CHAPTER - 6

SIX SIGMA
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Six Sigma is best described as a journey, a journey of business professionals, who are truly committed to improving productivity and profitability. Six Sigma is not a theoretical; it is an active, hand-on practice that gets results. In short, you don’t contemplate Six Sigma; you do it. And doing it has proven to be the fast track to vastly improving the bottom line.

INTRODUCTION

Quality Guru Philip Crosby was one of the first practitioners to focus on preventing defects. While working at Martin-Marietta from 1957 to 1965, he created the concept of zero defects. At the time, the organizations consider the idea of zero defects unrealistic. About 20 years later, Six Sigma set a goal of 99.9997% - just 0.0003% short of zero defects.

The Six Sigma story began in 1980's at Motorola, where it was first developed and proven.

In 1980, reliability engineer Bill Smith concluded that if a product was defective and corrected during production, then other defects were probably being missed and later found by customers. In other words, process failure rates were very much higher than indicated by final product tests. Point?

If products were assembled completely free of defects, they probably wouldn't fail customers later.

This is where Six Sigma took off. Mikel Harry, Ph.D., the founder of the Motorola Six Sigma Research Institute, further refined the methodology, to not only eliminate process waste, but also turn it into growth currency – regardless of the specific type of service, product or market sector. If we go back a little, we come to know that Motorola learned about quality the hard way: by being consistently beaten in the competitive market place.
When a Japanese firm took over a Motorola factory that manufactured television sets in the U.S., they promptly set about drastic changes in the way the factory was operated. Under Japanese Management, the factory was soon producing T.V. Sets with $\frac{1}{20}^{th}$ the number of defects they had produced under Motorola Management. In the late 1970s and early 1980s, the company responded to the competitive pressure by engaging in a publicity campaign decrying unfair competition. Finally, even Motorola's own executives had to admit 'our quality strikes' (Main 1994) and Motorola's CEO at the time, Bob Galvin started the company on the quality pattern and became a business icon largely as a result of what he accomplished in quality at Motorola.

Today Motorola is known worldwide as a quality leader. To accomplish its quality and total customer satisfaction goals, Motorola concentrates on several key operations at initial stage. At the top of the list is 'Six Sigma Quality'. And the rest is the history.

Similarly, in GE, which enjoys the distinction of having the highest marked capitalization of any public company, U.S.$321 billion CEO Jack Welch attributes part of this success to the company's Six Sigma programme. GE expects to reap $5 -10 billion in cost reduction alone from their investment in Six Sigma. These 2 examples undoubtedly state the importance of Six Sigma Methodology.

**Meaning and Definition**

1 A comprehensive and flexible system for achieving, sustaining and maximizing business success, Six Sigma is uniquely driven by close understanding of customers needs, disciplined use of facts, data and statistical analysis and diligent attention to managing, improving and reinvesting business processes.

2 According to Greg Brue – Six Sigma is a problem solving technology that uses human assets, data measurements and statistics to identify the vital
few factors to decrease waste and defects while increasing customer satisfaction, profit and shareholder value.

3 Six Sigma is a statistical concept that measures a process in terms of defects. Achieving Six Sigma means your processes are delivering only 3.4 defects per million opportunities (DPMO). In other words, they are working nearly perfectly.

Sigma (a Greek letter- Σ) is a term in statistics that measures something called standard deviation. In its business use, it indicates defects in the outputs of a process and helps us to understand how far the process deviates from perfection.

Most organizations in U.S. are operating at three to four Sigma quality levels. That means their processes deliver too many defects.

The central idea of Six Sigma Management is that if you can measure the defects in process, you can systematically figure out ways to eliminate them, to approach a quality level of 'zero defects'. Variation helps the management to fully understand the performance of its business and processes. Averages can actually hide the problems by disguising variations.

*Source Greg Brue – Six Sigma for Manufacturers).

SIX SIGMA IS SEVERAL THINGS

A statistical basis of measurement; 3.4 defects per million opportunities.

A philosophy & goal: as perfect as practically possible.

A methodology.

A symbol of quality.

A disciplined extension of TQM.

Probability of defects of different Sigma levels:
Successful Six Sigma organizations are naturally more creative because they incorporate the very things that traditional management works to prevent such as following:

There are multiple employees performing the same jobs – redundancy. This redundancy is essential if people have time to work on process improvement teams and other Six Sigma activities.

The same jobs are done differently by different employees – variation. This built in variability is a natural source of ideas for process improvement. Why does employee ‘A’ get a higher yield than employee ‘B’? Why is process ‘X’ so much better than the supposedly identical process ‘Y’? Major payoffs come from applying powerful statistical techniques to data to discover variation and use it to plan future improvements.

The constant experimenting by people trying to find ways to improve leads to many failures and much waste and inefficiency. Six Sigma

<table>
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<tr>
<th>SIGMA LEVEL (PROCESS CAPA)</th>
<th>DEFECTS PER MILLION OPPORTUNITIES (DPMO)</th>
<th>% OF OUTPUT DEFECT FREE</th>
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<tr>
<td>0.5 Sigma</td>
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<td>6.0 Sigma</td>
<td>3.4</td>
<td>99.9999%</td>
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</table>
experiments, even those conducted under the guidance of Black Belts, often produce unacceptable results. This is how people learn. The organization committed to eliminating waste at any cost will not sacrifice future improvement to short term efficiency.

At Nucor Steel people have a saying “if its worth doing, it is worth doing poorly”. In other words, don’t study an idea to death with experts and committees. Get on with it and see if it works (Iverson 1998). Nucor estimates that about half of the new ideas, their employees’ attempt fail. But the other half succeeds! People who are not experts produce an abundance of quirky designs, designs that sometimes work than the experts believed impossible. And like natural complex adaptive systems, the Six Sigma enterprise rewards the successful, leading to adaptation and higher pay offs for everyone.

**ESSENTIALS OF SIX SIGMA METHODOLOGY**

Six Sigma is predicated on educating and using people to direct and make phenomenal changes and sustain benefits. Everyone has a role in Six Sigma, from executives to line workers. Six Sigma is not a sidelined or occasional quality programme. It is an all out effort involving every single person in the organization in a full time front and center focus on your organization.

Six Sigma uses statistical tools to identify the vital few factors, the factors that matter most for improving the quality of process and generating bottom line results. It consists of 4 to 5 phases-

**Define** – the projects, the goals and deliverability to customers (internal and external).

**Measure** – the current performance of the process.

**Analyze** – and determine the root cause(s) of the defects.

**Improve** – the process to eliminate defects.

**Control** – the performance of the process.
Six Sigma professionals recognize that this approach is a roadmap for improvement and it doesn't matter if it is called DMAIC, MAIC, PCOR (from the Air Academy – prioritize, characterize, optimize and realize), GETS (from GE Transformation Systems – gather, evaluate, transform and sustain). This is set of tools aimed at helping managers and employers understand and improve critical process. (It focuses on few key concepts Defect/Variation, TQ, Process Capability, and Design for Six Sigma.).

FOCUS ON ENGAGING PEOPLE AND CHANGING PROCESSES

The very important thing about Six Sigma is that it doesn’t rely on the latest programme, fad or magic pills to fix organization. It relies on old-fashioned hard work coupled with factual data and a disciplined problem solving approach. It affects every aspect and every level of an organization to transform your people and your processes.

As a first step of that transformation, the Six Sigma considers the people in the organization as assets rather than costs (liabilities).

Once you are thinking in terms of ‘human assets’, it is equally important to realize the underlying monetary value of rooting out wasted materials and steps in processes, as this is a key to unlocking the hidden return or the investment in people.

By changing the way you look at processes, by understanding the vital few factors that cause waste, error, rework, you can improve the ability of processes to deliver higher quality to customers and at lower costs. The vital few factors are that directly explain cause and effect relationship of the process output being measured in relation to the inputs that drive the process. Once they are known, by focusing on them improvement made deliver dramatic results.
CULTURAL CHANGES

To achieve the best level of quality requires not just statistics, but changes in the culture of the organization.

Culture refers to the beliefs, expectations, ways of operating and behaviours that characterize the interactions of the people in any organization. It's about "how things are done around here", in an organization. Culture evolves over a long period of time and it often reflects the beliefs and behaviours of top management. Because Six Sigma affects the ways things are done, its successful implementation will require a change in culture that may be profound.

A Six Sigma approach is rigorous; requiring a deep commitment from the highest level of management that permeates the entire organization. It also requires a sense of urgency – an understanding that, in order to solve the problems that undermine profitability and customer satisfaction.

WHAT SIX SIGMA IS NOT?

Six Sigma is not another quality programme. Quality programmes lay a valuable foundation in creating a quality mindset. But many times a specific financial results are not generated by these programmes like Six Sigma; whereas a primary criteria for selecting Six Sigma projects is to return money to your balance sheet as the result of full time efforts by dedicated resources. The success of Six Sigma is directly linked to monetary outcomes as it generates a real world results. It uses the most readily available resources in an organization – its human assets.

Six Sigma is not a theory. It is a practice of discovering the vital few processes that matter most. It defines, measures, analyzes, improves and controls them to the quality improvement directly to bottom line results.
Six Sigma Myths: There are many myths and misunderstandings about Six Sigma like:

Six Sigma...

.............. works only in manufacturing settings.
.............. doesn't include customer requirements.
.............. is repackaged TQM.
.............. uses difficult to understand statistics.
.............. is just training.
.............. is an accounting game without real savings.
.............. is a "magic pill" with little efforts.

Just remember that Six Sigma actively links people, processes and outcomes in a rigorous, adaptable way to get you the results you are looking for. No matter the industry, business, product or service, as you apply Six Sigma, you will see the tangible results on your projects.

RESULTS/OBJECTIVES OF SIX SIGMA

Benjamin D Israeli has said that ‘the secret of success is constancy of purpose’. Six Sigma allows the organization to achieve the constancy of purpose that is the secret to success, by focusing the organizational efforts on understanding the variations in your processes and the defects that result.

-The basic results are:

1 Money
2 Customer Satisfaction
3 Quality
4 Impact on employees
5 Growth
6 Competitive advantages.
1 MONEY— Money is generally the most important reason for doing Six Sigma. Here it considers the cost of:

1 Scrap
2 Rework
3 Excessive Cycle time & delays: Cycle time refers to the time taking to complete a process from beginning to end, consisting of work time and wait time.
4 Business lost because the customers are not satisfied with product or service.
5 Opportunities lost because time and resources were not provided to take advantage of them.
6 Poor Quality (COPQ) in the organization: Total labor, material and overheads costs attributed to imperfections in the processes that deliver products or services that don’t meet specifications or expectations. These costs include inspection, rework, duplicate work, scrapping rejects replacements and reworks complaints, loss of customers and damage to reputation.

These are costs that would disappear if there were no quality problems. An important goal of Six Sigma management is to reduce or even eliminate the COPQ — which for traditionally managed organizations, has been estimated between 20% to 40% of budget.

2 CUSTOMER SATISFACTION— is the key factor for any organization. It must attract and satisfy and retain customers. Otherwise, it obviously won’t stay in business long. The better it satisfies it customers, the healthier its revenue.

Six Sigma focuses on critical to quality (CTQ) expectations of the customers of the organization, that’s what matters most to the customers. CTQ concept in Six Sigma allows the organization to focus on improving quality from the perspective of the customers. By using Six Sigma Methodology, the company can target the vital few factors in its processes that are allowing variations and defects that keep the company from meeting CTQ expectations of its customers.
Customer Satisfaction is an overworked phrase. But when we break it down in Six Sigma mindset, we refocus on its critical importance.

First a ‘customer’ is a person – not an organization – who buys something from you and with whom you have a relationship. Second ‘satisfaction’ is to be free of doubt, suspicion or uncertainty about a product or a service. The word assumes that the product or service fulfill the customers’ needs and meet certain standards. These standards are defined by the customer – not the organization. If the company doesn’t understand what its customer want, it can waste time and resources making improvements that don’t matter to the customer and miss improvements that customers consider vital.

Mr. Greg Brue, CEO Six Sigma Consultants, Inc, who has implemented Six Sigma Methodology for some of the world’s most recognized companies, has given a very interesting example in this regard.

In one conference in a hotel, he asked participants what they expected in their coffee breaks. The answer ‘lots of good hot coffee’, when he asked hotel banquet staff what they needed to provide beyond coffee the staff was concerned to provide lines, china, attractive displays and extra snacks, of course customers did not want dirty cups but they wanted fast line for refills, restrooms and access to telephones. So here is a bottom line. The hotel is putting time and money into things that matter less to the customers and miss all the things that customer expects.

3 QUALITY - The focus of Six Sigma is essentially on reducing or eliminating mistakes. Quality inspires employees, instills a culture and an attitude, creates an image in the market and the community and attracts investors.

Six Sigma is not just a quality but also a Six Sigma level of quality, which is close to perfect – 99.9997%.
If 99% were good enough, then the goal is not high enough and we would be accepting-
Every hour the postal service would lose 20,000 piece of mail.
Every day our drinking water would be unsafe for almost 15 minutes.
Every week 5000 surgical operations would go wrong in some way.
Every month we would be without electricity for almost 7 hours.

4 IMPACT ON EMPLOYEES - These are benefits of Six Sigma which don’t translate into dollars – at least not directly. The effect on employees can be powerful.

Six Sigma inspires employees, promotes morale and a sense of self esteem, gives them opportunity to make a difference, instills a culture and an attitude, emphasizes the importance of viewing processes, products and services from perspective of the customers, promotes professional development for employees. It helps them to think critically and make them more and more competent.

5 GROWTH - As the company correct process variations, it saves on expenses and invest money in the growth of business. When higher customer satisfaction is achieved, it results into more sale, more income.

6 COMPETITIVE ADVANTAGES - Six Sigma makes company more competitive – regionally, nationally or internationally (globally). A company which gains its customers confidence, earns reputation for quality and foster a culture of dedication and pride will certainly enjoy advantages over its competitors. This can be proved if the gains achieved by companies are checked.

At G.E., Six Sigma added more than $2 billion to the bottom line in 1999 alone.
Motorola saved more than $15 billion in the first 10 years of its Six Sigma effects.
We can expect a return on investment of three to four times the cost of implementing Six Sigma.

To achieve the above, the top leaders of the company must be committed to the Six Sigma process.

‘Commitment’ is a simple often-overlooked term. We should forget the difference between ‘involvement and commitment’. When you are making eggs and bacon, the hen is involved but the pig is committed. What happens to eggs doesn’t affect hen very much but the pig is totally committed to the process as it is going to sacrifice its life to make bacon. Though this analogy may be somewhat silly, it makes point about involvement and commitment. The company leaders need to be more like pig in Six Sigma. They have to give their all. If such is the case, we can say that company is ready for Six Sigma.

SETTING BUSINESS METRICS

William Thomson, Lord Kelvin (1824-1907) said once, ‘when you can measure what are speaking about and express it in numbers, you know something about it. But when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind. It may be beginning of knowledge but you have scarcely, in your thoughts, advanced to the stage of science’.

In short, if we don't have measurements, we cannot make progress because we don’t know where we are. We need a scoreboard and in business the most important scoreboard is profit. When Six Sigma is being implemented, other important measures are COPQ, COGS, COSS, and customers’ satisfaction, net income and of course – defect.

There are certain factors, which are added to or subtracted from a company’s overall profitability. To quantify the effects of these factors, we
need to implement metrics. If we can measure our processes, we can understand them, if we can understand them, we can correct, control and improve them and reduce cost and improve quality.

Business metric is a unit of measurement that provides a way to objectively quantify a process. Any measurement that helps management understands its operations might be business metrics. Number of products completed per hour, % of defects from a process and so on. Business metrics provide data that Six Sigma managers can use to better understand this process and identify target areas for improvement.

The basic steps to be followed in setting metrics-
1 Start with your customers – find CTQ.
2 Establish key, consistent metrics.
3 Define baselines.
4 Benchmark processes.
5 Set goals.

Metrics apply statistical tools to evaluate and quantify the performance of any process. They show the true cost of poor quality and indicate the direct relationship between quality and cost. It should be noted that when quality is increased, cost is reduced, resulting in greater customer satisfaction.

While discovering COPQ, a structured approach is required.
1 Internal failure——- cost resulting from defects found before customer receives the products (scrap, rework, retesting, downtime, reinspection, etc.).

2 External failures – cost resulting from defects found after the customer receives the product or service (warranty charges, complaint adjustment, returned material, damage to reputation, etc.)
3 Appraisal – costs of determining the degree of conformance to quality and requirement.

4 Prevention – costs of minimizing failures and appraisal cost (quality planning, policies, procedure, new design, in process inspection, testing, etc.)

5 Non-value added activities – cost of any steps or processes that don’t add value from the customers’ perspective.

The COPQ usually has a personal side. People who work in an organization that has problems with quality may be affected in various ways, poor morale, conflicts, decreased productivity, increased absenteeism, health problems related to stress burnout and higher turnover. These human consequences add to cost of poor quality.

Metrics must be clear and simple and must yield information quickly so company can improve its processes continuously. Metrics helps company to decide the current status of its performance, i.e. baseline and once the baseline is established; the next in Six Sigma implementation is benchmarking. It allows the company to figure out where you want to go with your processes. Benchmarking is a method of comparing the processes using standard or best practices on a basis. Benchmark may be internal or external. The most Six Sigma initiatives use Benchmark outside the company, which is complicated practice.

It is also necessary to think what capability does the target process demonstrate in the terms of matrix? The process capability refers to a statistical measure of inherent variations for a given event in a stable process. More generally it is the ability of the process to achieve certain results, based on performance testing. Process Capability (CPK) answers the questions, what can your process deliver?

Once you know what you can achieve, you can retain it for sustained productivity and profitability. Six Sigma enables you to know what you can
expect from your people and processes. By maintaining and controlling the performance, the value and purpose of Six Sigma efforts can be kept in the forefront of all your activities, both today and in future. It should be considered as a return on investment with far reaching effects.

SIX SIGMA’S TECHNICAL COMPONENT

As Peter Drucker said whenever you see a successful business, be sure, someone once must have made a courageous decision. Deciding to do Six Sigma is a courageous decision. It takes courage to implement it. The success of Six Sigma relies on the people, who are responsible for implementing it. Dennis Sester, Senior Vice President of Motorola Service has put it very carefully “Six Sigma is not a product you can buy, it is a commitment”!

Although Six Sigma is a new approach to management, it has a strong technical component.

Key players of Six Sigma:

Champion and black belts

\[\downarrow\]

Master Black Belts

Black Belts

\[\downarrow\]

Green Belt

Six Sigma Project

Just a Design for Six Sigma (DFSS) varies from organization to organization, their business operations, their structure and their culture,
the key players and their titles, responsibilities, qualifications roles also vary. The general guide to the key people involved in Six Sigma project is as follows:

**Executive Leader:** To commit and promote Six Sigma in the company. CEO is normally an executive leader. Jack Welch CEO of General Electric is considered as an ideal CEO as he made Six Sigma a “part of genetic code” of the company.

**Champion** – is a leader of the project. They own the process. He is higher-level manager. He selects projects, resources, and barriers and suggests black belt. He is familiar with statistics.

**Master Black Belt** – serves as an inventory trainer and guide. He provides technical leadership. He is an expert in Six Sigma Tools and tactics.

**Black Belts** – work full time on the project. Generally each works on 4 to 6 projects every year. A rule of thumb is to have 1 to 3 Black Belts for every 100 employees in the organization. They are the ones who move theory into action. They also coach team members, manage risks, break through barriers and keep the project scorecard. In Nashik companies, Black belts are working successfully on 3 to 4 projects at a time.

**Green Belts** – Green Belts assist Black Belts in the project. They work on the project part time. They have enough understanding of Design for Six Sigma.

**IMPLEMENTING SIX SIGMA**

Six Sigma can be implemented successfully, only when certain ‘DOs’ and ‘Don’ts’ are kept in mind.

‘Dos’

Do keep the focus on results.

Do embrace customers – keep in mind CTQ expectations of customers.

Do plan for success.
Do communicate the commitments company wide.
Do demonstrate the commitment to company leaders.
Do empower key human resources – selection of right people for Six Sigma be made.
Do provide on site mentioning for black belts.
Do be patient.
Do claim advertise early ‘wins’ to keep the teams’ enthusiasm high.
Do benchmark.
Do think of calculating real savings with hard dollars (tangible saving – exact quantifiable cost saving, such as reduced inventory, hours, etc.) and soft dollars (intangible savings – not increasing hours, inventory).

‘Don’ts’
Don’t make Six Sigma a massive training exercise and don’t train many at one time.
Don’t focus resources on training material.
Don’t skip steps.
Don’t be afraid to lean and use statistical tools.

After keeping in mind all ‘DOs’ and ‘Don’ts’ properly company can plan for Sigma project. At this stage, it is necessary for a company to know where it stands in term of its Six Sigma readiness. There is a checklist, which helps the company to quickly assess its readiness.

If the company can answer the following questions, it may be ready on the Six Sigma Journey:

- Can you list your customers’ top 4 expectations?
- Can you quantify your customers’ current level of satisfaction?
- How many major repetitive processes are in your business? How many times you do these processes per year?
- What is the cycle time, % of defect yield of major processes presently?
- Do you have required data of the processes?
Can it be trusted? Is it accurate and precise? If yes, what are the results of the test? What is the % of R & R (repeatable and reproducible). 
Do you know what are the vital few factors to decide the quality problems?
Can you calculate (a) result equation of process? (b) Financial result of the project?
How does your company transfer knowledge?
What are the goals that have been met by your company last two years?

If you understand and answer the questions, you are ready for Six Sigma Project. Proper planning, communication and education, identification of projects and developing infrastructure are the important stages of foundation of Six Sigma. There are ‘outside partners’ who can help the company to start Six Sigma project. The outside consultants are selected only taking into note of his actual performance or the results given; after all, that’s what Six Sigma is all about.

THE CORE OF SIX SIGMA (THE DMAIC METHOD)

Define phase – The Six Sigma should start with clearly defining the problem:
A Identify the problems in your processes.

B Select a problem to combat one or more of the problems and define the parameters of the projects.

C Determine the vital few factors to be measured, analyzed, improved and controlled.

Measure Phase:
D Select CTQ (critical to cost) quality characteristic (s) in the product or process, e.g. (TQY)

E Define performance standards for ‘Y’.
F Validate measurement system for 'Y'.

G Establish process capability creating 'Y'.

Y = f (x). Y is the outcome of process; it is a function of X's, the key variables (the vital few factors) in a process. Y is the characteristic of quality you are trying to achieve.

By identifying the X's, you can measure, analyze, improve and control them to achieve optimal results in the shortest time. By funneling all process elements through this equation, you will get the vital few factors, that best predict the outcome. Once you have a predictable outcome, charges can be made to reduce the costs. The equation let the organization identify what it did not know – and that’s the power of Six Sigma knowledge into practice.

A measure phase is completed when a black belt can successfully measure the defects generated by a key process that affects the CTQ characteristic. At this stage a black belt conducts gauge studies. The purpose of gauge (or gage) repeatability and reproducibility study (gauge R & R) is to ensure that your measurement systems are statistically sound. A gauge R & R measures how you are measuring. It alerts you to any discrepancy within defined measurement so that it can be corrected at the beginning of the projects. It also validates that the metrics will not only make good sense but will get the requirement information to reduce or eliminate defects.

The measure phase is all about mapping the process, evaluating the measurement system, using matrices and estimating the process baseline capability. It is truly complete when black belts identify the vital few factors X's, demonstrate the capability of process and establish valid measurement system.

**Analyze Phase:**
H Define improvement objectives for Y.
I Identify variation sources in Y.
J Screen potential courses for change in Y and identify vital few factors.

At this stage, the black belts team will ask, which inputs are affecting the outputs? At this stage the black belts have probably come to some assumptions about your business metrics and the inputs affecting it. So hypothesis can be formulated and statistically tested to determine which factors are critical to the outcome. While doing this continuous transforming in a statistical sense is needed.

**Improve Phase:**

K Discover relationship among vital few factors X's.
L Establish operating tolerances on the vital few X's
M Validate measurement system for X's.

At this stage actual testing of theory to find an equation to solve the problem is done. At this stage each variable can be modified so that it stays within acceptable range. It is possible as key variables and their effect on CTQ is confirmed.

**Control Phase:**

N Determine ability to control vital few factors.
O Implement process control system on vital few factors X's.

All this stage the changes made in X's in the equation in order to sustain the improvement in the resulting Y's is maintained. Sometimes control phase doesn't exist as the problem is eliminated entirely. Otherwise documenting and monitoring processes is continued.
But it is observed that if control phase is not followed by the company doing Six Sigma, it faces regression.

By following the logical sequence of DMAIC, a higher level of quality and productivity can be maintained.

**TOOLS OF SIX SIGMA**

The overall Six Sigma Methodology is implemented by using a specific set of statistical tools throughout each phase.

It is exciting, challenging and ultimately rewarding as the project team uses Six Sigma tools to return unfold dollars to the bottom line.

1 **Basic Statistics:** 1) Basic Statistics – mean mode, media, 2) Graphical Analysis – Histogram, 3) Range, 4) Variance, 5) Standard Deviation, 6) Run Chart or Line Chart and 7) Co-relation studies.

2 **Process making:** Flow-chart of the steps in the process operations, delays, and movements, rework loops and control or inspections. A process map is an illustrated description of how a process works. It helps to control the change + makes the team alert for variation.

3 **XY Metric/House of Quality (HOQ):** This tool is used to link customers CTQ requirement to process input, to ensure to have high set of priorities. In the process improvement activities, how? By brainstorming through highly structured approach and by cause and effect diagram (already discussed).

List of inputs is compared with outputs that are really important for the customers. The purpose of XY Matrix is to study and understand the relationship between the inputs (what is put in) and outputs (what customer get).
4 Measurement System Analysis (MSA): undertaken during Measure Phase, MSA determines whether or not you can take a certain measurement and repeat or reproduce it among different people, who take the same measurement.

Within a MSA tool, there is another tool called as Gauge R & R study (discussed in Measure Phase).

5 Process Capability Tool: At the end of Measure Phase, in DMAIC/MAIC, the last tool, process capability is very important. It is a measure of a process being able to meet specification requirement and fulfill customer CTQ needs on a long-term basis.

Through a series of steps, process capability analysis establishes short & long term deviation pattern and baseline performance of each process. The tools determine whether or not the process is performing within the specifications, show you how to decrease variation and help to chart the direction, necessary to reach optimum, statistically proven capability. When process capability is understood properly, it can be controlled. Pareto Chart can be used in a process, helps to focus on a few important factors. It also helps to select proper Six Sigma project.

6 Multivariate Study: In ‘Analyze stage’, the use of this tool is made. It is an analysis that offers a way to reduce possible causes of variation in a process to a family of related causes, by graphing the interrelationship of multiple variables. The multivariate chart presents an analysis of process variation by differentiating three main sources-
Infra – piece (Variation within a piece or batch or a lot)
Inter piece (additional variation from piece to piece).
Temporal (variation related to time).
7 Hypothesis Testing: During ‘Analyze Phase’, this tool is used. It is actually an approach – procedure for making rational decisions about possible causes of a given effect.

Through measuring process attributes and capabilities and identifying variables that may affect CTQs, some assumptions or hypothesis are developed about the key process; key variables and areas to target for improvement. Now through logical sequence of steps, hypothesis testing defines the problem, statistically tests data assumptions, selects samples and determines whether or not the probability of defect is caused by a random chance or has more tangible cause hidden in the process.

8 Failure Mode Effect Analysis (FMEA): During Analyze Phase, FMEA takes place. It is a disciplined procedure that allows you to anticipate failures, identify them and prevent them. Simply put, failure modes prevent defects. FMEA process asks for the cause of a defect, its effect and the probability of the defect occurring. It assesses the defects and their relative risks in a structured format. It assesses the severity and urgency of the defects. FMEA can be used to correct each and every failure mode.

9 Anticipatory Failure Determination: (AFD) (a trademark of Ideation International). It is a failure analysis method. It can be used to identify and minimize potential failures in the design of the product and also in the process. But unlike FMEA, which is used to look for a cause of a failure mode, Anticipatory Failure Determination (AFD) is used to reverse the problem and review a failure as something intended and the team tries to devise ways to ensure that failure always happens reliably. AFD offers an advantage over FMEA for more complex failure analysis. FMEA works because team members identify failures and their root causes through personal experience or the knowledge of others. But in case of complications, people tend to resist thinking about unpleasant possibilities unless they have experienced them – and even then, they may be reluctant to identify or document these problems. AFD by reversing the
problem overcomes this psychological issue and opens up the analysis of failures.

9 Monte Carlo Simulation: is a statistical method used in Analyze Phase that estimates possible outcomes from a set of random variables by simulating a process a large number of times and observing the outcomes, which represents a distribution of likely results. This tool provides a long-term data to get the team a clear picture of how process performance will vary over the long term.

10 Design of Experiments (DOE): It is a way of determining and measuring the importance of two or more factors on the outcome of process, by experimenting with many factors and variables simultaneously. It is used in Improve Phase. At this point the data is assembled and implications of the defined failure mode are understood. It is time to start correcting the problems.

DOE helps to identify and quantify the effect of X's on the Y's. It helps to determine which inputs are significant in affecting output of the process. It helps to gain the knowledge of processes and understand them better. Through DOE many factors are simultaneously experimented. In traditional approach in 5 interacting factors are to be studied, it would require $2^5 = 32$ experiments to explore all potential interactions among the five factors. It also takes a lot of time and money. As the number of factors rises, the cost also increases.

DOE allows identifying smaller number of experiments that can measure the interaction more efficiently. Typically designed DOE requires 8 runs to build empirical model to predict process behaviour based the results for the values of these factors.

11 The Scatter Diagram: The Six Sigma team can validate the data through a scatter diagram: The Scatter Diagram takes an idea about root
causation and tracks corresponding data in the response the team is trying to improve.

**Graph 6.1 Correlation**

Co-relation refers to the degree to which two variables are related, measured in terms of co-relation, co-efficient (1 and -1).

For e.g.: In positive co-relation, if we track, attendance of the students and their performance, we see if the two variables having perfect linear relationship with positive slop; the co-relation co-efficient is 1; whenever one variable has a high value or a low value so does the other.
In Negative Co-relation, the two variables have a perfect linear relationship with negative slope, the co-relation co-efficient is -1; one variable has a high value, the other has a low value. As the number of students increases time spent for each student reduces.

A co-relation co-efficient is 0 means variables have no linear relationship.

12 Control Plan: Control plan is a tool used in 'Control Phase'. It provides a written description of the system to control parts and processes. It improves a quality by doing a thorough evaluation of process, characteristics and variation sources.

Control Plan is a detailed assessment and guide for maintaining all positive changes the project team has made.

For Six Sigma to work, the process must be in control. Control Chart helps to state whether the process is under control or not. It indicates the range of variability that is built into a process. It helps to determine whether or not a process is operating consistently or any special cause, which is unpredictable and not due to normal causes, is occurred to change the process mean or variance.

13 Pokayoke can be useful tool in Six Sigma (Discussed in UNIDO).

14 The process summary worksheet. The goal of Six Sigma project is to improve effectiveness and efficiency. Efficiency measured in terms of cost, time, labour and value.

The process summary worksheet is a 'roll-up' of the sub process map indicating which steps add value in the process and which steps don’t add value. Moreover, each of the non-value added steps is categorized for the type of non-value added activity.

The following are the most common types of non-value added activities:
1 Moves – where the product/service is moved from one place to another.
2 Delays – where the product/service is waiting for the next step in the process.
3 Set up – that prepares the product/service for the future steps.
4 Internal failures – steps that have to be done.
5 External failures – steps where the customer detects a failure.
6 Control inspection – steps where product/service is reviewed to ensure customer satisfaction.
7 Value enabling – steps which technically don’t add value but are necessary for the functioning of the organization.

When (1) the customer of the step in process consider step important (2) when there is physical change in product/service (3) when it is done right the first time, then the step is value added step.

Table 6.2 PROCESS SUMMARY ANALYSIS WORKSHEET

<table>
<thead>
<tr>
<th>Process steps</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Total Minutes</th>
<th>%age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (Minutes)</td>
<td>1</td>
<td>20</td>
<td>15</td>
<td>45</td>
<td>10</td>
<td>15</td>
<td>106</td>
<td>100</td>
</tr>
<tr>
<td>Value added</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>16</td>
<td>16</td>
<td>15.1</td>
<td></td>
</tr>
<tr>
<td>Non-value added</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>90</td>
<td>84.9</td>
</tr>
<tr>
<td>Internal Failures</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>25</td>
<td>23.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Failures</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td>18.9</td>
<td></td>
</tr>
<tr>
<td>Control Inspection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45</td>
<td>42.5</td>
<td></td>
</tr>
<tr>
<td>Set up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Moves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Value enabling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

In the above example, most of the steps don’t add value and over 40% of the non-value added steps are due to delay.

If the goal of the project team is to improve cycle time of the process, the percent column could be time, not frequency as shown in the above figure.

Once the process summary analysis worksheet has been completed, create a micro problem statement about the most frequently occurring
non-value added steps, for e.g. from the above figure, we would create a micro problem statement, such as 'why is there so much time in step 4 (the delay)?'

15 The Affinity Diagram – It is used to help, sort and categorize a large number of ideas into major themes or categories. It is especially useful when the team is ready to brainstorm solutions in the Improve Stage of DMAIC.

SELECTING SIX SIGMA PROJECT

There are two important criteria for a successful project; the efforts required and the probability of success.

First before starting the project, the Six Sigma Team must have good understanding of the duration of the project in relation to the return on investment. The efforts of the team need to be evaluated in terms of resources deployed and the time to produce the results.

Second the probability of success must be considered, considering the risk associated with the project.

Priority should be given to projects that address one or more factors that are customers' expectation of quality, cost and delivery.

COPQ is the criterion by which potential projects can be judged. The projects must define cost savings attached to them. That is the only mark of successful Six Sigma Project.

Project selection should reflect the major issues confronting the business. Any business has three main elements associated with it, sales, profits, and costs. The projects are designed to attack and reduce or even eliminate costs.
When the suspected sources of issues affecting CTQ are identified and prioritized, it is necessary to identify the ‘owners’ of the suspected sources.

Creating a good project statement is one of the hardest things to do in Six Sigma. The statement must be quantifiable and specific. Through this everyone understands what the problem is and what the benefit will be once the problem is solved. For e.g. a good problem statement reads like “product returns are 5% of sales, resulting in a profit impact of $2 million”. On the other hand poor problem statement reads like, “our product return levels are too high due to product A” and will be reduced by analyzing first and second level Pareto chart. Also project objective must be clear which will tell what the team is going to do to change the process? The period to do so, estimated money saving, etc.

Then with the help of Pareto, problem is selected. ‘Pareto’ is discussed in detail in Quality Circle. Pareto charts separate factors and chart them in descending order from most troublesome to least.

There are numerous issues and challenges involved in selecting projects – when top down approach of Six Sigma is taken and strategic objective and customer expectations are addressed, Six Sigma team can get to the operational factors that have the greatest impact. If average Six Sigma project returns a minimum of $175000 to the bottom line, the benefits of implementing this disciplined, data driven methodology speak for itself. As Automobile giant Henry Ford said, highest quality, lowest cost projects delivered by well paid employees is the single most important business rule of all – and it is a rule that will yield continual results. The Six Sigma bottom line is to make sure that this bottom line continues to grow – to return hidden revenue to the balance sheet and boost the productivity at every level.

What is essential of Six Sigma Success is dedicated well trained black belt teams and support structure that rewarded and championed their efforts in
every way possible to get the results they needed. Looking into the future, the goal is to get the maximum return on Six Sigma investment by spreading it throughout the company, continuing black belt population and sustaining gains the company achieve by keeping it going. But there is another dimension to consider. While the principles of Six Sigma remains constant, there is an evolution of its message that can take companies in exciting new dimension known as Design for Six Sigma (DFSS), to carry improvement into the development and design of new product. DFSS is not different from Six Sigma. In fact, it is a natural progression to continually and relentlessly root out defects and route widen dollars to the bottom line.

**Six Sigma for the little guy**

*Six Sigma and Small and Medium Sized Enterprises (SME's)*

Although six sigma programs have delivered billions of dollars of profit to large enterprises, they've done nothing for small to midsize companies. The original Six Sigma architects didn't design their delivery systems for businesses of that size.

But the business initiative programme continues to grow and change, and many small companies can now afford to implement the most recent iteration of Six Sigma, called Generation III. In fact, the very drivers of Six Sigma Generation III are small to midsize companies that need to improve their performance and profitability. The program is now more affordable for them because advances in online training technology and a new, smaller-scale training option help reduce training expenses.
Evolution of Six Sigma from Generation I to Generation III

<table>
<thead>
<tr>
<th>Generation I</th>
<th>Generation II</th>
<th>Generation III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focuses on defect.</td>
<td>Focuses on cost.</td>
<td>Focuses on value.</td>
</tr>
<tr>
<td>Emphasizes provider</td>
<td>Emphasizes customer.</td>
<td>Emphasizes both customer and provider.</td>
</tr>
<tr>
<td>Used in large-scale industrial organizations</td>
<td>Used in large-scale industrial and commercial businesses.</td>
<td>Used in small, medium and large-scale industrial and commercial businesses.</td>
</tr>
<tr>
<td>Black Belts</td>
<td>Green Belts</td>
<td>White Belts</td>
</tr>
</tbody>
</table>

Over the past 20 years, Six Sigma has moved its focus from reducing costs to creating value. The first iteration of Six Sigma was concerned mainly with reducing defects; its second iteration was concerned with reducing costs. The latest iteration, Six Sigma Generation III, aims to help companies deliver goods and services of the highest value possible. For business purposes, value is defined as delivering a product or service to the right spot, at the right time, in the correct volume, and at the lowest possible cost.

A key change in Six Sigma Generation III's professional designations makes the program more affordable for smaller businesses. The operational roles for these Six Sigma professionals—who carry out programs for companies—are referred to as X-belts, such as green belt or black belt. The high cost of training a black belt in an actual classroom and the relatively long wait for a return on investment makes the black belt cost-prohibitive for those without the deep pockets of a multinational company. Even a green belt can be expensive to train in a traditional classroom situation.

But with the introduction of Six Sigma Generation III, a new belt was created—the white belt—that requires far less training and offers a much
quicker return on investment. The white belt professional has a much
closer focus than the black belt professional; he or she might look
closely at a work cell within an organization rather than at the organization
as a whole, for example. A person with a white belt could complete up to
12 projects each year with the potential of returning $25,000 from each
project to the employer's bottom line.

A group of well-placed white belts can return significant savings to the
profit column of a small business. In a multinational company, a high
percentage of the work force can be trained as white belts. Through the
skills of those with white-belt training, Six Sigma can be extended into
previously inaccessible areas throughout every aspect of the business.

**Six Sigma Generation III online training**

Another way Six Sigma Generation III makes the business initiative
program more affordable—in addition to creating the white belt
professional—is through online training, which cuts the cost of training by
a factor of 10 or more as compared to traditional classroom instruction.

Although the classroom or the onsite training and materials are expensive,
it's the huge cost of employees' lost production time and travel that puts
Six Sigma out of reach for small to midsize companies. Small businesses
don't have the reserves to take employees out of production for four to six
weeks of training. The Internet and its attendant technologies have made
online training as effective as classroom training, and online training can
be done regardless of the belt one seeks.

When online training first appeared in the early 1990s, the Internet
technologies then available didn't allow for the depth of training students
received in an actual classroom. Today, technologies allow online students
and teachers to develop and present curriculum that is as effective as
classroom training. This has substantially cut the cost of training and lets
small, midsize, and large companies take advantage of Six Sigma. In fact, anyone who wants to improve skills and earning potential can take the online classes.

**Six Sigma Return on Investment (ROI) for SME's**

In Six Sigma Generation II, the key operational roles of professionals are referred to as X-BELTS, such as GREEN or BLACK BELT. However, the high cost of training a BLACK BELT in a brick & mortar classroom and longer ROI makes it cost-prohibitive without the deep pockets of a multinational company. Even a GREEN BELT can be expensive to train in a brick & mortar classroom situation. However, not all processes require a BLACK or GREEN BELT. With the introduction of Six Sigma Generation III, a new belt was created, the WHITE BELT. It requires far less training and ROI is much faster. For example, a WHITE BELT can do up to 12 projects a year with the potential of returning $25,000 per project to their employer's bottom line.

The key operational roles of Six Sigma professionals are referred to as X-belts, specifically white, green, or black belt. The tabulated quantities are normative in nature.
<table>
<thead>
<tr>
<th>BLACK BELTS</th>
<th>BLACK BELTS</th>
<th>WHITE BELTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation I</td>
<td>Generation II</td>
<td>Generation III</td>
</tr>
<tr>
<td>160 hours training.</td>
<td>80 hours training.</td>
<td>40 hours training.</td>
</tr>
<tr>
<td>Large line of sight cuts across geographic regions, divisional boundaries, and product lines.</td>
<td>Typical line of sight would be within the green belt's division.</td>
<td>Individual focus and local problem-solving team focus.</td>
</tr>
<tr>
<td>Relies on statistics and probability.</td>
<td>Utilizes many of the black belt tools, but with an industry-specific focus.</td>
<td>Less reliant on statistics, more reliant on the equivalent graphical approach.</td>
</tr>
<tr>
<td>Understands the theory and can generalize in many different situations.</td>
<td>Understands the theory and can apply within the &quot;line of sight.&quot;</td>
<td>Understands how to apply to an individual and localized process.</td>
</tr>
<tr>
<td>$300,000 savings per black belt project.</td>
<td>$100,000 savings per black belt project.</td>
<td>$25,000 savings per white belt project.</td>
</tr>
<tr>
<td>4 projects per year.</td>
<td>8 projects per year.</td>
<td>12 projects per year.</td>
</tr>
<tr>
<td>$1.2 million savings a year per black belt.</td>
<td>$800,000 savings a year per green belt.</td>
<td>$300,000 savings a year per white belt.</td>
</tr>
</tbody>
</table>

The white belt has a much narrower focus, such as a work cell, but a group of well-placed WHITE BELTS can return significant amounts of savings to the profit column in a small business. In a multinational company, a high percentage of the work force can be trained as WHITE BELTS. Through WHITE BELTS, Six Sigma can be extended into previously inaccessible areas in every aspect of the business - every day.

Ultimately, all companies, whether big or small, will need Six Sigma to improve their profitability. These companies will drive the new, affordable
generation of this business initiative. Six Sigma professionals seeking to improve their career opportunities have never been in a better place to do so.

Six Sigma Deployment Plan for SME's

The deployment of Six Sigma into large organizations has been quite well developed over the past 10 years. These large corporations have the resources to launch full-scale into major change programs.

Small and Medium Sized Enterprises (SMEs) have unique constraints that limit their ability to initiate a large scale Six Sigma implementation:

- SMEs can't afford to have full-time Master Black Belt. For large corporations, there is typically one Master Black Belt for every 1,000 employees. For SMEs that range in size from 25 to 500 employees, that would work out to only a fraction of a Master Black Belt. It doesn't make sense to have a highly qualified Master Black Belt who would only be needed for a fraction of their time.
- SMEs don't have large reserves of excess cash to earmark for the massive training programs employed by the large corporations in implementing their Six Sigma programs
- SMEs don't have the personnel with the skills and expertise to step into the role of Black Belts without extensive training

To overcome these limitations, Process Quality Associates (PQA) has developed a Six Sigma Deployment Plan for SMEs. The highlights of this Deployment Plan are:

1. PQA will act as your Black Belt for the initial projects until you have generated sufficient savings to be able to provide some of those savings for training your own Green Belts and black belt(s). Your Six Sigma implementation is self-funding. As it generates more and more savings, you can increase the scope and velocity of its implementation.
2. PQA acts as your Master Black Belt. When you need guidance in any area of your Six Sigma implementation, and particularly when you need to conduct complicated design of experiments or other sophisticated statistical techniques, you call on us. The majority of improvement projects can to perform using less sophisticated statistical techniques.

3. Your senior management team becomes directly involved in developing, implementing and monitoring the Six Sigma program.

**Lean Six Sigma**

As we all know, Six Sigma is one of the most widely used quality improvement methods available today. A LEAN is a discipline that focuses on process spread and efficiency. It uses data to identify and eliminate process problems. It establishes a whole new set of roles and procedure inside an organization that work to continuously generate results. Lean Six Sigma lives within the broader framework of meeting a Company’s goals and Customers needs. It helps Companies flourish in a new world where Customer expects high quality and fast delivery at minimal coast. Many Companies have tried other improvement efforts in the past only to see them fail. So it is not skeptical about Lean Six Sigma. But even if the worst happens and ultimately the efforts go nowhere, the kind of training and education offered through Lean Six Sigma can only enhance your job Skills.

The Second best argument for getting involved in Lean Six Sigma is that the upside is enormous. By using Lean Six Sigma is your work area you can------

1. Help you company become more profitable.

   - Grow revenue
   - Cut costs
   - Improve delivery time
Reduce inventory
Increase Customer satisfaction

2. Develop valuable job skills such as

- Decision making
- Problem solving
- Team work

3. Make your own job and workplace work better

- Get rid of lot of waste, which will save your time and make you work more meaningful.

The Keys to Lean Six Sigma

KEY 1 DELIGHT CUSTOMER

Delight your Customers with speed and quality. Nowadays a new attitude that only Customer can define quality is widely accepted. They are the people who compare your product with your competitors’ and decide whether to spend money on your product. In a hotel business ‘quality’ to some customers will mean five star hotel and to others it will mean a low priced motel that is clean and close to highway. In manufacturing it might mean having goods delivered twice a week in small batches or meeting very narrow specifications. Thus it all depends on what the customers want.

Again it is not just the external Customers. You have internal Customers too to whom you hand off your work.
In Six Sigma often the term Voice of Customer, [VOC] is used to indicate that opinions and needs of customers are being represented in decisions about product or service.

There are VOC techniques that help companies live up to the ideal of meeting or exceeding customer needs. Whatever techniques you use, the biggest obstacle is developing the awareness.

**The Goal:**

Lean Six Sigma starts with Customers, its goal is clear. The goal to eliminate defects. In Lean Six Sigma the things that don’t meet customers needs are called defects

So one of the challenges in Lean Six Sigma is defining and measuring defects and for that the thing to keep in mind is what aspects of product and service are most important to the customers. Also checking on consistency in the product, service or processes is very important.

**The link between quality, speed and cost**

When the customer orders the product he wants the delivery of it as quickly as possible and on time [speed], with no errors [high quality] and at lowest possible price [low cost].

It is necessary to note that any of these goals cannot be achieved without doing all of them at the same time. If a process makes lots of errors it cannot keep up its speed. So high quality makes it possible to attain fast speed. For that things that create process speed are to be done, [eliminating delays] if highest levels of quality is to be achieved.

Again highest speed and quality reduce the inventory resulting into lower cost.

It is because of these links that Lean Six Sigma offers advantages over other improvement methods. Six Sigma method focuses on quality than speed where as; Lean’ methods are better at improving process flow and speed than on improving quality Combining the two is what makes Lean Six Sigma such a powerful improvement tool.
Focus on Customers

Developing a focus on Customers means a lot more than just doing a survey now and then. It means developing awareness that customer needs should shape most of the work we do every day.

We should all make conscious efforts to make what we are doing against our customers want. We need to know what they would define as quality work, what they would see as ‘defects’ and so on.

Key 2 Improve your process

Once you understand your customers the next step is figuring out the way to get better at delivering what they want. The answer lies in improving the processes your company uses to generate the services and products you sell.

Dr. W. Edwards Deming, an American Statistician who led the quality improvement in Japan and later in America spent much of his time trying to convince people that most quality problems are in 'the process not the person.' He promoted his 85/15 rule based on his experience that 85% of the problems were ‘built into’ the way the work was done [and hence under the control of management]. Only 15% of the problems he said were really the fault of individual employees. In the last few years of his life Dr. Deming admitted his 85/15 ratio was probably wrong. More than likely he said it is 96% of problems that are built into work system. Individual employees he concluded could only control perhaps 4%.

So it is utmost important that if you want to improve quality, you have to change the way work is done. That is why Lean Six Sigma focuses on process improvement.

When we talk about process improvement, there is a great deal of emphasis on

1. Documenting how work gets done
The steps that comprises the process
2 Examining the flow of work between people or workstations.
3 Giving people the knowledge and methods they need to constantly improve that work. Almost all the process improvement methods serve one of two purposes:

1. To eliminate variation in quality and speed. [a major source of defects.]
2. To improve process flow and speed.

1. Eliminate variation. When we think of variation it is important that the way, in which variation takes place, the pattern in the variation can expose the cause of problems and point the way towards solutions.

We take the same chart and add lines to indicate what the customers want [their ideal target] and what they will find acceptable figure 3. 2. In the top chart there is a lot of variation means a lot of defects and disappoint a lot of people whereas bottom chart shows a process that operates with very little variation means a lot of defects and disappoint a lot of people whereas bottom chart shows a process that operates with very little variations.

All the sigma levels over four are up in the 99% yield range. It gets harder and harder to make improvement in yield the better a process operates. In other words it is relatively easy to make improvements in a bad process sigma [1 or 2] but difficult to improve a process that is already working fairly well.

Though variation is one of the most common sources of problems, another source should be taken note of. That’s how the work flows through the process, the hand offs from one person or workstation to another, the physical path that the work follows in an office or on the factory floor.
Process improvement is the only way to improve the results that your company wants to improve. For that you need to become a process thinker.

**Key 3 WORKS TOGETHER FOR MAXIMUM GAINS**

Work Together for maximum gains doesn’t just mean having formal teams for making improvements. There is a feeling of ‘we’ are all in this together. Information including bad news is shared openly. It sounds too good to be true but organization who have encouraged teamwork have reaped the benefits.

The skills of collaboration - for effective collaboration or a team work it is necessary that the employees need to be trained in specific skills such as listening skills and brainstorming and discussion techniques organizing ideas and decision-making.

In addition to the above-mentioned skills, the employees need to be trained in the following to avoid waste of time.

A Set goals  
B Assign accountability  
C Handle conflicts  
D Pay attention to how decisions are made  
E Have effective meeting  
F Foster continuous learning  
G Collaborate with other groups.

**Key 4 Base Decisions on Data and Facts**

There are many good reasons why data and facts are true foundation of Lean Six Sigma. The Importance can be understood well from the following case study.
When the utilities in one State were de-regulated, one company suffered a great deal of ‘Churn’ losing Customers about as fast as it gained new ones.

The Customer Service Staff noticed that new customers came on the board and then they changed their minds and switched to different company. So they assumed that new customer turnover was the reason behind this Churn. The service staff therefore began focusing on how to keep new customers from switching. They developed new welcome pack at a cost of 8 US $ explaining their services and benefits.

At one point, however a Lean Six Sigma team collected data on Churn and found that new Customers accounted for only 4 % and other 96 % were long-term customers who were switching.

The company was spending thousands of dollars to solve only 4% of the problems. So they directed their marketing efforts to try to keep the customers they had for some time.

This Company’s experience is common. Having data can make a huge difference in the decisions we make everyday on the job. and particularly important in improvement projects. However there are many roadblocks in learning a data habits.

1. A lack of available data People working on early Lean Six Sigma projects are often starting from a scratch when they begin to collect data. How many customers are happy with your products or services? What is the error rate of the group working on average? The answers to these questions anyone hardly knows.

2. Little training in collecting data is required. What data is to collect? How to measure it? Is it that everyone collecting data will do it in the same way? There is lot to learn.
3 Data to make decisions about improvement. Many organizations have used data to punish or reward people like Did you meet your Sales Quota? No? Then your pay will suffer.

But in Lean Six Sigma data is collected to monitor the process performance and even after improvement you will collect the data to know how well your process is doing.

The data falls under 2 categories - result measures and process measures. Both are important. [Final score of football game is ‘result’ measure whereas hits, kicks, walks are all ‘process’ measures.] We need both, as we have to keep track of final result.

We need to measure
1 Customer satisfaction [result measure]
2 Financial outcomes [result measure]
3 Speed / Lead time [result / process]

If the speed of the process is measured at the end - it is result measure, if measured an individual step, it is process measure.
4 Quality/ Defects [result/ process measure] Quality can be a result measure if data is collected on the final product / service But most teams also use it as process measure. Collecting data on what happens within the process skipping the data collection step is NOT an OPTION in the organization that are really serious about Lean Six Sigma.

It is a hard habit to learn because we are so used to not collecting data. Before taking any decision we have to retrain ourselves to pause and think whether there is any data we could look at or whether there is need to collect new data? Learning to ask simple question 'what does the data tell us' will make a huge difference in your improvement efforts.
Implementing Lean Six Sigma.

Lean Six Sigma cannot be done by everyone involved having an other full time job and responsibilities. So companies usually have some people who work on improvement efforts 100 % of their time.

Linking Lean Six Sigma to business priorities

They also face the problems such as _

1 Projects didn’t address important business problems.

2 The people working on Lean Six Sigma became quality commandos, looking down on anyone who was not involved in improvement full time.

3 There was little or no monitoring of projects. So a lot of teams spent a lot of time doing things they were not increasing profits or lowering costs.

These problems are so common that Lean Six Sigma incorporates ways to avoid them. Above all Lean Six Sigma encourages the mentality that improvement is something that should be done to support business goals, not something done instead of ‘real work.’

To have any chance of success, implementation of Lean Six Sigma must be accompanied by new position, new training and new ways for different layers of the organization to communicate. This new infrastructure helps the companies to translate their investment in Lean six sigma into measurable results to the organization and its customers.

The success of Lean six sigma depends on the environment that managers create around that initiative. There are six ‘must dos’ for managers that will set the stage for employees’ success.

1 Pick the right projects- attention on 5 or 10, not more.

2 Pick the right people.

3 Follow the method.

4 Clearly define roles and responsibilities.

5 Communicate, communicate and communicate.
6 Support education and training.
Achieving Six Sigma aim linked up with Lean is a long-term goal requiring a tremendous hard work, sincerity and perseverance. As already stated it also requires a huge investment. In Nashik, few big organisations are trying to implement this methodology and it is at initial stage in these organisations. There is not a single instance where in a small or medium scale industry is implementing Six Sigma.
In one organisation, where Six Sigma is being implemented from April 2004 and where improved performance is seen is given here as a case study.

**Case study**

The company in the case study is a manufacturing company.
There are 4 black belts in the company and each black belt is working on 4 projects.
Supplier was made a part of the programme

**Goal statement** [SMART] [Specific, Measurable, Achievable, Realistic, Time bound.]

**REDUCTION OF CHROME CHIP OFF REJECTION IN DUCTILE RINGS FROM 8% TO 2.5%**

MAXIMUM OF THE RING VALUE IS LOST IN DUCTILE RING. SO IT IS TAKEN FIRST
Table 6.3 Business case

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Business Element</th>
<th>Unit of Measurement</th>
<th>Current level</th>
<th>Targeted level</th>
<th>Annualised gains Rs. Lac</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quality</td>
<td>% Rejn On Insp. basis</td>
<td>8%</td>
<td>2.5%</td>
<td>63.965 Thousands Rings Rs.25.6 Lacs at Rs40 per ring.</td>
</tr>
<tr>
<td>2</td>
<td>Cost</td>
<td>93.4Thousand Rings</td>
<td>29.075Tho usand Ring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Productivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Intangible gain</td>
<td>Less scrap PPC, low scrap, low inventory, better house keeping, better delivery.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Team Plan
2. Define : 10-May-2004
3. Measure : 25-May-2004
4. Analyze : 15-June-2004
5. Improve : 10-July-2004

Input-Rings, machining operation involved in ductile rings.
Rings for finish turn
Output product in scope-All ductile rings

**DEFINE**
Problem-The business pain area was identified as High chrome rejection in Chrome Plated rings.
Current situation: it was observed that over 71% rejections was contributed by one defect head i.e. Chrome chip off.
On further analysis it was observed that maximum business opportunity was lost in ductile rings.
Project Target: Hence the project was scoped as "Reduction of Chrome chip off Rejection in Ductile Rings from 8% [last qtr. Avg.] to 2.5%"

Graph 6.2

Defect contribution in Chrome Rejection

<table>
<thead>
<tr>
<th>Defect</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinholes</td>
<td>0.12</td>
</tr>
<tr>
<td>Chip-off</td>
<td>4.38</td>
</tr>
<tr>
<td>Chrome defect</td>
<td>0.99</td>
</tr>
<tr>
<td>Tap not OK</td>
<td>0.64</td>
</tr>
</tbody>
</table>
Opportunity Loss (Oct 03 - Mar 05)

Graph6.3

MEASURE

R&R: Visual inspection R&R was done and found <10% i.e. O.K.
Defect Definition: Chrome chip off defect was defined and categories in 3
category.
--Near Gap Chrome Chip off
--Edge Chrome chip off
--OD Chrome chip off.

ANALYZE

The end to end mapping of manufacturing process was done and process
to act upon was decided.
The process parameter affecting the output i.e. chrome chip off was
analyzed using various statistical tools such as Multi vary analysis, DoE,
etc.
IMPROVE

The solution to the "cause analysed" were tried in lot approval method. The solution to giving good results were further run on observation for bigger lot and implemented after standardization.

Graph 6.4

[Diagram showing Chrome chippage trend with months from April 2004 to December 2004 and various causes for improvement such as reinstatement of PM action, inclusion of FNT & OD chamber, stone deburning, size standardization, blasting setup, and control problem.]
Graph 6.5

Trend of Ductile(-crft) Acceptance

Graph 6.6

BB01: Process Loss Project Trend
The above case study shows the result of Six Sigma. The problem was so serious that during October 03-Mar 05 opportunities lost amounted to Rs.17.5 lacs.

The process was analysed. The solutions to the cause analyzed were tried in lot approval method. The solutions to giving good results were further run on observation for bigger lot and implemented after standardisation. We find that 'Chrome Chippage Rejection started showing downward trend from 8% initially to 2.5 % in September 2004. After achieving the target the company did not follow rigorously the 'Control' phase, [like it happens in many cases] so rejection rate increased in October and November. But as stated by the black belt the company is following Control Phase. The company is expecting good results in the time to come.
CONCLUSION

From the case study of Six Sigma and the interviews of the black belts conducted in Nashik it can be stated that Six Sigma is the most effective tool for the company in its quality improvement programme.

As a disciplined approach for achieving world-class performance in any process from manufacturing to transactional, the Six Sigma plays an important role in reducing cost achieving high quality of the products in a competitive market. Also it has the capacity and capability to deliver concurrently customers' and suppliers' satisfaction. In many projects suppliers have been made a part of the projects.

Total customers' satisfaction results into increased market share and improved profit margin. To achieve total customers' satisfaction, what is required is defect free products, which is the base of Six sigma projects. It requires along term plan and a tremendous commitment and patience to follow such plan. In many cases throughout the world it has been experienced that many companies achieving their goal did not follow the 'Control Phase' and then have been badly affected due to regression. When something is transferred from one country to another, it is common to change its contents mixed with the existing culture and create a new aspects to add to it. Six Sigma when transferred from U.S. to India, it is natural that in Indian context the companies adapting Six Sigma might not be taking it seriously like that in U.S.A. Here many companies have the problem of funds, manpower and even sometimes machinery to collect the data. This is found true when the survey was conducted in Nashik during thesis and this is the reason there are very few companies in Nashik, which are trying to adopt Six Sigma methodology. It should be also noted that in these companies Six Sigma is in initial stage.

There is another threat to Six Sigma. It frequently happens that we are apt to learn only apparent aspect of the transferred technology and miss something essentials behind it. Six sigma teams learn to understand the philosophy of Six Sigma. It is much more important than statistical methods. It is based on process facts and data. It believes in

1. All work is a system of interdisciplinary processes.
2. Every process has inputs and outputs.
3. Inputs and outputs can be measured.
4 All measurements exhibit variations.
5 Reducing and controlling variations is the key to continuous and breakthrough improvements.

So Six Sigma takes note of each and every process, its variations and finds out the ways to reduce the variations. It uses various tool and techniques and tries to achieve the goal.

It should be noted that achieving Six Sigma goal is a long-term process. Still many companies in U.S are trying to achieve the goal of 3.4 defects per million but have not yet succeeded G.E has achieved 4 Sigma and with that enjoyed a very huge amount of profits.

However, benefits of Six Sigma implementation are definitely enjoyed by the companies doing Six Sigma.

Many black belts doing Six sigma in the companies in Nashik do accept that they are enjoying the benefits such as –

1 expanded knowledge of the product and processes resulting into more interest and initiative in the working they have got involved in Six Sigma so much so that one black belt remarked, “I am not ‘doing’ Six Sigma, I am in Six Sigma.”

2 reductions of errors, mistakes and cycle time.

3 improvements of customers' satisfaction and profitability.

4 business growth

5 improved communication and teamwork through sharing of ideas, problems and successes and failures.

Six Sigma focuses on quality than speed, Lean methods are better at improving process flow and speed than on improving quality. Combining the two is what makes Lean Six Sigma, such a powerful improvement tool.

Lean Six Sigma concentrate on process. As Dr. doctor Deming said that 15 % of the problems were really the fault of individual employee and 85 % problems were built into the way the work is done. So with Six Sigma process can be improved and defects can be eliminated. In the later years of his life Dr. Deming came to the opinion that 96 % problems are built in
the work system and employees could control only 4%. So it is utmost important that if you want to improve quality you have to change the way the work is done. So Lean Six Sigma focuses on process improvement. Defect free products gained customers satisfaction, which will also result into increased confidents in persons who work in the processes.

When the companies operate at 3 to 4 Six Sigma level, the cost of quality is 15 to 25 % of revenues if they move to Six Sigma level, their cost of quality decreases to a level of 1 to 2%. These dramatic cost savings come as their quality cost move from Failure costs (warranty repair, customer complaints, etc). to prevention costs (things like reliability analysis in design or customer surveys to reveal requirements.)

The road from five sigma to Six Sigma is the most difficult journey. With emphasis on designing processes and products with Six Sigma defect levels in mind from the start. Six Sigma organization is able to fully utilize its resources. Six Sigma project is planned and deployed at executive level. Deployment is scaled based on company size. A good rule of thumb is that the mature Six Sigma organization should have about 1% of their work force in the black belt's role.

A Six-Sigma program can be integrated with other initiatives. Motorola developed their Six Sigma program in pursuit of the Malcolm Balridge Award. A Six Sigma program can serve as the shell that wraps around other initiatives including Lean Thinking or Shewhart / Deming's P D C A on which basis DMAIC methodology of Six Sigma works. The Document Control aspects of ISO 9000 are useful for standardizing on known practices in the organization.

When you decide to change practices or procedure, revision control ensures that the proper personnel review the changes. These changes are incorporated into standard practices. Six Sigma provides the tools and methodology to implement change in the organization. Six Sigma projects are selected and sponsored by management to achieve strategic objectives. While some of these objectives may be discovered through analysis, ISO 9000 Corrective action data, Six Sigma organizations often
take more proactive approach to maximize value to the customers and improve the organization’s competitive position.

As we all know that Six Sigma delivered billions of profit to large enterprises, they have done nothing for small to midsize companies. The original Six Sigma architects did not design their delivery systems for businesses of that size which is the common criticism about Six Sigma. But the business initiative programme continues to grow and change. Many small companies can now afford to implement the most recent iteration of Six Sigma called Generation III. It is said that a person with white belt [new belt in Generation III] could complete up to 12 projects each year with the potential of returning $25000 from each project to the employers bottom line.

From the above discussion we get to know the importance of Six Sigma. Now at this stage we cannot call Six Sigma a fad. Every industrial sector that hears about Six Sigma initially thinks it is a fad and think that they are the first people to realize it. This is typical of the way that evolutionary ideas cross boundaries; only a few people stop and look back at the beginning of something. The number of reports claims that Six Sigma Is one of them. One thing they all agree on is that the typical fad lasts about 5 years, with 2 to 3 years of exponential growth followed by 2 to 3 years of steady decline.

For each new industry exposed to Six Sigma this might appear true [until you see that there is not a decline phase] but when you look at the bigger picture it is apparently that the companies who started things rolling are still at its 20 years on.

The pattern is actually closer to that of adoption of computers from to 60s through the present day. ‘USA Today’ famously said in 1998,” Six Sigma will eventually go the way of other fads but probably not until Welch (GE) and Bossidy (Allied Signal ) retire. Both of them retired two years ago and
neither GE nor Honeywell has given even the slightest sign of changing their track of Six Sigma.

"According to Mr. Mikel Harry, " Six Sigma is not just about reducing costs nor is it just about getting to 3.4 defects per million opportunities. [DPMO.] Six Sigma has degraded into toolkit. But it is a mindset. Its most powerful feature is that it reshapes the way we think. He says "Six Sigma is not a panacea. It does not run my coffee for me. It cannot help you with brainwaves. It helps you innovate better not invent. Six Sigma is nothing more than a better mousetrap which helps you bring about higher levels of value with customers and shareholders by improving a core processes of the business He is very passionate about its strength especially vis a vis other quality tools. To have accountability we must have measurement. Six Sigma provides a roadmap to do that. In Harry 's words the first generation of Six Sigma was about the defects reduction, the second about the cost reduction and the third about the value addition. Will there be generation IV? Generation IV will be Six Sigma at the personal level It is already something I am inculcating in my person life, Harry says. India is missing a big time opportunities. It is not leveraging its biggest strength-the brilliant minds of its people on problem solving capabilities. India should create a center for excellence, which would enable it to spearhead Six Sigma everywhere from small and medium scale enterprises to improving water levels in the country. Though China is capturing word market and Indian market, in Harry words _Right now they (China) are still trying to get into the game. China is 10 years away from the world-class quality. In the years to come India will be number 1 in the world-class quality. It is rightly said that when you see a successful business someone must have taken courageous decision and doing Six Sigma is that courageous decision and at this juncture that 'someone' should be the industries in Nashik.

(speech on 15th June, 2004 in Delhi in India times Strategy Summit)*

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