Software Quality Model Six Sigma Initiatives

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***Abstract* - An attempt is made to review the quality improvement efforts in the software industry. Six sigma implementation efforts in the industry is analyzed and studied. In this paper a detailed analysis is carried about the impact of development environment. Process selection and process maturity also plays important role in the software development environment. In this paper software quality models are analyzed and concept of six sigma in the software development industry.**

***Index Terms*- Software Quality, Six Sigma, Models, Efforts.**

I. INTRODUCTION

Measurement is very much required in the software development industry but it is not an easy job to measure the effectiveness of the development process. At the same time it is very difficult to quantify all the parameters in the software development industry. To avoid some quantification and effectiveness problem modeling can be used a tool but still it don't solve the problem. Enforcing quality in the software development process with quantification require enforcement of quality model in the development model. Software Metrics provides some solution to software development process and strongly support software project management activities. Without measurement, we cannot compare the effectiveness of differing methods, tools, techniques and designs and cannot make any objective statement concerning the quality of software products that we claim to engineer. Reliability pertaining to software is the probability that software will provide failure-free operation in a fixed environment in a fixed interval of time.

II. SOFTWARE QUALITY PLANNING MODEL

A. *Quality Model Six Sigma*

Six Sigma is a successful quality improvement technique. Unlike conventional quality improvement programs like TQM, Six Sigma is known for its ability to produce organization wide results in a short period of time. There have been a number of widely published success stories from the manufacturing and service industries. But the application of six sigma as a method has been limited in the software industry. The main challenges in applying Six Sigma to software industry are:

- The one of a kind, nature of projects: Many a time's software projects are one of a kind and do not bear any resemblance to previous projects. So management process needs lot of tweaking to handle each process, stripping the organization the advantage of a repeated process.
- The intangible nature of software: Software being an intangible thing, correctly measuring the progress, quantitatively tracking completion, etc are a challenging task by itself.

III. THE DETAILS OF SIX SIGMA

Six sigma is old technique and it started with the birth of the concept in mathematics called normal curve. In early 1920s six sigma was adopted in the production industry for product variation measurement standard and it was initiated as three sigma and it is found that it was very much effectively used in process correction during that time.

With advancement in the manufacturing and production norms new standards like Cpk, Zero Defects, and many more came for the measurement and improvement. In late 1980s Motorola want to improve quality in the products and services offered so Bill Smith of Motorola initiated this concept of six sigma. It is observed the traditional quality levels like measuring defects in thousands of opportunities -- didn't provide enough granularities in the process. Measurement of defects per million opportunities is introduced in the industry and the company took the initiatives to create a culture and environment to support this six sigma concept. It is observed that six sigma helped Motorola to identify the bottom lines in the business process Instead the company saved billions as a outcome of the six sigma initiatives. After that thousand of companies around the world have adopted Six Sigma for improving their business performance and the companies improved significantly. Six sigma initiatives are started in all most all sectors of industry ranging from production, process, manufacturing and service and the results obtained are very significant in terms of quality and quantity. The sis sigma concept adaptation helped companies to save revenue and able to generate business value in the market [6].

Six Sigma is defined since from its birth with different definitions and it has many popular definitions. Some of the classical ones are very relevant in today's context are:

- Six Sigma is a highly technical method used by engineers and statisticians to fine tune products and processes

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- Six Sigma is a sweeping cultural change effort to position a company for greater customer satisfaction and competitiveness.
- Six Sigma is a comprehensive and flexible system for achieving, sustaining and maximizing business success. It is uniquely driven close understanding of customer needs, disciplined use of facts, data, statistical analysis and diligent attention to managing, improving and re-inventing business processes.

Software industry is a trillion dollar industry and very interesting statistics is available that says 90% software developed are never used, 8% used after rework and only 2% used as it is. This is the statistics released by software Engineering Institute one of the prestigious institute in the software sector. Software industry needed some kind of initiative that can help to reduce the burden of cost and quality in the software development environment. It is suggested to adapt the concept of six sigma which claims that six sigma has become a symbol of high quality because a company operating at six-sigma level produces less than 3.4 million defects per opportunities. Logically it is next to impossible in the software industry to reach on such standard immediately but it is nice to start the small improvement in sigma level which notifies an order of magnitude improvement in quality level in the software development process.

A. Statistical Basics

In statistical parlance Six Sigma is all about dropping variation. The variant in a sample population is measured in terms of standard deviation [6]. As much the standard deviation increase, as more the variation of individual samples from the mean value. The capability of any process is its capability of meeting the specification limits. Six Sigma requires that six times the standard deviation [6] should be less than the specification limit. The Six Sigma has a relation to the specification limit which are nothing but customer outlook. Therefore Six Sigma clearly indicates the ability of the process to meet customer expectations

IV. Methodology for implementing six sigma

Six Sigma is a disciplined, data-driven approach and methodology for abolishing defects of driving towards six standard deviations and the nearest specification limit in any process -- from transactional to manufacturing and from product to service. The statistical representation of Six Sigma describes quantitatively how a process is performing. A Six Sigma defect is defined as anything outside of customer specifications.

The Six Sigma fundamental objective methodology is the implementation of a measurement-based plan that focuses on process enhancement and variation decline through the application of improvement projects which is accomplished through the use of two Six Sigma sub-methodologies: DMAIC and DMADV, process (define, measure, analyze, improve, control) system improvement for existing processes falling under specification and looking for better improvement. The process DMADV is an enhancement system used to develop new products or processes at Six Sigma quality levels. It can also be engaged if a current process needs more than just incremental improvement. The benchmarking parameters for the software industry are decided and five companies are evaluated and analyzed for the six sigma performance.[3][4].

V. Six Sigma Process

A. Success of six sigma in Industry

One of the key factors that attracted corporate leaders to six sigma is the measurable return on investments that six sigma provided to the cooperate bottom line. Even though many success stories happened in the industry it has been GE and its legendary leader Jack Welch who made Six Sigma a corporate business success "mantra". The following section outlines some of the success stories and key factors that enabled the organization to achieve success through Six Sigma.

i) Motorola:

Motorola is credited with the contribution of the formalized Six Sigma methodology to the world. By 1990 Motorola under the visionary leader ship of Robert Galvin started the formal Six-Sigma program. It was the adoption of a best practice from its own Government electronics group. Quickly Motorola demonstrated how US could build products with Japanese quality at lower costs. The key factors that helped Motorola in this journey are

- Visionary leadership
- Already a Malcolm Balridge award winner Motorola had excellent quality system and culture
- The innovation drive in the company with a year of adoption the key divisions of the company achieved more than 50 % reduction cost of quality.

ii) GE:

GE started its Six Sigma program in 1996 with a target to achieve Six Sigma by 2000. Unlike many other companies, GE true to its style made it an organizational mandate to adopt to the Six Sigma methodology. So the program was driven across the hierarchies and divisions of the organization as a historically massive initiative. One of the key achievements of GE has been the successful implementation of the Six Sigma methods in the service industry. GE has proved that the management processes yield higher returns with six sigma than the production process, thus changing the perception about six sigma from a manufacturing process improvement program to an organizational improvement program [3].

The key factors that enabled GE's successes are

- The leader ship drive and management commitment to the program
- GE's organizational culture which demanded results from any investments
- The successful "work out" program started in 1998, which prepared GE for the Six Sigma embrace.

iii) Polaroid:

Polaroid started the Six -Sigma program in 1995 with

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objective of renewing Polaroid. The strategic objective was to bring Polaroid back as a company that grew every year. Carol J Ulrich spearheaded the Six-Sigma program within Polaroid and her drive passion was major factor in the success of the program. By moving from 3.5 sigma to 5 sigma level itself Polaroid was able to save 1 Million dollar in increased sales intend.

The key success factors in the Polaroid case are

- The management endorsement to the Six sigma initiative
- The presence of a motivated person to drive the program
- Help of qualified external consultants in identifying CTQ

The three companies out lined above have successfully implemented Six Sigma to achieve their goals. But the three organizations are different in their intent, culture and organizational quality level. Motorola has an innovative culture and very high process orientation. On the other hand Polaroid also shares the innovative culture but it's process orientation is limited. GE and Motorola have diverse businesses but Polaroid is in a focused business segment. Apart from these differences certain common themes have driven these organizations successful Six Sigma programs. They are

- Visionary leadership
- Strong leader ship commitment for the Six Sigma program
- A strategic vision to achieve through the Six Sigma program

iv) Reports From Software Industry

There are only few published cases of software industry success stories in Six Sigma. In many software organizations, which have adopted Six Sigma, the application of the program has been limited to support services (eg: Infosys). The two early adopters from India are TCS and Wipro. The following sections describe the status of Six Sigma program in these companies.

v) TCS

TCS started six sigma initiatives after certifying itself for SW-CMM level-5. It has certified all its 17 centers at CMM Level-5 by 1998. The company blended its CMM process with six sigma to come out with a common set of procedures for the development of projects. The approach adopted by the company has been to use six sigma as a tool to drive the quantitative process management requirements and reduce variation to reach the continuous improvement stage. The Six Sigma initiative has been limited to one center of TCS. The company has achieved the following benefits out of six sigma.It achieved a 100 percent defect removal before delivery. In terms of sigma it has reached 5.85 sigma in delivered defects. The schedule slippage has been brought down from +20 to a level of +2 over a period of two years.

vi) Wipro

Wipro was the first Indian software major to openly embrace six sigma in the project development efforts. The CEO Vivek Paul who was instrumental in the six-sigma effort of GE Medical has driven it. The company has achieved a 90% on time delivery for its project compared to an industry average of 55 %. Also Wipro reports a 50% reduction in cycle time and 35 % improvement in productivity through its six-sigma program. Wipro has reported a cost saving of 4 Core in the first year of Six Sigma implementation.

VI. Operational Parameters

The competitors are selected to be the best software companies working in the engineering software and embedded domain and have got significance presence in the Indian market and the same can be found in Table I. It signifies that the six sigma initiatives have great impact in the software development industries.

TABLE I
OPERATIONAL PARAMETERS

Company	1	2	3	4	5
Utilization %	70	60 -70	65	??	50 -60
Billing Rates US $/hr	2.-25r	12 -15	12 -20r	15 -30	12 -20
Customer Retention	Good	Good	Avg	Good	Poor
Revenue Growth %	26	33	50	30	-10
Attrition rates %	17	12	11	11	>25

1-Wipro,2- PCS Tata,3-Elxi HCL,4-Technologies, 5-MindTeck

A. Six sigma strategy for the company:

The six-sigma strategy to be adopted in an organization is directly dependent on what it wants to achieve from six sigma. The following Table II summarizes the basic strategies that can be adopted by organizations

Addressing the macro problems:

The core processes identified are:

- Business development which includes business forecasting and realization
- Resource planning which includes hiring, bench planning.
- Project Execution

TABLE II
SIX SIGMA STRATEGIES FOR THE COMPANY

No	Objective	Description
1	Business Transformation	A major shift in how organization works. Includes restructuring.
2	Strategic Improvement	Target key strategic or operational weakness or opportunities.
3	Problem Solving	Fixes specific areas of high cost, re-work or delays.

Six Sigma is slowly breaking the notion of not suitable to the software industry. In India itself success stories has started to trickle in. Software Company may be CMM- L5

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COMPANY is well poised to use six sigma as a methodology to drive process improvements.

The supporting factors for six-sigma success in the organization are

- It is already a CMMI-L5 organization. So the software development process is well laid out.
- The organization has an open and innovative culture aiding changes
- Company Should see big growth opportunity
- So the organization needs a business transformation strategy to revitalize itself.
- The quality levels of the organization are satisfactory. But it can improve with a lot of Projects are provided with the required number of resources with required skills. Having the right resources is critical for the success of a project.

  The right resource availability to a project is defined as providing the required number of resources with projects required skill set on time. The skills set are classified into three categories as follows.
- Programming skills which include platform, language and tolls skills
- Domain specialization
- Functional Specialization, which include Project management, configuration management, testing, design etc

Measurement

After the completion of the project feedback will be given to the resource planning department in the following format. The benchmarking parameters are given in Table III.

A form is filled with sample case for clarity.

Resource Evaluation Sheet

Each resource entry is considered a record. A resource sheet is the collection fo all resource records for the project.

Target to achieve

The target to achieve in the first iteration is as given below.

- The number of green records should be more than 70 % and number of red records should be less than 10 % for all projects data.
- The number of green sheets should be 90 % and number of red sheets should be zero.

Analysis of feed backs

The feedback from projects will be consolidated on six monthly bases.

Each record should be analyzed for the following

- The feedback scores for particular resource consistent across projects
- Is there any skill/domain/functional area, which shows poor rating across projects?
- Is there any change in pattern on skill/domain/functional area coming in project requests from past six months.

If the target is not met resource-planning department should initiate following actions based on analysis.

- If the low rating is due individual resource problem, it should be addressed with training/mentoring.

TABLE III
BENCHMARKING AGAINST COMPETITIONS ON OPERATION PARAMETERS

No	Parameter	Expected Range	Remarks
1	Delivered Defects	0	
2	Cost of Quality	<20%	
3	Defect in System Testing	< 1%	
4	Schedule Variation	<5 %	Variation from initially estimated schedule

- If the low rating is due to wrong assignments and if the overall resource requirements in the organization is balanced with respect to resource requirement and skill availability then re-deployment of resources across projects should be attempted.
- If there is poor any skill/domain/functional area or if there is change in patterns on skill requirement organization wide training should be attempted.

Pilot Plan

To validate the approach the project will be piloted in five projects covering different domains. The results from the pilots will be analyzed to fine tune the deciding parameters. The feedbacks from Project Managers and resource planning group will be taken further to improve the process. After this a formal process will be defined and training will be imparted to different departments.

Return on investment on Six sigma

Utilization of each man-day available to the organization is a critical factor to the success of the software organization. The majority of the projects in companies are turnkey projects. So the there is higher possibility or resources getting idle in the interval between projects. The objective of the zero bench initiative is to reduce the unutilized man-days in the organization. The objective of the initiative is to do a good project planning exercise in the initial stages of the project itself. A good project planning exercise is expected to do

- Analysis of the project requirements
- Work staffing plan
- Look at the past problems faced by similar projects to identify preventive actions
- Identify unique requirements of the project

In short a well-planned project will not have surprises. A person is on bench when he has completed the assigned task in a project and he is released from the project. There is four possible ways of using that resource as given below.

- Deploying to another project
- Deploying to organization tasks like R&D, conducting training
- Sending for training

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- Sending on paid leave

From the business perspective of company the ideal situation is deploying the resource to another project. If that is not possible the other three options should be considered in decreasing order.

So the target for resource management group is to maximize deployment in the first two categories. To achieve this critical aspect knows in advance when a resource will be available.

Measurement

The key measurement data here is the accuracy of predicting resource availability. The accuracy is defined in the following way. Measurement for Zero Bench Initiative

The target set for this project is to achieve accuracy targets for 80 % of resources in the organization.

Pilot Plan

There is no piloting required. It can be directly applied with simple tool help.

Investment Requirement

One person 10 hr/week will have to spend tracking each resource release date on weekly basis across project to update a resource deployment database.

So for a year 500-man hrs need to be spent. On an internal cost of 12 US$/hr it translates into 6000 US $. The project is targeted to make available at least five man days of half the resources in NeST for better utilization.

The total man days gained = 300/2*5 = 750

So return on internal cost basis = 750 *100 = 75000 US $.

The goodness of a project plan can be measured by the percentage of tasks, which are completed as per the original plan. Directly setting target on variation form original plan doesn't help the projects to achieve this objective. So further analysis at sub-process level is required to identify the proper set of targets. The project planning process includes the following steps.

- Identification of resource requirements
- Identification of life cycle
- Identification of quantified goals for the project
- Scheduling, critical path analysis
- Risk identification
- Analysis of previous projects experience to look for preventive actions
- Plan documentation.
- Every project needs to complete the above set of activities in the early phase of project to make a good planning process.

Measurement

The measurement on effectiveness will be the following.

- The effort spends on the project planning. It should be in the range of 2-4 % of the project effort depending on the project size.
- Number of preventive actions identified y the project team
- The number of days from the project starts date form the project authorization to complete the plan. It should be in the range of 5-10 days.

The target for the organization is to make 80% of the projects meet the above three criteria.

B. Investment required for excellence in Project Management

Company does 50,000 Man day projects on every year. The above proposal can save up to 5% of total effort for a project.

Total saving in man-days= 2500 man days.

Total Saving in cost =250,000 US $

VII. CONCLUSION

Concept of Six sigma is discussed in the details for improving software development quality. In this paper it is suggested that how six-sigma concept can be implemented in the software industry. Return on investment is calculated for the six sigma concept and it is proved that six sigma is good quality modeling technique for the software industry also. All the collected data from various companies suggest that there is significant improvement after six sigma initiatives in the companies.

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