iEVM (INTEGRATED EARNED VALUE MANAGEMENT)

AN APPROACH FOR INTEGRATING QUALITY WITH TRADITIONAL EVM FOR EFFECTIVE PROGRAM AND PROJECT MANAGEMENT

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***Abstract**: **Earned Value Management (EVM)** is a simple yet powerful performance management and feedback tool which provides the project progress in terms of scope, cost and time/schedule. EVM enables project managers in predicting the future of the project from trends and patterns of the past. Though EVM addresses and integrates three critical element of project management – scope, cost and schedule – the quality aspect is not explicitly considered in EVM and is supposed to be implicitly included in the scope. Ignoring Quality explicitly may result in escalated Cost of Quality (COQ) and nullify the efforts put in during monitor and control of projects in traditional EVM. Therefore the aim of this paper is to introduce a **new EVM model, iEVM (Integrated Earned Value Management)** which **integrates Quality along with Time, Scope and Cost** as in traditional EVM to monitor, control and predict the projects better and more accurately. The model utilizes the **concept of Cost of Quality (COQ)** and integrates the same in EVM to make fool proof.*

***Keywords:** Program Management, Project Management, EVM, Earned Value Management, Cost of Quality*

1. INTRODUCTION

Project management is application of processes, methods, knowledge, skills and experience to achieve specific project goal/objectives. Project is a unique and transient endeavor with specific objectives which are generally defined as outputs or benefits.

Project Management discipline has 8 key components:

1. Stakeholder Management
2. Risk Management
3. Issues Management
4. Resource Management
5. Task Management
6. Quality Management
7. Project Change Management
8. Project Team Management

These project management disciplines are applied in would be applied in each of the project phases.

In order to manage the projects effectively, ensuring 100% success of achieving planned objectives / goals, project management discipline requires objective tools and techniques to ascertain the status/health of project at any point in time. An experienced project manager has to apply objective tools and techniques across each of the 8 disciplines to measure the performance of project execution and ensure success. This is where **Earned Value Management (EVM)** technique comes as handy tool to measure the performance of project at any point of time and also predict the future state of project execution based on past trends and patters.

Earned Value Management (EVM) is a simple yet powerful performance management and feedback tool which provides the project progress in terms of scope, cost and time/schedule. EVM also enables project managers in predicting the future of the project from trends and patterns of the past. The Earned Value technique takes into consideration the project context for the planned and actual expenditures and integrates the project scope, schedule and resource characteristics into a comprehensive set of measurements.

The Earned Value technique allows for the temporary and intermittent nature of project work by scheduling the expenditures based upon the project plan, including the spikes and valleys in resources requirements. Further, Earned Value tracks how much money has been spent on the project in relation to how much project work has been accomplished. This takes into consideration all that has happened on the project such as schedule delays or acceleration. The variances that have occurred can then be separated into those due to timing, either ahead or behind schedule; and those due to mis-estimating the work; true under-runs or over-runs. Finally, the indices and variances generated by the Earned Value technique will aid the project management team in forecasting the financial conditions at project completion.

Even though EVM addresses and integrates three critical

varying degrees through the project phases. An experienced project manager would understand the nuances of each discipline and knows when and to what extent each disciple

approach may work for several industries where rework effort is minimal or non-existent. However in practical aspects there are not many industries where the rework is non-existent; in fact the most projects at the start will not even have clearly defined project scope; taking the example of software project management where there is substantial rework owing to specific characteristics. These reworking costs are directly related with the Quality. Thus Quality affects the project progress and future significantly. In this study, I am proposing a **new EVM model, iEVM (Integrated Earned Value Management)** which **integrates Quality along with Time, Scope and Cost** as in traditional EVM to monitor control and predict the projects better and more accurately. The model utilizes the **concept of Cost of Quality (COQ)** and integrates the same in EVM concept to make fool proof. The paper tries to theoretically identify and explain the shortcoming of the traditional EVM model and also tries to theoretically integrate the COQ into traditional EVM model to make in comprehensive. iEVM model can realistically provide feedback about the health and future of project at any given point during project execution. The model thus developed can be further implemented in real projects & evaluated from practical perspective and usefulness.

2. PROBLEM BACKGROUND

Information Technology / Software development industry is suffering from unsuccessful projects with exceeded budget, late in delivery and with low quality. Almost every year billion dollars are wasted on failed projects. Poor project management is usually addressed as the main reason causing project failures and overruns. The main objective of information technology / software project management is to deliver the project successfully, in other words, in agreed scope, on time and within budget and in accordance to customer requirements. Hence, the project management success basically depends on integrating four dimensions of projects, scope, time, cost and quality.

There are several tools and techniques that are used in the project management to achieve project objectives successfully. EVM/EVA is leading industry standard method for monitoring and control of projects. It has the ability to combine the measurement of the 3 constrains of project namely, Scope, Time and Cost. EVM/EVA method of monitoring and control assumes Quality as part of scope and thus does not lay any emphasis separately on how to monitor & control Quality. In the project management discipline; Scope Management and Quality Management are two separate disciplines and have different tools and element of project management – scope, cost and schedule – the quality aspect is not explicitly considered in EVM and is supposed to be implicitly included in the scope. **This**

IT projects entities are remarkably complex compared to any other construct since there are no two parts alike in general. IT projects cannot ignore or simplify details of the real world. Complexity grows exponentially as the size of the system increases. Since there is no physical reality, it cannot be accurately modeled as in the case of, for example, construction. The projects are continuously subject to change even after being completed. It represents all the changes to the existing system as well as corrective actions of defective, failed or non-conforming items. Reworking itself introduces further complexity in terms of planning, estimating, monitoring and controlling. It could also cause further rework in a recursive cycle that can affect the project timeline.

Even though the tools, techniques and methods used in the traditional project management have been utilized in IT projects for years, in general, these traditional project management approaches cannot be sufficient for IT projects in their traditional forms without adapting according to the difficulties of IT projects. Even though EVM is commonly accepted in project management and has been employed to a wide variety of projects of different sizes and complexities around the world, this powerful technique is still little used in IT industry. The main issue of EVM here is the volatility of the value earned. Any kind of reworking i.e. unpredictable changes, requirement and design errors, software bugs affect the EV. If we would do it 100% correct in every aspect for the first time, we would not have such an issue and we would have exactly the same EV in every calculation. Example; At a given time in the project, the task is completed and the scope is achieved, but after some time, it is changed due to defects, and more effort is spent. The scope is still the same but cost spent is more, it is not the cost of scope, it is the cost of quality for scope was not complete before.

EV is particularly significant and key data of EVM in order to reveal the current status as well as predicting the future of the project. It is vital to have EV as accurate as possible and as illustrated in the paras above, it is difficult to get the same EV at any time of project progress because of the rework or the changes that are inherent of any IT project. For that reason, we need an improved EVM approach for IT projects to calculate more accurate EV, to provide enhanced current and future estimates of the projects and to have an idea about the project quality status.

3. INTRODUCING iEVM

The purpose of this paper is to develop a new EVM model, called iEVM, as an extension to traditional EVM that

techniques for management, monitoring and control. The tools and techniques of the two disciplines are independent and outcome of one is no way related to the outcome of other. Thus EVA/EVM method of monitoring and control should also treat scope and quality as 2 different parameters and provide mechanism to monitor and control both separately and effectively and which is a problem.

The objectives of iEVM model are:

- to provide a model, which is integrating quality element into traditional EVM
- to discern the quality status of the project by means of EVM in addition to scope, schedule and cost
- to estimate project progress more accurately at any given time using past quality cost data
- to offer more realistic future forecasts

The quality element makes use of the concepts of CoQ. CoQ has four parts under two main categories, conformance costs and non-conformance costs. Non-conformance costs, which include IFCs (internal failure costs) and EFCs (external failure costs), are the main focus to estimate reworking cost and integrate quality dimension into the new model. Also, CCs (conformance costs) are also the interest of the model, especially in terms of providing benchmarking.

iEVM could have three different approaches depending on the relation of reworking effort to the origins, which are task-based, phase-based and project based:

- Task-based approach tracks the FCs (failure costs) for every task.
- Phase-based approach requires the FCs of the tasks that are completed in the specific phase.
- Project-based approach needs the FCs of the whole project.

The project manager has to decide the approach at the beginning of the project and collect data accordingly. It is possible to apply the project-based approach in any case but the phase-based and task-based approaches require the link of the reworking with the origin phases or tasks.

iEVM and Project Management Process

In project management cycle, iEVM has two main key practices; Establishing a PMB (performance baseline) in the planning process and measuring and analyzing performance against the baseline in executing and controlling processes.

In project planning process, EVM needs planning all the work and establishing PMB. Initially, project work is decomposed into executable and manageable tasks using incorporates the quality aspect by means of CoQ (Cost of Quality) and provides quality related measures during tracking project progress and performance. Such model shall enable measuring project performance by means of quality aspect in addition to existing scope, schedule and cost. Design of the iEVM model is also such that it is compatible with project management principles and goes further by including quality costs explicitly.

At the end, PMB is established with the all work scope including reworking and marking quality investment related tasks as preventive and detective ones.

During project execution process, EVM requires recording all execution data of planned work including actual start and finish dates, efforts and resource utilization for the performed work. iEVM adds two new activities to project execution process:

- Recording the data of internal and external failures including their occurrence and fix dates, the origin of the failure, efforts of fixing
- Gathering the actual investment costs as well as actual costs

In project controlling process, EVM assesses performed work based on the completion rates and calculates EV. Consequently, EV analysis is performed with this EV data, planned value data from PMB of the planning process and actual cost data from execution process. iEVM focuses on the FCs here and recalculates past EVs based on the FCs gathered in execution. iEVM observes EV changes according to FCs and analyzes their trend. It assumes this change will occur for the calculated current EV and predicts its value based on the potential FCs. iEVM adds five new quality performance related activities to controlling process and updates all schedule and cost related ones incorporating quality metrics into EV:

- Calculating quality performance index (QPI) and quality cost factor (qcf), based on the FCs
- Recalculating past EVs retroactively using qcf
- Analyzing quality performance based on EV deviations in time
- Estimating current EV (EVest) based on quality performance trends
- Analyzing and forecasting cost/schedule performance
- Reporting performance problems and taking action
- Benchmarking quality CC
- Benchmarking FCs

work break down structure and resources are assigned to the tasks. After all the project work is scheduled, the project scope, schedule and cost are integrated into a time-phased budget, which is PMB.

iEVM adds three new activities to the planning process:

- Identifying the tasks related with prevention and appraisal activities
- Calculating and benchmarking quality investment cost
- Planning rework explicitly at the beginning based on the historical data in order to have more realistic plans

(FC) till that specific time.

- Estimated EV (EVest) : The aim of calculating Estimated EV is to adjust current EV by utilizing reworking trends of the project.
- Conformance Cost: CCs represent the total cost that is planned to achieve good quality in a project by means of preventing failures or detecting them.

List of FCs (failure cost)

Failure Cost Items
Internal Failure Cost Items
(prior to delivery to the customer/or milestone)
Any development rework; errors, changes, improvements
Failure analysis
Re-designing
Fixing errors
Improving and changing features
Updating documents due to the changes
Re-integration
Re-testing
…
External Failure Cost Items
(after the delivery to the customer/or milestone)
All IFC items mentioned above
Activities regarding issues from customer
Technical support
Re-integration
Re-production
Upgrade
Updating documents due to the changes
…….

ACTUAL COST OF FAILURE (ACF)

ACF = AC + FC

ACF could increase through the time as soon as reworking occurs, so it is possible to display its status as the following:

Using iEVM

The three key data points of traditional EVM, which are PV, EV and AC, are also the key data elements for iEVM since this new model is an extension to traditional one by improving it with quality aspect. In addition to these three key data points, iEVM defines the following key elements and measures:

- Failure Cost: FCs are the total effort spent for correcting errors after activities are completed. It covers all reworking efforts.
- Actual Cost of Failure (ACF) : ACF is the total effort of a task, phase or project at a specific time, which is the sum of the initial cost for completion (AC) and reworking cost needed afterwards for fixing defects or improving it

retroactive EV of current EV, which is estimated EV.

Estimated EV is only meaningful for the current application phase. It is the specialized form of retroactive EV at the present time. Retroactive EVs uses the occurred reworking related with the specific task or phase but estimated EV is a prediction using the past reworking trends that are not happened yet for the new ones. qcf is the depiction of this reworking trend. Estimated EV does not make sense for the tasks. After EV calculated for the tasks and total EV aggregated, estimated EV is calculated using the factor, qcf.

iEVM calculates qcf only for past phases and based on iEVM application approach, qcf value could be selected differently as the following:

- If the task-based approach is followed, qcf and retroactive EV values for the tasks are calculated separately. Afterwards, total retroactive EV is calculated summing up retroactive EVs of all the tasks. qcf is calculated by dividing total retroactive EV to total EV.

- If the phase-based approach is followed, qcf is calculated based for the phase using the failure cost of the phases. Regression models could be used to find the appropriate qcf and qcf of the phase with the similar characteristics could be chosen.

- If the project-based is followed, only one qcf is available and used for estimated EV calculation.

- iEVM favors estimated EV and assumes that it gives a better, clearer and more accurate status of the project than EV does and so uses estimated EV for all future estimates.

QUALITY COST FACTOR (qcf)

qcf is the reworking factor of a specific task, phase or project. qcf represents the ratio of the tasks that cannot be

Task/Phase	1	2	3	...	n
T1	ACF1	ACF2	ACF3	...	ACFn
...					
Phase1	ACF11	ACF12	ACF13	...	ACF1n
...					
Phase2		ACF22	ACF23	...	ACF2n
.....					

ESTIMATED EV

Estimated EV aims to represent the actual EV based on the assumption that quality cost trends in the past will occur in the future. iEVM uses two significant concepts during Estimated EV calculation: Retroactive EV, and qcf.

Estimated EV is the projected value of EV by means of retroactive EVs. In other words, it corresponds to the future retroactive EV of the current calculated EV. The idea is to track EV and retroactive EV differences for earlier phases and then apply this pattern to the current EV to estimate specific time by means of incorporating FCs that has occurred after the initial EV was calculated.

The steps for EVr are described in the following:

- Collect AC, FC, ACF and then calculate qcf.
    - If iEVM is applied task-based, FC is needed to be related with the tasks. If iEVM is applied as phase-based, FC is needed to be related with the phases.
    - Otherwise, if iEVM is applied project-based, total FC is enough and EVr of the project is calculated. qcf is calculated for the previous period.
- Calculate EVr with the following formula:

$EV_r = EV * (1-qcf)$

- If the task-based approach followed, we have qcf and EVr values for the tasks. For the application period of QEV, total EVr is found by summing all the tasks. In that case, total qcf is calculated using this total EVr by the following formula and this final one is used calculating EVest .

$qcf = 1 - (\Sigma EV_r / \Sigma EV)$

- If the phase-based approach followed, we have qcf value for the phases obtained from FCs. EVr are found by using qcf.

$qcf = 1 - (\Sigma EV_r / \Sigma EV)$

completed right at the first time and earned the claimed value considering the work and the ratio of rework for that particular task or phase.
The steps for qcf are described as the following:

- Collect AC of the completed tasks, all the FCs for the completed tasks and keep the relation of the completed tasks and their reworking effort
- Calculate qcf with the following formula (at a specific time, t):

$Qcf_t = FC_{t-1}/ACF_{t-1}$

RETROACTIVE EV (EVr)

Retroactive EV, EVr, is a significant concept of iEVM originated from the finding that EV is changing over time. It represents the recalculated value of EV retroactively at a

based on EVest and ACF rather than EV and AC in order to decide whether the project is under or over budget.

$CV_{est} = EV_{est} - ACF$

$CV_{est} > 0$, under budget

$CV_{est} < 0$, over budget

CPI_{est} (Estimated Cost Performance Index) is an index showing the efficiency of the utilization of the resources allocated to the project. It is an improved version of CPI of traditional EVM. CPIest is defined to consider FCs during calculating the efficiency of cost performance.

$CPI_{est} = EV_{est}/ACF$

$CPI_{est} > 1$, efficiency in utilizing the resources allocated to the project is good

$CPI_{est} < 1$, efficiency in utilizing the resources allocated to the project is poor

ETC_{est} (Estimate to Complete) is the estimated effort required to finish all the remaining work, calculated when the initial assumptions are not valid anymore and revised estimates are needed. It is an improved version of ETC of traditional EVM. ETCest is defined to consider FCs during remaining work calculation.

$ETC_{est} = (BAC - EVest) / CPIest$

EAC_{est} (Estimate at Completion) is the estimated final effort of the project that is required to finish all the work. It is calculated using the performance indices. It is an improved

CONFORMANCE COST

iEVM includes CC concept to give insight to the project manager at the beginning of the project about their quality investment and benchmark this cost with the other projects. CCs represent the total cost that is planned to achieve good quality in a project by means of preventing failures or detecting them.

The steps regarding CC calculation are:

- Mark preventive and detective tasks during project planning or PMB generation.
- Calculate PCs, APCs and so CCs and benchmark CC/PV with the organizational /industry values by means of CCI.

COST ANALYSIS AND FORECAST

iEVM improves EV by estimating EVest which is supposed to be the actual current EV. CVest (Estimated Cost Variance) shows whether a project under or over budget. It is an improved version of CV of traditional EVM. CVest is defined in iEVM to consider FCs and calculate cost variances variances to take action.

$SV_{est} = EV_{est} - PV$

$SV_{est} > 0$, ahead of schedule

$SV_{est} < 0$, behind of schedule

SV_{est} is the improved version of traditional SV. Even SV displays objectively how much the project is ahead or behind schedule for new features, SV_{est} improves it including reworking costs.

SPI_{est} (Estimated Schedule Performance Index) is an index showing the efficiency of the time utilized on the project.

$SPI_{est} = EV_{est}/AC$

$SPI_{est} > 1$, efficiency in utilizing the time allocated to the project is good

$SPI_{est} < 1$, efficiency in utilizing the time allocated to the project is poor.

4. CONCLUSION

iEVM, which is the extension of traditional EVM and incorporates quality cost metrics into the model. iEVM provides the usable and valuable model for software version of EAC of traditional EVM including FCs.

$EAC_{est} = BAC / CPI_{est}$

$= ACF + ETC_{est}$

$= ACF + ((BAC - EV_{est}) / CPI_{est})$

VAC_{est} (Variance at Completion) represents the variance on the total budget at the end of the project. It is the difference between the cost that is initially planned and the cost that is now estimated. It is an improved version of VAC of traditional EVM including FCs.

$VAC_{est} = BAC - EAC_{est}$

SCHEDULE ANALYSIS AND FORECASTS

This section describes the updated and new schedule analysis and forecasts of iEVM by estimating EVest.

SV_{est} (Estimated Schedule Variance) shows whether the actual costs of the work accomplished exceed the initially planned costs. It is important to identify the significant

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projects since it takes the significant quality costs into consideration. Even though the software projects suffer from a lot of reworking, those costs are not incorporated into traditional EVM. iEVM provides the quality related metrics to the project manager in order to not only track the quality status but also integrate the cost of quality with the project cost status.

iEVM will deliver more visibility to effort and costs, more accurate forecasts and better predictions of future. Including FCs into total costs will increase the visibility of the project aspects, quality status and effort should become visible. The revealed FCs will result in more accurate total cost, schedule and cost indices and so improves the accuracy of the project. Accuracy in current progress information will enable more accurate estimations of future values of project.

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