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Best Combinations of Software Practices from CDP Model by using Crystal Ball Tool to Achieve Quality Goals of an Organization

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ABSTRACT
This paper presents the results of the best combinations executed by using crystal ball tool to achieve quality and time constraint goals of an organization. The software practices of SDLC phases used from the CDP model [1]. This paper reveals that how crystal ball has executed the different combinations or simulations to find the best combination to be used further for a particular domain i.e. for particular type of projects. For example: software applications such as web applications, mobile applications and so on. This is was done as the part of process improvement of a software organization "Saber Corps (made up)". This whole process represents the output of process improvement process of an organization.

Keywords
Software quality, best combinations of software practices.

1. INTRODUCTION
As per the trend, technology is growing day by day. Today the information systems are the need of every arena. So to manage day to day tasks, information technology has been adopted by the organizations worldwide. As the level of usage of software is increased, the scale of quality is also been moved up. Now the quality of software has become the main requirement of the consumer as well as for the software companies who develop software. Software quality management has become a crucial part for the software development firms. Organizations have to adopt the quality processes, standard formats, quality standards while developing software. Many process improvement standards have been proposed by CMMi, ISO, Six Sigma and so on.

2. EXECUTING PREMEDITATED/ STRATEGIC PLANNING WITH PREDICTIVE MODELING
Making the right decisions requires anticipating and planning for possible changes in the future. A common approach to anticipate these changes is to first assess the company's current position by analyzing historical information to understand the company's past[26]. The questions can be arisen:

- What must be the goals of company?
- Which one is the most effective goal which is to be considered?
- What can be done to achieve these goals?

To answer these, organization has to make right decisions by using the following approach as it is in the diagram.

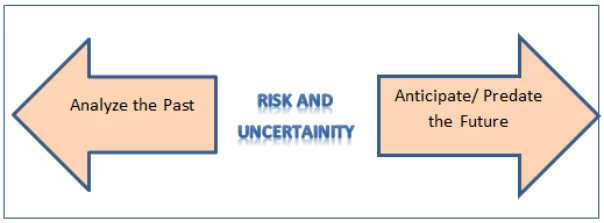


Fig 1: Understanding the past can help model the future

We must first ascertain the potential upside and downside of future results and the probability of each outcome actually occurring [26].

To perform sophisticated modeling and analysis, we must be able to access quality information to determine the impact of expected results. We should also be able to quickly and easily make different operating assumptions and create alternative scenarios that are determined by the assumptions that most affect the outcomes.

As per the process performance objectives (PPOs), process performance baselines (PPBs) and process performance models (PPMs) generated [1] to set up the best practices to create the CDP model. The PPOs, PPBs and PPMs which were created are now used to set the goals.

The three goals of an organization [1] were set to work on three areas - Quality, Cost and Time. Three goals which were set by the organization ABC(made-up) :

- Review Effectiveness : It is basically to review the work by the senior in every SDLC phase
- Effort Variance : It is the difference the actual effort spent on every and phase the estimated effort quoted for every phase initially.
- Rework: The volume of work is done again in every phase. There could be multifarious reasons such as problems at requirement end, developer was not very experienced so the architecture he made was not flexible, client changed the requirement and so on.

Now the different Y factors and X factors were detected [1]. In other words, different metrics (X factors) were detected which affects these goals or by which we can control these Y factors. Different project data was collected and as per the metrics and formulas, PPOs; PPBs and PPMs were made by using Minitab Tool.

Now the values for the standard deviation, mean and probability were identified. Now by taking these specifications, best combinations of the SDLC practices are specified in this paper.

Different combinations of the SDLC practices from CDP model run in the tool for various projects.

Table 1. CDP Model

SDLC Phases	Method 1	Method 2	Method 3
Requirement Gathering or Analysis (SRS Preparation)	Wire-framing	Document of Understanding (with screens)	Scope of Work (SOW)
SRS Review	Intra Team Review	Inter Team Review	Senior Review
System Design	HLD	LLD	
Design Review	Walkthrough	Peer Review	Senior Review
Coding(Including Unit Testing)	Reusable Code	Non-Reusable Code	Third Party component
Code Review	Sample based	Run Complete Checklist	Expert Review
QC Test Preparation	Detailed scenario based test cases	Simplified Checklist	Separate for Functional & Non-Functional/UI
QC Testing	Test Case driven testing	Ad-hoc testing	Functional & Performance Testing

3. HOW CRYSTAL BALL WORKS OR USED TO ACHIEVE THE RESULTS??

Crystal Ball is the leading spreadsheet-based software suite for predictive modeling, forecasting, simulation, and optimization[25].

Now following paragraphs will describe that how crystal ball tool is used. Which methods were used for different projects?

- Firstly, projects data was consolidated and identified the methods that are used in the project according to the phases (Please refer to the screenshot below).
- Then, we grouped the data according to the methods for every project
- Afterwards, we checked the Normality via Minitab to attain the normally distributed data points.

Table 2. Methods Used for Web Projects from CDP Model

Projects / SDLC Phases	P1	P2	P3	P4	P5
Requirement Gathering or Analysis (SRS Preparation)	Wire-framing	Document of Understanding	Document of Understanding	Document of Understanding	Reference Websites/Applications
SRS Review	Intra-Team Review	Inter-Team Review	Inter-Team Review	Inter-Team Review	Intra-Team Review
System Design	LLD	LLD	LLD	HLD	HLD
Design Review	Senior Review	Senior Review	Senior Review	Peer Review	Walkthrough
Coding(Including Unit Testing)	Non-Reusable Code	Non-Reusable Code	Reusable Code	Third Party Component	Third Party Component
Code Review	Expert Review	Expert Review	Complete Checklist Run	Complete Checklist Run	Expert Review
QC Test Preparation	Detailed Scenario based Testing	Detailed Scenario based Testing	Detailed Scenario based Testing	Functional Plus Performance Testing	Detailed Scenario based Testing
QC Testing	Functional Plus UI Testing	Functional Plus UI Testing	Functional Plus UI Testing	Test Case Driven Testing	Test Case Driven Testing

Listed below are the Process Performance Objectives starting August 2012: -

- The Effort Variance should be Less than 13% with a mean of 10% a standard deviation of 1%
- The Review Effectiveness should be Greater Than 48% with a mean of 60% and a standard deviation of 4 %
- The Rework should be Less Than 1.6 Hrs/Wtd Pt with a mean of 1 Hrs/Wtd Pt and a standard deviation of 0.2 hrs /wtd pt .
- The Delay should be Less Than 20% with a mean of 15% and a standard deviation of 2%. (Note :As of now, we do not have the data for Delay and will start observing the same from August 2012 onwards)

After normalizing the data, CDP Model is prepared. On the basis of this, the OPT Quest test is performed which outlays the Decision Variable values and hence represents the best solution to be catered.

Let's proceed further to observe how OPT Quest is performed on CDP Model

CDP MODEL

CDP Model showcases the SDLC Phases along with their methods to be performed. In CDP Model, we defined the Assumption Variable of every method via Crystal Ball. The Assumption Variables are highlighted (cells are highlighted with light grey color). To define an Assumption Variable, we followed the below steps:

1. Open CDP Model in Crystal Ball.
2. Click on 'Define Assumption' and select 'Normal' Option.
3. Then enter the 'Mean' Value and 'Standard Deviation' Value from the 'Supporting Data' Sheet of a particular method of the selected Assumption Variable.

The Decision variables are the projects(P1, P2, P3, P4, P5). These variables basically outlays the result in Binary form i.e. 0 or 1 which signifies which method to be opted through OPT Quest Test. The Decision variables are defined with 'Constraints' to fetch the appropriate value for a Decision Variable of a method.

To define a constraint, following steps were performed:

1. Click on 'Crystal Ball'.
2. Select 'OPT Quest' Test.
3. Select the 'Constraint' Option and then click on "Add Constraint" Button.
4. Afterwards, define the constraint i.e. the Sum of all the Decision Variables will be Equal to 1 and the Sum will be shown in the 'Calc' Column. The Constraint is defined to get value of a decision variable for a particular method for every phase of the SDLC.
5. After adding the constraints, proceed with other option of the test.

Now, to find out best solutions for the Phases, we will perform OPT Quest Test. Following are the steps to perform OPT Quest Test:

1. Click on 'Crystal Ball'.
2. Select 'OPT Quest' Test.
3. Now, we need to enter the objective, Our objective for iPhone Application program is to minimize Effort i.e. our objective will be "**Minimize the Mean of Total Rework**".
4. Furthermore, we specified the number of simulations to be performed, which is to be set on '5000'simulations for '10,000' trials.
5. Click on 'Run' Test.

The test began and represented whether there is any feasible solution on the basis of requirements entered. We can also view the impact on CDP Model, as the values would change in Assumption Variables in accordance to the simulation.

After the test is completed, we were shown with the Best solutions for every Phase.

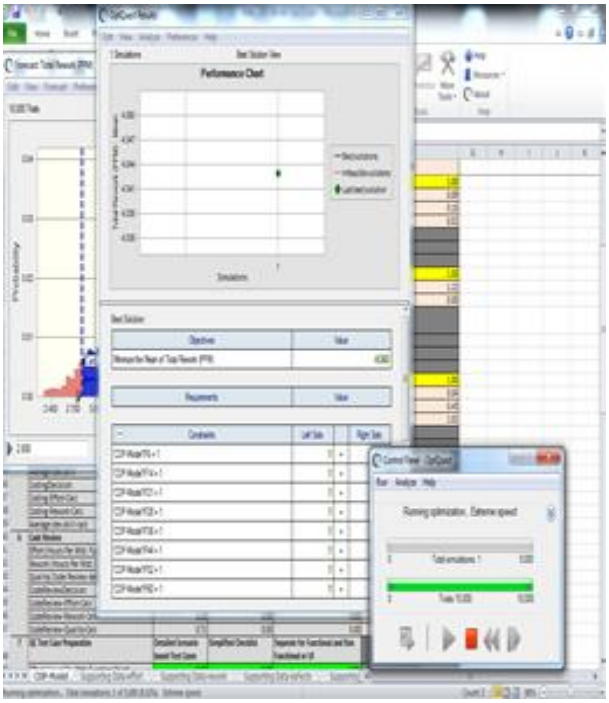


Fig 2: Showing Feasibilities of methods opted

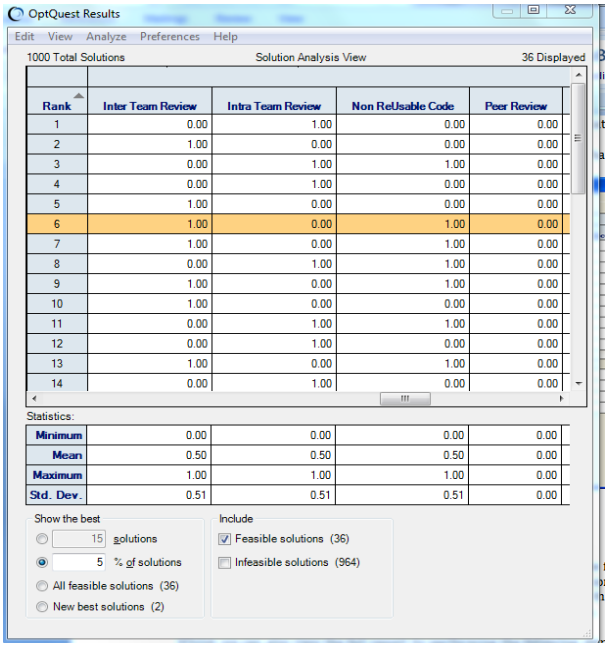


Fig 3: Showing Feasibilities of methods opted

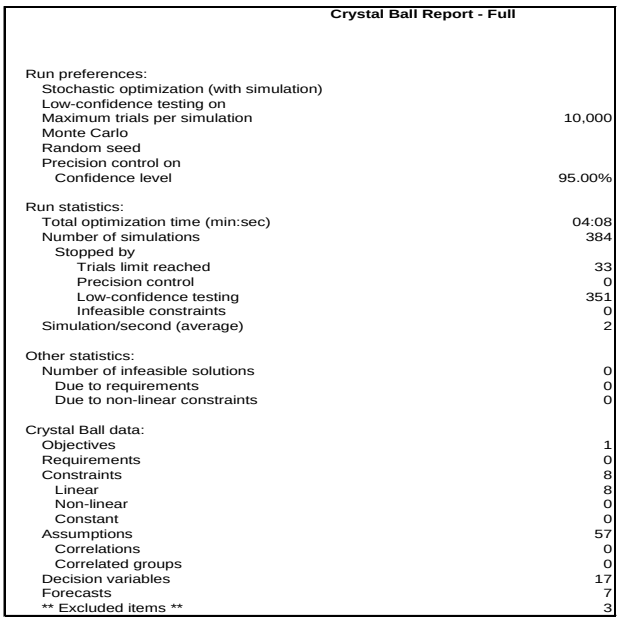
The Best Solution sheet will now show us that which methods are best to be followed. This will be observed as processes which have the value as '1' will be considered as the best ones or feasible solutions and those processes which have the value '0' will not be catered as they are considered as the infeasible solution.

Whilst, we can also view the full report by performing the following steps:

1. Click on 'Analyze'.
2. Select the 'Full Report' Option.

Highlighted below is the Full Report of OPT Quest in Crystal Ball:

The full report basically briefs in the statistics report.



Crystal Ball Report - Full

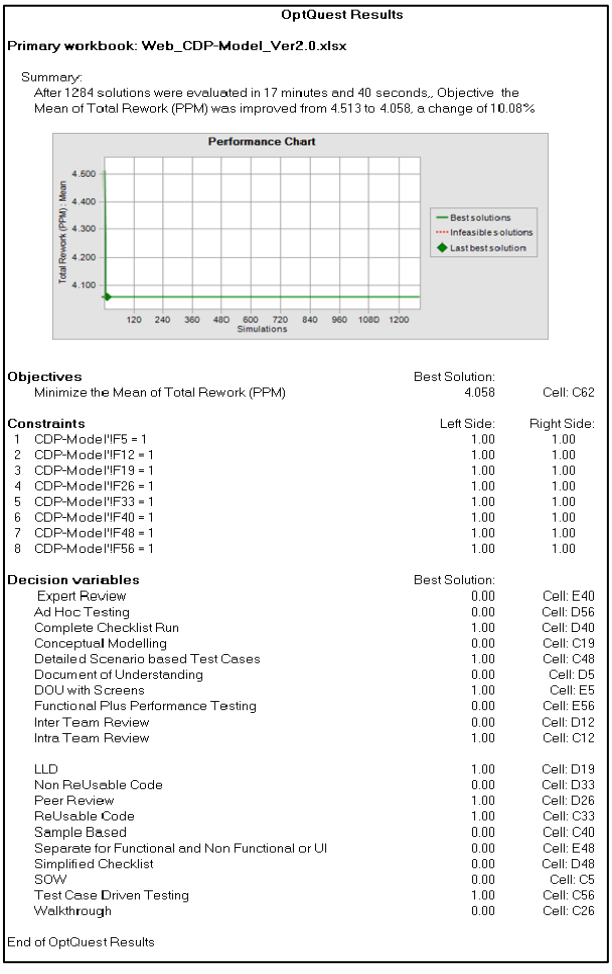
Run preferences:
- Stochastic optimization (with simulation)
- Low-confidence testing on
- Maximum trials per simulation: 10,000
- Monte Carlo
- Random seed
- Precision control on
  - Confidence level: 95.00%

Run statistics:
- Total optimization time (min:sec): 04:08
- Number of simulations: 384
- Stopped by
  - Trials limit reached: 33
  - Precision control: 0
  - Low-confidence testing: 351
  - Infeasible constraints: 0
- Simulation/second (average): 2

Other statistics:
- Number of infeasible solutions: 0
- Due to requirements: 0
- Due to non-linear constraints: 0

Crystal Ball data:
- Objectives: 1
- Requirements: 0
- Constraints: 8
  - Linear: 8
  - Non-linear: 0
  - Constant: 0
- Assumptions: 57
  - Correlations: 0
  - Correlated groups: 0
- Decision variables: 17
- Forecasts: 7
- ** Excluded items **: 3

Fig 4: CDP Full Report



OptQuest Results

Primary workbook: Web_CDP-Model_Ver2.0.xlsx

Summary:
After 1284 solutions were evaluated in 17 minutes and 40 seconds., Objective the Mean of Total Rework (PPM) was improved from 4.513 to 4.058, a change of 10.08%

Objectives	Best Solution:	
Minimize the Mean of Total Rework (PPM)	4.058	Cell: C62

Constraints	Left Side:	Right Side:
1 CDP-Model!F5 = 1	1.00	1.00
2 CDP-Model!F12 = 1	1.00	1.00
3 CDP-Model!F19 = 1	1.00	1.00
4 CDP-Model!F26 = 1	1.00	1.00
5 CDP-Model!F33 = 1	1.00	1.00
6 CDP-Model!F40 = 1	1.00	1.00
7 CDP-Model!F48 = 1	1.00	1.00
8 CDP-Model!F56 = 1	1.00	1.00

Decision variables	Best Solution:	
Expert Review	0.00	Cell: E40
Ad Hoc Testing	0.00	Cell: D56
Complete Checklist Run	1.00	Cell: D40
Conceptual Modelling	0.00	Cell: C19
Detailed Scenario based Test Cases	1.00	Cell: C48
Document of Understanding	0.00	Cell: D5
DOU with Screens	1.00	Cell: E5
Functional Plus Performance Testing	0.00	Cell: E56
Inter Team Review	0.00	Cell: D12
Intra Team Review	1.00	Cell: C12
LLD	1.00	Cell: D19
Non ReUsable Code	0.00	Cell: D33
Peer Review	1.00	Cell: D26
ReUsable Code	1.00	Cell: C33
Sample Based	0.00	Cell: C40
Separate for Functional and Non Functional or UI	0.00	Cell: E48
Simplified Checklist	0.00	Cell: D48
SOW	0.00	Cell: C5
Test Case Driven Testing	1.00	Cell: C56
Walkthrough	0.00	Cell: C26

End of OptQuest Results

Fig 5: OPTQuest Test Results

Below are the Process Performance Objectives:-

- The Mean of Review Effectiveness (PPM) must be greater than or equal to 80 % with std. dev of 3 %

- The Mean of effort variance (PPM) must be less than or equal to 8 % with std. dev of 1 %
- The Mean of rework (PPM) must be less than 1hrs/pt with std. dev of 0.2 hrs/pt
- The Mean of %Delay (PPM) must be less than 5 % with std. dev of 1 %

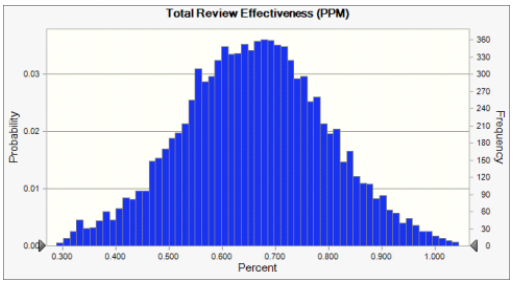
Below are the highlighted Forecasts:

1. Review Effectiveness (PPM)

Here, the calculated Mean is observed to check the difference between our set goal of Mean Value and its impact on 90% - 95% percentile which specifies that the Actual Value of the Mean is 66 % and std. dev 13.7 % which signifies that the mean and std. dev are far away from the goals so I will closely monitor these two and while doing prediction or what if I will increase or decrease the efforts accordingly so that these two values come near to goal .

Forecast: Total Review Effectiveness (PPM) **Cell: C65**

Summary:
Entire range is from 0.288 to 1.177
Base case is 0.321
After 10,000 trials, the std. error of the mean is 0.001



Statistics:	Forecast values
Trials	10,000
Base Case	0.321
Mean	0.660
Median	0.660
Mode	---
Standard Deviation	0.137
Variance	0.019
Skewness	0.0581
Kurtosis	2.91
Coeff. of Variability	0.2074
Minimum	0.288
Maximum	1.177
Range Width	0.889
Mean Std. Error	0.001

Forecast: Total Review Effectiveness (PPM) (cont'd) **Cell: C65**

Percentiles:	Forecast values
0%	0.288
10%	0.484
20%	0.546
30%	0.588
40%	0.624
50%	0.660
60%	0.695
70%	0.730
80%	0.774
90%	0.836
100%	1.177

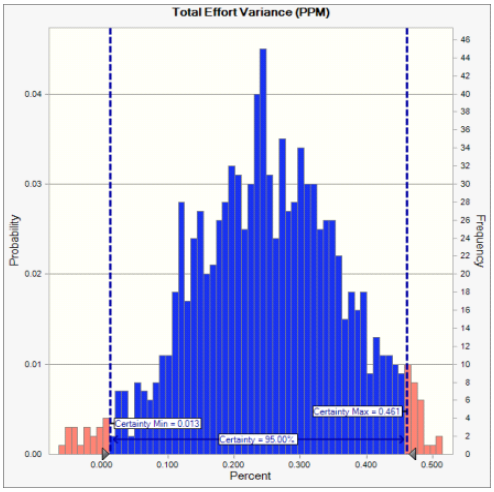
Fig 6: Total Review Effectiveness

2. Effort Variance (PPM)

Here, the calculated Mean is observed to check the difference between our set goal of Mean Value and its impact on 90% - 95% percentile which specifies that the Actual Value of the Mean is 24 % and std. dev is 11.2 % which signifies that the mean and std. dev are far away from the goals so I will closely monitor these two and while doing prediction or what if I will increase the efforts accordingly so that these two values come near to goal.

Forecast: Total Effort Variance (PPM) **Cell: C**

Summary:
Certainty level is 95.0%
Certainty range is from 0.013 to 0.461
Entire range is from -0.151 to 0.515
Base case is 0.515
After 1,000 trials, the std. error of the mean is 0.004



Forecast: Total Effort Variance (PPM) (cont'd) **Cell: C**

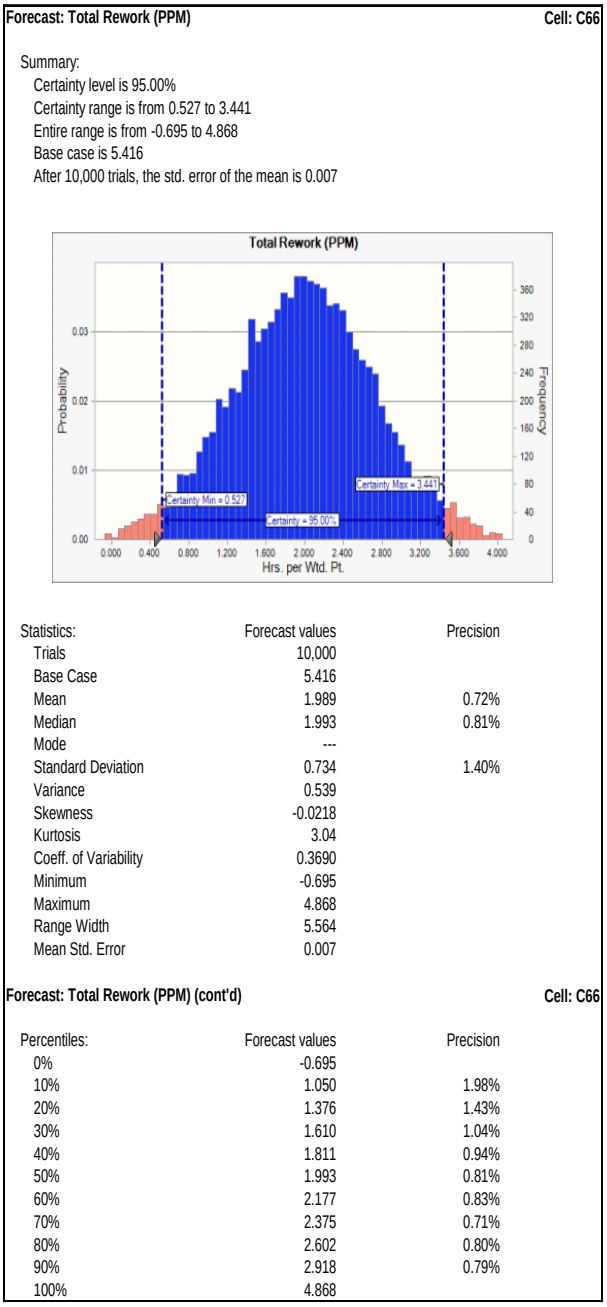
Statistics:	Forecast values
Trials	1,000
Mean	0.249
Median	0.248
Mode	---
Standard Deviation	0.112
Variance	0.013
Skewness	-0.1923
Kurtosis	2.87
Coeff. of Variability	0.4510
Minimum	-0.151
Maximum	0.515
Range Width	0.666
Mean Std. Error	0.004

Percentiles:	Forecast values
0%	-0.151
10%	0.109
20%	0.152
30%	0.191
40%	0.225
50%	0.247
60%	0.279
70%	0.313
80%	0.346
90%	0.394
100%	0.515

Fig 7: Total Effort Variance

3. Rework

Here, the calculated Mean is observed to check the difference between our set goal of Mean Value and its impact on 90% - 95% percentile which specifies that the Actual Value of the Mean is 1.98 hrs/pt and std. dev is .734 which signifies we are some were near but need to what this also to achieve goals.



Forecast: Total Rework (PPM) **Cell: C66**

Summary:
Certainty level is 95.00%
Certainty range is from 0.527 to 3.441
Entire range is from -0.695 to 4.868
Base case is 5.416
After 10,000 trials, the std. error of the mean is 0.007

Statistics:	Forecast values	Precision
Trials	10,000	
Base Case	5.416	
Mean	1.989	0.72%
Median	1.993	0.81%
Mode	---	
Standard Deviation	0.734	1.40%
Variance	0.539	
Skewness	-0.0218	
Kurtosis	3.04	
Coeff. of Variability	0.3690	
Minimum	-0.695	
Maximum	4.868	
Range Width	5.564	
Mean Std. Error	0.007	

Forecast: Total Rework (PPM) (cont'd) **Cell: C66**

Percentiles:	Forecast values	Precision
0%	-0.695	
10%	1.050	1.98%
20%	1.376	1.43%
30%	1.610	1.04%
40%	1.811	0.94%
50%	1.993	0.81%
60%	2.177	0.83%
70%	2.375	0.71%
80%	2.602	0.80%
90%	2.918	0.79%
100%	4.868	

Fig 8: Total Rework

4. CONCLUSION

From above all procedures and methods, we came with the best suitable practices which are required to be used for web and mobile domain projects to achieve the organization's goals for quality, less effort variance and less rework.

From above all procedures and methods, we came with the best suitable practices which are required to be used for web and mobile domain projects to achieve the organization's goals for quality, less effort variance and less rework.

The screenshot below clearly outlays the Best Methods highlighted in "Grey" Color for every Phase of the SDLC to be used for all the Projects under web application domain.

Table 3. Best Methods for Web Application Domain

SDLC Task	Method 1	Method 2	Method 3
Requirement Analysis (Prepare SRS)	SOW	Document of Understanding	DOU with Screens
SRS Review	Intra-Team Review	Inter Team Review	
System Design	HLD	LLD	
Design Review	Walkthrough	Peer Review	
Coding (Including Unit Testing)	Reusable Code	Non-Reusable Code	Third Party Component
Code Review	Sample Based	Complete Checklist Run	Expert Review
QC Test Case Preparation	Detailed Scenario-based Test Cases	Simplified Checklist	Separate for functional & Non-Functional / UI
QC Testing	Test Case Driven Testing	Ad-Hoc Testing	Functional Plus Performance Testing

Same procedures were executed for the projects under Mobile Application domain which constitutes Gaming Applications, Android Applications and IPhone Applications.

Following are the results for Mobile domain:

Table 4. Best Methods for Mobile Application Domain

SDLC Task	Method 1	Method 2	Method 3
Requirement Analysis (Prepare SRS)	SOW	Document of Understanding	DOU with Screens
SRS Review	Intra-Team Review	Inter Team Review	
System Design	HLD	LLD	
Design Review	Walkthrough	Peer Review	
Coding (Including Unit	Reusable Code	Non-Reusable Code	Third Party Component

Testing)			
Code Review	Sample Based	Complete Checklist Run	Expert Review
QC Test Case Preparation	Detailed Scenario-based Test Cases	Simplified Checklist	Separate for functional & Non-Functional / UI
QC Testing	Test Case Driven Testing	Ad-Hoc Testing	Functional Plus Performance Testing

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