Enterprise Solutions Competency Center
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CPI Tools

This section provides a collection of tools and techniques that are used by the industry practitioners and are used in various industries as the best practices. Tools such as Six Sigma and Lean Six Sigma provide a systematic approach and analytical tools for managing various phases of the CPI project. Purpose of this section is to not dive-deep into tools such as Six Sigma or LEAN , but it is to provide you with the history, definition and key building blocks for conducting a successful CPI initiative. In addition to general introduction of the CPI tools and techniques, this section also provides detailed description of Define, Measure, Analysis, Improve and Control (DMAIC) as part of the lean Six Sigma section. This section also include links to various documents and websites for industry practitioners and the ones who what deeper coverage of these analytical techniques.

- Six Sigma
- Lean
- Lean Six Sigma
- IDEF
- TQM
- Process Modeling
- Activity Based Costing

Six Sigma

Did You Know?

Six Sigma can be used in service industries as easily as it can be used in manufacturing as proven by organizations such as GE, Bank of America, and DuPont.

Six Sigma is a management technique that aims at developing and delivering near perfect products and services. It has been claimed that Six Sigma is only useful for problems that are "hard to find, but easy to fix" as contrasted with the radical reengineering approach, whose advocates focus on problems that are "easy to find, but hard to fix."

History of Six Sigma

- Started by Motorola in the mid 1980s
- Today, Motorola averages 5.6 Sigma, has saved $11B and tripled worldwide productivity
- The principal architects of Six Sigma at Motorola left to deploy the methodology at ABB
- In 1994, the Six Sigma Academy was founded
- By 1995, Allied Signal and GE had implemented Six Sigma
- In 4Q 1998, DuPont implemented Sig Sigma; Dow followed suit
- Over 20 companies use this management philosophy

The term "Six Sigma" refers to statistical constructs that measure how far a given process deviates from perfection. Six Sigma is of course a process, a discipline in its own right that measures how many defects exist in a business process and then systematically determines how to remove them. Its focus on process quality evolved out of the quality movement that began in the 1980s. It is, however, now used for a much wider range of process improvement activities. It could in fact be applied to many different types of processes, since the measured attributes can be very varied. Companies such as GE have completely internalized Six Sigma as a way of doing business.

The principles of quality applied in implementing Six Sigma are almost always defined in terms of the company vision and its strategy. Processes are designed from the perspective of the customer and involve an infusion of process thinking across the firm. Metrics such as performance, reliability, price, on-time delivery, service and accuracy provide the targets. The customer focus creates market knowledge that can illuminate the need for process change in areas where the company can add value or implement improvements that customers themselves value most. Advocates of Six Sigma believe that customers are interested in comparing, not the average performance of companies, but the relative merits of each and every process touch-point used to deliver goods or services to them.

Rigorous Six Sigma requires that a process produce no more than 3.4 defects per million occurrences of the process, but its main goal is continuous improvement. Its principles apply not only to manufacturing but also to the delivery of services. Six Sigma can be used by the travel industry just as easily as it can be by the automobile industry. In GE's implementation, Six Sigma revolves around just a few core concepts:

- Critical to quality: Attributes the customer values most.
- Defect: Failure to deliver what the customer expects.
- Process capability: What a process can deliver.
- Variation: What the customer sees and feels.
- Stable operations: Ensuring consistent, predictable processes to improve what the customer sees and feels.

Key Roles

There are six Key Roles in Six Sigma:

- Green Belt - Part-time project participant; trained in Six Sigma
- Black Belt - Full time project leader
- Master Black Belt - Six Sigma expert; trainer; counsels Black Belts
- Process Owner - Responsible for the business process
- Leader or Champion - Senior management

References

- Achieve the Sixth Sigma
- Six Sigma

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Lean

The origins of Lean date back well before the twentieth century even though it wasn't called Lean. The word Lean came from a student at MIT while he was doing research to discover the differences between some Japanese carmakers and the traditional North American carmakers.

The key thought processes within Lean are identifying 'waste' or 'non-value-added activities' from the customer perspective and then determining how to eliminate it the 'right' way. Waste is defined as the activity or activities that a customer would not want to pay for and/or that add no value to the product or service from the customer's perspective.

At the heart of lean is the determination of value. Value is defined as an item or feature for which a customer is willing to pay. All other aspects of the process are deemed waste. Lean framework is used as a tool to focus resources and energies on producing the value-added features while identifying and eliminating non value added activities.

Reference:

- GE approach to Six Sigma- "The Roadmap to Customer Impact".
- Principles of Lean
- US Army Lean Six Sigma training presentation

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Lean Six Sigma

The root of both Lean and Six Sigma reach back to the time when the greatest pressure for quality and speed was on manufacturing. Lean rose as a method for optimizing automotive manufacturing; Six Sigma evolved as a quality initiative to eliminate defects by reducing variation in processes in the semiconductor industry. It is not surprising that the earliest adopters of Lean Six Sigma arose in the service support functions of manufacturing organizations like GE Capital, Caterpillar Finance, and Lockheed Martin.

Lean Six Sigma for services is a business improvement methodology (refer to Lean Six Sigma Tools and Techniques for details on DMAIC) that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital. The fusion of Lean and Six Sigma improvement methods is required because:

- Lean cannot bring a process under statistical control
- Six Sigma alone cannot dramatically improve process speed or reduce invested capital

- Both enable the reduction of the cost of complexity

Ironically, Six Sigma and Lean have often been regarded as rival initiatives; Lean enthusiasts noting that Six Sigma pays little attention to anything related to speed and flow and Six Sigma supporters pointing out that Lean fails to address key concepts like customer needs and variation. Both sides are right. Yet these arguments are more often used to advocate choosing one over the other, rather than to support the more logical conclusion that we blend Lean and Six Sigma.

How is it that Lean and Six Sigma are complimentary? Here's a quick overview:

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-valueadded" work with tools to eliminate the root causes of non-valueadd activities and their cost
    - The 8 Wastes/Non-value-added work
        - Wasted human talent – e.g., Damage to people
        - Defects – 'Stuff' that's not right and needs fixing
        - Inventory - 'Stuff' waiting to be worked
        - Overproduction – 'Stuff' too much/too early
        - Waiting Time – People waiting for 'Stuff' to arrive
        - Motion – Unnecessary human movement
        - Transportation – Moving people and ' Stuff"
        - Processing Waste – Stuff we have to do that doesn't add value to the stuff we are supposed to be producing.
        - Provides a means for quantifying and eliminating the cost of complexity

The two methodologies interact and reinforce one another, such that percentage gains in Return on Investment Capital (ROIC %) is much faster if Lean and Six Sigma are implemented together.

In short, what sets Lean Six Sigma apart from its individual components is the recognition that you can not do "just quality" or "just speed" you need the balanced process that can help an organization to focus on improving service quality, as defined by the customer within a set time limit.

Using DMAIC to Improve Service Processes

No matter how you approach deploying improvement teams in your organization, they will all need to know what is expected of them. That is where having a standard improvement model such **DMAIC (Define - Measure - Analyze - Improve - Control)** is extremely helpful. It provides teams with a roadmap. DMAIC is a structured, disciplined, rigorous approach to process improvement consisting of the five phases mentioned, where each phase is linked logically to the previous phase as well as to the next phase.

There are a lot of resources out there that describe the DMAIC process. Our purpose here is to focus on special considerations for using the *Lean Sigma* DMAIC process in a service environment, including both methods and tools that are particularly helpful as well as hints on how to model the people side of each phase.

Elements of Define (*D*MAIC)

Key Concept

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 it's 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 *Define* 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 fails to meet their customers need, "Voice of the customer or Critical-To-Quality (CTQ)", and so on. 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 the project's link to corporate strategy and its contribution to ROIC

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 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 clarify what is expected of the team
- To keep the team focused
- To Keep the team aligned with organizational priorities
- To transfer the project from the champion to the team

Back to *Define* Tools

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.

Back to *Define* Tools

SIPOC Process Map

A SIPOC is a high-level process map that includes **S**uppliers, **I**nputs, **P**rocess, **O**utput, and **C**ustomers. 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 in Figure 1.

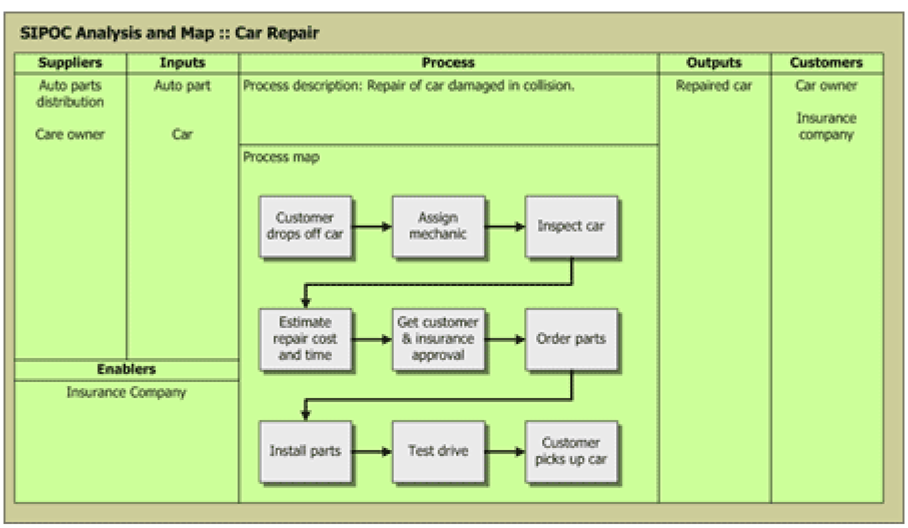

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Figure 1: SIPOC Process Map example

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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 customer with the best in class service/product quality. This process is all about being proactive and constantly innovative to capture the changing requirements of the customers with 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 to 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
- Get a baseline in measure of customer satisfaction to measure improvement against
- Identify key drivers of customer satisfaction

The following is a list of typical output of 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

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Affinity Diagram

An *Affinity Diagram*(sometimes referred to as a "KJ", after the initials of the person who created this technique, Jiro Kawakita) is a special kind of brainstorming tool (see Figure 2 for an example).

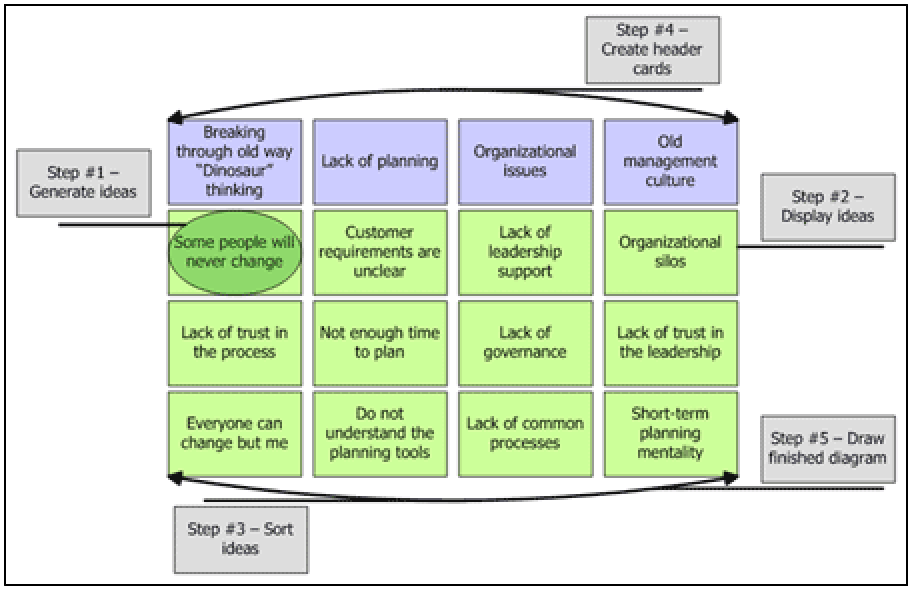

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Figure 2: Affinity Diagram example

You use an Affinity Diagram to:

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

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 that encourages true participation because everyone's ideas find their way into the exercise.

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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 onto 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 get 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 they can be difficult to establish as needs up front. Sometimes called unknown or latent needs.

An example of Kano Model is provided below in Figure 3.

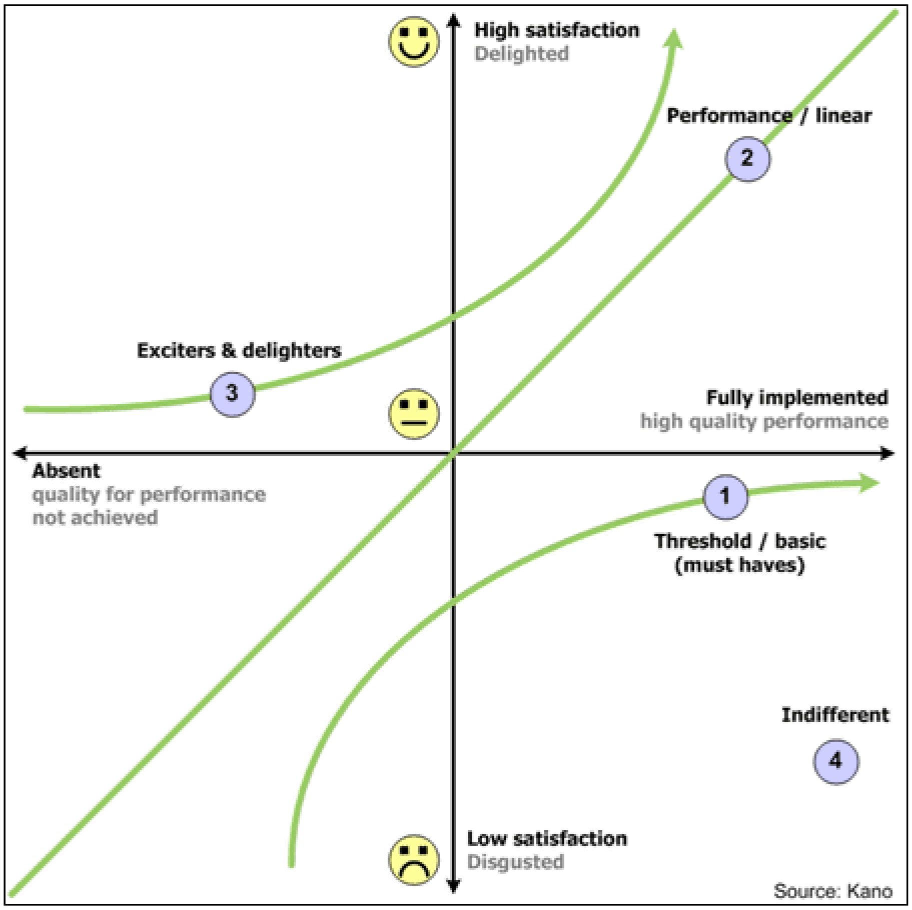

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Figure 3: Kano Model example

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Critical-To-Quality (CTQ) tree

The purpose of the Critical-To-Quality tree 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 the 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 the mandatory warranty visits and made all warranty visits optional. Eliminating the mandatory visits satisfied the customers who thought there were too many visits and adding an extra optional visit satisfied the 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 too difficult.

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.

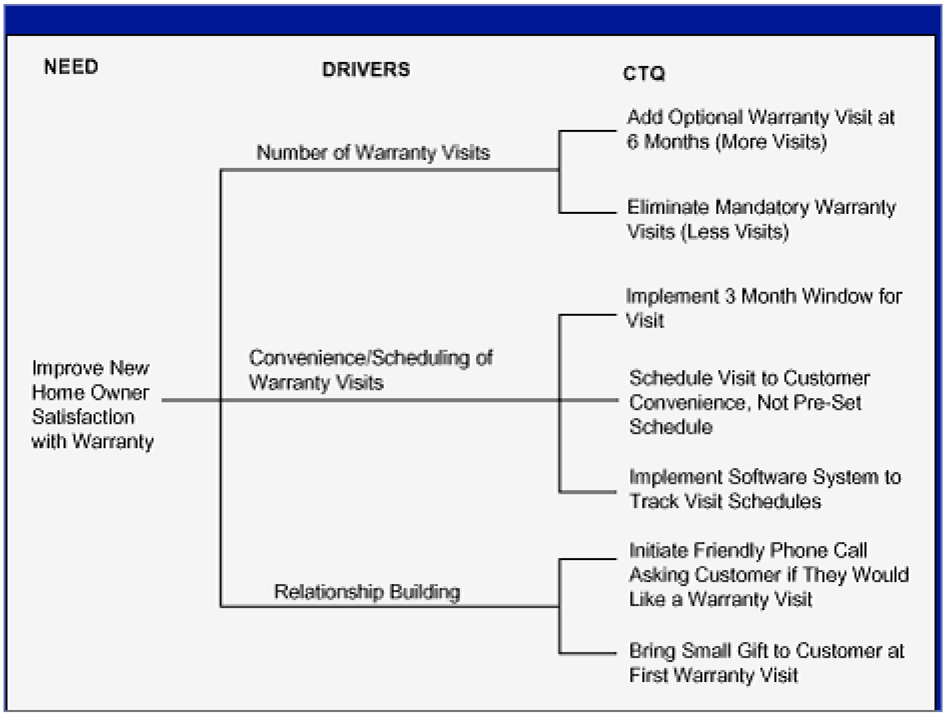

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Figure 4: Critical-to-Quality (CTQ) tree example

Back to *Define* Tools

Define | Measure | Analyze | Improve | Control

Elements of Measure (D*M*AIC)

Key Concept

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

- **Complexity Value Stream Map (CVSM)**
- **Prioritization Matrix**
- **Process Cycle Efficiency**
- **Time Value Analysis**
- **Pareto charts**
- **Control charts**
- **Run charts**
- Falure Modes and Effect Anaysis (FMEA)

One of the major benefits of Six Sigma is its *demand* for fact based and data driven analytical approach. Most other improvement methodologies, including Lean, tend to try to improve processes without sufficient data to really understand the underlying causes of the problem. The result is typically a lot of quick-hit projects with short-lived or disappointing results. Combining data with knowledge and experience is what separates true improvement from mere process tinkering. One of the goals of the *Measure* phase is to pin-point the location or source of problem as precisely as you can by building a factual understanding of existing process conditions and problems. That knowledge will help you narrow the range of potential causes you need to investigate in the *Analyze* phase. An important part of *Measure* is to establish a baseline capability level.

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

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

The following sections provide a brief description of the above tools and techniques.

Prioritization Matrix

The Prioritization Matrix provides a way of sorting a diverse set of items into an order of importance. It also enables their *relative* importance to be identified by deriving a numerical value of the importance of each item. Thus 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. So, in order that the items can be compared with one another in this way, each item is scored against each of a set of key criteria, and the scores for each item are then summed.

The Prioritization Matrix is usually counted as one of the second seven tools.

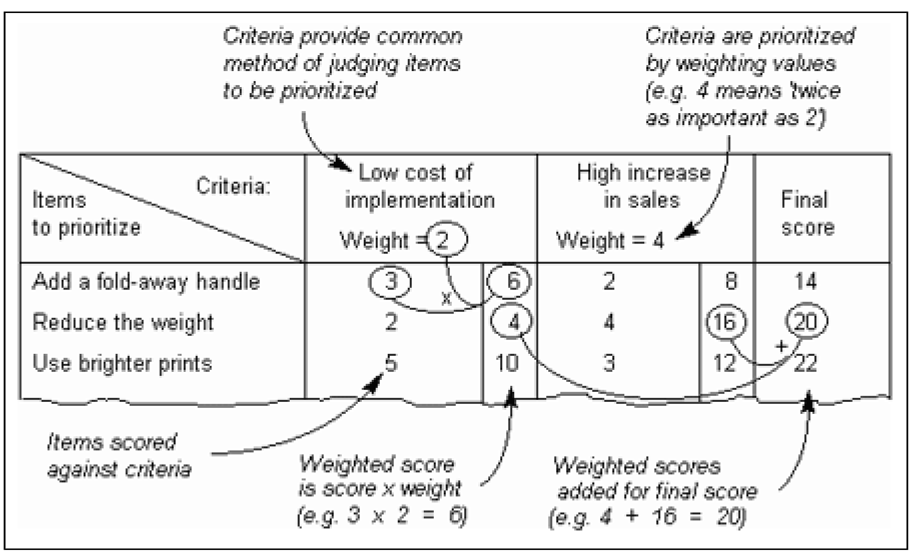

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Figure 5: Prioritization Matrix

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Process Cycle Efficiency

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

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Time Value Analysis

A chart visually separates value-added from non-value added time in a process.

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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.

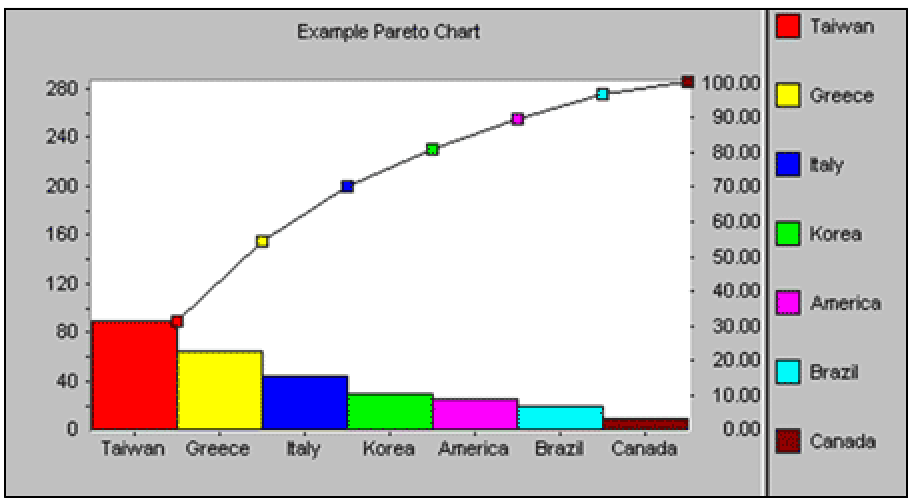

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Figure 6: Example Pareto Chart

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 will have a greater impact and be more cost-effective than undirected efforts.

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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, many processes, it is important to notice special causes of variation as soon as they occur.

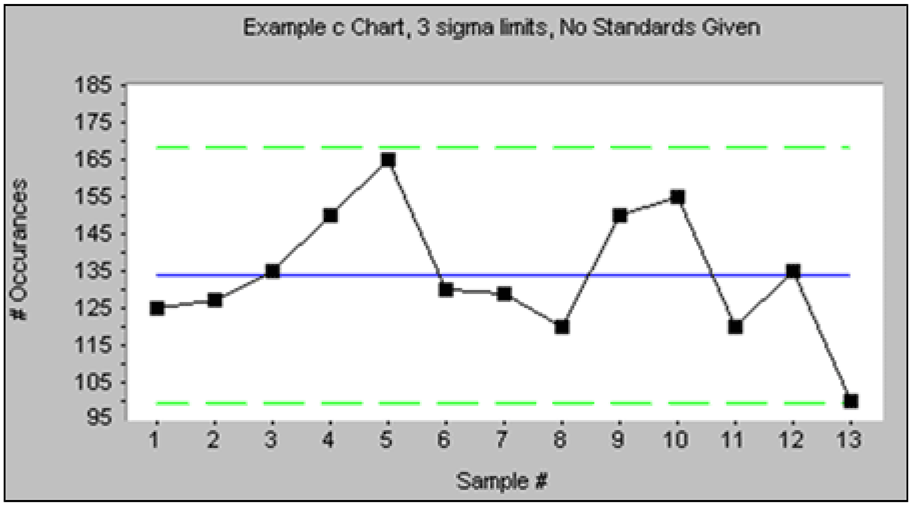

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Figure 7: Example Control Chart

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 fat pitches out 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.

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.

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Run chart

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 for improvement. 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.

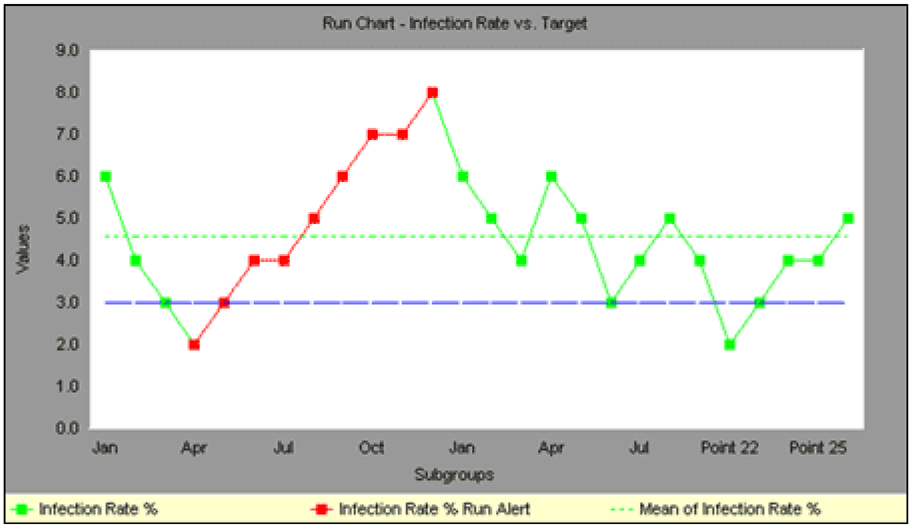

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Figure 8: Example Run Chart

Failure Modes and Effect Analysis (FMEA)

A procedure and tools that help to identify every possible failure mode of a process or product, to 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 failures as well as develop and implement preventative actions, with responsible persons assigned to carry out these actions.

Back to *Measure* Tools

Define | **Measure** | **Analyze** | **Improve** | **Control**

Elements of Analyze (DM*A*IC)

Key Concept

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

- 5 Whys analysis
- Brainstorming
- Cause and Effect Diagram
- Affinity diagram
- Flow diagram
- Pareto chart
- Regression analysis
- Scatter plots
- Stratified frequency plots

The *Measure* phase has produced the baseline performance of the process. By having stratified (sequenced in order of ranks or order) the data in the baseline performance, it becomes possible to pinpoint the location or source of problems by building a factual understanding of existing process conditions and problems. That helps to focus the problem statement. In the *Analyze* phase you will develop theories of root causes, confirm the theories with data, and finally identify the root causes(s) of the problem. The verified cause(s) will then form the basis for solutions in the Improve phase.

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

- 5 Whys analysis
- Brainstorming
- Cause-and Effect diagram
- Affinity diagram (covered in the *Defined* phase)
- Control Charts (covered in the *Measure* phase)
- Flow Diagram
- Pareto Chart (covered in the *Measure* phase)
- Regression analysis
- Scatter plots

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 anaysis to be used

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), you can peel away the layers of symptoms that can lead to 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.

An example of a five Why Analysis. ...Here is our "wheel" life example.

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

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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 performance 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.

Back to *Analyze* Tools

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. 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 was drawn to resemble the skeleton of a fish, with the main causal categories drawn as "bones" attached to the spine of the fish, as shown below in Figure 9.

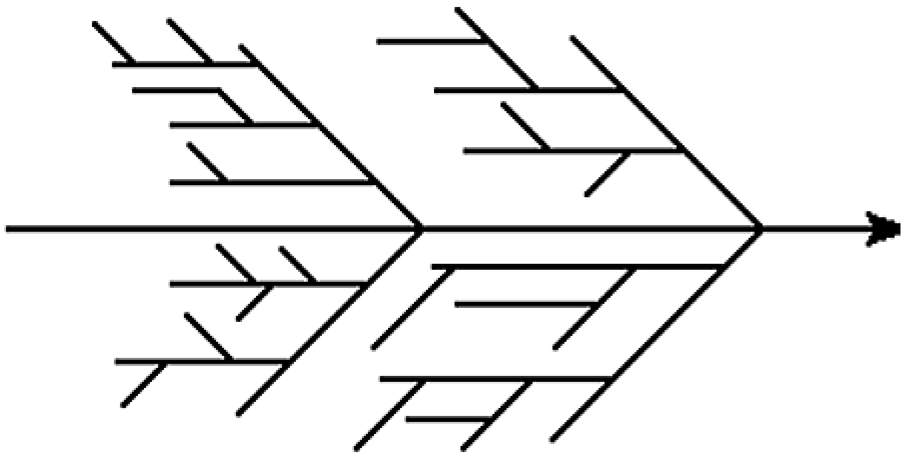

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Figure 9: Example C&E diagram

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Affinity diagram

(covered in the Defined phase)

Control Charts

(covered in the Measure phase)

Flow Diagram

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 for a good overview (see Figure 10 below).

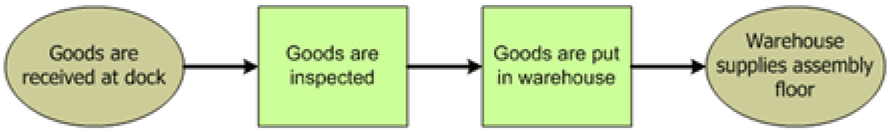

Figure 10: High-level flow diagram example

- Detailed flowcharts show a step-by-step mapping of all events and decisions in a process (see Figure 11 below).

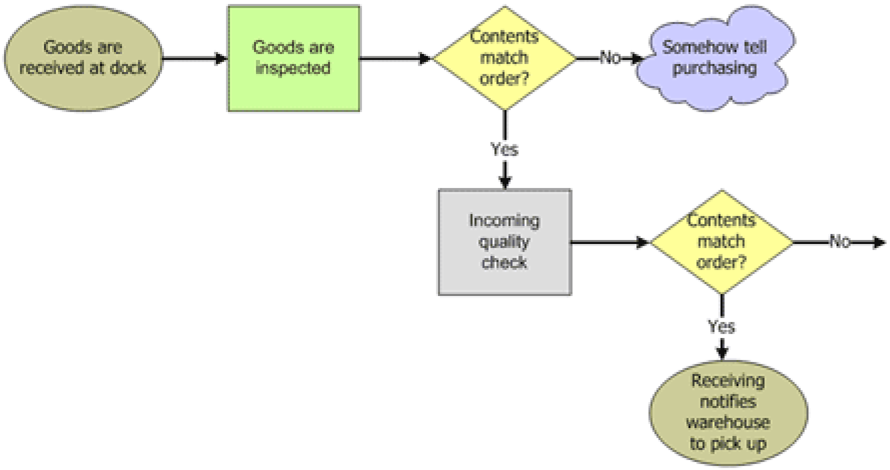

Figure 11: Detailed flow diagram example

- Deployment flowcharts which organize the flowchart by columns, with each column representing a person or department involved in a process (see Figure 12 below).

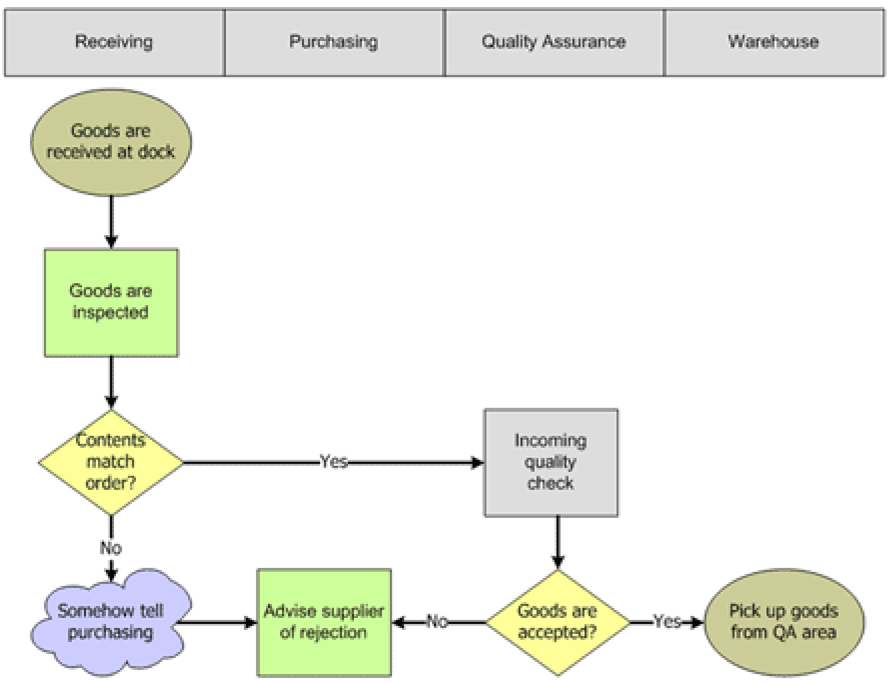

Figure 12: Deployment flow diagram example

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Pareto Chart

(covered in the Measure phase)

Regression analysis

Regression analysis is a statistical forecasting model that is concerned with describing and evaluating 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* value of one variable from one or more other variables whose values can be predetermined.

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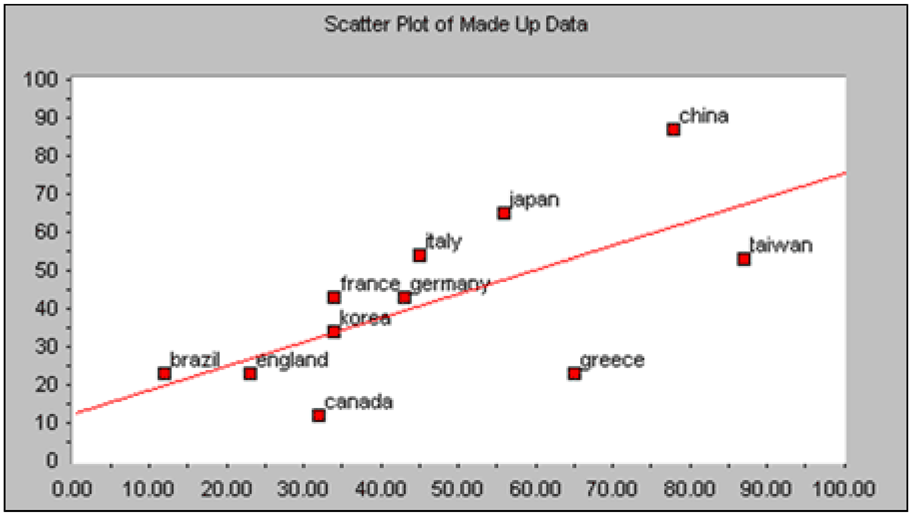
Scatter plots

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. See Figure 13 below for an example.



View large image | Read accessible description of image

Figure 13: Scatter plot example

Things to look for:

- 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.

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Define | **Measure** | **Analyze** | **Improve** | **Control**

Elements of Improve (DMA/C)

Key Concept

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

- **Brainstorming** phase
- **Follow charting** phase
- **FMEA phase**
- **Planning tools section**
- **Stakeholder Analysis**
- **Setup reduction**
- **Queuing methods for reducing congestion and delays**
- **5S's method**
- **Kaizen**

The sole purpose of *Improve* is to demonstrate, with fact and data, that your solutions solve the problem and to make changes in a process that will eliminate the defects, waste, and unnecessary costs that are linked to the customer need identified during the *Defined* phase. Tools and strategies you will find for the *Improve* phase will include solution matrices that link brainstormed solution alternatives to customer needs and the project purpose, and methods for implementing desired solutions.

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

- Brainstorming (covered in the *Analyze*) phase
- Flow diagram (covered in the *Analyze*) phase
- FMEA (covered in the *Measure)* phase
- Planning tools (covered in the Project Management) section
- Stakeholder Analysis (covered in the *Defined* phase)
- Setup reduction
- Queuing methods for reducing congestion and delays
- 5 S's method
- Kaizen

Key Concept

Benefits of the 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

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. 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 go through value-added work without any none 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.

Back to *Improve* Tools

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 holiday session. Once identified, there are three principle 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, train office and other staff to help out with registration with both unexpected peaks and predictable peaks.
- 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 identified then develop different strategies to deal with each category.

Back to *Improve* Tools

Key Concept

Benefits of the 5 Ss Method

- Improve safety and communication
- Reduce space requirements
- Increase compliance with processes and procedures
- Boost morale by creating a pleasant workplace

5 S's method

5 S's method/visual is the process of creating workplace cleanliness and organization including visual signals. The 5-S process includes five steps:

- Sort: Organize and separate needed from unneeded

- Straighten: Arrange and identify for ease of use
- Shine: Clean and look for ways to keep it clean
- Standardize: Maintain and monitor the first 3 S's
- Sustain: Discipline, stick to the rules and maintain motivation

By eliminating the unnecessary, establishing a place for what remains, and cleaning up remaining equipment, tools, and storage devices, clutter is reduced and needed items are readily found. Visual management involves the use of visual cues (e.g. road traffic signs and signals) to assure things happen and improve documentation.

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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 ofthe implementation of the Kaizen concept in Japanese corporations. In contrast to the usual emphasis on revolutionary, 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 education 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.

Back to *Improve* Tools

Define | **Measure** | **Analyze** | **Improve** | **Control**

Elements of Control (DMAI*C*)

During the *Improve* phase, the solution was piloted, and plans were made for full scale implementation. Putting a solution in place can fix a problem for the moment, but the work in *Control* phase is designed to help you make sure the problem stays fixed and that the new methods can be further improves over time.

The tools most commonly used in *Control* phase are:

- Control charts (covered in the *Measure* phase)
- Flow Diagram (covered in the *Analyze* phase)
- Charts to compare before and after such as Pareto chart (covered in the *Measure* phase)
- Quality Control Process chart
- Standardization

Quality Control Process chart

Did You Know?

History of PDCA:

The PDCA cycle is also known by two other names, the Shewhart cycle and the Deming cycle.

Walter A. Shewhart first discussed the concept of PDCA in his 1939 book, Statistical Method From the Viewpoint of Quality Control. Shewhart said the cycle draws its structure from the notion that constant evaluation of management practices, as well as the willingness of management to adopt and disregard unsupported ideas, is key to the evolution of a successful enterprise.

Deming is credited with encouraging the Japanese in the 1950s to adopt PDCA. The Japanese eagerly embraced PDCA and other quality concepts, and to honor Deming for his instruction, they refer to the PDCA cycle as the Deming cycle.

A Quality Control (QA) Process Chart is a tool that helps you document **P**lan-**D**o-**C**heck-**A**ct (PDCA) for the process. The plan-do-check-act (PDCA) cycle is a well-known model for Continual Business Process Improvement (CPI). It teaches organizations to plan an action, do it, check to see how it conforms to the plan and act on what has been learned.

The PDCA cycle is made up of four steps for improvement or change:

- **P**lan: Recognize an opportunity, and plan the change.
- **D**o: Test the change.
- **C**heck: Review the test, analyze the results and identify key learning points.
- **A**ct: Take action based on what you learned in the check step.

If the change was successful, incorporate the learning from the test into wider changes. If not, go through the cycle again with a different plan.

Standardization

Standardization is what allows high quality to happen on a reliable, predictable and sustained basis. Standardization is making sure that important elements of a process are performed consistently in the best possible way. Changes are made only when data show that a new alternative is better. Use for standard practices will:

- To reduce variation among individuals or groups)and so make process output more predictable)
- To 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 unused conditions

Define | Measure | Analyze | Improve | Control back to top

IDEF

IDEF is a method designed to model the decisions, actions, and activities of an organization or system. IDEF was derived from a well-established graphical language, the Structured Analysis and Design Technique (SADT). The United States Air Force commissioned the developers of SADT to develop a function modeling method for analyzing and communicating the functional perspective of a system. Effective IDEF models help to organize the analysis of a system and to promote good communication between the analyst and the customer. IDEF is useful in establishing the scope of an analysis, especially for a functional analysis. As a communication tool, IDEF enhances domain expert involvement and consensus decision-making through simplified graphical devices. As an analysis tool, IDEF assists the modeler in identifying what functions are performed, what is needed to perform those functions, what the current system does right, and what the current system does wrong. Thus, IDEF models are often created as one of the first tasks of a system development effort.

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TQM

Total Quality Management is a management approach that originated in the 1950s and has steadily become more popular since the early 1980's. Total Quality is a description of the culture, attitude and organization of a company that strives to provide customers with products and services that satisfy their needs. The culture requires quality in all aspects of the company's operations, with processes being done right the first time and defects and waste eradicated from operations.

Total Quality Management, TQM, is a method by which management and employees can become involved in the continuous improvement of the production of goods and services. It is a combination of quality and management tools aimed at increasing business and reducing losses due to wasteful practices. Some of the companies who have implemented TQM include Ford Motor Company, Phillips Semiconductor, SGL Carbon, Motorola and Toyota Motor Company.

Reference

- Gilbert, G. (1992). Quality Improvement in a Defense Organization. Public Productivity and Management Review, 16(1), 65-75.

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Process Modeling

For details on Process Modeling please refer to “ Work process documentation guide ”.

Process Simulation

One of the greatest complaints we hear from senior managers is “projects are successfully completed, but I’m not seeing a significant change to the bottom line.” That’s because in the *Define* stage of DMAIC Six Sigma experts don’t have enough information to quantify the benefits. They are predicting a bottom line financial benefit without truly understanding how the process behaves, let alone how it would behave after the change. Without seeing the big picture you may complete a successful six sigma project and see no impact in dollars to your company. There is a better way. With Process Modeling you create a simple simulated model of the process. You will visually see which projects will affect the total output and which will sub-optimize the system.

Key advantages of integrating Six Sigma phases (DMAIC) with Process Modeling are provided below:

Overall interdependencies in processes

The standard Six Sigma toolbox has no way of showing the interdependencies between one area of the process and another. In complex change initiatives where there are interdependencies between processes when things happen that cause delays, bottlenecks, variability etc., if you can't show the interdependencies, understanding the system and resolving issues are very difficult. If you can't understand the system and pinpoint the waste and bottlenecks, changing the system could be risky and typically does not provide the desire results. A simulated model shows those interdependencies, which allows you to uncover changes that will affect the overall system.

Risk free experimentation

It is proven that experiments in real life are costly and can have enormous negative impact on the system. If you are experimenting with a simulated model of the system, the only cost is setting up the experiment and reviewing the results. There are no negative impacts to system output or to the morale of the workforce in trying new process experiments. You can change the parameters and run various experiments and if it the outcome is not what is desired you can pinpoint the root causes, all the while gathering more information about system behavior - without any disruption to the real system.

Reduced experimentation time

You can run hundreds of experiments a day rather than hundreds of days per experiment. Many processes have a cycle time of weeks or even months. Running enough replications of an experiment to validate the results can be overwhelming. With a simulated model, you can set up as many experiments as you want and the computer runs experiments while you do other tasks.

Impact of change on the existing process

Processes that achieve the goal of Six Sigma (or a high sigma level) fall out of spec if the volumes change. For example a 50% change to incoming calls to a call center may drive a customer oriented sales process to its knees. Planning for change in your system by using a simulated model in order to understand the effects of volume change, product stream substitution, staffing policy or other changes will significantly reduce the project risks and the associated costs.

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Activity Based Costing

Activity Based Costing is an accounting system that assigns costs to products based on the resources they consume. The costs of all activities are traced to the product for which they are performed. Overhead costs are also traced to a particular product rather than spread arbitrarily across all product lines. The true cost of a product can be determined with much more fidelity than was previously available with a traditional accounting system. An ABC system gives visibility to how effectively resources are being used and how all activities contribute to the cost of a product.

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