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DMAIC Approach for Defect Predictability and Control

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Abstract

The goal of DMAIC approach is to reduce the variation in output result by business process improvement. DMAIC of "6σ" methodologies can be implemented in software development life cycle (SDLC) to be competitive in the market by making the focus to customer satisfaction. Implementing "6σ" in every smallest section of SDLC will give enough value addition to the organization towards achieving customer-based quality. This paper will describe the implementation of "6σ" tool in the testing process; improvements of customer satisfaction and project cost effectiveness. Here we will be measuring the variation of testing metrics, control of the variation and how it affects the post release defects using QFD and regression analysis.

Keywords: *6σ, QFD, Defect, Analysis*

1. Introduction

1.1 History of 6σ:

"6σ" is a statistical term for variation measurements since 1920. The industrial uses of "6σ" was initiated by Motorola as a measurement standards in the 1980's. Since then, it has become a useful technique for measuring quality. It has become a tool among the big technology player such as General Electric, Toyota and etc. "6σ" has developed into not only a quality measurement tool but also a whole new way of doing business keeping tab on business goal to achieve the business mission and vision [1, 2].

1.2 Aim of 6σ:

Ultimate aim of quality team is to achieve the highest customer satisfaction by implementing "6σ" principles in the regular industrial process area of an organization. Customer's main aim to get the best quality product with budgeted cost. Simultaneously organization should achieve the reasonable profit to sustain the business. The quality team plays a major role to bridge the gap between customer and organization by implementing "6σ" principles, *i.e.,* waste elimination in cycle time and reduction in defect density [3].

"6σ" is different from other Quality Models/Programs:

a. <u>"6σ" is customer-centric</u>. It's compulsory to focus on customer's requirements.
b. <u>"6σ" produces high ROI</u>. "6σ" implementation in every phase of SDLC will reduce the defect occurrences. Due to this defects decrement, the cost decreases 10 folds for defects finding and fixing. It always gives the monetary benefit to the organization. It speaks about profit. Implementation [1, 4] of "6σ" helps to reduce the cycle time and to do proper budgeting for any project. It will save lot of revenue and ultimately gives customer satisfaction.
c. <u>"6σ" helps to management</u>. "6σ" implementation in an organization requires various tools to measure the variation of various phases in SDLC. This will help to reduce the defect density for each phase. Management needs to remember only six levels of σ

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values for any phases in SDLC [5]. So Management will review the projects in terms of σ level.

Sigma Level	Percent	Defects per Million Opportunities
6	99.9999998	3.4
5	99.999943	233
4	99.9937	6220
3	99.73	6700
2	95.45	308300
1	68.27	691462

1.3 How does "6σ" Require in Testing Phase:

Each phase of the SDLC is a contributor of the defects in the application. Testing phase detects these defects but still there is a possibility of defect leakage in the production. If this defect leakage occurs then it costs 10 folds more of each phase to the organization with low customer satisfaction. Testing phase [2] is filter phase where all the defects can be fished out. It has been noticed that more than 90% of total defects are detected in testing phase only, but still there are defects seepage in production. There is always a chance of 2% – 5% defects in the production or post release. To achieve the goal of 0% defects in production, management has put the view in the direction of "6σ" implementation and this will result with high success rate. Targeting the testing phase for "6σ" implementation is a wise decision for management because it has highest impact on defect detection. Testing phase deals with major metric as "defect density". "6σ" deals also with defects. So it will be easy to correlate the metric to measure the σ value, which gives the state of the process. The actual number of the opportunities for defects occurrence will be normalized to one million opportunities to find the Defects per Million Opportunities (DPMO) [6]. Now it will be easy to determine the corresponding σ value. This means that ideally, the implementation of 6σ will result in an average of only about 3.4 defects per million units produced. Implementation of "6σ" in testing phase reduces the cost of defects detection in later phase, increases the customer satisfaction and reduces the cycle time.

2. 6σ Implementation in Software Testing for Defect Prediction & Control

Implementation of "6σ" has been done with the Define-Measure-Analyze-Improve-Control (DMAIC) methodology. Our business goal is to achieve zero post release defects.

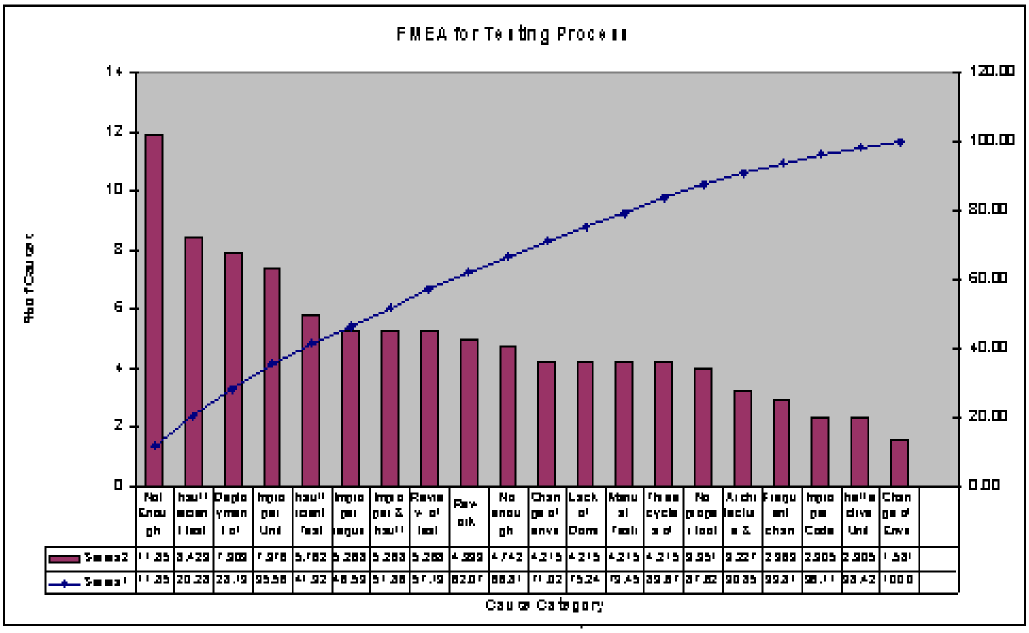
2.1 Define

Problem definition, categorization of the process and customer requirement has been done with the help of Quality Function Deployment (QFD) tool. With consideration of business goal following are the most impacted requirements.
Process Requirement:

- Test case review
- Functional Testing
- System Testing
- Customer Requirement:
- No defects in production
- Highest Test case sufficiency

2.2 Measure

With the help of Failure Mode Effect Analysis (FMEA) the most potential causes have been identified and listed below. These causes have high Risk Priority Number (RPN) to contribute maximum for the potential failure of an application.



High Impacted causes for potential failure are below:

- Not enough effort for testing
- Insufficient test cases
- Deployment of application in the customer's environment
- Improper unit testing
- Insufficient test case review
- Improper requirement and design analysis

So the conclusion is "to minimize the Post Release defects" and it will be defined as 'Y' of the project. These potential causes are the key contributor for this "Y".

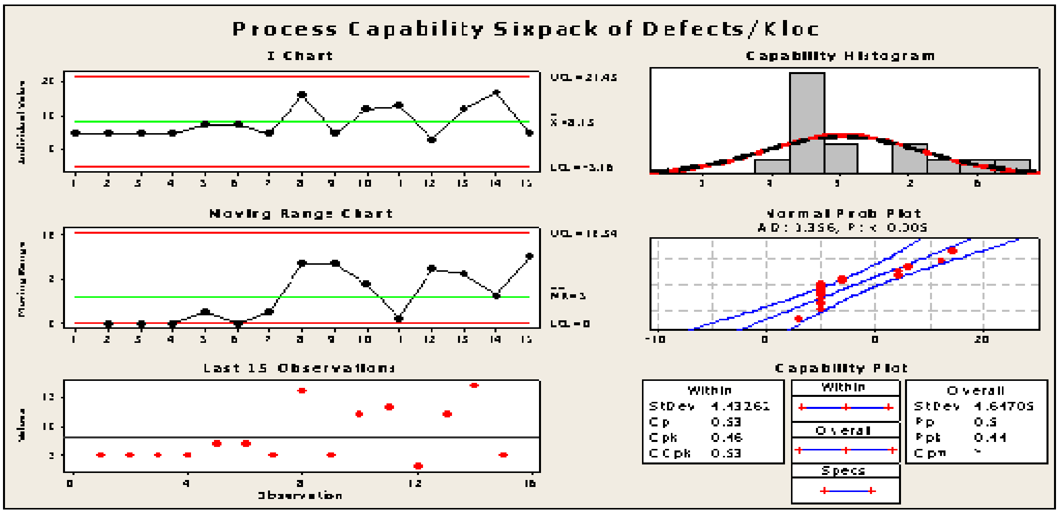
$$Y = f(X)$$

Let's find out what is 'X'. Final problem statement and metrics definition will be defined in project charter. There is a proper data collection plan for a particular period of time. These metrics are collected to determine the relation between Y and X.

- In Process Defects (IPD)
- Post Release Defects (PRD)
- Defect Seepage (DS)
- Number of cycles of testing (NCT)
- Number of Deliverables (ND)
- Testing effort (TE)

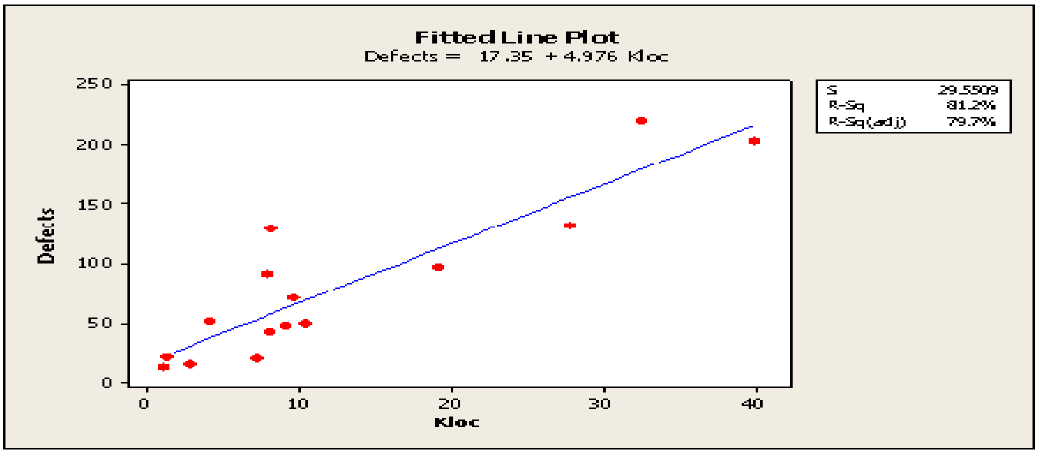
The Sixpack analysis has been done for all the metrics. These data has been collected for a period of 6 months. Initially the process capability is very low and it is 0.44. The graph has been shown for "IPD". The unit of normalization has been taken as Defects/KLOC. Kilo lines of code (KLOC) is excluded the comments. Below is the month wise data collection table. We have collected the month wise data over a period of 6 months for 50 projects of spatial analysis software in Object Oriented (OO) technologies.

Month: Jan- 2007	IPD/ KLOC	PRD/ KLOC	DS / KLOC	NCT	ND	TE (Hrs.)
Project1	8.1	0.23	9	3	7	560
Project2	7.3	1.01	11	4	19	356
Project3	5.8	0.89	8.5	2	9	400
Project4	6.7	0.61	12.1	3	11	420
-	-	-	-	-	-	-
Project50	5.81	0.88	8.7	2	12	420



2.3 Analysis

With the help of above metrics multiple regression analysis has been conducted. This test has been concluded that all the metrics have no direct relation with "Y". We have identified this relation from the R^2 value. Below is one of the best scenario among all other relation.



Y= F (X)
Y= Number of post release defects
X1 = Cycles of testing
X2 = Efforts for testing
X3 = Defects Seepage
X4 = In Process Defects/KLOC

(Post Release Defects) / KLOC = A + B (Actual Testing Efforts) + C (In Process Defects)/KLOC + D (Defect Seepage)/KLOC

This equation has been developed based on 2 years of base line data for object-oriented technology. There are more than 100 projects data has been collected and normalized to draw this equation by multiple regression analysis. The bottom equation shows A, B, C, D values for the JAVA/J2EE application. Same equation can be used any other OO application. The parameter value has to be calculated from base line data for an organization.

PR Bugs/Kloc =0.0674 + 0.0136 Actual Effort - 0.0639 Defects/Kloc + 0.207 Bugseepage/Kloc

As defects are the attribute data so Poisson's method is best to calculate the σ value.

Type of measurement	Total Size in Kloc	Defects	DPU	E^{-DPU}	$(1-e^{-DPU})$	DPMO	DPMO /1000	Long Term σ Value from table	Short Term σ Value
Post release defects	3090.8	473	0.153034813	0.85809985	0.1419002	141900.2	141.900152	3.63	5.13
Defect Seepage	3090.8	3405	1.101656529	0.33232013	0.6676799	667679.9	667.67987	3.21	4.71
In Process Defects	3090.8	6521	2.109809758	0.12126103	0.878739	878739	878.738967	3.13	4.63

With the help of Fish-bone diagram followed by Nominal Group Technique (NGT), most potential causes will be identified to refer "Y".

2.3.1 Solution for these Potential Causes:

With the help of solution metrics and Root Cause Analysis (RCA) there are most identifiable solution for the high impacted causes. These solutions have been implemented by keeping in mind of above regression analysis relation. Our ultimate aim is to produce "Zero" defect application in the production. Solution will be aiming those Xi are highly bonded with Y. Few highly impacted solutions are listed below.

- Unit testing and usage of unit testing tool
- Automated regression testing
- Test case review and etc.

2.5 Improve Phase

Solution will be implemented for minimum of six months period

Type of measurement	Total Size in Kloc	Defects	DPU	E^{-DPU}	$(1-e^{-DPU})$	DPMO	DPMO /1000	Long Term σ Value	Short Term σ Value	% Of σ value change

Post release defects	3412.9	294	0.086143749	0.91746234	0.0825377	82537.66	82.5376623	3.77	5.27	3
Defect Seepage	3412.9	441	0.129215623	0.87878446	0.1212155	121215.5	121.215541	3.67	5.17	11
In Process Defects	3412.9	1667	0.488440915	0.61358228	0.3864177	386417.7	386.417724	3.36	4.86	6

2.6 Control

Process control mechanisms were implemented to ensure the changes could be sustained, and that the gains achieved from improvement activities would not be lost over time. The control plan outlined the procedure for monitoring the critical X as well as the number of on-time delivery and customer satisfaction. Regular reporting to the project's executive sponsor reinforced the importance of the initiative and insured that changes would become imbedded into the organization's culture. To sustain and control the σ level improvement, testing phase has decomposed as following.

DMAIC Vs Test process Management					
Define	**Measure**	**Analyze**	**Improve**		**Control**
Knowledge of business requirement	Testing magnitude/ requirements	Create Test cases & Plan	System integration testing	Test execution & reporting	Certified business application

This value proposition maps the traditional testing process to DMAIC and supports successful development and implementation of new products and services for customers. The DMAIC approach also ensures completeness of testing. During the “Define” phase, knowledge is gained about the business requirement. In the “Measure” phase, the testing magnitude/requirements are determined. The test cases and plan are developed during the “Analyze” phase. In the “Improve” phase, the testing is completed to provide a business-as-usual environment.

Each phase of the DMAIC process is initiated by defined inputs and outputs. Each phase goes through a tollgate process to determine if the next phase should be initiated.

	Define	Measure	Analyze	Improvement	Control
Activities	▪ Understanding the business requirement ▪ Define client participation ▪ Define metrics	▪ Gather and document testing requirement ▪ Determine the schedule ▪ Determine the cost and resource	▪ Analyze dependencies ▪ Define dimension of testing ▪ Create test case and test data ▪ Create & review test plan ▪ Update the schedule plan	▪ Schedule plan ▪ Resource allocation ▪ Update Test plan, test case & test data ▪ Test execution ▪ Metric	▪ Certify business application ▪ Metric reporting
Outputs	Knowledge of business requirement	Requirements for testing	Test plan, test case, test data	Test report	Metrics

The testing activity is recognized as being an effort that is owned and managed by the Technology Group during the Improve phase. The Technology Group in most instances is using ISO 9000 or the Capability Maturity Model to conduct its project execution. The Control phase is where continuous improvement is done based on data that is captured and tracked to assure the business-as-usual environment is operating within the desired control parameters. The configuration management is the driver of the testing process. It provides the tools to execute the process: deliverable templates, change control, version management and automated testing.

3.0 Conclusion:

Cpk	**Quality level**	**Dpm**
1.00	3 sigma	2,700.000
1.33	4 sigma	63.000
1.66	5 sigma	0.570
2.00	6 sigma	0.002

“6σ” is far more in depth than this paper has illustrated. It is a tool that if used correctly, can identify key areas of business processes that need attention to lower defect rates. One of the greatest advantages is that all the measured improvements achieved through this technique can be directly converted into financial results. In fact, more and more small processes in SDLC even require that “6σ” method be implemented. It has been noticed that 3% σ value improvement leads to 40% improvement in defects count for PRD. This improvement gives customer satisfaction and more business to the organization.

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Author

Author is having around 15 years of experience in various fields of testing. He is six sigma green belt.

