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Innovative Quality Measurement System—Ideas for a Project Manager

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> “Only a well-researched, scientific approach can help design an optimal and objective system of measurement and one that will be acceptable to all the critical stakeholders.”

Quality management is an integral and key component of project management. Often, quality measurement systems manifest themselves in the success or failure of projects and, subsequently, of operations. A well-designed quality measurement system is characterized by an ability to detect critical defects throughout the project life cycle and beyond.

Traditional quality measurement systems have certain inherent deficiencies, some of which are:

- Static sample-size calculations
- General views of all the agents (people and machines) involved in production
- Non-discrimination between errors of varying criticalities

These deficiencies lead to problems like increased cost of quality measurement, reduced customer satisfaction due to poor quality output, improper defect analysis, poor training management, and so forth. The project management community needs a more dynamic and advanced quality measurement system.

The project manager is in charge of most of the project or operational base-lining effort, so designing a good quality measurement system is his or her responsibility; however, in designing it, he or she often faces some cost-quality tradeoffs. Only a well-researched, scientific approach can help design such an optimal and objective system of measurement and one that will be acceptable to all the critical stakeholders.

This paper presents the efforts of the project management team involved in the design of a “universal quality system” for business process outsourcing projects. This unique quality system applies certain statistically fundamental principles to provide an objective view of the project status across stakeholders and has the following unique characteristics:

- N-phase audit mechanism
- A complex algorithm to ensure a progressive adjustment of the number of transactions to be audited based on history (dynamic sample sizes)
- Empirically proved for a power of test (beta) of more than 80% and a low type-1 error (alpha)
- Flexible enough to allow for dynamically changing quality and productivity baselines
- Incorporates Six Sigma best practices
- Standardization through the unique concept of “defect equivalents” to ensure a normalized view of employee performance within a project for a zero-bias performance appraisal system

Introduction

Project management as a philosophy puts much emphasis on the importance of quality. *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, which is the benchmark standard for the project management discipline, has articulated the importance of balancing various project constraints. One of the key constraints is "quality." This is a clear evolution from the classic "triple constraints" of scope, time, and cost articulated in earlier versions of the *PMBOK® Guide*. As much as this evolution speaks of the versatility of the *PMBOK® Guide* as being one of the most up-to-date standards, it also highlights the importance of quality as a key project constraint. Moreover, the fact that the *PMBOK® Guide* lists Project Quality Management as one of the Knowledge Areas itself is testimony to the fact that quality management is quite integral to project management. Figure 1 depicts the growing importance of quality in project management.

The Emerging Business Model

The emerging business model in the reset economy[1] is that of "extreme customer-centricity," as evidenced by business leaders in various forums. Businesses have realized that aligning to the business requirements of the client is the only way to survive and experience growth. This model is applicable to the entire gamut of economy—agriculture, manufacturing, services, information technology, the government, and so forth. It is the "voice of the customer" that matters the most, and effective quality management constitutes a properly interpreted and codified voice of the customer.

The project management discipline has been cognizant of this constantly evolving trend, as discussed in the previous section, and has reiterated its commitment to quality by having "customer satisfaction" as one of its key focus areas. In fact, the *PMBOK® Guide* has maintained that modern quality management complements project management.[2]

Projects are important aspects of organizations and, in general, organizations with strong project management capabilities are the ones that succeed in maintaining a competitive advantage; this applies to organizations, irrespective of their strategic orientation toward being sales driven or operations driven. Hence, sound project management practices are extremely critical for organizations in order to thrive in the reset economy. As a corollary, organizations need to focus heavily on good project management and quality to ensure that they stay in business and grow, and even more so in the new economy. Investments

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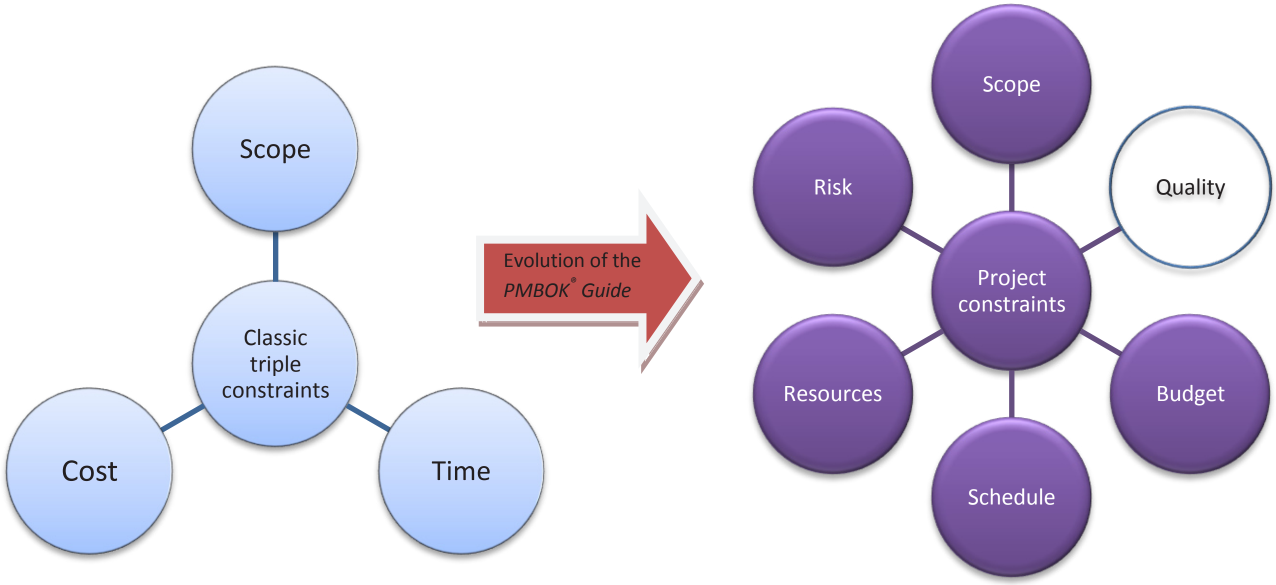
[1] This is a generally accepted term for the economy in the aftermath of the economic recession that started in 2008. The reset economy is characterized by a severe scarcity of capital, hyper-competitiveness, aggressive expectations from customers about the quality of deliverable, mounting cost pressures, tremendous importance for business/technological innovation, etc; the general agreement being that the economy can never reach the same levels of growth that existed before the beginning of recessionary trends.

[2] *PMBOK® Guide* – Fourth Edition Chapter 8, Project Quality Management



Quality is not part of the project constraints (*PMBOK® Guide*, Third Edition)

Quality is an important part of the project constraints (*PMBOK® Guide*, Fourth Edition)

Figure 1: Evolution of the *PMBOK® Guide* to include "quality" as a key project constraint.

in project management capabilities and delivering good quality to the customer are sure to yield extremely high returns in terms of an increased top-line, improved bottom-line, value to investors, and employee satisfaction. Organizations oblivious to this important aspect will either face extinction or get amalgamated into larger entities that are characterized by sound project management and innovative quality management practices.

The Project Manager's Role in Quality Management

Every business transaction or process starts off as part of a project and can be mapped to some project, even at the most operational level.

Good management of business transactions or processes is determined to a significant extent by the way its measurement system is designed. Most often, the design of the transaction/process and of the measurement system is done as part of some project even before the transaction/process enters the operations mode.

This paper leaves the scope of "transaction/process design" for a later deliberation and deals exclusively with the design of a quality measurement system as part of the Project Quality Management knowledge area. The author takes a very firm stand that it is the responsibility of the project manager to initiate, plan, execute, and institutionalize an efficient quality measurement system as part of the project quality management, plan quality process.[3]

It is often observed that systems designed in the early stages of a project tend to have a lasting impact on operations. One of the main reasons for this is that the stakeholders' enthusiasm for adopting and learning the systems is at its peak during the outset. Any subsequent changes to the system are costly both from the re-engineering and the change management points of view.

This makes the role of the project manager extremely crucial, because a lot depends on the project manager's innovativeness in building a good quality measurement system early on in the project, so that the subsequent handover to operations teams is healthy, seamless, and fulfilling.

In this paper, the author explains and builds on his experience as a project manager in developing an innovative quality measurement system for business process outsourcing (BPO) engagements. Nonetheless, the concept is universal and can be customized to many industrial scenarios that involve high-volume, business-rule driven transactions.

The Traditional Quality Measurement System

A lot of research has gone into designing quality measurement systems and many theories have been postulated. One of the key objectives of any measurement system is to reduce the statistically important type 1 and type 2 errors. Table 1 depicts these possible errors.

	Accept Null Hypothesis (H_0)	**Reject Null Hypothesis (H_0)**
Null Hypothesis (H_0) is true	Desirable outcome, probability of which is called confidence level, 1-α	Type 1 error, the probability of which is denoted by α
Null Hypothesis (H_0) is false	Type 2 error, the probability of which is denoted by β	Desirable state, the probability of which is equal to 1-β, often called "power of test"

Table 1: Depictions of type 1 and type 2 errors.

Depending on the application, one type of error can be more significant than the other. With the null hypothesis being that the accuracy of the output is greater than the desired, a high type 1 error in a typical business set up would mean that there is unnecessary rework due to holding back valid outputs, which generally means a higher cost to the organization. This often means a stringent quality inspection, by which the customer would get a high-quality output at the cost of the supplier organization. In other terms, a high type 2 error means that there is a higher probability of defective output not being detected by the measurement system and ending up being supplied to the customer. This, in turn, would lead to many warranty claims and a tarnished image for the supplying organization in the marketplace.

Project managers generally build quality measurement systems that are designed for a certain probability of type 1 error (α). Type 1 error reflects the organization's tolerance for deviations in quality. A very low acceptable probability of type 1 error means a less stringent quality measurement system but this would mean that the probability of accepting defective outputs (β) would go up. In other words, the power of the quality measurement system (1- β) goes down. Figure 2 illustrates the relationship between the error types, although not exactly linear in real life.

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[3] *PMBOK® Guide* – Fourth Edition, Chapter 8, Section 8.1.3.2 Quality Metrics

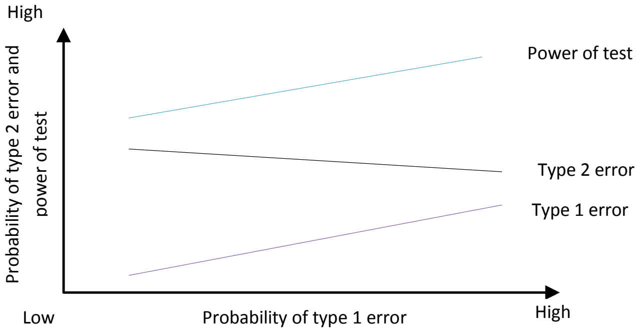

Figure 2: Relationship between type 1 and type 2 errors.

The entire consideration of type 1 and type 2 errors arises out of a practical limitation on the number of outputs that can be "economically measured" for accuracy. The only way to reduce the probabilities of type 1 and type 2 errors is to increase the number of the samples that will be inspected. Theoretically, a calibrated measurement system applied consistently over 100% of output would have zero probabilities of type 1 and type 2 errors. This, however, is definitely not economically feasible from a business perspective. For a given sample size, type 1 and type 2 errors will always be correlated as shown in Figure 2.

This brings us to the most important question: What should be the sample size to achieve a maximum power of test for a given tolerance for type 1 error? Much data have been tabulated to assist quality managers in fixing a sample size based on type 1 error, but these tables have a limitation in that they assume normal distribution of the attributes, whereas in practical terms this is often not the case. The general formulas for calculating sample sizes also have some limitations, such as the population variance required for calculations not generally available or very difficult to estimate.

So, it is general practice to estimate the sample size based on experience. Even if the project manager or the quality specialist in the project team uses statistical tables or formulas to calculate the sample size required, most often the relevance of the logic behind arriving at the sample size gets lost in the long run. In fact, the main shortcoming of the sample size calculations is that they do not consider dynamically changing requirements and scenarios. For example, when the customer revises the accuracy requirement from the earlier 96% to 98%, the sample size that needs to be considered for quality inspection is also likely to go up to ensure that the power of the test ($1-\beta$) is increased so that the probability of the customer receiving defective outputs is minimized. Most often, the operations/delivery teams stick to the same sample size that was proposed in the project stage and once the project team disengages, it becomes even more difficult to really understand the logic behind such a sample size and make changes to it, depending on the dynamically changing business requirements.

One more crucial aspect that traditional quality systems overlook is the fact that the behavior of people or the machines involved in the production of output is not uniform. Different sets of agents (people or machines) require varying degrees of monitoring and measurement. The traditional quality measurement systems often prescribe a "blanket" sample size in the form of "percentage output to be audited" or number of samples to be audited for different agents. This often leads to a lack of the much required discrimination between various agents as far as sample sizes are concerned. For example, auditing a high-performing individual at the same rate as a low-performing individual can lead to a waste of time and effort. Conversely, a low-performing individual may require a higher degree of auditing compared with a high-performing one to ensure that the customer does not get defective output.

Apart from the deficiencies in the sample size considerations, a major problem with the traditional quality measurement systems is that all defects observed are generally considered at par with each other. This often leads to skewed analysis, which leads to penalizing less critical defects at the same rate as the more critical ones or, conversely, not penalizing an identified critical defect as much as it should be. The defect rate measured could be made up of all business non-critical errors, all extremely critical errors, or a combination of both. For example, if one page of an automotive manual has ninety-eight words and two illustrations, there are effectively one hundred opportunities for error[4] on that page. A defect in the illustration could be extremely critical, because the driver stranded on a highway due to a breakdown may actually get into a serious problem because the part he should be repairing is not well explained in the owner's manual. At the same time, an incorrectly capitalized letter or a missing punctuation mark is not as critical as an incorrect illustration. Traditional quality measurement systems tend to measure these defects "at par" and this is obviously not the most appropriate way to measure.

In addition, the "degree of quality requirement" that varies from project to project is often overlooked, which leads

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[4] Opportunities or Opportunities for error (OFE) is a Six Sigma concept that measures the number of components of an entity or output that "can" go wrong.

to the same sampling methodology in all projects. Moreover, traditional systems do not consider the fact that different projects and operations have different benchmarks as far as quality requirements are concerned. For example, in the same department, there can be two projects—one with an accuracy requirement of 95% and the other with a requirement of 99%. The traditional quality system would prescribe the same sampling rate for both projects rather than basing it on the absolute accuracy requirement.

Dynamic Quality Measurement System

A major area of involvement for a project team and the project manager is the Plan Quality process of Project Quality Management, as mentioned in the *PMBOK® Guide*. Statistical sampling[5] is a very important tool in the Plan Quality process. As mentioned in previous sections, many project managers find it difficult to come up with a reliable sampling frequency because there is always bound to be a tradeoff between the cost of sampling and the effectiveness[6] of the sampling plan.

Also, quality metrics and quality checklists are critical inputs to Perform Quality Assurance and Perform Quality Control processes of the Project Quality Management process group. Identifying the right Quality metrics and checklists is very important; hence, project managers should spend considerable time in identifying and formulating a good defect tracking system that "normalizes" various defects against a standard criticality. Table 2 is a summary of the shortcomings of the traditional quality systems as explained in the above section.

The *PMBOK® Guide* does provide for proprietary quality management methodologies, keeping in mind the complexity of the desired outputs of the quality management plan. With this as the background, this paper proposes a customized and proprietary quality measurement system that makes up for the deficiencies of the traditional systems. The unique aspect is that this system considers agent-wise work allocation as the basis for audit sample size; hence, productivity considerations are inherent in this system. One of the ultimate outputs of this system is a composite employee performance index made up of productivity and quality scores for each individual.

The proposed quality measurement system inherently incorporates the "central limit theorem"[7] by progressively and dynamically adjusting the sample size based on the output of the previous sampling, thereby obviating the need for the data to be normally distributed for any kind of statistical analysis and making it fit into the Six Sigma paradigm. This is likely to increase the overall sample size, with an increase in the quality effort, but the benefits in terms of better customer satisfaction far outweigh the costs associated with the increased quality effort and it also reduces the rates of type 1 and type 2 errors as seen empirically. One of the main advantages of this system is that for a particular "class"[8] of projects, whatever the starting audit percentage, ultimately the overall audit

Reason	Effect	Results in…
Static sample size calculations	Decreased power of test when the customer's quality requirements go up or increased cost of auditing when the quality requirements are relaxed	Poor customer satisfaction and deterioration of the organization's image and business
Blanket view of all agents (people and machines) of production	A common "average" sample size selection without discriminating between high-performing and low-performing individuals or agents, leading to either too much or too little auditing effort	Poor quality output reaching the customer, increased cost of quality measurement
Non-discrimination between errors	An average "count" of errors without a proper normalization based on criticality leading to skewed analysis	Improper training needs, improper analysis of defects/reworks, and poor corrective action

Table 2: Summary of the shortcomings of traditional quality measurement systems.

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[5] PMBOK® Guide – Fourth Edition, Chapter 8, Section 8.1.2.6 Statistical Sampling

[6] Effectiveness of the sampling plan indicates the degrees to which type 1 and type 2 errors are minimized when a particular sampling plan is used

[7] Central limit theorem states that, "As sample size increases, the sampling distribution of sample means approaches that of a normal distribution with a mean the same as the population and a standard deviation equal to the standard deviation of the population divided by the square root of n (the sample size)"

[8] Although projects are unique, there would still be some similarities between some of them. By "class" the author intends to convey projects/transactions that have certain inherent similarities, however different they appear to be. For example, quality inspection for customer form processing is quite similar to the quality inspection of a manufactured automobile tire.

percentage over various phases of the audit will converge into a band of percentage values that will give statistically accurate results. This saves the project team valuable time and effort that would otherwise go into determining and designing a good quality measurement system as part of the Plan Quality process. This quality measurement system can be used as a "plug-and-play" system that covers all the deficiencies mentioned in Table 2.

The proposed system is driven by a complex algorithm that was empirically derived, using heuristics. The main feature of this system is that the entire quality audit is divided into "phases." The system can be configured as an N-phase audit mechanism, depending on the "perceived" requirement of the power of test.

We will explain this concept through a practical example, because much of the insights have come from practical project management experiences; before that, however, a mathematical representation is attempted to give it a generic flavor that can be replicated in a variety of scenarios through proper customization. For example, the logic for this system was derived through a series of experiments involving three phases of audit (for each lot), which seemed to be a practical upper limit. A one-phase audit is nothing but the traditional quality measurement system in which a lot is either passed or rejected based on the quality of a single sample. Nevertheless, there may be practical scenarios that might warrant more than three phases of audit per lot; for example, if the volumes of production are very high.

The required audit percentage is represented mathematically as per Equation 1.

Equations 1, 2, and 3 are applicable to each employee or agent separately, which allows for an agent-level analysis of the quality. Schematically, the model is represented as in Figure 3. Figure 3 applies to the output from a single agent and each agent would have a similar scheme of measurement.

The concept of defect equivalents remains to be explained. This component of the framework is a very important one and needs special consideration because it is a marked deviation from the traditional method of measuring all defects "at par."

$$a_{ij} \begin{cases} = f\,(Q,\ amin_{ij},\ q_{i,\,j-1}),\ \text{for } i = 1 \text{ to } L \text{ and } j = 2 \text{ to } N \\ = f\,(Q,\ amin_{i1},\ qavg_{i-1}) \text{ for } i = 1 \text{ to } L \text{ and } j = 1 \\ = \text{a random audit percentage} > 5\% \text{ for } i = 1,\ j = 1 \text{ (represented as } a_{11,} \text{ which is} \\ \quad \text{the minimum first phase audit percentage for the first lot) ………. equation (1)} \end{cases}$$

where

a = system generated audit percentage (except for $a_{11,}$ which is the starting audit percentage for the first phase of the first lot)

i = lot number ranging from a minimum of 1 to a maximum of L

j = phase number of the audit ranging from a minimum of 1 to a maximum of N

Q = benchmark quality as a percentage of defects in all opportunities for error (customer requirement)

q = detected quality percentage at each phase calculated by the number of defect equivalents and the number of opportunities for error. It can be represented by equation 2

$$q_{ij} \quad = f\,(de_{ij},\ ofe_{ij}) \text{ for } i = 1 \text{ to } L \text{ and } j = 1 \text{ to } N \text{ (definitions of notations maintained as in equation 1) ……………………… equation (2)}$$

where

de = number of defect equivalents observed during the audit of a lot in a phase

ofe = the number of calculated or counted opportunities for error

$amin$ = minimum audit percentage for each phase of audit, which is > 1%

$qavg$ = weighted average of detected quality across all phases for a lot, with the number of samples at each phase as the weights. This is system generated and can be represented mathematically as in equation 3.

$$qavg_i \quad = f\,(q_{ij}) \text{ for a given } i \text{ and for } j = 1 \text{ to } N \text{ (definitions of notations maintained as in equation 1) ………………. equation (3)}$$

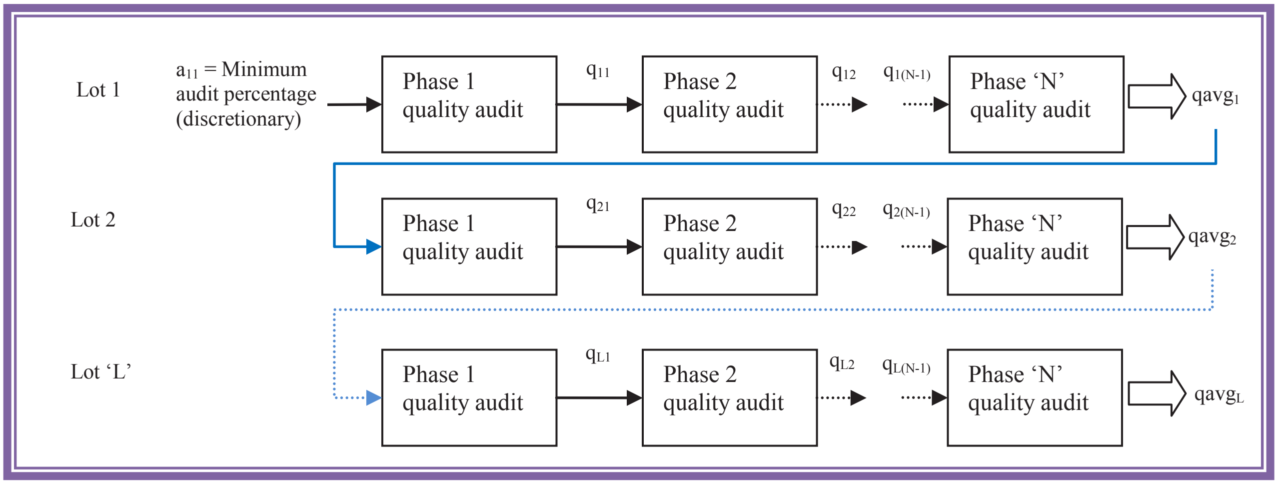

Figure 3: Schematic of an N-phase audit mechanism.

Every output or entity has a finite number of opportunities for error (OFE). For example, in an automobile tire there are components like the tread, the sidewall, the bead, and the ply, which represent the opportunities for error/defect. Each opportunity for error can have a certain number of known modes of failure. Each mode of failure has its criticality and this is where the proposed quality measurement system borrows from the concept of FMEA (failure mode and effects analysis)[9]. Figure 4 is a mathematical representation of these ideas, illustrated through mapping diagrams.

The failure modes, in turn, can be classified as fatal, critical, and non-critical based on their impacts on the deliverable. The failure modes are given scores, with fatal and critical ones having the highest values. The non-critical failure modes are given scores that are "normalized" against the fatal or critical ones. Although fatal and critical failure modes technically have the same scores for a particular opportunity for error, a clear distinction is made to facilitate a differential action in case a fatal error is encountered during quality audit.[10]

Because we are hypothesizing over a finite set of opportunities for error and a finite set of corresponding failure modes, all failure modes (irrespective of their relationship

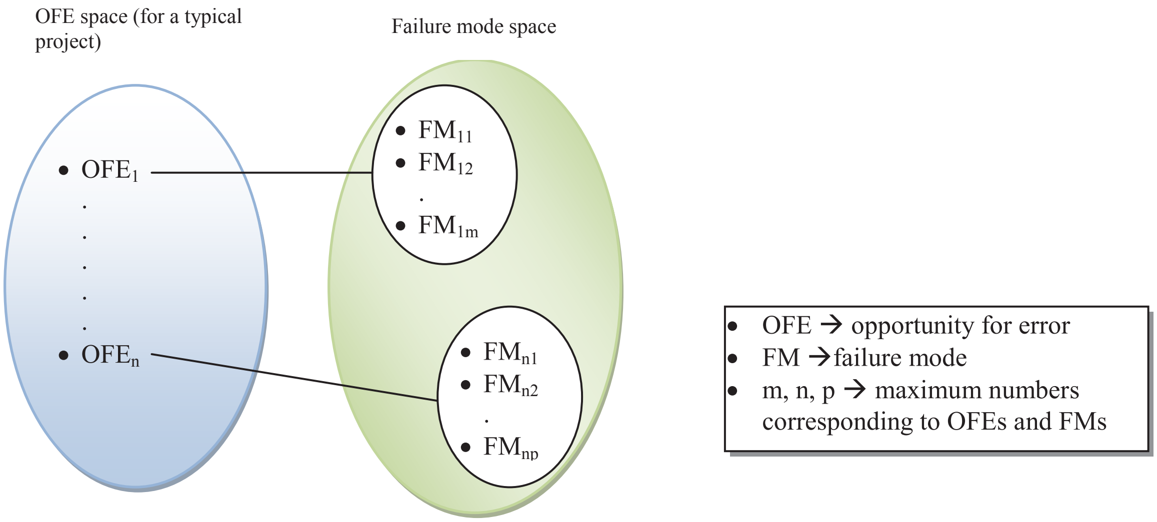

Figure 4: Mapping of error opportunities and failure modes.

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[9] FMEA is a quality and project management concept that gives an objective format to the criticality of the failure modes of various components through an index called the risk priority number (RPN) that is a composite of the severity, occurrence and detect-ability ratings of a particular failure mode. Often the ratings are arrived at through techniques like the Delphi, brainstorming, benchmarking, and so forth.

[10] In many industrial scenarios, including manufacturing and call centers, the detection of fatal errors during quality audits is treated seriously and often leads to the rejection of the entire lot of output (in case of product output) or 100% monitoring (in case of services)

with the OFEs) are put on a normalized scale, with the fatal and critical errors having the highest scores, but subject to a set of constraints to ensure that, logically, the total score of all failure modes is equal to the total number of opportunities for error. The total score of the failure modes observed will be the "total critical defect equivalents," also referred to in this paper as "defect equivalents." The same logic is applicable to both homogeneous and heterogeneous opportunities for error.[11]

One of the limitations of this logic is that it fails to normalize projects. For example, with the proposed system, an accuracy of 98% for a project with lower complexity and an accuracy of 98% for a project with higher complexity would be viewed as being equivalent. One way to overcome this limitation is to expand the mapping mentioned in Figure 4 to include all projects, their corresponding opportunities for error, and then normalize all failure modes across projects. This is not only logically challenging but also practically infeasible but it does serve as a theoretical possibility, which probably can be evolved into practical terms over a period of time as businesses gain maturity Until that time, however, this limitation can only be addressed by attaching an overall complexity index for each project and discriminating by way of policy intervention, like differential salaries, complexity-based incentives to employees, and so forth.

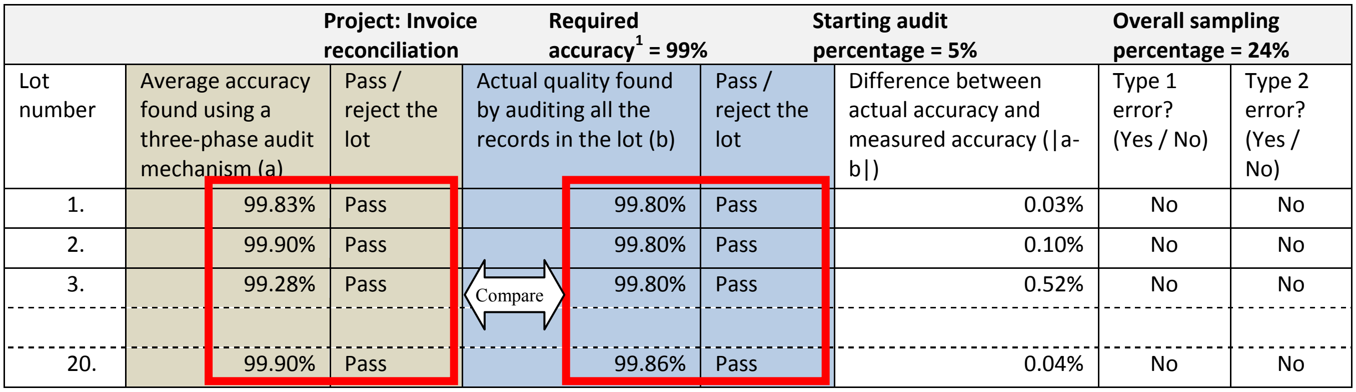
Practical Example Of Three-Phase Audit Mechanism

Although the proposed quality measurement system looks mathematically complex, it can be easily automated using computer software. The logic mentioned in the above section can be codified using the information technology component of the project team. The project team the author was part of actually created a software application using the available software and put it to use across three projects of varying scopes. By using the software application, the project team recorded the performance of a cross section of employees (agents).

Table 3 gives a sample summary of the findings and the effectiveness of the three-phase quality audit system applied to one of the projects. The table summarizes the results measured for one employee. The cells of the table shaded in grey indicate the results using the proposed three-phase audit mechanism. The project team then measured the accuracy levels by inspecting 100% output of each lot. The values appear in the cells shaded blue. A comparison of the values in grey and blue cells indicates that the three-phase audit mechanism is as good as the inspection of 100% output.

Table 4 presents a broader summary of the three-phase quality measurement system applied to a data entry project, an invoice reconciliation project, and a voice-based customer feedback management project. The "overall sampling %" is a system-generated value that takes into consideration the accuracy levels detected across the three phases of each lot.

It is empirically evident from Table 4 that the three-phase audit mechanism has very low incidences of type 1 and type 2 errors, thereby leading to lower rework costs (due to low type 1 error) and lower risk of passing on bad output to the customer (due to low type 2 error). In fact, the power of test is as high as 100%, and the type 1 error is as low as 0%.[12] We observe that there is a pattern in that a higher overall sampling requirement might mean that the process is not stable from an accuracy perspective, owing to lack of standardization, uncontrollable external factors, the need for closer scrutiny of the particular agent, and so forth.



		Project: Invoice reconciliation	Required accuracy[1] = 99%		Starting audit percentage = 5%	Overall sampling percentage = 24%	
Lot number	Average accuracy found using a three-phase audit mechanism (a)	Pass / reject the lot	Actual quality found by auditing all the records in the lot (b)	Pass / reject the lot	Difference between actual accuracy and measured accuracy (|a-b|)	Type 1 error? (Yes / No)	Type 2 error? (Yes / No)
1.	99.83%	Pass	99.80%	Pass	0.03%	No	No
2.	99.90%	Pass	99.80%	Pass	0.10%	No	No
3.	99.28%	Pass	99.80%	Pass	0.52%	No	No
20.	99.90%	Pass	99.86%	Pass	0.04%	No	No

Table 3: Sample summary of the results of three-phase quality measurement system.

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[11] For example, in an automobile tire, we have heterogeneous opportunities for error in the form of the tread, the ply, the bead, and so forth, with each opportunity being associated with different sets of failure modes; whereas in a plainly typed paper, all the words form a homogeneous set of opportunities for error with exactly similar failure modes.

[12] The figures for type 1 error and power of test are observed for limited sample sizes.

Sample output #1 of three-phase audit mechanism	**Project: Invoice reconciliation**	**Required accuracy = 99%**	**Total number of outputs = 750**	
Start audit percentage	Effective sample size for 20 lots	Overall sampling %	Number of type 1 errors observed	Number of type 2 errors observed
5%	182	24%	0	0
10%	220	29%	0	0
15%	261	35%	0	0

Sample output #2 of three-phase audit mechanism	**Project: Data entry**	**Required accuracy = 99%**	**Total number of outputs = 750**	
Start audit percentage	Effective sample size for 20 lots	Overall sampling %	Number of type 1 errors observed	Number of type 2 errors observed
5%	181	24%	0	0
10%	223	30%	1	0
15%	288	38%	1	0

Sample output #3 of three-phase audit mechanism	**Project: Voice-based feedback management**	**Required accuracy = 90%**	**Total number of outputs = 450**	
Start audit percentage	Effective sample size for 20 lots	Overall sampling %	Number of type 1 errors observed	Number of type 2 errors observed
5%	258	57%	0	0
10%	277	62%	0	0
15%	277	62%	0	0

Table 4: Summary of the results of three-phase quality measurement system applied across various projects.

Because accuracy is measured as a proportion of “critical defect equivalents,” the N-phase quality measurement system allows for comparing the performances of all employees working for a particular project on a common scale. An example of how defect equivalents are measured is shown in Figure 5. The failure modes represented in bold font are the critical defects and all other defects are measured as a percentage or a fraction of the critical defects to arrive at the total defect equivalents as mentioned earlier. For example, a simple error like a formatting error can be treated as being only 10% as serious as a critical defect, much like a wrong currency being mentioned in payment terms. In other words, if wrong currency is given a weight of 1, a formatting error would have a weight of 0.1. The project team that implemented the N phase quality measurement system actually brainstormed and arrived at the weights for various defects against the critical defects. Of course, the software application would adjust the final weights in such a way that the sum of all defect weights would be equal to the total number of opportunities for error.

A word of warning here: As in any measurement system, the N-phase quality measurement system also needs to be periodically calibrated to ensure its relevance in dynamically changing business scenarios. For example, if a certain defect becomes irrelevant due to some technological intervention, that particular defect needs to be removed from the list, and the weights need to be reconstructed in such a way that the original constraint (of matching the sum of defect scores to the number of failure modes) is not violated. Another example is that a defect that is considered critical today may actually become non-critical in the future.

In fact, the example mentioned above has further integration with the employee productivity tracking system. The work done by each employee is logged into a productivity tracker similar to the traditional “timesheets.” The quality measurement system in turn picks these efforts and throws up the number to be audited at each phase by multiplying the employee’s effort with the audit percentage calculated as per Equation 1. A multiplication of an employee’s efforts (e.g., the number of invoices an employee processes or the number

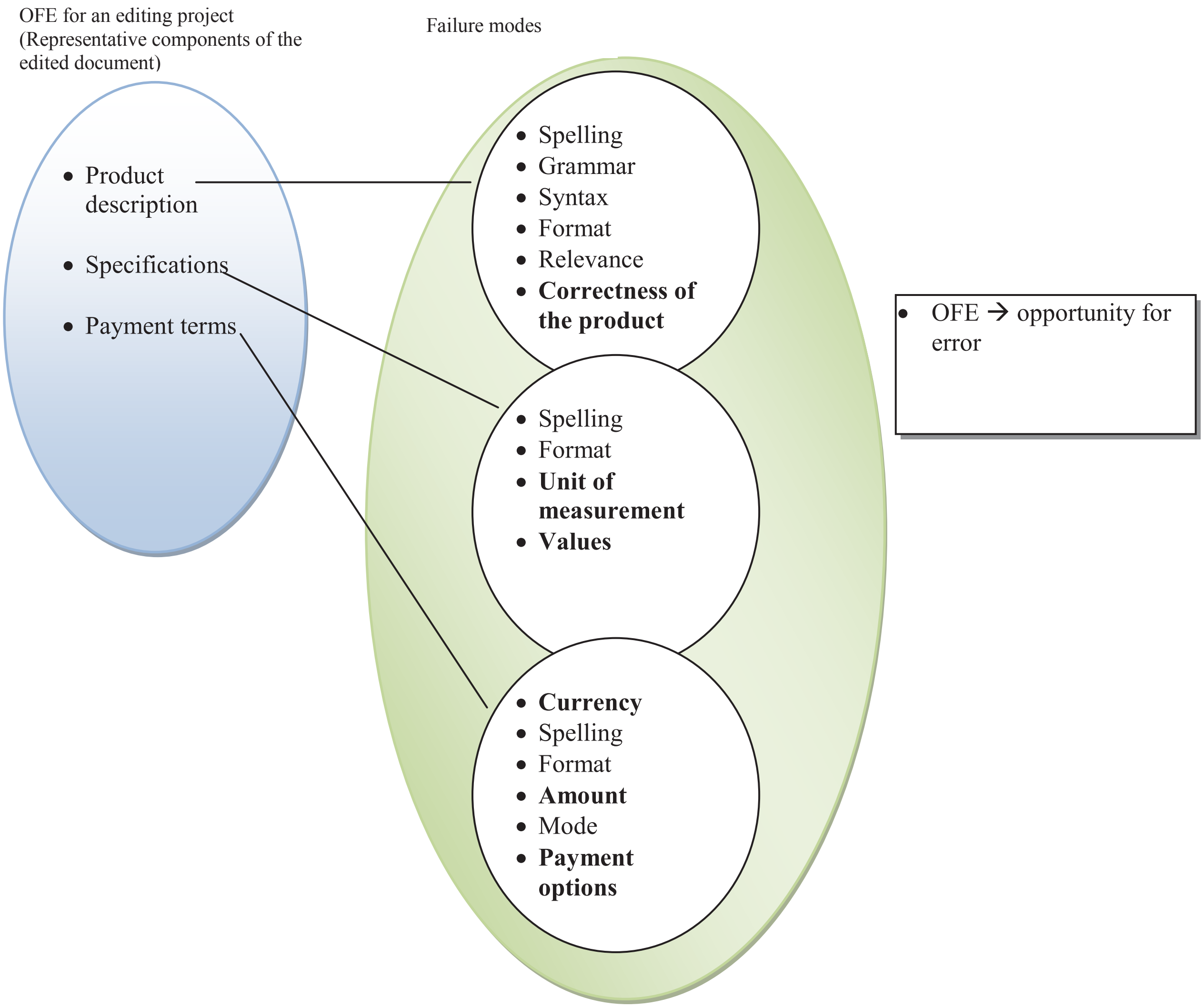

Figure 5: Practical example of measuring defect equivalents.

of automobile tires the employee builds) in a particular audit duration and the measured accuracy would give the "incentive index" for that particular employee. This system will ensure that both productivity and accuracy are considered while comparing employee performance. This will ensure that the performance of one parameter (productivity or accuracy) does not come at the cost of the other, because the system tends to instill an operational discipline among employees owing to its objectivity and non-biased treatment of performance parameters.

Conclusion

The proposed N-phase quality measurement system can be used as a very effective tool to improving customer satisfaction. It is an intelligent and self-evolving system that can give project managers very good insights into the aspects of project quality management. Project managers, equipped with the wisdom embedded in the *PMBOK® Guide* and the power of their own experiences are the best people to drive such innovative research-driven concepts. This paper is an attempt to reiterate the commitment of the project management discipline to quality. It is hoped that scientific project management, as envisioned in the *PMBOK® Guide* will lead the way to recovery in the reset economy, and that research in project management will start gaining more prominence in the near future.

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About the Author

Krishna V. R. Muppavarapu is an active member of Project Management Institute (PMI)® and a PMP®, is a Certified Six Sigma Black Belt from the American Society for Quality (ASQ),and also holds a mechanical engineering degree from BITS, Pilani, India's premier technology institution and a master's degree in management from SP Jain Institute of Management and Research (SPJIMR), Mumbai, a leading business school in India. Mr. Muppavarapu has worked for close to 10 years in the manufacturing, information technology, and business process outsourcing industries. At the time of this writing, he is working as the head of quality and process management at eGramIT Services Pvt. Ltd., a company that has made groundbreaking efforts in delivering business process outsourcing services. The company website is www.egramit.com,and Mr. Muppavarapu can be contacted at mvrkrishna@gmail.com.

Footnotes

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[1] Accuracy is defined and measured as the "number of critical defect equivalents divided by the total number of opportunities for error"

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