SIX SIGMA ...THE ROAD TO EXCELLENCE IN ALL WE DO

Maj Eric Brenkert &
CMSgt Martin Miller

ACC Quality and Management Innovation Squadron

Abstract

In the midst of budget cuts and an increase in worldwide defense commitments, tomorrow's Air Force must reduce cost while increasing combat capability. Six Sigma allows leaders to efficiently use their limited resources to live up to the Air Force core value of "excellence in all we do." It does this by helping them to concentrate on the defects that reduce combat capability, cause rework and waste and increase the cost of doing business. Six Sigma looks at vital measures of customer, process and supplier aspects of operations to determine critical success factors and actions needed to ensure successful mission accomplishment. Six Sigma can be used to compare quality levels in similar processes. This ability helps organizations aggregate a wide variety of data while highlighting major improvements and areas requiring further attention. These comparisons allow leaders to focus efforts in critical areas for maximum impact. This tool is not a fancy sounding program, but encourages a wider application of sound process analysis techniques and process improvement methods already in use by most Air Force organizations. The concept of Six Sigma is nothing new, but its application will help us meet the needs of a 21st Century Air Force.

Understanding the Six Sigma Concept

The Six Sigma concept has its basis in understanding and eliminating defects in a process. Data on defects forms the basis of a metric, or standard of measurement, used to determine the performance of that process. Fewer defects in the final product or service provided to the customer indicates higher customer satisfaction. This higher satisfaction level can be accomplished by inspecting in quality, which is costly and inefficient, or by designing in quality from the start of the process. When measured over time, we can make short-term performance predictions and establish stretch goals to drive continued improvement. When you standardize performance definitions between processes and define complexity between them, we can establish benchmarks through comparative analysis, identifying high performance processes and opportunities for improvement. We can then use established tools and techniques to drive the necessary improvements once we identify lower performing processes.

The Six Sigma concept systematically measures defects within processes, determines performance levels, benchmark best practices, and utilizes existing tools and techniques to drive process improvement towards achievement of stretch goals. This system leads towards the vision of Six Sigma; elimination of all defects within a process.

The History of Six Sigma

Motorola started the movement towards excellence in manufacturing in the mid 1980s (Ficalora, 1997) when they adopted a new philosophy of zero defects. Motorola worked towards this by thoroughly reviewing their customers needs, analyzing their processes and the abilities of their suppliers. By doing this they were able to produce a product that was reliable and allowed them to meet the needs of the customer. The philosophy, measure, and methodology of Six Sigma form a framework that helps an organization to focus on reducing defects while improving their processes and reducing business costs.

A number of companies have since adopted the philosophy of Six Sigma. They discovered that designing and manufacturing a product without defects was not only possible, but essential to remain viable in a highly competitive marketplace. Removal of defects in any process eliminates rework and reduces cycle time thereby reducing the cost of doing business. Texas Instruments adopted the Six Sigma methodology in 1991(Ficalora, 1997) and discovered not only a manufacturing application, but a universal application in all their processes. They proved the Six Sigma concept was applicable anywhere you could collect and analyze customer satisfaction, process and supplier data.

With reductions in the Department of Defense budget it was essential to become more efficient and effective at producing combat power for the United States. In 1996, Air Combat Command (ACC) consulted with Motorola, General Electric and Texas Instruments on the Six Sigma concept. The Six Sigma approach demonstrated the defect reduction and increased efficiency characteristics sought by Air Combat Command. ACC personnel noted a striking similarity between the Six Sigma concept and process improvement techniques already being used within ACC and the Air Force.

Philosophy

The Six Sigma concept aligns very well with the ideals and values of the Air Force as stated in the vision for Air Force culture. (Handy, 1995) The Air Force core value of "excellence in all we do" is at the center of the philosophy of Six Sigma. If ACC personnel allow themselves to accept anything less than their best, they are short-changing themselves and the individual to whom they are responsible...the American taxpayer.

The philosophy of Six Sigma includes six elements; 1) a common goal, 2) teamwork promotion, 3) a common language, 4) synergism, 5) comparison capability, and 6) desire for improvement. Each element is vital towards achieving the end state of "excellence in all we do."

- **A Common Goal:** Improved process performance through defect reduction. Every process has one commonality. They all contain defects. When focusing on defects, everyone is working towards that common goal. This commonality also leads towards the Air Force desire for a common metric.

- **Teamwork Promotion:** Many operations within ACC are task-oriented; based on an individual performing just that part of the process for which they are responsible without regard for other tasks or individuals in the process. Six Sigma drives a process focus requiring individuals to team together to improve the overall process.

Also, by measuring the process, supplier performance and customer satisfaction, individuals team with those customers and suppliers to identify everyone's needs and requirements.

- **A Common Language:** Using Six Sigma as the basis for all process measures within an organization, leaders and managers can more easily understand process performance without having to interpret numerous types of charts for different processes.

- **Synergism:** Reduction of defects is not the only benefit from Six Sigma. When we reduce defects, we also reduce the cost of rework as well as the cycle time required to deliver the product to the customer. The result is a product or service that costs less, takes less time to produce, and is of higher quality.

- **Comparison Capability:** With the defect-based sigma scale providing variance for process complexity, we can compare similar processes to determine overall performance and improvement opportunities.

- **Desire for Improvement:** Current metrics are reactive in nature. When we don't meet a desired standard, we make changes to the process or metric to achieve the standard. The Six Sigma concept is proactive in nature by communicating current performance, allowing stretch goals to be established for continuous improvement.

We need a new mindset that focuses on providing a defect free, value-added product or service to the customer. The philosophy demands a cultural change from the attitudes of the past. Organizations must move away from the current attitude of accepting the standard and an acceptable defect level, to a point where they actively seek out information on defects in order to eliminate them. It is a culture change that does not allow measures to drive improvement, but replaces it with desire for improvement to be the motivating agent. They must cultivate a desire for improvement where they actively search out and eliminate system defect sources at the root cause and prevent their recurrence to save the limited resources. The new philosophy demands a change in attitude from focusing on individual tasks to focusing on the processes as a whole. We must progress from "look good" metrics to ones that enable organizations to perform better.

Gen Handy described essential elements that must be included in order to operationalize quality fundamentals in daily operations. In the Air Force end state vision for the Air Force culture. He noted that organizations must link mission accomplishment to the strategic focus at all levels. Figure 1 shows how closely the strategic planning process aligns with Six Sigma

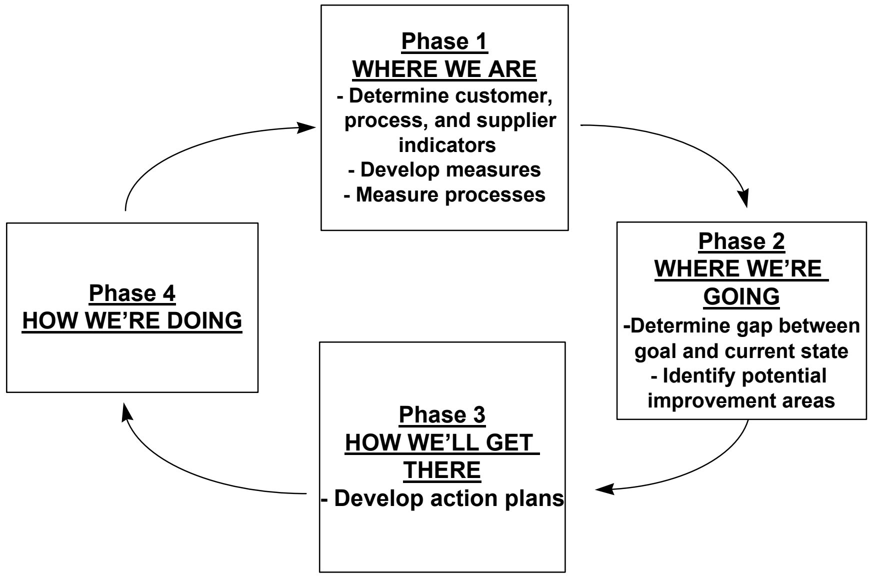

Figure 1

Six Sigma drives a measure of key output areas and then uses these measures to plan for the future. In order to have meaningful goals, organizations must have a measure that gives leaders an accurate picture of their current process quality and capability (Where we are).

With this information, they can determine where they want to go as an organization and see exactly where the gaps exist between where they are and where they want to be (Where are we going?) This drives goals that strive for higher effectiveness and efficiency to the customer without over-tasking the process of the suppliers to produce beyond their capacity or ability. Dr. Mikel Harry, a noted expert on Six Sigma, said in his book *The Vision of Six Sigma, Tools and Methods for Breakthrough,*

> "We don't know what we don't know
> We can't act on what we don't know
> We won't know until we search
> We won't search for what we don't question
> We don't question what we don't measure
> Hence, we just don't know"

From here organizations can make action plans that focus on reducing these gaps, (How will we get there?), then monitor progress toward reaching the established goals (How are we doing?).

Six Sigma addresses another aspect of the end state vision by encouraging team work to fix problem areas, leveraging innovative solutions and benchmarking to find the best way to provide high quality products and services for the customer with reduced cost. By including process workers in formulating process improvement strategies, we get valuable insight to how the process actually works.

Six Sigma allows focus on the areas that are important and the ability to see what the impact of defects is on the customer. Finally, it uses the same process improvement techniques that are available at all bases in the manpower and quality (MQ) office and taught since starting on the "Quality Journey".

Six Sigma Basics

Though the term "Six Sigma" may sound like a fancy new word, it is actually a simple concept. An integral aspect of the Six Sigma concept is the measure of the process. We define a **process** as a value-adding activity that takes resources/raw materials from a supplier and produces an output to meet the needs of the customer. The **unit** of work is normally the output of a process or process step. In order to establish meaningful measures, an organization must focus on the process and assure an understanding of the relationship between the different process elements in producing a unit. We must focus the measures on these different elements to know how each one affects the unit provided to the customer. The measure needs to be accurate and provide actionable data in order to be valuable to reduce the defects that cause customer dissatisfaction.

In order to attain desired goals, measures are required which point to improvement opportunities. In the quality journey, organizations have too often taken the "Ready-Fire!-Aim" approach to process improvement. This approach not only wastes resources but, more importantly, causes employees to see quality as a non-value-added activity that itself wastes the time and resources it is designed to save. By concentrating on eliminating defects that affect essential process factors, organizations can make improvements that will result in increased efficiency and cost reduction. Once we identify problems, we can effectively use process improvement tools and techniques to analyze the process, make the changes that improve the process and standardize the improvements to make it part of the job.

The process focus must start with a COPIS as shown in figure 2; Customer, Output, Process, Input, Supplier.

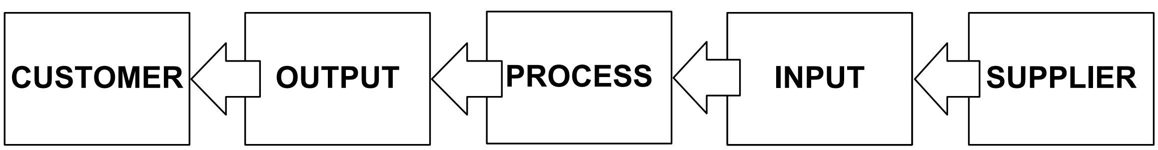

Figure 2

Organizations need to identify what they provide and for whom they provide it. They must know the critical needs of the customer, how the processes are built to meet these needs and what are required from suppliers to produce the output in the way it meets the customer needs.

Once we understand **what** is being done, it is necessary to understand **how** it is done. This understanding comes from defining the process from a starting point to a point of completion. In this way we can identify both the customers and the suppliers to the process. If the organization doesn't focus on the needs of the customer, they stand the chance of mission failure not because they couldn't do it, but because they didn't know what they need to do.

Going back to the COPIS model, the same two measures in each customer, process, supplier area are vital to knowing the overall health of a process as figure 3 demonstrates. In customer satisfaction, the area of availability (Do I get it when I need it?) and reliability (Does it work as intended when I get it?) reflect the key customer requirements. Within the process, these same areas determine how well a process is working. Process measures focus on the availability (How much can I produce?) and reliability (How much confidence do I have in the process?). Supplier availability focuses on the ability of the supplier to meet my needs as far as delivery (Do I get it when I need it?) and reliability (Does it work as intended once I get it?).

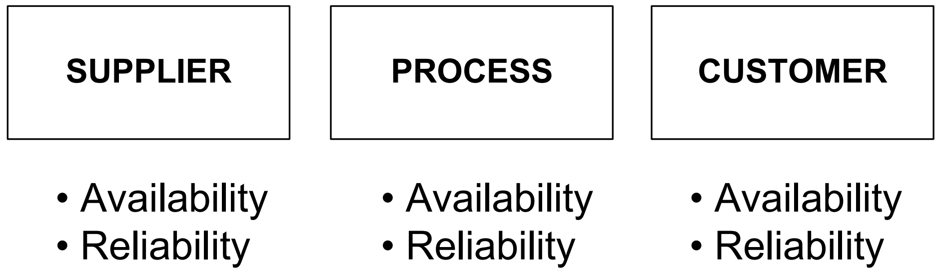

Figure 3

These six measures in availability and reliability provide a picture of the entire process and the vital elements that we must satisfy to provide an effective and efficient process.

Certain additional definitions are needed to provide information on the different aspects of the Six Sigma measure. A **defect** in the process is a mistake or error that is passed on to the customer. The places and/or steps of a process where defects can occur are known as **opportunities for error**. These opportunities for error illustrate the complexity of a process; the more complex the process, the more numerous the opportunities for error.

To illustrate how the measure works we can look at a common process example. We will look at the process of kicking a field goal in football. The process begins with the snap of the ball from center and ends when the referee blows the whistle at the end of the play. The unit is a completed field goal attempt. The defect is a missed field goal. From a macro view, there are eleven opportunities for error when kicking a field goal. Each player has a specific job to perform during the play, resulting in an opportunity for error. We could break down each player's job into its own process with numerous opportunities for error in each. For this example, the macro view is the focus of attention.

The primary measure of performance in a process under the Six Sigma concept is defects per unit (DPU). This compares the number of defects that occur in a process with the number of units produced by that process. In the football example, assume the place kicker attempted 27 field goals and missed twice. The DPU for this example is:

DPU = # of Defects Found / # Units Produced = 2 / 27 = .074

The result (.074) indicates the average number of defects found in each unit produced. With a good sample size, it could be predicted that for each field goal attempted, the probability of success would be .926 (1 - .074). DPU can be calculated for any single review point or summed for an overall operation, as in this example. DPU does not measure the severity of the defect. A defect in a car can be as small as a broken cigarette lighter or as big as a seized engine. When defining defects, ensure it is a defect that causes customer dissatisfaction.

DPU does not take into account the complexity of a process. Two processes may have the same DPU but may have vastly different complexity. This has been the reason for not comparing process quality before. Trying to compare similar processes of differing complexity was like comparing "apples to oranges." We must define Opportunities for error to account for complexity in the process to make this comparison possible. Using the opportunity for error factor in the measure changes "apples" and "oranges" into a common entity for comparison. Besides complexity, we must normalize a process measurement over a large population size to reduce the affect of variation in small sample sizes. We use one million (1,000,000) units as the standard for sigma measurement. We can determine the **defects per million opportunities (dpmo)** by multiplying the DPU by 1,000,000 and dividing the result by the opportunities for error. For the example, the calculation is:

dpmo = (DPU x 1,000,000) / opportunities for error = (.074 x 1,000,000) / 11 = 6727

In the example, for one million opportunities for defects in field goal kicking, 6,727 defects would occur.

Sigma is a statistical term that measures the variability of a data set (population) about its mean (μ). (Figure 4)

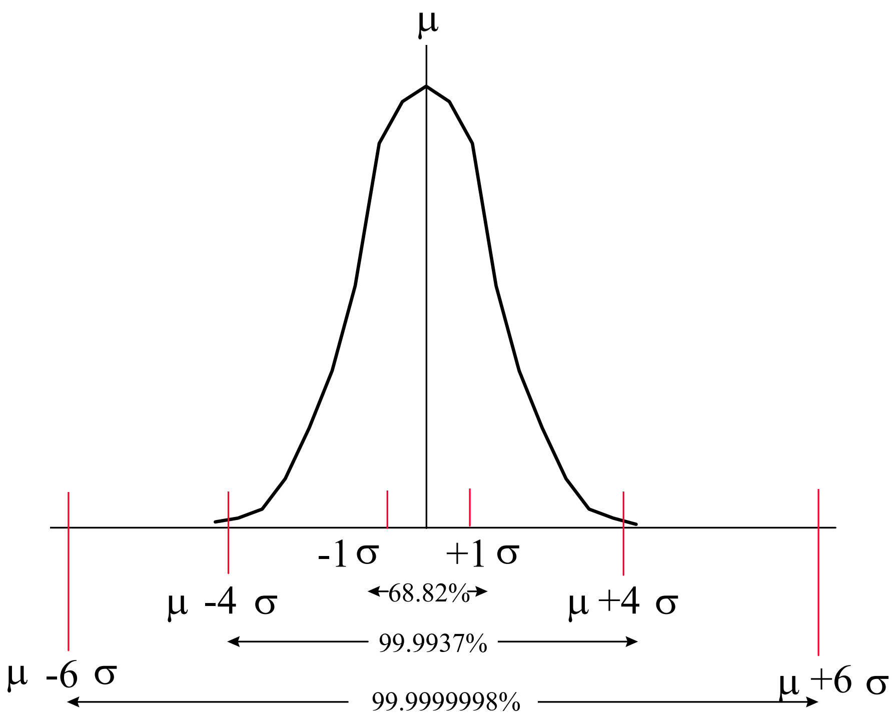

Figure 4

For a normally distributed bell-shaped curve, approximately 69% of the data points will fall within one standard deviation, or one sigma, of the mean; 95% within two sigma; 99.73% within three sigma; 99.9937% within four sigma; and 99.9999998% within six sigma. These calculations are determined using a process that does not shift. Unfortunately, shift does occur in a process. In manufacturing, as we use a machine in a process, its accuracy changes as a result of wear and tear. The accuracy of humans who work in the process also changes. External factors like temperature, pressure to finish the job or health changes their capability to perform a consistent repetitive task.

Motorola's research has shown that a process can shift by a much as 1.5 sigma from the mean over time (Harry, 1988) (Figure 5). When a process shifts, areas that were within tolerance at $\pm$4 sigma, now see many defects. What was 99.9937% without shift now becomes 99.37% with the shift. Even with the shift however, the process that was performing at the six sigma level still will have 99.9996% of the data points within six sigma.

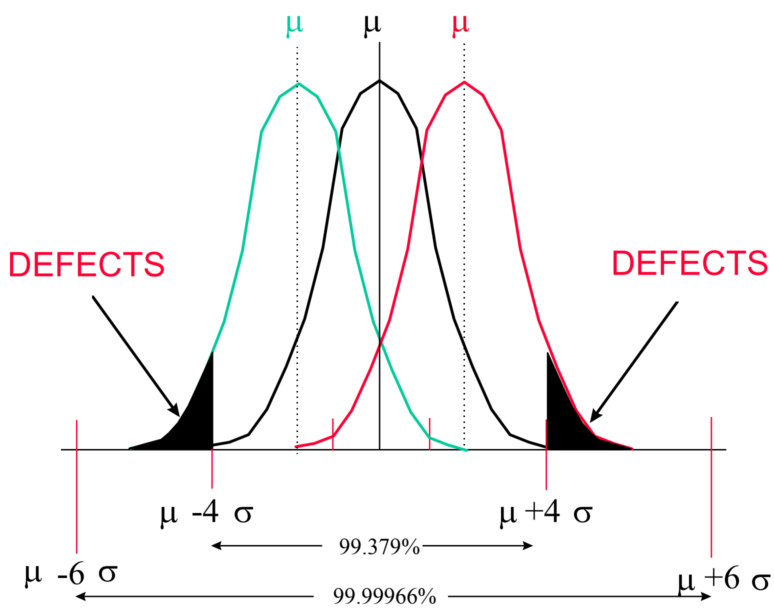

Figure 5

With Six Sigma, defects will occur only 3.4 times in one million opportunities. For our processes, we consider six sigma to be defect-free work.

With dpmo calculated, we can determine a sigma level for the football process using a standard deviation chart (Figure 6). Calculating sigma for the field goal example results in a 3.96 sigma level.

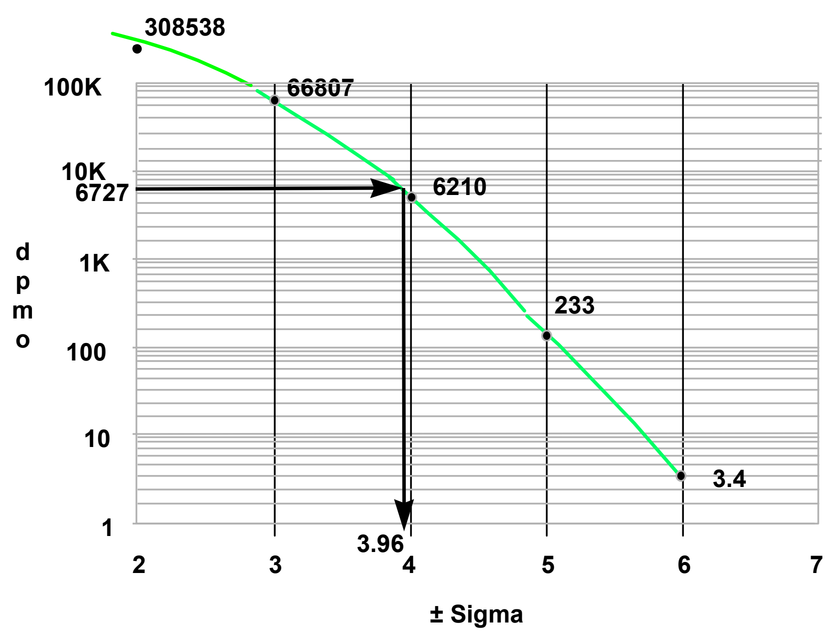

Figure 6

Once we can determine a sigma level, we can compare the process to other processes for benchmarking purposes. Figure 7 shows comparative sigma levels for various processes.

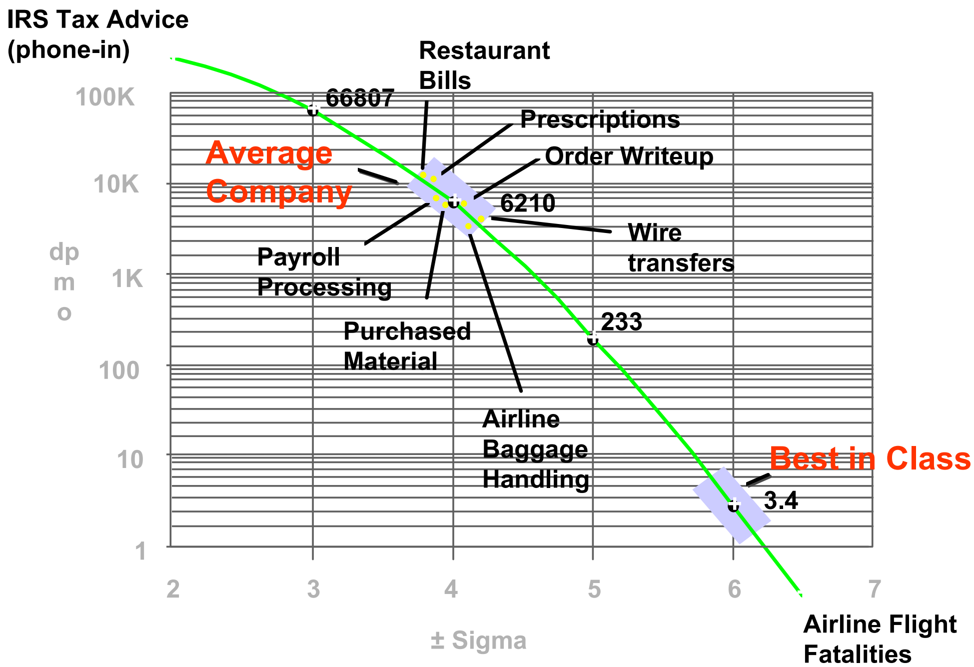

Figure 7

Six Sigma Methodology

With all processes in an organization measured and graphed, leadership can make a comparative analysis to determine best candidates for process improvement tools and resources. Not all processes need to operate at the six sigma level. We must make every effort to move every process towards the six sigma level, but the resources or technology necessary for such achievement may not be available. As in the airline industry, passenger safety is worth the effort of achieving and maintaining a six sigma level or higher. Baggage handling, however, may not appreciably increase customer satisfaction by spending the money to make it perform at the six sigma level.

The methodology of Six Sigma is the final element that pulls everything together. The four steps of the methodology approach allow us to examine, analyze, improve and standardize the process.

The four steps to Six Sigma are:

1. **Maintain a COPIS Focus.**
2. **Measure and Analyze the Process**
3. **Take Action to Improve the Process**
4. **Standardize the Process Improvement**

The first step again looks at the COPIS, but this time in a more micro view. This view shows a detailed breakdown of the process and the individual steps of the process. A flowchart showing the steps of the process is produced to identify where defects are introduced. Second, with defects defined, we develop process metrics to measure process performance. Through analysis and comparison of metrics, we can make objective decisions for allocation of resources for continuous process improvement. Third, once we determine an improvement opportunity and establish a desired improvement goal, organizations can apply standard process improvement techniques like Action Workout or the 7-step continuous improvement process to achieve the goal. These process improvement techniques should concentrate on "goof-proofing" the process by eliminating defect-causing steps where possible, changing procedures to simplify the process or providing more reliable equipment to make it more efficient and defect free. The fourth step in the methodology is the most critical. Failure to standardize improvements made in a process through rewriting policy, changing technical data, or training material, dooms the improvement to revert back to its former state. This regression will cause a rapid return to the former, defect-producing, less efficient state and will frustrate process workers and waste valuable resources.

Summary

The process analysis tools used by industry provide a direction towards reaching the goal of excellence. The road to that goal lies in the elimination of defects; not through fancy sounding programs, but through the application of sound process analysis techniques and process improvement methods already in use by Air Force organizations. The concept of Six Sigma provides the process analysis system to identify the defects in processes. Once we objectively identify the defects, we can use the tools and techniques already in existence to eliminate these defects. The application of quality principles within key processes is the only course that will produce the kind of efficiency and effectiveness required to meet the needs of an Air Force in the 21st century.

References

ACC QMIS (1997). *ACC "Unofficial" Strategic Planning Guide.* Langley AFB VA: Air Combat Command.

Ficalora, P (1997) Texas Instruments Six Sigma briefing to Air Combat Command Commander.

Handy J. (1995) *Charter Statement* , AF Quality Reengineering (1996)

Harry, M. ( ) *The Vision of Six Sigma, Tools and Methods for Breakthrough.*

Harry, M. (1988) *The Nature of Six Sigma Quality.* Rolling Meadows, IL: Motorola University Press

Motorola University Customer and Supplier Services, (1996). *Six Sigma*. Schaumburg, IL: Motorola, Inc.