

# Six Sigma In Software Engineering: Turning a Dream Into Reality

Kalaimagal Sivamuni , Jagan Amgoth

*Abstract— The software industry is a multibillion industry today .All organizations, individuals and businesses use software today for a variety of purposes that range from paying bills online to managing aerospace systems. However, software by itself is prone to errors and bugs leading to disastrous results at times. This has caused many software agencies to look for standardized software engineering processes which result in increased reliability, less debugging and improved quality control. Six Sigma has taken the manufacturing world by storm with its proven results in increasing quality and reducing defects. It is therefore natural that in the past few years, software corporations and firms are now looking to see how Six Sigma methods can be incorporated into the software engineering process. Many companies have tried and successfully implemented Six Sigma methods in the software development , design and testing processes in Software Engineering. However there is still a lot of skepticism with regard to the application of the Six Sigma process to software .There is also a lack of academic research in this area. This paper is an attempt to clear the misconceptions and demonstrate that Six Sigma can be successfully applied to the software engineering scenario with the help of real time cases. This study was conducted as part of a research project sponsored by the Department of Science and Technology(DST) ,Govt of India.*

*Keywords—Six Sigma, DMAIC, DFSS, Lean Six Sigma, Software Process, Software Development*

## I. Introduction

A decade ago when people talked of software they would have probably thought of Microsoft Word and Excel. Today when people think of software, it's more likely to be Gmail, twitter ,Face Book or Angry Birds. However the real software that runs today's world is not the android or Windows phone applications but the huge creaking applications that run Ford's motor line, stock markets across the world including nuclear plants. Software is pervasive in today's world[4]. Yet we still get to see headlines like "**Software Errors cost U.S Economy \$59.5 Billion Annually**", or "**Only 35% of all projects succeed and so on**". This despite the fact that there so many quality processes ,quality frameworks and quality models that have been around for quite some time and which have been widely used in the IT industry like CMMI ,ISO 9001[2].

This has forced companies to look at new and better ways to increase software productivity and quality and improve software processes.

Six Sigma has proven to be a successful quality improvement tool that reduces variations and defects[6]. Many software firms are slowly realizing that the defects should be avoided even before they exist and that' s precisely what Six Sigma aims to do. Software corporations and firms have therefore started incorporating Six Sigma tools and techniques in their software engineering processes[8]. According to Richard E.Biehl[7] , Six sigma is increasingly penetrating software engineering and practices. However there are a lot of misconceptions and disbelief regarding the use of Six Sigma in software and this has prevented the widespread use of Six Sigma in software engineering[3]. This paper aims to debunk the myths and attempts to explain how Six Sigma can be aligned and adapted to make the software engineering process more successful with the help of real time examples from corporations .

The ultimate aim of this research is to design a software design framework that can be used to develop high quality web portals using either Six Sigma DMAIC or DFSS methodologies. The first step taken for the research was to check the feasibility of incorporating Six Sigma in the software engineering process. This meant conducting a study on the current state of art of Six Sigma in software research. This paper is a result of the above attempt.

Section 2 of this paper gives a brief description of Six Sigma , section 3 talks about the misconceptions, section 4 illustrates successful case studies and section 5 presents the conclusions of the study.

## II. Six Sigma Fundamentals

Six Sigma has its origins in statistics and in fact it is a statistical term. It is a set of tools that aim to improve processes and products and was pioneered by Motorola in 1981.The objective of Six Sigma is to measure the defects in a product or a process and systematically determine to eliminate them to get "**zero defects**" [9].Six Sigma achieves this by minimizing variation because variation results in inconsistency in meeting customer specification or defects which in turn leads to dissatisfied customers and "**Customer Satisfaction**" " is the fulcrum of the Six Sigma Philosophy. Figure 1 illustrates the Six Sigma curve.

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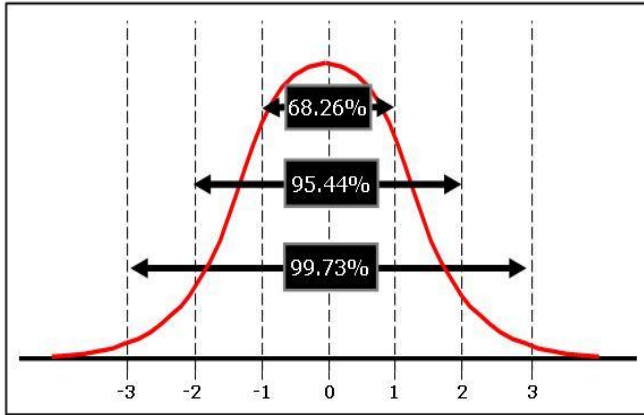


Figure 1 : Six Sigma Curve

Every process or product has measurable characteristics. These characteristics can be represented by a frequency distribution which is usually a normal curve. The variation of the curve or the process is measured by standard deviation which is the distance between the mean and the point on either side where the curve changed from concave to convex. This distance is called the six sigma level. As seen in Figure 1 above, higher levels of sigma correspond to lesser defect levels and six sigma represents the near elimination of defects at 99.9997 percent goodness or only 3.4 defects per million (DPMO), a quality level that is synonymous with world class quality.

There are three different Six Sigma methodologies DMAIC (Define, Measure, Analyze, Improve, Control), DFSS (Design for Six Sigma) and Lean Six Sigma and all three techniques have been successfully incorporated in the software industry in one form or the other. Let us first understand what the different methodologies and their differences are to better understand the case studies which will be explained later in this paper.

DMAIC is the six Sigma methodology used to improve processes or products and reduce defects in them. The DMAIC methodology has the following steps:

- **Define** : The problem is defined, customers are identified and critical customer requirements are established in this stage.
- **Measure**: Key aspects of the existing process or product is measured by collecting the relevant data in this stage.
- **Analyze**: The results of the previous stage are analyzed to verify the cause and effect relationships between the defects and steps in the process. This is used to investigate the root causes of the defects and to check what factors can be adjusted to improve the performance.
- **Improve** : The improvements are implemented.
- **Control**: The improvements are recorded, monitored and maintained continuously.

DFSS is the Six Sigma methodology used to create new products or processes[1]. There are a number of frameworks available in DFSS but the most widely used one is DMADV (Define, Measure, Analyze, Design and Verify).

TABLE 1 : DIFFERENCES BETWEEN DMAIC AND DFSS

Methodology	Primary Purpose	Action Taken	Timing of Action
Six Sigma	To reduce defects in Product or Process	Analyze	At any point in the lifecycle
DFSS	To design a new product or process	Design	Before the process or product development starts.

Other design frameworks under DFSS are IDOV (Identify, Define, Optimize, Verify), CDOV (Concept, Design, Optimize, Verify) and DMADOV (Define, Measure, Analyze, Design, Optimize, Verify).

Lean Six Sigma is the DFSS methodology used to eliminate seven different kinds of waste and focus only on value based activities or processes[5].

As can be seen from all the three methodologies, Six Sigma focuses on good customer feedback and continuous process improvements with reduced defects. This is what IT managers expect in their software process and products but most of them are not convinced of adapting Six sigma because of certain misconceptions which are discussed in the next section.

### III. Six Sigma -Misconceptions

We shall now list out the most common misconceptions associated with applying Six Sigma in the IT industry. The misconceptions generally associated with Six Sigma are:

**Misconception 1: IT cannot benefit unless the whole company has adopted Six Sigma.**

**Fact** : This is not true as Six Sigma tools have been used in software processes to improve or design both software products and processes in big corporations without involving the entire company[10]. This will be demonstrated by the case studies in the next section.

**Misconception 2 : Six Sigma Applies to the Manufacturing Process and not IT.**

**Fact**: This is also not true since several IT corporations have proved that Six Sigma has worked if it has been used by the right people for the right projects by employing the right methods[10].

**Misconception 3 : Six Sigma is all about statistics only.**

**Fact** : Although the foundation of Six Sigma is statistics, Six Sigma is about disciplining and streamlining processes whether they can be quantified or not[9].

To further illustrate the above facts, we shall discuss some case studies of IT corporations where project teams have successfully used Six Sigma methodologies with success and reaped results.

## IV. Six Sigma Case Studies

Some of the Six Sigma success stories are:

### A. Case Study #1

**Company Name :** Tata Consultancy Services(TCS)

**Project Background :** TCS was handling research, design, development, and support for a product software for a leading telecommunications provider. On Time Delivery(OTD) was the Critical to Customer Requirement. However, it was discovered the Turn Around Time(TAT) for fixing bugs was too long and was a road block in the process. The goal was to reduce the TAT.

**Six Sigma Methodology:** DMAIC

**Results:** TCS successfully used Six Sigma to significantly reduce the TAT required to resolve change requests(CRs) resulting from software bugs detected during the testing. The DMAIC project increased the Customer Satisfaction index and also reduced the Turn Around Time by over 42%. In addition, US 50,000\$ was also saved.

**Remarks:** The project team did face some difficulties on the way because it was the first time that they were implementing the DMAIC improvement process. The project team had to train the associates in the Six Sigma process and also had to be flexible about the metrics used. At the end of the project, there were also secondary benefits like a better measurement collecting system for further improvement projects, standardized repository for metrics and better accountability for laboratory utilization.

### B. Case Study #2

**Company Name:** Tata Consultancy Services:

**Project Background:** One of the clients of the TCS Banking and Financial Services BPO was an international financial services company who had outsourced end to end banking services to TCS. One of the services provided by TCS was printing, dispatch and delivery of the credit card statements to the bank's credit card customers also called as rendition. One of the key issues faced by the bank was an high incidence of complaints (85% of total complaints) from customers regarding their credit card statements which was also creating a negative perception about the bank. Therefore there was an urgent need to reduce the complaints and increase customer satisfaction.

**Six Sigma Methodology:** DMAIC

**Results:** DMAIC was used to proactively identify customer defects and reduce customer complaints. The team was able to reduce customer complaints by 44 percent and duplicate statements by 48 percent. The team also managed to save US \$ 225,107 in the process.

**Remarks:** The above case study shows that DMAIC can be used to identify, prioritize and reduce root causes and also to modify software processes to get correct results. The project had the advantage of having readily available data (existing credit card statements of customers) which helped to accelerate the DMAIC process.

### C. Case Study # 3

**Company Name :** Motorola

**Project Background:** Motorola is an international company that sells mobile devices throughout the world. These devices have user interface software in more than 50 different languages. The mobile business unit of Motorola discovered that defects such as lack of language translation, wrong language translation and other problems were escaping from earlier test phases and were detected during the later test phases close to the release of the product. Some defects were not reported until after product release and these were the most expensive because they resulted in negative customer experience.

**Six Sigma Methodology:** DMAIC

**Results:** Motorola appointed a team to redesign the testing process used to validate language based errors in the user interface software using DMAIC. This resulted in earlier detection of defects and reduced development time. In fact the percentage of bugs detected earlier was increased from 26.6 percent to 61.6 percent. The project also resulted in a savings of US \$760,000.

**Remarks:** This was a widely appreciated project which gave additional credence to the Six Sigma approach within Motorola. Even though this project reduced language based errors, this can be taken as a learning example on adapting DMAIC to reduce defects in software companies. However, different solutions will be required based on the need of individual companies and processes.

### D. Case Study #4

**Company Name :** Infosys

**Project Background:** Infosys was responsible for the development and maintenance services of the online banking service for an international bank. Errors in online banking services can prove fatal. The bank wanted to the company to

reduce the incidence of transaction errors that occurred online and to increase customer satisfaction.

**Six Sigma Methodology : DMAIC**

**Results:** The project team succeeded in reducing errors by 18 percent exceeding the project goal of 12 percent reduction. Customers were delighted to see their issues resolved before they became incidents. The timely closure of transactions resulted in a profit of US 14 million dollars for the bank and enabled Infosys to become the preferred vendor of the bank.

**Remarks:** The project team did not use classical Six Sigma steps but tweaked the process to suit their requirements. This is because different instances of online software applications have varying degrees of complications and require different methods and tools. Also, preventive maintenance is best suited to address challenges with very little documentation as it is tedious to trace the root cause and fix it. Still, this project demonstrates the fact that DMAIC can be successfully used to improve online applications also. It should be mentioned that Infosys used the DMAIC process to increase productivity for the online service for another multinational bank and succeeded also. As Anshuman Tiwari says[10], Infosys has repeatedly proved that the myth that Six Sigma cannot give results in software is baseless since Infosys is constantly adapting Six Sigma methodologies to its projects successfully.

*E. Case Study #5*

**Company Name :** Infosys

**Project Background:** One of Infosys clients was a major US telecom service provider with a large global wired and wireless network. Infosys maintained the billing service of the company. The company was having problems with the billing service with customers complaining about errors in billing amount and bill payment dates. The customer's requirement was to reduce errors in bills and delayed bills with the ultimate goal of reducing operational expenses.

**Six Sigma Methodology : DMAIC**

**Results:** A cross functional Six Sigma team was found. Improvements were implemented and the company saw a 20 percent reduction in operational expenses for maintaining customer billing. Invoices were generated in a timely manner which resulted in earlier revenues. Cost benefits amounted to US 9 million dollars.

**Remarks:** In the above project we find that DMAIC has been used to improve a customer processes. Even though Six Sigma is usually projected as a tool for promoting internal efficiencies, this project illustrates that it can be used for external software processes also. It also reiterates the fact that

diligent and intelligent implementation of Six Sigma is more important for success than statistical analysis only.

*F. Case Study # 6*

**Company Name :** Motorola

**Project Background :** This Lean Six Sigma Project was launched by Motorola to solve a fundamental challenge that most IT companies face – too much documentation that was either not updated or redundant. The goal was to reduce project documentation and make it more effective .

**Six Sigma Methodology:** Lean Six Sigma

**Results:** The team reduced project documentation by 35 percent and significantly reduced the effort required to complete project documentation. This reduced costs by 1.08 million dollars and gave a return of investments of about 10.57\$ dollars.

**Remarks:** This case study proves that the hidden waste in an organization is not only in the product or process but also the documentation produced by the process. Software documentation is significant and time consuming in a Software Engineering process and companies must make efforts to streamline documentation also. Using Lean Six Sigma to do this was an innovative idea and it also shows that Six Sigma Methodologies are flexible. However this project is dependent on the fact that it requires experts to scrutinize each document carefully using specific criteria.

In addition to the above case studies, it should also be mentioned that Motorola's Mobile Device Business Unit leveraged Six Sigma using DFSS to redesign the code review process in order to dramatically reduce effort and cycle time within R&D operations[10]. The project team managed to reduce the effort by sixty percent. The project resulted in an annual cost avoidance by reduction or elimination of non value added tasks of approximately US 500,000 \$. Motorola also used the DFSS methodology to design a new version of push to talk over cellular applications[10].

**v. Conclusions and Future Directions**

The various case studies show us that it is possible to implement Six Sigma Methodologies and tools into the software process albeit with some changes and tweaking depending on individual process and product needs. It was also noted that intelligent application of the tools and a committed team are two important requisites for software six sigma projects to be successful.

It is time that academia also consider research of various ways of integrating Six Sigma with software engineering important

since it was one of the future directions of software engineering..Although some papers have already prepared in the past few years , not enough research has been made in this direction. The next step in this research is to use DFSS and DMAIC to create a design framework for web portal services.

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