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# Six Sigma-Thesis

## *Introduction:*

Six Sigma is about solving business problems by improving processes. Typical problems fall into two major categories: solution known, and solution unknown. Six Sigma is aimed at solving the problem in which the solution is not known.

Such problems include decreasing errors in invoices, increasing the yield of a chemical process, decreasing the defect rate of an assembled project, and decreasing the days outstanding in accounts receivables. In 1989, J.M. Juran pointed out that "a project is a problem scheduled for solution." We define a Six Sigma project as a problem scheduled for solution that uses a set of metrics to set project goals and monitor progress. The second category of problems frequently encountered is that in which the solution is known at the outset. Implementing a new computer network to conform to corporate guidelines, installing a new piece of equipment in manufacturing, or building a new plant are examples of known-solution projects. Most capital projects also fall into this category.

In each of these situations it is known what has to be done. The project is completed by assigning a project manager to the project, providing the needed resources, and using good project management techniques. Six Sigma techniques are usually not needed here, although project management can benefit from the process thinking, measurement, and monitoring techniques used by Six Sigma.

An organization's improvement plan typically includes projects of both types: solution known and solution unknown. Both types of projects are important and are needed to improve the performance of an organization. Solution-unknown projects are led by Black Belts or Green Belts. Solution-known projects are lead by project managers.

It is also essential that you carefully identify and document the process that contains the problem. The process provides the focus and context for the Six Sigma improvement work. Process identification is usually easy in manufacturing where you can simply follow the pipes, but it is much less obvious in finance or marketing. A Black Belt or Green Belt who utilizes the Six Sigma methodology then completes the project. Of course, there is no guarantee that every problem will be successfully solved, but with proper project and people selection we can expect a very high (80 to 90%) success rate.

To use Six Sigma, you also need one or more measurements that quantify the magnitude of the problem and can be used to set project goals and monitor progress. These measurements are usually called critical to quality (CTQ) measures. Six Sigma takes a

disciplined, rigorous approach to problem identification, diagnosis, analysis, and solution. It is well suited for problems that do not have a known solution.

***Executive Summary:***

*This module includes:*

- Introduction to six sigma, what is six sigma, why is important, who to use it and when to use it.
- Origin of six sigma and why is it important to companies.
- How does six sigma works and six sigma calculations.
- Six Sigma -Focuses

***What is Six Sigma?:***

**Six Sigma** is a quality management program to achieve "six sigma" levels of quality. It was pioneered by Motorola in the mid-1980s and has spread to many other manufacturing companies, notably General Electric Corporation (GE).

Six Sigma aims to have the total number of failures in quality, or customer satisfaction, occur beyond the sixth sigma of likelihood in a normal distribution of customers. Here sigma stands for a step of one standard deviation; designing processes with tolerances of at least six standard deviations will, on reasonable assumptions, yield fewer than 3.4 defects in one million

Training Sigma processes are executed by Six Sigma Green Belts and Six Sigma Black Belts, and are overseen by Six Sigma Master Black Belts.

According to the Six Sigma Academy, Black Belts save companies approximately \$230,000 per project and can complete 4 to 6 projects per year. General Electric, one of the most successful a company implementing Six Sigma, has estimated benefits on the order of \$10 billion during the first five years of implementation. GE first began Six Sigma in 1995 after Motorola and Allied Signal blazed the Six Sigma trail. Since then, thousands of companies around the world have discovered the far-reaching benefits of Six Sigma.

"Six Sigma" means a failure rate of 3.4 parts per million or 99.9997% perfect; however, the term in practice is used to denote more than simply counting defects. Six Sigma can now imply a whole culture of strategies, tools, and statistical methodologies to improve the bottom line of companies. In all, six sigma is a rigorous analytical process for anticipating and solving problems. The objective of six sigma is to improve profits

through defect reduction, yield improvement, improved consumer satisfaction and best-in-class product / process performance.

## **Tools and methods**

Although Six Sigma's tools and methods include many of the statistical tools that were employed in other quality movements, here they're employed in a systematic project-oriented fashion through the define, measure, analyze, improve and control (DMAIC) cycle. In addition, advances that facilitate the application of these tools have taken place over time. Empowering all employees with Kaoru Ishikawa's seven quality tools creates a workforce capable of solving many problems, as was learned through total quality management. Using these tools in conjunction with other statistical methods embodied in the scientific method and the availability of modern statistical software with graphical outputs reduces the drudgery and helps statistically oriented personnel to better ply their trade. It frees problem solvers to lead their teams to improve quality, reduce cost and reduce time to delivery simultaneously.

Each organization should tailor its Six Sigma program, with the help of specialists, to meet its particular needs. Some organizations may wish to include other topics such as lean thinking. However, the training materials should not be simply a collection of defunct programs.

The statistical methods employed in Six Sigma differ substantially from those taught in run-of-the-mill engineering or statistics programs. Six Sigma emphasizes observational methods and experimentation in the scientific context--for example, two-level factorial experiments are standard, and graphical methods are emphasized for the analysis of these experiments. Experimentation is not simply analysis of variance. While the latter facilitates understanding of experimental results for statisticians, for engineers it can be an impediment to planning and carrying out experiments

### ***Why is Six Sigma important? :***

World-class companies typically operate at about four sigma or 99% perfection. To get to the six-sigma level means cutting down on huge costs and thereby the wasted dollars. For example, if you are four sigma - you would be producing products at the rate of 6200 defectives for every million you produce vs. 3.4 defectives if you are at the six sigma level. Moreover, six sigma improvement projects typically return in excess of \\\$150k to \\\$250k per project with a Black Belt returning as much as \$1 million to the bottom-line each year.

The popularity of Six Sigma is growing. Companies such as Motorola (1987), Texas

Instruments (1988), IBM (1990), Asea Brown Boveri (1993), Allied Signal/Kodak (1994), GE (1995), Whirlpool, PACCAR, Invensys, & Polaroid (1996/98), and many other companies worldwide have successfully implemented Six Sigma. Recently Ford, DuPont, Dow Chemical, Microsoft and American Express have started working on instituting Six Sigma processes

### ***When to use it? :***

Bottom line drives management action. What is your Cost of (poor) Quality? First you need to determine that. Properly implemented, six-sigma implementation can become a profit-center for the company. Jack Welch at GE claims that the returns on six-sigma implementation amount to about \\\$500 million as of 1998. Remember that six sigma is complementary to other initiatives such as ISO or QS 9000 (which is mainly procedural), Total Quality Management (which is mainly cultural) and Statistical Process Control (which is primarily statistical process monitoring).

### ***How to use it? :***

Six Sigma focuses on process quality. As such, it falls into the category of a process capability (Cp) technique. Traditionally, a process is considered capable if the natural spread, plus and minus three sigma (a yield of 99.73%), was less than the engineering tolerance. A later refinement considered the process location as well as its spread (Cpk) and tightened the minimum acceptable so that the process was at least four sigma from the nearest engineering requirement. Six Sigma requires that processes operate such that the nearest engineering requirement is at least plus or minus six sigma from the process mean. This requires considerable scientific and testing actions - often thousands of tests are run on multiple variables to get an understanding of what's going on. Once you determine the process variables and using the other process analysis techniques, you need to consider the ones causing the major losses and work on making them more capable.

- Understand who your consumers are and what your product / service is
- Review consumer surveys, concession reports, and other data
- Screen and prioritize issues by severity, frequency/likelihood of occurrence, etc.
- Determine the internal processes causing the most pain
- Find out why and where the defects are occurring
- Devise ways to address these defects effectively
- Setup a good metrics (six-sigma places a lot of emphasis on measurement)

Who or what is a **Green Belt**?

A person trained in the Six Sigma methodology that is a team member of six sigma process improvement action teams.

Who or what is a **Black Belt**?

A person that is part of the leadership structure for process improvement teams are called "Black Belts" (just as Total Quality utilized "Quality Improvement Team Leaders" to provide structure). Black Belts are highly-regarded, technically-

oriented product or line personnel who have an ability to lead teams as well as to advise management.

Who or what is a **Master Black Belt**?

A person trained in the six-sigma methodology that acts as the organization-wide Six Sigma director or a program manager. He oversees Black Belts and process improvement projects and provides guidance to Black Belts as required. A Master Black belt teaches other six-sigma students and helps them achieve Greenbelt and Black belt status.

Who drives Six Sigma?

Usually a top executive or senior manager who "talks the talk" and "walks the walk" of six sigma. This person is the sponsor, a catalyst and the driving force behind the organization's six-sigma implementation.

### ***Origin of Six Sigma: Designing for Performance Excellence:***

The late Bill Smith, a reliability engineer at Motorola, is widely credited with originating Six Sigma and selling it to Motorola's legendary CEO, Robert Galvin. Smith noted that system failure rates were substantially higher than predicted by final product test. He suggested a number of possible causes for this phenomenon, including a dramatic increase in system complexity and the resulting opportunities for failure and a fundamental flaw in traditional quality thinking. He concluded that a much higher level of internal quality was required and convinced Galvin of the importance of setting Six Sigma as a quality goal. Smith's holistic view of reliability (as measured by mean time to failure) and quality (as measured by process variability and defect rates) was indeed new, as was the Six Sigma quality objective.

Prior to Smith's analysis, a number of gurus, including Joseph M. Juran, Dorian Shainin, Genichi Taguchi and Eliyahu Goldratt, had presented their programs for quality and productivity improvement at Motorola. Mikel Harry, president of the Six Sigma Academy and co-author of *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*, attended some of these programs and developed a program for the Government Electronics Division of Motorola that included Juran's quality journey, statistical process control (SPC) and Shainin's advanced diagnostic tools (ADT) and planned experimentation (PE).

Harry later teamed with Smith on the Six Sigma initiative and created Motorola's Six-Sigma Institute prior to forming his own firm. Smith and Harry's initial Six Sigma umbrella included SPC, ADT and PE. Later, they added design for manufacture (product capability and product complexity) and, as quality was linked to business performance, accomplishing quality through projects.

Motorola's design margin had been 25 percent (or  $4\sigma$  or  $C_p = 1.33$ ). When Smith noted that escaping and latent defects under this strategy were far too high, he reasoned that the disparity between actual reliability and the reliability expected at final test could be accounted for by increased product complexity and deviations of the process mean from the target value, arriving at a value of 1.5 sigma. The complexity phenomena had been noted previously by Wernher von Braun in the U.S. space program: If a large number of components must function for a system to accomplish its objective, the probability of system success diminishes rapidly as the number of components increases unless the reliability of each is essentially perfect. The 1.5-sigma deviation remains controversial, but it's not a fundamental issue. What is important is that Smith recognized that a process mean could not be maintained exactly on target, and when it deviated from target, the traditional three-sigma process produced large numbers of parts that exceeded specifications. Thus, this breaking with the three-sigma quality tradition was a major contribution, as was the recognition of the role of complexity, which dramatically increases the number of opportunities for (and thus, probability of) defects and the likelihood of subsequent system failure.

But what about the then-existing theory of optimal quality levels? Motorola observed that Japanese products were of much higher quality than was predicted by the traditional optimal quality level curves. Independently, Robert Cole investigated this issue and noted several reasons for this change in the quality viewpoint. Japanese quality professionals, he asserted, realized that the costs of poor quality were far larger than had been supposed; recognized that focusing on quality improvement as a company wide effort improved a wide range of performance measures; established a system that moved toward quality improvement and low-cost solutions simultaneously; shifted the focus of quality improvement from product attributes to operational procedures; developed a dynamic model in which customer demands for quality rise along with their willingness to pay for these improvements; and focused on preventing error at the source, thereby dramatically reducing appraisal costs.

As Motorola set out on its quality journey, Harry noted that the company ran into a five-sigma wall. Motorola found that it could attain a three-sigma level by installing process improvement and control in its own installations, and improve this to the four- or five-sigma level through the education of its suppliers. However, Six Sigma only became possible once the company had attained a better understanding of the role of robust design--systems design, parameter design and tolerance design. Not coincidentally, Motorola won the Malcolm Baldrige National Quality its concepts to the world. Thus, as Six Sigma was approaching adolescence, quality professionals at Motorola were describing their methods to their colleagues and learning how far Motorola had advanced in comparison to other companies. At this point Harry wrote a strategic vision for accelerating Six Sigma. This included a change in focus, anchoring quality by dollars and seeking a business transformation. It included a description of different competence levels in the Six Sigma methods, which, in the karate tradition, were designated by belts--Green Belt, Black Belt and Master Black Belt. Elsewhere, GE's Jack Welch and AlliedSignal's Larry Bossidy (first at GE Financial) led their organizations' cultural change through Six Sigma initiatives. In 1998, *Business Week* reported that GE saved \$330 million through Six Sigma, doubling its CEO's previous prediction. Welch has predicted a savings of \$10 billion over five years. Its no wonder Six Sigma has gained industry's attention.

### ***Why is it important to the companies?:***

6-sigma improvement projects typically return between \$150-250k per project. However, the reason for instituting consumer oriented six-sigma goes beyond just the dollars. Some of the projects undertaken for six-sigma change the very dynamics of the ways things get done and provide a significant competitive boost to the company or product.

For example, it was reported that, Allied Signal found a way to clean dirt, oil and stains from old carpets so that 100 million pounds of old carpets will be recycled back into new rugs rather dumped into landfills. This kept the company from building a \$85 million plant in addition to annual savings of \$30-\$50 million per year. Practice and perseverance are the key to successful implementation of these projects. United Technologies

Automotive [UTA] molds plastic into casings used for car side view mirrors.

Environmental laws prevented UTA from making more casings because they were limited by pollution caused by the painting.

Using six-sigma, GE found a way to add a carbon-based conductor to plastic causing far more paint to stick and cutting UTA's pollution by 35%. Now GE sells more plastic to UTA!

Through constant application of the six-sigma principles companies need to move beyond regular problem solving towards more proactive needs analysis and coming out with better performance.

### ***The Six-Sigma Methodology:***

Sigma is a symbol meaning how much deviation exists in a set of data. It is sometimes called a "bell curve." In statistics, this is called a standard normal distribution, but the idea is the same. In a bell curve, 50% of the values lie above the mean (average) and 50% of the values lie below the mean. In Statistics we take it a step further and delineate certain data points within that timeline

The sigma value is measured against this. The further out from the mean on the time line the greater the sigma. The objective is to get the minimum sigma. To reduce the variance as much as possible.

### ***The 6 Sigma Proposition:***

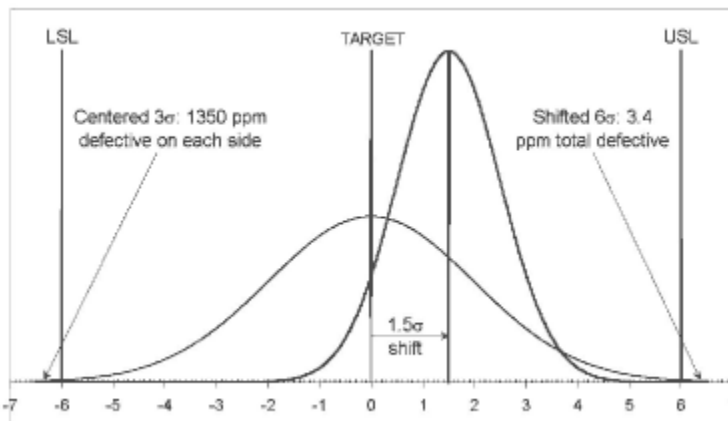
All too often businesses base their performance on an average and average-based measures of the recent past. However, customers don't judge businesses on averages; they feel the variance in each and every transaction. Customers value consistent, predictable business processes and products that deliver world-class



levels of quality. Six Sigma focuses first on reducing variation and then on improving process capability

A common goal with a Six Sigma program is to minimize variation within all of our critical processes. Examples of key processes include: Invoicing/Billing customers; New product development; Processing customer orders; Managing human resources (including payroll, holiday applications, etc.); Hiring employees; Budgeting; Paying bills; Evaluating vendors.

Quantitatively, this means working towards Six Sigma quality, or fewer than 3.4 defects per million “opportunities.” An opportunity is defined as a “chance for non-conformance” (or put another way not meeting required specifications). So the business must adjust its culture towards accepting a near perfect operation in executing key processes. Such a cultural change will directly contribute towards customer satisfaction and increased productivity.



**Figure 1: Six-Sigma Process with +1.5σ Shift vs. Centered Three-Sigma Process**

### *How six sigma works:*

Let's take a closer look at the difference between three-sigma and six-sigma processes under the assumption of normality, which is critical to the calculations that follow. (The assumption of stability is also critical. Without it, one cannot predict the operation of the

process or state probabilities.) Figure 1 illustrates a three-sigma (centered) process and a six-sigma (+1.5  $\sigma$  shifted) process. Both process distributions appear to be entirely within the product specifications.

We define LSL as lower specification limit and USL as upper specification limit. The target, T, equals  $(USL + LSL)/2$ . For this example, we chose  $T = 0$ ,  $USL = -6$  and  $LSL = +6$  for ease of explanation.

We have traditionally operated at the three-sigma level. Given the specifications, the process variation ( $\sigma$ ) must be small enough so that the base of the normal distribution fits within the specifications, when the mean equals the target. That is, the length from  $\mu - 3\sigma$  to  $\mu + 3\sigma$ , a length of  $6\sigma$ , must be less than  $USL - LSL$ . Hence  $\sigma = (USL - LSL)/6$  is the largest variation allowable. The figure illustrates this situation with a normal distribution where the mean,  $\mu$ , equals 0, and the variation,  $\sigma$ , equals 2. A process operating in this mode will produce 2,700 parts per million (PPM) defectives, with 1,350 PPM beyond each specification limit. And should the process mean shift to  $\mu = \mu \pm 1.5\sigma$  (which would be  $\pm 3$ ), then it would produce 66,807 PPM defectives.

Following the same reasoning as was given for the three-sigma process, a process variation of  $\sigma = 1$  or smaller is required to achieve the six sigma objective [ $\sigma = (USL - LSL)/12$ ]. If the six-sigma process mean were centered on the target value, the process would produce defectives at a rate of two parts per billion (PPB), one PPB beyond each specification limit. Should the process mean shift by 1.5 sigma; the defective rate would increase to 3.4 PPM defectives. The figure illustrates the latter situation, with a normal distribution where the mean,  $\mu$ , equals 1.5, and the variation,  $\sigma$ , equals 1.

Note that every process has a variation that can be estimated through a process capability study. It isn't determined by the specifications of the product being produced. Here we are determining how precise a process must be to accomplish a three- or six-sigma objective for the product. P.R. Tadikamalla showed that the 3.4 PPM rate could be obtained in other ways depending upon the process spread and the process shift.

### **A look at some criticisms**

Despite the evidence that it does work, Six Sigma still has its critics. One of the more common criticisms is that it has little to offer that can't be found elsewhere, that it's simply a marketing ploy. It's true that Six Sigma programs have incorporated tools that have been useful in previous quality initiatives. It also includes some older measures such as defects per unit, representing them in a modern quality context as defects per million opportunities. Although the quality movement has attempted to move from defect measures to a variable measure of product and process performance, the older methods don't necessarily represent a primitive way of thinking about quality. After all, defect and defectives counts provide tangible, measurable results that we can use.

Strangely, another criticism is that Six Sigma doesn't take enough of a preventive, proactive approach to problems, that it's more of an appraisal system or a corrective

action system. There's much more to Six Sigma than appraisal, including the education and training of the entire workforce and the creation of an infrastructure of experts who focus on projects to improve quality, timeliness and cost. Further, this criticism unfairly assumes that appraisal programs aren't useful. In fact, appraisal can be a great starting point--it makes clear the terrible consequences of current practices. Appraisals also provide a foundation for identifying and tracking improvements, which is critical to the well being of any program. Any program director who believes a supervisor who tells him or her to just do a great job and not worry about tracking accomplishments will be out on the street sooner rather than later.

As with appraisals and assessments, prescriptive corrective actions aren't the evil they're made out to be. All organizations reside in some state of operation. How can that situation be improved if it's not assessed, with the assessment followed by corrective actions? Although it may be preferable to design a whole system, all too often that cure ignores the original problems.

Some have made the argument that the success of quality programs, whether they have a corrective or a preventive approach, depends more on the establishment of the right organizational culture than on the program--in other words; no quality program will result in improvement if it can't be internalized. This is one area where Six Sigma truly stands out: Unlike many of the earlier programs, Six Sigma's training system addresses the importance of company wide program buy-in. Indeed, Six Sigma recognizes that cultural issues, including leadership development, are among the most important issues to be addressed in the improvement of any organization.

Leadership is key to the success of any plan that attempts to change the way an organization does business. Without the support, participation and leadership of top- and mid-level management and the development of an appropriate infrastructure, any program is destined to become just another fad or the latest flavor-of-the-month program.

For example, let's imagine that an important component of a system is regularly shipped on schedule for installation in the main system. Each time, following installation, inspectors find that the component, while functional, isn't quite ready for deployment. It's removed from the system, returned back to the supplier, repaired, shipped back, installed and retested. Look at the wasted steps, the costs and the quality losses caused by removal, shipping and reinstallation. Why does this continue? Perhaps the supplier is recording the component as complete when first shipped and receives payment or credit, but no record is kept about the return. This hypothetical situation is commonplace. Six Sigma can facilitate resolution of these situations through its fact-finding approach.

Other criticisms are more technical. Some argue that assuming a process mean to be 1.5 sigma off target is ridiculous. (See "Origin of Six Sigma," page 30, and "How Six Sigma Works," page 32.) Perhaps 1.5 sigma is a bit large, but even more ridiculous is the assumption that one could keep the process mean exactly on target. Furthermore, sigma,

as defined in process capability studies, is the "short-term within sample variability." Thus the 1.5-sigma shift allows for variation of the mean about the target. Any process's long-term variation is often larger than its short-term variation due to other sources of variability introduced by operator, materials and operating conditions. In this setting, the shift serves as a proxy for this variation as reflected in a substantially smaller Cpk than the corresponding Cp.

Another technical criticism is that the normal distribution is just a model and doesn't represent most processes. This is true--but it doesn't mean that a model can't still be useful. The normal distribution is reasonable for many situations. Furthermore, any other realistic process model (log-normal, student's t, normal mixture) will make the case for Six Sigma even more emphatically because they all will predict a much larger probability of producing a product outside the specifications.

### **Six Sigma-Focuses:**

1. Improve processes
  - a) By reducing defects – lower the DPU
  - b) By reducing cycle time
2. customer and his/her CTQ requirements
3. sigma level is a measure to improve
4. defects per million is a beacon
5. measure, analyze and improve
6. can be applied to any process that one is doing

### **Six steps to six sigma:**

Step 1. Identify the product or process to be improved

Step 2. Identify the customer(s) for the product or service and determine their CTQ requirements

Step 3. Identify your needs

Step 4. Define and understand the current product/process

Step 5. Mistake proof process, eliminate wasted effort and reduce defects

Step 6. Implement and ensure continuous improvement by measuring, analyzing and controlling the improved process

## Six Sigma- Terms:

**Unit** - A unit of product or process that is to be improved

**Defect** - Any thing that causes customer dissatisfaction

**CTQ requirements** - Critical to Quality requirements of customer

**Opportunity for error** - Chance of making an error that causes a defect to happen

**DPU** - Defects per unit

**DPMO** - Defects per million opportunities

## Understanding the magnitude of difference...

<b>Sigma</b>	<b>Spelling</b>	<b>Time</b>	
<b>1</b>	1.5 misspelled words per page in a book	3 –1/2 months per century	Floor space of store
<b>2</b>	1 misspelled word per 30 pages in a book	2-1/2 days per century	Floor space of room
<b>3</b>	1 misspelled word in a set of encyclopedia	30 minutes per century	Size of the telephone
<b>4</b>	1 misspelled word in all the books in a small library	6 seconds per century	Size of a typewriter

## Six Sigma

### Methods to lower defects:

Simplify key tasks

Increase training specific to error opportunity points

Provide written work instructions

Create user manuals

Standardize procedures

Create formats

**Methods to minimize cycle time:**

Eliminate activities that do not add value

Eliminate unnecessary or redundant tasks and steps

Eliminate waiting periods and delays

Perform essential tasks more efficiently

Increase usage of available tools

Automate repetitive tasks

**Six Sigma in non-manufacturing areas:**

**Some project examples:**

**Human Resources**

Reducing the training dropout rate

Defect-free organization of training programs

Group insurance claims

Compensation revision process

Cycle Time Reduction in recruitment process

**Operations (Admin, Travel, Facilities, Purchase)**

**Defect free processing of GRN**

Travel - Apartment Booking

Travel – Work Permit processing

Admin - Company Leased Vehicle

- Facilities -
  - 1) House Keeping
  - 2) Communication Process
- Operations - Monthly Report to MT members

**Six Sigma-Calculations:**

**Medical Insurance**

Product (unit)		Claim
Opportunities for error per claim		1
No of defects		12
No of claims (units)		73
DPU	$12/73 =$	0.164
DPMO	$0.164 \times 1,000,000 / 1 =$	164000

**Sigma level is about 2.5**

**Defect Free Training Programs**

Product (unit)		Training Program
Opportunities for error per program		20
No of defects		23
No of programs (units)		141
DPU	$23/141 =$	0.1631
DPMO	$0.1631 \times 1,000,000/20 =$	8155

**Sigma level is about 3.9**

**Training Dropouts**

Product (unit)		Training Program
Opportunities for error per program		20

No of defects (dropouts)			285
No of programs (units)			238
DPU	$285/238$	=	1.20
DPMO	$1.20 \times 1,000,000/20$	=	60000

**Sigma level is about 3.05**

### **Defect free IT Returns**

Product (unit)			IT returns
Opportunities for error per return			28
No of defects			280
No of returns (units)			720
DPU	$280/720$	=	0.39
DPMO	$0.39 \times 1,000,000 / 28$	=	13929

**Sigma level is about 3.7**

### **Peer Reviews**

Process (unit)			Review
Opportunities for error per review			10
No of defects (valid comments)			552
No of reviews (units)			80
DPU	$552/80$	=	6.9
DPMO	$6.9 \times 1,000,000/10$	=	690000

**Sigma level is about 1**



### **Error-free Programs**

Product (unit)	Program
Opportunities for error per program	15
No of defects	465
No of programs (units)	5000
DPU	$465/5000 = 0.093$
DPMO	$0.093 \times 1,000,000 / 15 = 6200$

**Sigma level is about 4**

*Conclusion:*

*“Six Sigma is not mathematics or statistics....it is a way of life”*



