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A Quantitative Approach to Measure Effectiveness of Defect Prevention Process

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ABSTRACT: This article is a Proposal which provides a step-by-step guideline for ensuring a systematic defect prevention process and introduces a quantitative approach to measure the effectiveness of the process through a scoring model. It starts with identification of potential causes that usually impacts the defect prevention effectiveness. The proposed solution takes care of the most vital or critical causes as identified by the fish-bone-diagram analysis. The overall analysis method is segregated among five steps – fixing timeline, defect data collection, analysis technique, review process and reporting process. Each step is elaborated further with introduction of its own parameters. Especially, the review process introduces the scoring model on different aspects of defect prevention reporting which generates RAG (Red-Amber-Green) score for each independent entity. This RAG scoring is very helpful in portraying the current status of any project to senior management and helps in accurate judgment of improvement scope for the betterment of delivery quality and customer satisfaction.

KEYWORDS: Defect Prevention, Defect Density, Cost of Quality, Review, Defect, RAG Score,DP life-cycle,Quality Managers

I. INTRODUCTION

The Defect Prevention process in any Software/IT organization is the back-bone of Deliverable Quality Management. In most of the cases this process suffers due to lack of a very systematic Defect Prevention (DP) process and need of any strong evaluation method to measure the effectiveness of the process.

In this article the entire DP process has been re-organized through different phases in such a way that the integrated approach adds value to the overall analysis and provides clarity on the entire DP life-cycle to all the stake-holders. Also a scoring mechanism has been proposed which can represent an equivalent quantitative measure of the effectiveness of process.

The execution of the proposed approach holistically consists of following phases or steps: fixing timeline, defect data collection, analysis, review and reporting. The entire “Analysis life-cycle” has been demonstrated with associated time-lines that involved stake-holders must stick to in order to make the execution effective and value adding to the organization as well customers. The feedback from Quality Managers or Leadership teams will help project teams to close the existing gaps in next analysis instance. The evaluated score helps the Leadership as well project teams to assess the level of effectiveness of the existing DP process. The Analysis Phase is the heart of the DP life-cycle, which is/to be actively done by the project team and must be aware on the month-on-month progress on relevantmetrics. The focus on Trend Analysis helps identification of gaps and potential improvement areas. Quality Managers in an Organization are responsible for reviewing and checking the effectiveness of Defect Prevention process. To achieve maximum review effectiveness in minimum time, it is a good practice to prepare standard review checklists and follow that uniformly for all project entities. That way Quality Managers get rid of writing descriptive review feedback which is time consuming.

The article is composed of sections as listed below:
Section II details the related work done and progresses made in this field
Section III is the Root Cause Analysis for identification of potential gaps in process
Section IV details the proposed process structure with relevant details

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Section V lists the expected benefits that can be achieved by implementing the proposed model

II. RELATED WORK

There are many defect prevention strategies available in different journals. This work is based upon the literature review of few of those articles clubbed with authors' real life project experiences in defect handling with preventive techniques.

[1]JÖRG RECH from Fraunhofer Institute for Experimental Software Engineering (IESE) talked about defect handling in Agile Software Development. Apart from regular process of code refactoring and inspection, he introduced annotation language in storing defect information which blocks reinvention of wheel at a later stage of inspection.

[2]Suma V and T.R. Gopalakrishnan Nair explained the differences among Error, Fault and Failure; put special emphasis on Inspection process in effective defect prevention in their paper "Effective Defect Prevention Approach in Software Process for Achieving Better Quality Levels". They provided guidelines about defect detection time and defect fixing time to be used in analysis, combined with Orthogonal Defect Classification (ODC).

[3] Leanne Howard, Account Director, PlanIt Software Testing proposed the idea of "The Defect Management Meeting" as part of Agile Development in his article "Agile – Why the Fear?" from PlanIt Software Testing journal. His time-boxed defect management meeting serves the purpose of prioritization of defects as well as status tracking, while the key challenge of this type of meeting is "defect ping pong" – means forward and backward movement of defects among individuals.

[4] Another Agile Development defect management approach as cited by Rida Noor, Muhammad Fahad Khan in their article "Defect Management in Agile Software Development" focuses various attributes like Quality Assurance Methods, Defect Handling Techniques and Priority Setting to work together in achieving effective prevention of defects. In this article quality assurance methods include Software Inspection, Testing, Product metrics and Refactoring. Four major techniques to reduce defects are Defect Prevention, Defect Removal, Defect Tolerance and Defect Forecasting. Here mainly four severity levels are suggested: Critical, Serious, Moderate and Low.

[5] Hafiz Ansar Khan's "Establishing a Defect Management Process Model for Software Quality Improvement" article suggests mainly three levels: Defect Detection, Defect Analysis and Defect Prevention. Its prevention level focuses on Failure Mode Effect Analysis (FMEA) and Fault Tree Analysis (FTA).

[6] Varsha G. Palatse and Prof. V. S. Nandedkar published a survey on Software Defect Prediction using Data Mining Tools and explained how Defect Prediction plays an important role in preventing potential defects.

[7] Bhagavant Deshpande and Suma V published a survey where relationship among project complexity, its defect count etc control the CSI. This survey has considered 10 projects from CMMI Level 5 Organizations and comparative analysis is presented.

[8] Sreenivasa Pisupati, the Vice President of W3Softech India Private Limited proposed a step by step guideline in defect prevention process as one of the major key performance area in CMMI level 5 Organization

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III. RCA – POTENTIAL CAUSES FOR INEFFECTIVE DEFECT PREVENTION PROCESS

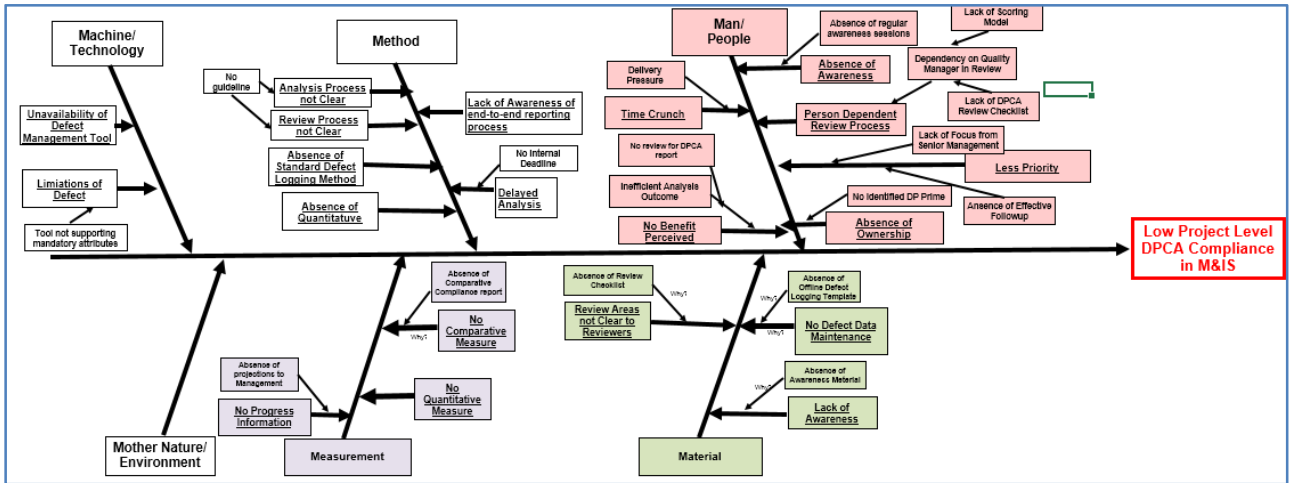

Figure 1: Fishbone diagram for IneffectiveDefect Prevention Process

This fishbone diagram is prepared using 6M principle of Toyota Production System (TPS). The potential causes for Inefficient Time Management are contributed by Man / People, Material, Method /Process and Measurement. Our solution tries to address these elementary level causes as much as possible.

Below are short explanations for each and every cause:

Causes pertaining to Man or People:

1. Time Crunch: Due to Time Crunch in delivery schedules especially when teams work in Agile mode, teams avoid going through Defect Prevention analysis practices

2. No Benefit Perceived: Due to inefficiency in analysis process teams are not able to perceive any benefits from detailed analysis process and they lose interest in it

3. Absence of Awareness: The basic necessity of an analysis process and its purpose are often not communicated to teams due to lack of proper awareness building sessions

4. Person Dependent Review Process: Due to lack of explicit review techniques, different quality managers review defect prevention analysis process in different ways. Review process plays a very important role in achieving its intended effectiveness

5. Lack of Priority Setting: In everyday rush of delivering products to customer, quality improvement idea generation or analysis activities get less priority. As a result these activities normally get delayed or totally avoided

6. Lack of Ownership: Like all other process areas, defect prevention analysis process too need dedicated ownership absence of which leads to irregular execution of activity

Causes pertaining to Method or Process:

1. Lack of clarity in Analysis and Review Process: Due to lack of understanding in basic analysis and review processes, deriving efficiency out of Defect Prevention analysis becomes a challenge

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2. Lack of Standard Defect Logging Method: Quite often entities fail maintaining defects in a systematic way, with necessary analysis parameters due to lack of tool or lack of prior planning. Absence of all defects make the analysis inefficient.

3. Absence of Quantitative Feedback: Quantitative Feedback helps accurate judgement of any entity. Hence defect prevention effectiveness should be measured through pre-defined scoring model

4. Delayed Analysis: Timeline of any analysis is very crucial as window of opportunity lies within that timeline itself. Perceptions change as time progresses. Hence fixing analysis timeline and following it is another aspect of effectiveness

Causes pertaining to Machine or Technology:

1. Unavailability of Defect Management Tool and its Limitations: Often defect management tools do not provide provisions for necessary analysis attributes like defect cause, defect type, defect severity and defect detection phase. Teams need to take additional responsibility to include these information for all internal and external defects

Causes pertaining to Material:

1. Unavailability of Defect Data, Training Materials: Lack of Defect Data is the most severe materialistic issue in carrying out analysis. Apart from that Training Materials and Guidelines related to basics of defect prevention model, its analysis process, its review process are important elements in propagating knowledge

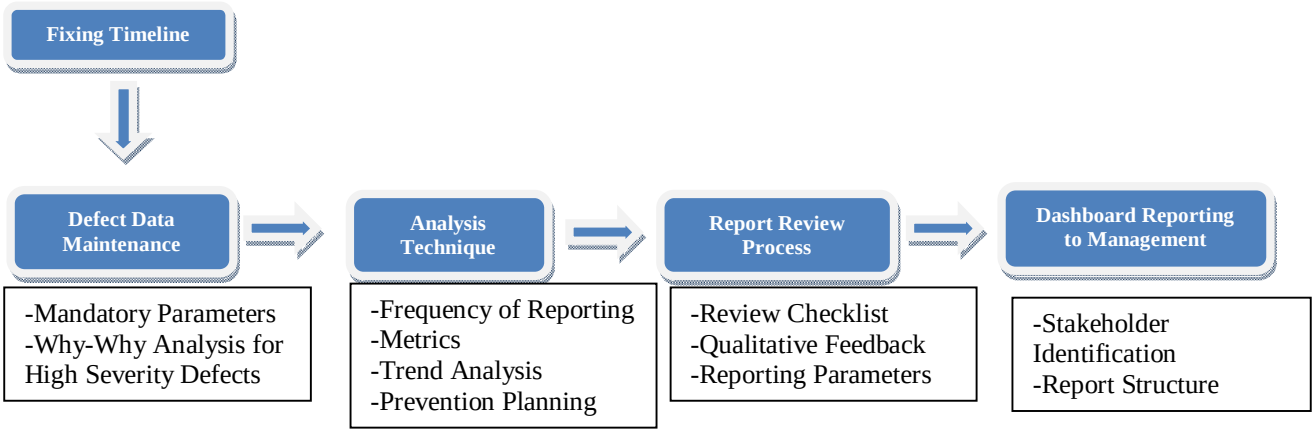
Causes pertaining to Measure or Inspection:

1. Absence of Progress Information & Comparative Trends: Positive or Negative progress information for each entity in an Organization with respect to certain metrics are necessary for stakeholder to have an idea of the entity's health and its required action points

2. Absence of Quantitative Measure: Numeric Scoring is necessary for accurate performance analysis and it also gives insight into other similar entities; hence stimulate comparative analysis

IV. PROPOSED STRUCTURE OF EFFECTIVE DEFECT PREVENTION PROCESS

Steps for Defect Prevention Process Owner



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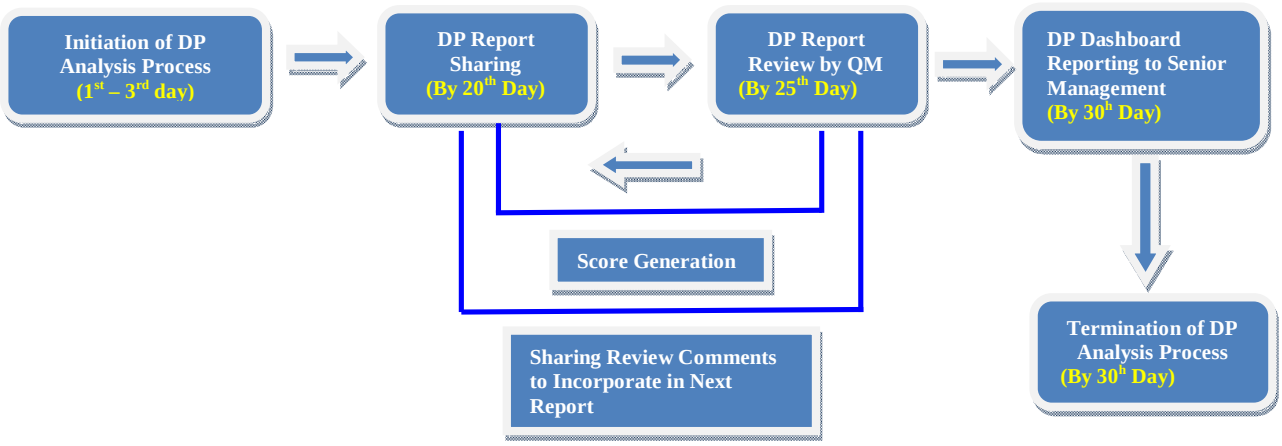
Overall Process flow can be depicted using below flow structure diagram:



A. Fixing Timeline

Determination of activity wise timeline is very important for maintaining the rigor among employees. It ensures uniformity of reporting process across all entities in an Organization.

Below is the proposed timeline which is feasible to implement and provides good result:

Activity	Timeline (Days of Month)
Initiation of Defect Prevention Analysis Process	1st Day to 3rd Day
Reporting by entities to Quality Managers for review	20th Day
Review of Defect Prevention Analysis reports by Quality managers	25th Day
Defect Prevention Dashboard to Senior Management	30th Day
Termination of Defect Prevention Analysis Process	30th Day

Figure 2: Activity wise Suitable Timeline

B. Defect Data Maintenance

Maintaining high quality defect data is an important aspect for achieving efficient defect prevention analysis process. The only criteria is each and every defect data needs to be logged irrespective of defect identification or defect injection step.

1. Mandatory Parameters:

For enabling analysis process below listed five defect parameters must be provided with reasonable values:

i. Defect Description
ii. Defect Severity
iii. Defect Type
iv. Defect Cause
v. Defect Detection Phase (Peer Review, System Testing, QA Testing, Integration Testing, External Review, UAT etc)

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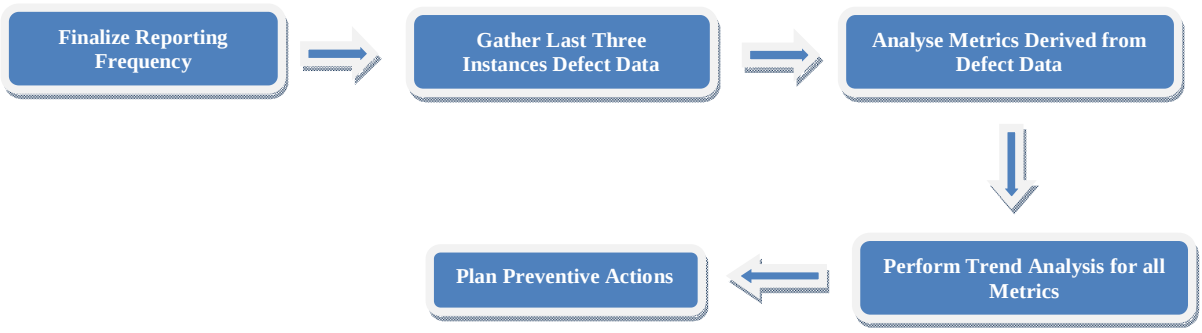
2. Why-Why Analysis:

It is good and safe practice to go through why-why Analysis for each and every high severity defect in order to capture its actual root cause, instead of assuming its cause. This is because high severity defects normally come with high impact and it is necessary to confirm their actual causes for proposing preventive action.

C. Analysis Technique



This section describes necessary techniques to be followed by entities which are going through Defect Prevention and Analysis Process on a predefined frequency. It contains necessary parameters and provides parameter wise guidelines which can be utilized by independent entities for ensuring an effective analysis. Listed are the necessary attributes combination of which can help in building analysis strategy.

1. Frequency of Reporting

Standard reporting frequency should be monthly, or based on presence of deliverables. Teams may decide to go for regular monthly analysis irrespective of whether deliveries are made in that month or not.

In case of no deliveries in a particular month teams may focus on already open preventive actions and track their progress.

In another way, teams may decide to go for Defect Prevention analysis only when they deliver. So every time new analysis as well as preventive action tracking take place.

2. Metrics

Listed are useful Metrics and their formulae which can be used for defect prevention analysis process:

Metric Name	Formulae	Purpose
Defect Free Delivery(DFD)	(No of deliverable where severity 1 acceptance testing bugs = 0 and severity 2 acceptance testing bugs = 0) * 100 / (no of deliverables in the period considered)	Measures Quality of Delivery
Appraisal Defect Density	(No. of defects)/(Total Review and Testing Effort)	Measures how many defects per unit of review and testing effort is able to capture
% Rework	(Rework Effort) * 100 / (Total Effort)	Measures Effort Consumption forFailure Resolution
% Cost of Quality	(Preventive Effort + Appraisal Effort + Rework Effort) *	Measures Extent of Quality

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(COQ)	100 / Total Effort	Maintenance Cost
% Total Defect Containment Effectiveness(TDCE)	(No of pre-delivery defects) * 100 / (total no of defects)	Measure of Internal Review and Testing Process Effectiveness
%Bad Fix(BF)	(No of Re-Opened problems) * 100 / (no of problems resolved)	Measures Efficiency of Fix
%Review Efficiency(RE)	(No. of defects captured in Review) * 100 / (No. of defects captured in Testing)	Measures Efficiency of Review versus Testing
Mostly occurring Defect Cause	Topmost Defect Cause from last Three Instance Trend	Most Important Defect Cause
Mostly occurring Defect Type	Topmost Defect Type from last Three Instance Trend	Most Important Defect Type
% High Severity Defect	(No. of Severity 1 and Severity 2 defects) * 100 / (Total No. of Defects)	Measures Impact of Defects
%SLA Compliance	(No. of Resolved PRs/Incidents where SLA is met in the window) / (No. of resolved PRs/Incidents in the window)	Measures Consistency of Meeting Service Level Targets
Backlog Management Index	(No of Requests Closed during the month) / (Opening Balance for the month + No. of Request Scheduled to be closed during the month + No. of Early Closures in the month)	Measures Efficiency of Handling Backlog Tickets

Figure 3: Metrics to be used in Defect Prevention Analysis – Formulae and Purpose

3. Trend Analysis

For effective analysis it is recommended not to rely on single month's metric values in order to avoid any special cause of variation which may be applicable only for a particular month. It has been observed that last three months or last three instances trend makes more sense in identifying project's common concerns. Hence in this process we propose all applicable entities to follow at least last three months' or last three instances' trend before planning any action.

4. Prevention Planning

Based on trend analysis, mostly occurring pain needs to be selected for improvement. Hence Preventive planning for that particular pain area requires planned action to be taken. Planned action ensures permanent removal of identified gap. Listed below are important aspects of preventive planning which improves effectiveness:

i. Planning specific action which can be monitored
ii. Assigning dedicated owner to each action
iii. Planning closure date
iv. Monitoring status (Open/Closed) in every analysis
v. Tracking %age Completion for all Open actions
vi. Listing further action needed for all Closed actions
vii. Planning improvement projects or best practices from closed actions

D. Report Review Process

1. Review Checklist

Quality Managers in an Organization are responsible for reviewing and checking the effectiveness of Defect Prevention process, reports of which are shared by projects on a regular interval. For achieving maximum review effectiveness in minimum time, it is a good practice to prepare standard review checklists and follow that

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uniformly for all project entities. That way Quality Managers get rid of writing descriptive review feedback which is time consuming.

Below is a proposed checklist which can be used in a generic way by Quality Managers:

Checkpoints	Compliant? (Yes/No/NA)	Detailed Comments
Defect Data Maintenance Checkpoints		
Checkk if all Internal review, testing defects and all External review, testing defects are maintained by project team		
Check if below 5 mandatory columns have valid values for defect data 1. Defect Description 2. Defect Type 3. Defect Severity 4. Defect Cause 5. Defect Source		
Checkif every high severity defect has gone through Why-Why analysis to fnd out actual cause		
Parameter/Metric wise Checkpoints		
Check if parameter / metric value is calculated properly and in sync with raw defect data		
Check if LSL and USL values of the parameter / metric are being maintained as per Organizational standards/ Customer Specification		
Check if Causal Analysis of current montth is done if the parameter / metric is an outlier		
Check if Trend analysis comment is given for all considered historical instances for specific parameter / metric		
Check whether there is any improvement scope for the parameter / metric value and preventive actions are planned for that		
Preventive Action Checkpoints		
Check if planned action is specific and can be monitored		
Checkif dedicated owner is assigned for each action		
Check if closure date is planned for each action and that is reasonable		
Check if the action Status is being tracked		
For long running open actions check the progress		
Check if further action needed are listed properly for closed actions as relevant		
Check if performance improvement project or best practices are planned for closed actions		

Figure 4: Defect Prevention Analysis / Review Checklist

2. Quantitative Feedback Mechanism

Scoring Parameters	Value	Score
Reporting Timeliness	1st - 14th day of reporting Month	10
	15th - 20th day of reporting Month	5
	after 20th day of reporting Month	1

Scoring Parameters	Value	Score
Defect Prevention Performance Improvement	Performance Improvement Implemented	10
	Performance Improvement Scope Identified	5
	No Performance Improvement Scope Identified	0

Scoring Parameters	Value	Score
Defect Prevention Best Practice	Best Practice Articulated	10
	Best Practice Identified	5
	No Best Practice Identified	0

No. of RED (non-Compliant) points in DP Review Checklist	Value : (-2 * Count of RED Point)

Figure 5: Standard Scoring Parameters and their RAG Criteria

E. Defect Prevention Dashboard Reporting

1. Stakeholder Identification

Stakeholder identification is a crucial part of any reporting. It plays a vital role in putting entities into perspective and helps better judgement of project's current performance level with its potential improvement scope. Any managerial level employee who has significant impact on the project's quality aspects and can take decisions on to be process must be included in stakeholder list and notified the status.

2. Reporting Parameters

It is critical to showcase all relevant metrics and their trend (upward / downward / at same level) to senior management on a regular basis for a detailed insight into a project or entity's actual performance.

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Below are sample report structures created separately for Development and Support projects

Figure 6: DP Reporting Structure for Development Projects

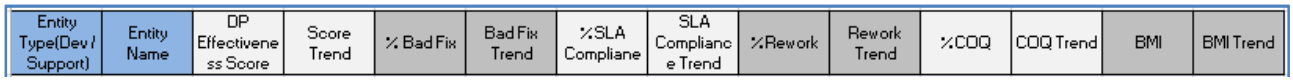

Figure 7: DP Reporting Structure for Support Projects

V. BENEFITS

1. Helps improving efficiency of Defect Prevention & Analysis process
2. Provides explicit guideline for entities or project teams in carrying out this analysis
3. Builds regular causal analysis rigor
4. Ensures systematic maintenance of defect data with mandatory attributes
5. Quantitative feedback mechanism helps identifying gaps more rigorously
6. Consolidated dashboard helps stakeholder gauge a project about its existing performance standard
7. Trend Analysis helps identifying common gaps existing in a project
8. Systematic analysis and step by step procedure generates Performance Improvement scope

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BIOGRAPHY

Mr. Suvankar Dhar has completed his M.Tech in Nano Science & Technology from Jadavpur University, Kolkata on 2008. He has almost 8 years of experience with Multi National Organisation in Development, Maintenance and Production Support projects having expertise in the area of Software Engineering Process and Quality Management. He has helped different real life project teams to sustain the alignment with ISO, CMMI Level 5 organization standards. He is also a Six Sigma Green Belt certified professional

Ms Suvra Nandi has completed her B.E in "Computer Science & Technology" from Bengal Engineering & Science University, Shibpur, Howrah during the year 2006.
Her M.E stream is "Software Engineering" from Jadavpur University, Kolkata and she completed M.E degree during the year 2015. She has 10 years of Software Engineering experiences with multi-national companies in different Development, Maintenance and Production Support projects. Also she is a Soft Engineering Process and Quality Facilitator, who is also facilitating different real life projects in executing and maintaining expected Quality Standards. She has 5year's experiences in Quality Audits and Performance Improvement practices pertaining to CMMI Level 5 organization standards. She is Six Sigma Green Belt certified professional.