique in which two programmers work together at one workstation. One types in code while the other reviews each line of code as it is typed in. The person typing is called the driver. The person reviewing the code is called the observer (or navigator). The two programmers switch roles frequently.

Parameter- A constant defining a particular property of the density function of a variable.

Pareto Diagram- A chart which ranks, or places in order, common occurrences.

Perturbation- A nonrandom disturbance.

Pitch- The amount of time required by a production area to make one container of products. Takt time x pack-out qty=pitch.

Plan for Every Part (PFEP)- A comprehensive plan for each part consumed within a production process. This would take the form of a spreadsheet or simple table and contain such data as pack-out quantity, location of use and storage, order frequency and so on. This provides one accurate source of information relating to parts.

Plan, Do, Check, Act (PDCA)- An improvement cycle introduction to the Japanese in the 50's by W. Edwards Deming. Based upon proposing then implementing an improvement, then measuring the results and acting accordingly.

Planning Poker- Also called Scrum poker, is a consensus-based technique for estimating, mostly used to estimate effort or relative size of tasks in software development.

Poka Yoke - Mistake-proof device or procedure designed to prevent a defect from occurring throughout the system or process. Error-proofing is a manufacturing technique of preventing errors by designing the manufacturing process, equipment, and tools so that an operation literally cannot be performed incorrectly. Poka Yoke is the Japanese phrase for do it right the first time.

Population- A group of similar items from which a sample is drawn. Often referred to as the universe.

Power of an Experiment- The probability of rejecting the null hypothesis when it is false and accepting the alternative hypothesis when it is true.

Prevention- The practice of eliminating unwanted variations of priori (before the fact), e.g., predicting a future condition from a control chart and when applying corrective action before the predicted event transpires.

Primary Control Variables- The major independent variables in the experiment.

Probability of an Event- The number of successful events divided by the total numbers of trials.

Probability- The chance of something happening in percent or number of occurrences over a large number of trials.

Problem- A deviation from a specified standard.

Problem-Solving- A process of solving problems; the isolation and control of those conditions which generate or facilitate the creation of undesirable symptoms.

Process- A particular method of doing something, generally involving a number of steps or operations.

Process Average- The central tendency of a given process characteristics across a given amount of time or a specific point in time.

Process control Chart- Any of a number of various types of graphs upon which data are plotted against specific control limits.

Process Control- SEE statistical process control.

Process Owner - Have responsibility for process performance and resources. They provide support, resources and functional expertise to six sigma projects. They are accountable for implementing developed six sigma solutions into their process.

Process Spread- The range of values in which a given process characteristic displays; this particular term most often applies to the range but may also encompass the variance. The spread may be based on a set of data collected at a specific point in time or may reflect the variability across a given amount of time.

Producers Risk- Probability of rejecting a lot when, in fact, the lot should have been accepted (see Alpha Risk).

Product Backlog- Acts as a repository for requirements targeted for release at some point. These are typically high level requirements with high level estimates provided by the product stakeholders. The requirements are listed on the backlog in priority order and maintained by the product owner.

Product Owner- The product owner represents the voice of the customer and is accountable for ensuring that the team delivers value to the business. The Product Owner writes

customer-centric items (typically user stories), prioritizes them, and adds them to the product backlog. Scrum teams should have one Product Owner.

Production Kanban- A signal that specifies the type and quantity of product that an upstream process must produce.

Program- A program is the umbrella structure established to manage a series of related projects. The program does not produce any project deliverables. The project teams produce them all. The purpose of the program is to provide overall direction and guidance, to make sure the related projects are communicating effectively, to provide a central point of contact and focus for the client and the project teams, and to determine how individual projects should be defined to ensure that all the work gets completed successfully.

Program Manager- A program manager is the person with the authority to manage a program. (Note that this is a role. The program manager may also be responsible for one or more of the projects within the program.) The program manager leads the overall planning and management of the program. All project managers within the program report to the program manager.

Project- A project is a temporary structure to organize and manage work and ultimately to build a specific defined deliverable or set of deliverables. By definition, all projects are unique, which is one reason it is difficult to compare different projects to one another.

Project Definition (charter)- Before you start a project, it is important to know the overall objectives of the project, as well as the scope, deliverables, risks, assumptions, project organization chart, etc. The project definition (or charter) is the document that holds this relevant information. The project manager is responsible for creating the project definition. The document should be approved by the sponsor to signify that the project manager and the sponsor are in agreement on these important aspects of the project.

Project Manager- The project manager is the person with the authority to manage a project. The project manager is 100 percent responsible for the processes used to manage the project. He or she also has people management responsibilities for team members, although this is shared with the team member's functional manager. The processes used to manage the project include defining the work, building the work plan and budget, managing the work plan and budget, scope management, issues management, risk management, etc.

Project Phase- A phase is a major logical grouping of work on a project. It also represents the completion of a major deliverable or set of related deliverables. On an IT development project, logical phases might be planning, analysis, design, construct (including testing), and implementation.

Project Team- The project team consists of the full-time and part-time resources assigned to work on the deliverables of the project. They are responsible for understanding the work to be completed; completing assigned work within the budget, timeline, and quality expectations; informing the project manager of issues, scope changes, and risk and quality concerns; and proactively communicating status and managing expectations.

Pull- Material flow triggered by actual customer need rather than a scheduled production forecast. Downstream process signal to upstream processes exactly what is required and in what quantity.

Push- The production of goods regardless of demands or downstream need, usually in large batches to ensure "efficiency".

Quality Function Deployment (QFD) - A systematic process used to integrate customer requirements into every aspect of the design and delivery of products and services. Output graphic is often the House of Quality.

R Charts- Plot of the difference between the highest and lowest in a sample Range Control Chart.

Random- Selecting a sample so each item in the population has an equal chance of being selected, lack of predictability.

Random Cause- A source of variation which is random; a change in the source ("trivial many'), e.g., a correlation does not exist; any individual source of variation results in small amount of variation in the response; cannot be economically eliminated from a process; an inherent natural source of variations.

Random Effects Model- Experimental treatments are a random sample from a larger population of treatments. Conclusion can be extended to the population. Interferences are not restricted to the experimental levels.

Random Sample- One or more samples randomly selected from the universe (population).

Random Variable- A variable which can assume any value of a set of possible values.

Random Variations- Variations in data which result from causes which cannot be pinpointed or controlled.

Randomness- A condition in which any individual event in a set of events has the same mathematical probability of occurrences as all other events within the specified set, i.e., individual events are not predictable even though they may collectively belong to definable distribution.

Range- The difference between the highest and lowest in a set of values or "subgroup".

Ranks- Values assigned to items in a sample to determine their relative occurrence in a population.

Ratio- Numeric scale which has an absolute zero point and equal units of measure through, i.e., measurements of an output parameter, i.e., amps.

Regression Analysis - includes any techniques for modeling and analyzing several variables. Linear regression was the first type of **regression analysis** to be studied rigorously, and to be used extensively in practical applications.

Reject Region- The region of values of which the alternate hypothesis is accepted.

Repeatability (of a Measurement) - the extent to which repeated measurements of a particular object with a particular instrument produce the same value.

Replication- Observations made under identical test conditions.

Representative Sample- A sample which accurately reflects a specific condition or set of conditions within the universe.

Reproducibility (of a Measurement) - The extent to which repeated measurements of a particular object with a particular individual produce the same value.

Requirements- Requirements are descriptions of how a product or service should act, appear, or perform. Requirements generally refer to the features and functions of the deliverables you are building on your project. Requirements are considered to be a part of project scope. High-level scope is defined in your project definition (charter). The requirements form the detailed scope. After your requirements are approved, they can be changed through the scope change management process.

Research- Critical and exhaustive investigation or experimentation having for its aim the revision of accepted conclusion in the light of newly discovered facts.

Residual Error- See Experimental Error.

Response Time- The Time that an order needs to be satisfied.

Retrospective- A team meeting that happens at the end of every development iteration to review lessons learned and to discuss how the team can be more efficient in the future. It is based on the principles of applying the learning from the previous sprint to the upcoming sprint.

Rework - Activity required to correct defects produced by a process.

Risk- There may be potential external events that will have a negative impact on your project if they occur. Risk refers to the combination of the probability the event will occur and the impact on the project if the event occurs. If the combination of the probability of the occurrence and the impact to the project is too high, you should identify the potential event as a risk and put a proactive plan in place to manage the risk.

Robust- The conditions or state in which a response parameter exhibits hermetic to external cause of a nonrandom nature, i.e., impervious to perturbing influence.

Safety Stock- Inventory held to compensate for variation in demand, quality and downtime.

Sample- One or more observations drawn from a larger collection of observations or universe (population).

Scatter Diagrams- Charts which allow the study of correlation, e.g., the relationship between two variable.

Scope- Scope is the way you describe the boundaries of the project. It defines what the project will deliver and what it will not deliver. High-level scope is set in your project definition (charter) and includes all of your deliverables and the boundaries of your project. The detailed scope is identified through your business requirements. Any changes to your project deliverables, boundaries, or requirements would require approval through scope change management.

Scope Change Management- The purpose of scope change management is to manage change that occurs to previously approved scope statements and requirements. Scope is defined and approved in the scope section of the project definition (charter) and the more detailed business requirements. If the scope or the business requirements change during the project (and usually this means that the client wants additional items), the estimates for cost, effort, and duration may no longer be valid. If the sponsor agrees to include the new work in the project scope, the project manager has the right to expect that the current budget and deadline will be modified (usually increased) to reflect this additional work. This new estimated cost, effort, and duration now become the approved target. Sometimes the project manager thinks that scope management means having to tell the client "no." That makes the project manager nervous and uncomfortable. However, the good news is that managing scope is all about getting the *sponsor* to make the decisions that will result in changes to project scope.

Scrum- Scrum is a framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value. It is based on the adaptive and iterative methodology of software development.

Scrumban- Scrumban is a mix between Scrum and Kanban, which supposedly contains the best features of both methods.

Scrum Master- Scrum is accountable for removing impediments to the ability of the team to deliver the sprint goal/deliverables. The ScrumMaster is not the team leader but acts as a buffer between the team and any distracting influences. The ScrumMaster ensures that the Scrum process is used as intended. The ScrumMaster is the enforcer of rules. A key part of the Scrum Master's role is to protect the team and keep them focused on the tasks at hand. The role has also been referred to as servant-leader to reinforce these dual perspectives.

Sensei- Japanese word for "teacher" and denotes mastery within their field of knowledge. A Sensei should be a wise and easily understood mentor that guides thinking with his subjects rather than dictates the point so as to promote learning.

Set-up Time- The amount of time required to changeover a process after producing the last part of one product to the first goo part of the next product.

Short Term Variation - The amount of variation observed in a characteristic which has not had the opportunity to experience all the sources of variation from the inputs acting on it.

Signal Kanban- A signal that triggers an upstream process to produce, when a minimum quantity is reached at the downstream process.

Single Minute Exchange of Die (SMED)- A technique to reduce setup or changeover times to eliminate the need to build in batches.

Spaghetti Chart- A visual chart showing the path taken by a product of person during a process to highlight excessive motion.

Special Cause- SEE Assignable cause.

Special Cause Variation - non-random causes of variation. Sometimes outside the project manager's control.

Specification Limits – the boundaries of acceptable performance.

Spike- A short, time-boxed piece of research, usually technical, on a single story that is intended to provide just enough information that the team can estimate the size of the story.

Sponsor (executive sponsor and project sponsor)- The sponsor is the person who has ultimate authority over the project. The executive sponsor provides project funding, resolves issues and scope changes, approves major deliverables, and provides high-level direction. He or she also champions the project within the organization. Depending on the project and the organizational level of the executive sponsor, he or she may delegate day-to-day tactical management to a project sponsor. If assigned, the project sponsor represents the executive sponsor on a day-to-day basis and makes most of the decisions requiring sponsor approval. If the decision is large enough, the project sponsor will take it to the executive sponsor.

Sprint/ Iteration- A fixed duration period of time where user stories are chosen to work on. The term Sprint comes from the Scrum methodology and is analogous to the term Iteration. A sprint is defined as a 2-4-week increment of software development activities that delivers working software and the end of the increment. External influences are not allowed to change the requirements of the stories being worked on.

Sprint Backlog- At the beginning of each sprint, the team has sprint planning with an end result being a backlog of work that the team anticipates completing at the end of the sprint. These are the items that the team will deliver against throughout the duration of the sprint.

Sprint Planning- Is a pre-sprint planning meeting attended by the core agile team. During the meeting the Product Owner describes the highest priority features to the team as described on the product backlog. The team then agrees on the number of features they can accomplish in the sprint and plans out the tasks required to achieve delivery of those features. The planning group works the features into User Stories and assigns Acceptance criteria to each story.

Sprint Review- Each Sprint is followed by a Sprint review. During this review the software developed in the previous Sprint is reviewed and if necessary new backlog items are added.

Story Points- Unit of estimation measuring complexity and size.

Stable Process- A process which is free of assignable causes, e.g., in statistical control.

Standard Deviation - One of the most common measures of variability in a data set or in a population. It is the square root of the variance.

Standardized Work- A defined work method that describes the proper workstation and tools, work required, quality, standard inventory knacks and sequence of operations.

Stakeholder- Specific people or groups who have a stake in the outcome of the project are stakeholders. Normally stakeholders are from within the company and may include internal clients, management, employees, administrators, etc. A project can also have external stakeholders, including suppliers, investors, community groups, and government organizations.

Statistical Control- A quantitative condition which describes a process that is free of assignable/special causes of variation, e.g., variation in the central tendency and variance. Such a condition is most often evidence on a control chart, i.e., a control chart which displays an absence of nonrandom variation.

Statistical Process Control (SPC) - use of basic graphical and statistical methods for measuring, analyzing, and controlling the variation of a process for the purpose of continuously improving the process.

Steering Committee- A steering committee is usually a group of high-level stakeholders who are responsible for providing guidance on overall strategic direction. They don't take the place of a sponsor but help spread the strategic input and buy-in to a larger portion of the organization. The steering committee is especially valuable if your project has an impact in multiple organizations because it allows input from those organizations into decisions that affect them.

Subgroup- A logical grouping of objects or events which displays only random event-to-event variations, e.g., the objects or events are grouped to create homogenous groups free of assignable or special causes. By virtue of the minimum within group variability, any change in the central tendency or variance of the universe will be reflected in the "subgroup-to-subgroup" variability.

Supermarket- A strategically controlled store of parts used by downstream processes.

Supplier – vendor on entity responsible for providing an input to a process in the form of resources or information.

Symptom- That which serves as evidence of something not seen.

System- That which is connected according to a scheme.

Systematic Variables- A pattern which displays predictable tendencies.

Takt time – Rate of demand from customer. It is the available operating time for the requirement.

Task- A user story can be broken down in to one or more tasks. Tasks are estimated daily in hours (or story points) remaining by the developer working on them.

Task board/ Storyboard- A wall chart with cards and sticky notes that represents all the work for in a given sprint. The notes are moved across the board to show progress.

Team- The Team is responsible for delivering the product. A Team is typically made up of 5–9 people with cross-functional skills who do the actual work (analyze, design, develop, test, technical communication, document, etc.). It is recommended that the Team be self-organizing and self-led, but often work with some form of project or team management.

Test Driven Development- Test-driven development (TDD) is a software development process that relies on the repetition of a very short development cycle: first the developer writes a failing automated test case that defines a desired improvement or new function, then produces code to pass that test and finally refactors the new code to acceptable standards.

Test of Significance- A procedure to determine whether a quantity subjected to random variation differs from postulated value by an amount greater than that due to random variation alone.

Theory- A plausible or scientifically acceptable general principle offered to explain phenomena.

Theory of constraints - theory describes the methods used to maximize operating income when an organization is faced with bottleneck operations. This theory also deals with how to handle the unknown.

Time Boxing- Time boxing is a planning technique common in planning projects (typically for software development), where the schedule is divided into a number of separate time periods (time boxes, normally two to six weeks long), with each part having its own deliverables, deadline and budget.

Total Cycle Time (TCT)- The time taken from work order release into value stream until completion / movement of product into shipping / finished goods.

Total Productive Maintenance- A means of maximizing production system efficiency by analyzing and eliminating down-time through up-front maintenance of equipment.

Toyota Production System- The production system developed and used by the Toyota Motor Company which focuses on the elimination of waste throughout the value stream.

Trend - A gradual, systematic change over time or some other variable.

Two-Sided Alternative- The value of a parameter which designate an upper and lower bound.

Type I Error- See Alpha Risk.

Type II Error-See Beta Risk.

Unnatural Pattern- Any pattern in which a significant number of the measurement do not group themselves around a center line; when the pattern is unnatural it means that outside disturbances are present and are affecting the process.

User Persona- Personas are a description of the typical users of a given software. A persona description should include: skills, background and goals.

User Story- A user story is a very high-level definition of a requirement, containing just enough information so that the developers can produce a reasonable estimate of the effort to implement it. A user story is one or more sentences in the everyday capture what the users want to achieve. A user story is also a placeholder for conversation between the users and the team. The user stories should be written by or for the customers for a software project and are their main instrument to influence the development of the software. User Stories could also be written by developers to express non-functional requirements (security, performance, quality, etc.)

Upper Control Limit- A horizontal line on a control chart (usually dotted) which represents the upper limits of process capability.

Value Added Activity- Any activity that changes the product in terms of fit, form or function towards something that a customer is willing to pay for.

Value Added Time- The time expanded in value added activity to produce a unit. Time for those work elements that transform the product in a way for which the customer is willing to pay for.

Value stream - all activities, both value added and non-value added, that are required to bring a product, group, or service from the point of order to the hands of a customer and a design from concept to launch to production to delivery.

Value Stream Map- A visual representation of a process showing flow of information and material through all steps from the supplier to the customer.

Value. This term refers to a product or service capability that is provided to a customer at the right time and at an appropriate price.

Variable- A characteristic that may take on different values.

Variables Data- Numerical measurement made at the interval or ratio level; quantitative data e.g., ohms, voltage, diameter, subdivision of the measure scale are conceptually meaningful, e.g., I.6478 volts.

Variation- Any quantifiable difference between individual measurements such differences can be classified as being due to common causes (random) or special causes (assignable).

Variation Research- Procedures techniques and methods used to isolate one type of variation from another (for example, separating product variation from test variation).

Velocity- It is a relative number which describes how much work the team can get done over a period of time.

Visualization- The design of a workplace such that problems and issues can be identified without timely and in depth investigation. Truly visual work-places should be capable of assessment in less than 3 seconds.

VOB - The voice of the business is derived from financial information and data. Voice of the business - Represents the needs of the business and the key stakeholders of the business. It is usually items such as profitability, revenue, growth, market share, etc.

VOC - Voice of the customer - Represents the expressed and non-expressed needs, wants and desires of the recipient of a process output, a product or a service. It is usually expressed as specifications, requirements or expectations.

VOE – Voice of the employee. Represents the expressed and non-expressed needs, wants and desires of what the employee needs to be successful.

VOP - Voice of the process - represents the performance and capability of a process to achieve both business and customer needs.

Waste (Muda) - includes anything that does not add value to a final product or service; an activity that consumes valuable resources without creating customer value.

WIP (Work in process)- These are items--material or information--that are between machines, processes, or activities waiting to be processed; any inventory between raw materials and finished goods.

Withdrawal Kanban- A signal that specifies the type and quantity of product that the downstream process may withdraw.

Work Cells- An arrangement of people, machines, materials and methods such that processing steps are adjacent and in sequential order thus parts can be processed one at a time.

Work Plan (schedule)- The project work plan tells you how you will complete the project. It describes the activities required, the sequence of the work, who is assigned to the work, an estimate of how much effort is required, when the work is due, and other information of interest to the project manager. The work plan allows the project manager to identify the work required to complete the project and also allows the project manager to monitor the work to determine whether the project is on schedule.

X – Input

X&R Charts- A control chart which is a representation of process capability over time; displays a variability in the process average and range across time.

XP- A software development methodology which is intended to improve software quality and responsiveness to changing requirements. As a type of agile software development, it advocates frequent "releases" in short development cycles (time boxing), which is intended to improve productivity and introduce checkpoints where new customer requirements can be adopted.

Y – Output

8 ABOUT SSD GLOBAL SOLUTIONS (Smart Simple Decision Making) and Terra Vanzant Stern, PhD.

SSD GLOBAL SOLUTIONS, INC, S*mart, **S****imple **D****ecision-Making* (SSD) began in 1996, as an international global and mergers acquisitions firm. In 2004, many companies who were previously invested in growing their businesses, decided to tighten their belts due to the economic climate. This was a great opportunity for SSD to introduce Lean Six Sigma to their existing customers!

SSD remained committed to making Lean Six Sigma easier for students to understand and achieve success. The company's principal, Terra Vanzant Stern, PhD, served as the ASQ Lean Enterprise Division Chair and met many people interested in simplifying Lean Six Sigma concepts. She also noticed that many of the core processes were things she was first introduced to in the military.

Dr. Stern embarked on a mission, a few years ago, to make Lean, "*Leaner*". As a result, Dr. Stern has written several books and white papers on topics related to critical thinking, problem-solving, project management and leadership available on Amazon.com and at major book stores.

SSD's primary products are now all based on *Leaner* Six Sigma (L*r*SS©) from development-to-delivery. The training programs at SSD are designed to not only help students in the certification process but to help those with a curiosity about LSS to apply the core concepts. The effort makes all activities (personal and professional) better, faster and more cost-effective. The newest project, writings and classes include Lean and Agile Project Management (LAPM©)

To learn more about Dr. Stern and her Lean journey, as well as, our award-winning training programs we invite you to visit www.SSDGlobal.net.