Analysis of "Estimate at Completion" of a Project's duration to improve "Earned Value Management System"

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Abstract – ***This paper presents a new method for Estimate at Completion (EAC) of project's duration to improve earned value management system (EVMS). The estimate at completion (EAC) is an independent forecast for what it will cost to complete any given level of the Work Breakdown Structure (WBS).The estimated cost to complete a defense acquisition contract, termed the EAC is a controversial number due to its complexity in multitude of formulas available for EAC estimation. The new formula established consists of four variables: Scheduled Performance Index (SPI), Scheduled Percent Complete by Duration (SPCD), Actual Percent Complete by Duration (APCD), and Sum of Durations to Due Time (SDDT). The results show a strong linear relationship between response variable and above four predictors. Therefore, it can be concluded that the model could be used in a wide range of projects for EAC estimation.***

Keywords – ***Earned Value, Project Performance Management, Estimate at Completion, Schedule Performance Index, Cost Performance Index***

I INTRODUCTION

The Earned Value method has been developed as a tool facilitating project progress control. It is used for determining a project's status (is it behind or ahead of schedule? is it over or under budget?) and the scale of current variances from the plan. Moreover, it allows a project manager to make inferences on the final effect of the project in terms of cost and, to some extent, in terms of duration, by extrapolating current trends. The method is simple: it assumes a simplified model of a project, and calculations require nothing more than four basic arithmetic operations. However, the method has been recognized as a useful tool by many practitioners and government agencies and has become a standard in project management. The analysis can be conducted on any level of work breakdown structure and used by both clients and Contractors. The method, if to be used efficiently, requires a disciplined approach to collection of data on project cost and progress (on weekly basis) and the findings are to be processed immediately. The purpose is to detect any deviation as soon as possible, so that there is enough time to asses if the deviation is dangerous for the project and, if necessary, to take corrective actions.

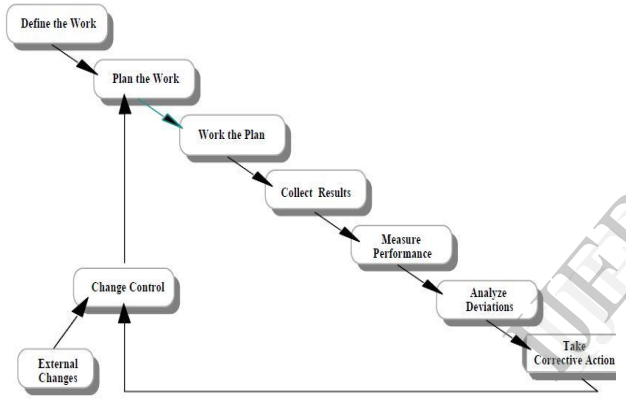
II DISCUSSION

A. Earned Value Analysis

Earned Value Analysis (EVA) is an incremental methodology for measuring project performance by determining cost and schedule performance of a project by comparing "planned" work with "accomplished" work in terms of the dollar value assigned to the work, and determining the need to recommend corrective actions. EVM results from an earned value analysis to indicate potential deviation of the project from cost and schedule baselines. Earned value is a Management Tool that provides a snapshot of project performance at a point in time, compares where the project is now with: (1) previous work accomplished and (2) where the project was planned to be and serves as an early warning system to detect deficient or endangered progress. EVA is a significant tool in the Project Manager's "toolbox" for gaining valuable insight into project performance and is the tool that integrates technical, cost, schedule and risk management. In addition, EVA provides valuable quantifiable performance metrics for forecasting at-completion cost and schedule for their project.

B. Earned Value Management

EVMS is a better method because it integrates cost, time and the work done (scope) and can be used to forecast future performance and project completion dates and costs. EVM is the basis for course correction and will lead to new forecasted completion costs, change requests and other items that will need to be communicated. EVM provides an accurate picture of contract status and supports mutual goals of contractor and customer. The major objectives of applying earned value to a contract are to encourage contractors to use effective internal technical, cost and schedule management control systems, and to permit the customer to rely on timely data produced by those systems, for better management insight to bring project in on schedule and cost.



This data is in turn used for determining product-oriented contract status and projecting future performance based on trends to date. EVM allows better and more effective management decision making to minimize adverse impacts to the project. It ensures a clear definition of work prior to beginning that work and presents a logical plan for accomplishing the work. It provides early and accurate identification of trends and potential problems, and serves as a key element of a project's risk management process.

C. Earned Value Management System

Estimation time and cost of work completion in a project are very important for project management team. The term of "Estimate at Completion – EAC" is used to define this concept. Earned Value Management System (EVMS) is a systematic approach for EAC estimation. EVMS concept is used to measure project progress and calculate Earned Value (EV) of project and forecast EAC in every period of controlling the project progress. The correct and on time EAC is very important to plan preventive actions during the project life cycle. If EVMS indicates an overrun in cost or time, the project managers can use proper cost reduction or fast tracking programs. In the case of cost overrun, project management team may execute a value engineering program for cost reduction either reducing scope and quality in some sections of project or providing additional budget to cover overrun cost. Similarly, for time overrun case, they may plan some program such as fast tracking or time crashing for time reduction. Therefore, the role of EVMS as well as correct and on time forecasting is very important to achieve project goals. This research includes a new method to forecast EAC based on statistical and econometrics techniques and traditional EV indexes as well.

D. Work Breakdown Structure

The WBS has been an integral part of the earned value concept. It is a graphic portrayal of the project, exploding it in a level-by-level fashion, down to the degree of detail needed for effective planning and control. It must include all deliverable end items, and include the major functional activities that must be performed. A project consists of the sum total of all the elements of the WBS. Conversely, an element that is not contained in the WBS is not a part of the project. Any work that cannot be identified in the WBS requires authorization to proceed, either as a recognized omission or as an approved change order. The lowest levels of the WBS are significant because each defines a discrete element of work or task to be performed against which resources can be assigned and cost and schedule measured. These lowest level activities or tasks in the WBS, when assigned a schedule and cost, together with required resources (people and material) and the individual responsible for its accomplishment, define a work package, which can be rolled up to a “control account” via a process called “cost aggregation”. The control account is a critical point for performance measurement to occur, for this is where the integration of scope, schedule, and resources will take place and where the project will measure its

performance throughout the duration of the project. Definition of the work package is critical to effective Earned Value Management and the use of earned value in risk management. Perhaps most critical to the use of earned value in risk management is the tenet that work packages either be limited in size to be accomplishable in a relatively short period of time, or that they include discrete milestones against which work performance can be measured.

D. Earned value analysis terms

Acronym	Term
PV	Planned Value
EV	Earned Value
AC	Actual Cost
BAC	Budget At Completion
EAC	Estimate At completion
ETC	Estimate To Complete
VAC	Variance At Completion
CV (EV – AC)	Cost Variance
SV (EV – PV)	Schedule Variance
CPI (EV / AC)	Cost Performance Index
SPI (EV / PV)	Schedule Performance Index
ETC (EAC – AC)	Estimate to Complete
VAC (BAC – EAC)	Variance at Completion
EAC`	Estimate at Completion

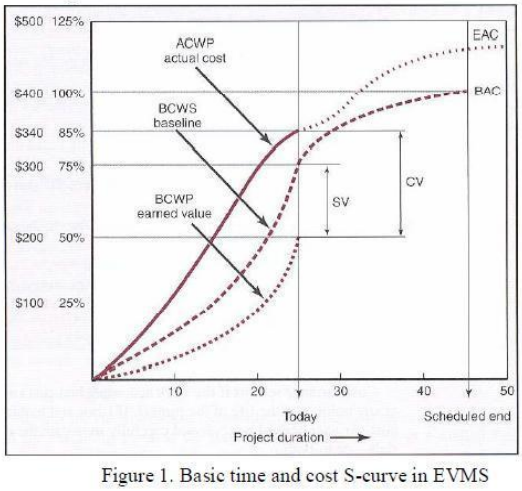


Figure 1. Basic time and cost S-curve in EVMS

II RELATED WORKS

There are several methods for computing EAC which are as follows.

Used if no variances from the BAC have occurred or you will continue at the same rate of spending.

BAC / CPI (1)

Actual plus a new estimate for remaining work. Used when original estimate was fundamentally flawed.

AC + ETC (2)

Actual to date plus remaining budget. Used when current variances are thought to be atypical of the future. AC plus the remaining value of work to perform.

AC + (BAC - EV) (3)

Actual to date plus remaining budget modified by performance. Used when current variances are thought to be typical of the future.

AC + (BAC - EV) / CPI (4)

Cumulative CPI method

$$EAC = ACWP + \frac{(BAC - BCWP)}{(CPI \times SPI)} \quad (5)$$

Cost/Schedule method

$$EAC = ACWP + \frac{(BAC - BCWP)}{\left(\frac{BCWP_{3MONTHS}}{ACWP_{3MONTHS}}\right)} \quad (6)$$

3 months average method

$$EAC = ACWP + \frac{(BAC - BCWP)}{((.8 \times CPI) + (.2 \times SPI))} \quad (7)$$

The EAC can be computed by formula using cost management data provided by the contractor to the government in the *Cost Performance Report* or the *Cost/Schedule Status Report*. The reliability of these reports depends on the degree to which the contractor adheres to internal controls involving measuring performance on a contract. All EAC formulas are based on the combination of several data elements presented on the cost management report: Budgeted Cost of Work Scheduled (BCWS); Budgeted Cost of Work Performed (BCWP); and Actual Cost of Work Performed (ACWP). These data elements are usually reported monthly. Cumulative and averaged data can

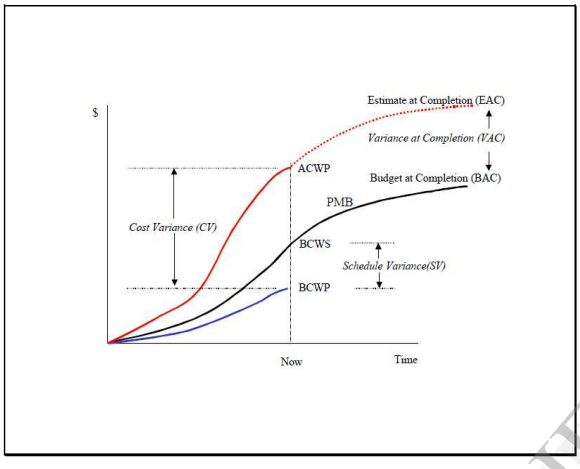
then be computed through the period of the contract's life.

The generic, index-based formula is as follows:

EAC = ACWPc + (BAC - BCWPc)/Index

The subscript "c" indicates cumulative data. Budget at Completion (BAC) is the total budget for the identified work.

A "performance index" is used to make this adjustment. The index is normally a combination of ACWP, BCWP, and BCWS. An assumption implicit in this adjustment is that the contract's past performance will continue to the end of the contract.



The performance indices are classified into four groups:

Cost Performance Index (CPI) = BCWP/ACWP

Schedule Performance Index (SPI) = BCWP/BCWS

Schedule Cost Index (SCI) = SPI X CPI

Composite Index = W1 X SPI + W2 X CPI

III PROBLEM DEFINITION

There is a well known time-cost curve with S shape as indicated in figure 1 in EVMS literature. EAC in time or cost could be calculated based on three variables: Budgeted Cost of Work Performed (BCWP), Budgeted Cost of Work Scheduled (BCWS) and Actual Cost of Work Performed (ACWP). ACWP is the total of expenditures that is consumed from the start until now and can generally obtain via accounting documents. A simple method for calculation of BCWPS and BCWP could be used as bellow:

$$BCWS = \sum_{i=1}^{n} C_i \times P_i$$

$$BCWP = \sum_{i=1}^{n} C_i \times P_i'$$

Ci is the baseline cost and Pi is planed percent completed and *'Pi* is actual percent completed of i th activity in a project which have n activities. First for the calculation of EAC, it is necessary to introduce 2 indexes called Cost Performance Index (CPI) and Schedule Performance Index (SPI) as follows:

$$SPI = \frac{BCWP}{BCWS}$$

$$CPI = \frac{ACWP}{BCWP}$$

If SPI were the project would be completed on planned time; if it were less than 1 the project would be completed more than planned time; if it were more than 1, the situation would be vice versa. In similar way, it could be forecasted the cost of project by using CPI. Various states of SPI and CPI could be seen in figure 2. For the calculation of EAC for the project cost the following equations are generally used:

$$EAC = ACWP + \frac{Work remaining}{CPI} = ACWP + \frac{BAC - BCWP}{CPI}$$

In similar way, EAC for time of project could be calculated by using SPI. In the equation 5 if it were used CPI×SPI instead of CPI, the worst estimation of EAC would be resulted. Also it could be employed a combination of SPI and CPI like 0.2×SPI+0.8×CPI or EAC estimation. It is obvious that the results would be changed in each case. Moreover, it is tried to find a proper function to forecast the time and cost of a project using simulation method. EV is an old concept in project management, and it is introduced in many sources and contexts. Projects are evaluated by the earned value management system (EVMS) and the multidimensional control system (MPCS) methods. The literature review shows the growth of EV's scientific papers has been very slow and in this field the studies and research is poor. The main core of the EV is forecasting and it needs to improve the technique in this area of study. Therefore, in this paper it is focused on the development of a new method to forecast EAC based on the statistical and econometrics techniques.

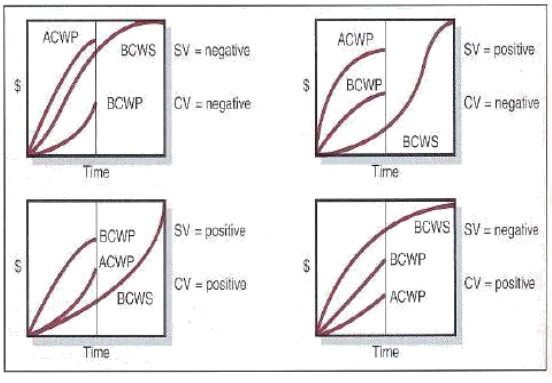


Figure 2. Various sates of CPI and SPI indexes

IV METHODOLOGY

As it was mentioned above, the main goal of this paper is to present a more accurate relation for prediction of real duration of projects. To find such a relation, the strategy of this paper was to simulate progress of some projects while calculating different indices in different time sections. Then multiple regression analysis was used to find most important predictor variables and suitable relation.

A. Steps

1) Calculate SPI, Scheduled Percent Complete by Duration (SPCD), Actual Percent Complete by Duration (APCD) and Sum of Durations to Due Time (SDDT), which are the predictor variables of the model and some other indices which according to regression analysis results.

2) Calculate the ratio of passed days to real duration of project in each time section, which will be seen as the response variable.

3) Report the necessary indices and response variables.

B. Assumptions

1) The duration of 80% of tasks are underestimated and the duration of remaining 20% tasks are overestimated.

2) In daily progress of the project, progress of an underestimated task can be 70% to 100% of scheduled amount of the day and progress of an overestimated task can be 100% to 130% of scheduled amount of the day.

3) The amount of daily progress of each task follows a uniform distribution and is within the limits mentioned in the previous number.

As in the literature the relation between SPI and prediction of real duration of project is not assumed to be linear and the experience with the data set of this article also confirms the non-linear nature of the relation.

V CONCLUSION

In this article a new method for estimation of duration of projects was presented. Based on a try and error procedure, Scheduled Performance Index (SPI), Scheduled Percent Complete by Duration (SPCD), Actual Percent Complete by Duration APCD), and Sum of Durations to Due Time (SDDT) were selected as predictor variables and finally a formula based on regression analysis was presented. The results showed a strong relation between predictor variables and response and the final function could explain 95.4% of variation in response according to predictors. Although he formula can be used in a wide range of projects, but in generalizing final relation one should be aware of its limitations

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