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Earned Value Management for Tracking Project Progress

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ABSTRACT

This paper describes an approach to managing software projects with earned value (EV).Earned value management is a technique for providing an objective analysis of the progress of a project in terms of program dollars. We have discussed various methods to calculate earned value for a software project and a typical algorithm for tracking progress using EVM. We have also shown how earned value acts as a variance and performance indicator for any deviations in the project budget and project schedule.

***Keywords*— Earned value, variance, performance, tracking progress, project budget, project schedule.**

I. INTRODUCTION

Performance review meetings can be a powerful tool to help control project costs. Knowing you have to report on your progress is an incentive for people to perform better. Performance measurement is another important tool for cost control. There are many general accounting approaches for measuring cost performance but earned value management (EVM) is a tool unique to project management. EVM is a project performance measurement technique that integrates scope, time and cost data. Earned value management is a technique for providing an objective analysis of the progress of a project in terms of program dollars [5]. The technique integrates schedule and budget performance to provide metrics that enable good decision-making. Earned Value helps determine if your project is on schedule and within budget. It does this by assessing the project on the basis of cost and schedule as compared to what has been accomplished. In determining the status of projects, three key components are examined -

• Cost and Schedule baseline
• Actual Charges (expenditures)
• Reported accomplishments or "Earned Value"

Earned value provides an "Early Warning" signal for prompt corrective action.Basically, Traditional management provides you with how much money and time a particular job is likely to require prior to starting and once started, how much money was spent at any given time. While Earned Value Management provides you with how much money and time a particular job is likely to require prior to starting and once started, how much money was spent at any given time.

II. TERMINOLOGY

A. Planned Value (PV)

The planned value (PV), formerly called the budgeted cost of work scheduled (BCWS), also called the budget, is that portion of the approved total cost estimate planned to be spent on an activity during a given period.[1]

$$Planned\ Value = Physical\ Work + Approved\ Budget$$

PV can be looked at in two ways:

1. Cumulative PV is the sum of the approved budget for activities scheduled to be performed to date.
2. Current PV is the approved budget for activities scheduled to be performed during a given period. This period could represent days, weeks, months, etc.

B. Actual cost (AC)

Actual cost (AC), formerly called actual cost of work performed (ACWP), is the total of direct and indirect costs incurred in accomplishing work on an activity during a given period.[1]

It can be looked at in terms of cumulative and current.

1. Cumulative AC is the sum of the actual cost for activities performed to date.
2. Current AC is the actual costs of activities performed during a given period.

C. Earned Value (EV)

The earned value (EV), formerly called the budgeted cost of work performed (BCWP), is an estimate of the value of the physical work actually completed. EV is based on the original planned costs for the project or activity and the rate at which the team is completing work on the project or activity to date.

EV is the quantification of the "worth" of the work done to date.Earned Value (EV) tells you, in physical terms, what the project accomplished.[1]

EV can be presented in a Cumulative and Current fashion.

1. Cumulative EV is the sum of the budget for the activities accomplished to Date.
2. Current EV is the sum of the budget for the activities accomplished in a given period.

D. Estimate at Completion (EAC)

The Estimate at Completion (EAC) is the actual cost to date plus an objective estimate of costs for remaining authorized work[1]. The most common is:

$$EAC = Actual\ Cost\ (AC) + Estimate\ to\ Complete\ (ETC)$$

The Estimate to Complete (ETC) is the cost of completing the authorized remaining work.

E. Rate of Performance (RP)

Rate of performance (RP) is the ratio of actual work completed to the percentage of work planned to have been completed at any given time during the life of the project or activity.[1]

For example, suppose the server installation was halfway completed by the end of week 1; the rate of performance would be 50% because by the end of week 1, the planned schedule reflects that the task should be 100% complete and only 50% of that work has been completed.

The EV would thus be $5,000 after week 1 ($10,000*50%)

F. Schedule Variance (SV)

Schedule Variance is the comparison of amount of work performed during a given period of time to what was scheduled to be performed. It is calculated as follows

$$SV = EV - PV$$

A negative schedule variance means the project is behind schedule i.e. it took longer than planned to perform the work.

G. Cost Variance (CV)

Cost Variance is thecomparison of the budgeted cost of work performed with actual cost.It is calculated as follows

$$CV = EV - AC$$

A negative cost variance means the project is over budget i.e. performing the work cost more than planned.

H. Schedule Performance Index(SPI)

SPI can be used to estimate the projected time to complete the project. It is calculated as follows

$$SPI = EV / PV$$

SPI = 1 means that project is on schedule.
SPI < 1 means that project is behind schedule.
SPI > 1 means that project is ahead of schedule.

I. Cost Performance Index(CPI)

CPI can be used to estimate the projected cost to complete the project based on performance to date. It is calculated as follows

$$CPI = EV / AC$$

CPI = 1 means that the planned and actual costs are same.
CPI < 1 means that project is under budget.
CPI > 1 means that project is over budget.

III. EARNED VALUE METHODS

EV is determined by what has been physically accomplished. Physical accomplishment is determined by measuring the progress of a given activity. There are numerous EV methods to measure progress. We will focus on the followingtechniques:

A. Fixed formula

The Fixed Formula method for determining progress applies to work packages and control accounts that span a short period of time (within an accounting period, < 3 months). This method applies a percent complete to the start and finish of an activity. Generally, the percentages used in the formula are 0/100, 50/50, or 25/75.

- ✓ 0/100 - Nothing is earned when activity starts but 100% of budget is earned when completed
- ✓ 50/50 - 50% is earned when activity starts and the balance is earned on completion
- ✓ 25/75 - 25% is earned when activity starts and the balance is earned on completion

The Fixed Formula method has several advantages and disadvantages. It works well for short term work packages, and requires minimaleffort to status. However, this method is not very effective for longer term work packages.

B. Milestone weighting

The Milestone Weighting method assigns budget value to each milestone. Not until full completion of each milestone is the budget earned. Milestone Weighting is used as a method for work packages with long term durations and ideally should have milestones each month or accounting period.

The advantage of Milestone Weighting is that it requires objective measurable milestones, which most customers or Project Managers prefer. However, disadvantages are that it does not allow partial credit for in-process work, and requires detailed milestone planning.

C. Milestone weighting with Percent Complete

The Milestone Weighting with Percent Complete methodassigns budget value to each milestone, and it is earned based on the percent of work Completed against each individual milestone. Like Milestone Weighting, Milestone Weightingwith Percent Complete is used as a method for work packages with long term durations and ideally should have milestones each month or accounting period.

The advantages of Milestone Weighting with PercentComplete are that it requires objective measurable milestones, which most customers prefer, and allows for partial credit against milestones. However, it has disadvantages like it requires a Control Account Manager (CAM) assessment of the % complete for each milestone and requires documentation of assessment methodology.

D. Unit Complete

The Unit Complete method uses a physical count to determine what is earned. To use Unit Complete you must have units

that are identical or similar and they must have the same budget value.The advantages of Unit Complete are that it is an objective and easy way of determining the earned value for an activity. While the disadvantages are that it is limited to production type atmosphere of similar items that are fixed unit prices. Also it does not take into consideration labor fluctuations somay misrepresent actual EV.

E. Subjective Percent Complete

The Subjective Percent Complete method applies a percent complete to a budget value to determine what is earned. The percent complete value is determined by the Control Account Manager or other designated individuals. The percent complete is applied to the Budget at Completion (BAC) for a given activity to determine the current and cumulative EV.Milestones do not apply to this method. Labor and non-labor must beidentified in separate work packages if this method is applied. This methodis highly subjective, and documentation in support of percent completederivations is required.

The main advantages of this method are thatit is one of the more subjective methods;earned Value isbased on the CAM's assessment of the work package progress anddetailedplanning at the milestone level is not required. However, it has disadvantages like the customer satisfaction maybe low due to the subjectivenessinvolved and the lack of detailed planning, however, CAMs are required toprovide the customer with their assessment methodology.

F. Level of Effort

The Level of Effort (LOE) method is based on the passage of time. A monthly budget value is earned with the passage of time and is always equal to the monthly planned amount. When using LOE, the PV is always equal to the EV (see chart below). This method is usually used for accounts that are more time related than task oriented.Example of an LOE account is Program andProject Management support.

The advantages of Level of Effort are it does not requirestatusing, and is appropriate forsustaining tasks like Program Management. While the disadvantages are that the Level of Effort work packages are often challenged by thecustomer. Also This EV method should be kept to a minimal number of workpackages. LOE work packages require accurate assessment (planning) ofmonthly performance.

IV. APPLICATIONS

The main application of EV is to track the relative progress of a scheduled work unit as a percentage of the allocated budget that has been spent for that work unit. It involves determining cost and schedule variance.

The process can be given by following flowchart [4]

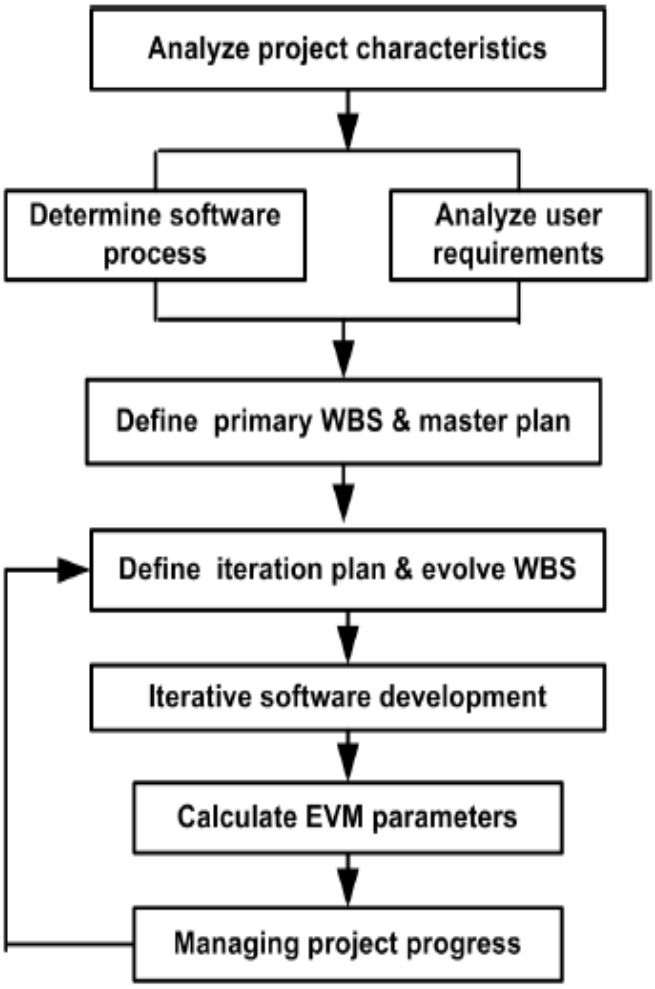

Figure 1:Tracking progress using EVM

In EVM, actual costs are also tracked. If at any point in the project, the actual accumulated cost exceeds the earned value of the project at that time, the project is considered *over budget*, with the shortfall representing a budget overrun. In EVM terms, this shortfall, or slack if actual costs are below earned value, is called *cost variance*.

If the accumulated earned value at a point in time is below the estimated total expenditures according to the planned budget, then the project is considered over schedule, with the difference representing the monetary expression of the project's schedule shortfall at that point. terms, the schedule shortfall or slack is called *schedule variance*. In EVM Schedule variance can also be expressed temporally, in calendar time.

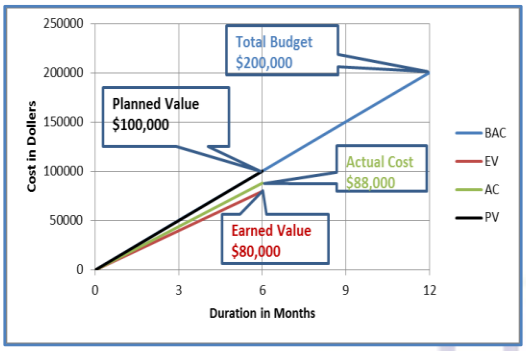

Figure 2: EVM of sample project

A simple project in Fig 2 will be usedillustrate the established EVM measures,variance, indices and calculation of EAC.Assume a project to install 100 desktops withan approved budget of $800 each and 100 laptops withan approved budget of $1,200 each, over aperiod of a year. The total project budget orBAC is $200,000. After six months, it is foundthat 40 desktops and 40 laptops have been installed, at a costof $88,000. According to the plan, 50 desktops and 50 laptops shouldhave been installed by now. Therefore $PV = \$100{,}000 EV = \$80{,}000$and $AC = \$88{,}000$.

EVM variancesand indices for both cost and time:

$$CV = EV - AC = 80{,}000 - 88{,}000 = -8{,}000$$
$$CPI = EV / AC = 80{,}000 / 88{,}000 = 0.9091$$

This project is over budget, with a cost varianceof negative $8,000 and a CPI that is trackingbelow 1.

$$SV = EV - PV = 80{,}000 - 100{,}000 = -20{,}000$$
$$CPI = EV / PV = 80{,}000 / 100{,}000 = 0.80$$

The project is also late, with a schedule varianceof negative $20,000 and a SPI also trackingbelow 1. It is not performing well. EVM theoryholds that if this project continues without anysignificant changes to its efficiency or rate of progress, then it will eventually complete as shown in the Figure 3 below. The project willend when all activities are finished, that is when

$$EV = PV = 200{,}000.$$

The cost Estimate at Completion (EAC) can be calculated using the formula below, and the total duration (TEAC) can be calculated as follows:

$$EAC = BAC/CPI = 200{,}000/0.9091 = 220{,}000$$
$$TEAC = PD/SPI = 12\ months / 0.80 = 15\ months$$

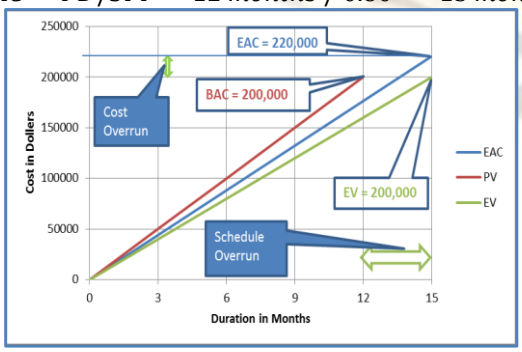

Figure 3: EVM EAC

So, EVM predicts that this project will finishthree months late, and $20,000 over budget.

V. CONCLUSION

There is a variety of challenges while planning software projectswhen we are working to deliver high quality software ontime and within budget constraints. Many of these challengesare related to a large degree of uncertainty, either in scheduleduration, quality factors, or in design issues. By applyingtechniques that help quantify the nature of the uncertainty,separate the distribution of uncertainty in project schedule andinsulate the project budget from the effects of the uncertainty,projects can be successful in gaining value from earned value analysis.EVM might not be adaptable in an out-of-the-box form for our industry, but it does offersadd-ons that many known alternatives don't mention.In comparing Earned Value Management to Traditional Management,Traditional Management does not allow for analysis of the physical amountof work performed. Earned Value Management allows for both scheduleand cost analysis against physical amount of work performed. The EVM approach deserves more attention from the software development community in environments where planning and estimation is needed.

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