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EVM MODIFICATIONS TO IMPROVE COST CONTROL OF CONSTRUCTION PROJECTS

Hesham A. Abd-Elkhalek, Remon F. Aziz, Mohamed M. Mohamed

Professor of Construction Engineering and Management,

Structural Engineering Department, Faculty of Engineering, Alexandria University, Egypt.

Assistant professor, Structural Engineering Department, Faculty of Engineering, Alexandria University, Egypt.

M. ENG. Candidate

ABSTRACT

Earned Value is a well known project management tool that uses information on cost, schedule and work performance to establish the current status of the project. For all of the accomplishments of (EVM) in expressing and analyzing cost performance, it has not been as successful for schedule performance. The (EVM) schedule indicators are reported in units of cost rather than time. This fundamental mistake is not just semantic. It influences the schedule performance indicators in a way that make them practically useless and often even misleading. Beyond this problem, there is the much more serious issue: the (EVM) schedule indicators fail for projects executing beyond the planned completion date. The objective of this paper is to discuss the basic principles, main goals and benefit of the use of (EVM) in projects. In addition, the paper attempts to clarify the application of common time (EVM) metrics and compare them with the new set of time metrics to interpret the schedule performance of a project. All satisfactory results of the (EVM) application are displayed in this paper by using a case study which is conducted to compare and demonstrate the difference of analysis between both methods.

KEYWORDS: Construction Management (CM); Earned Value Management (EVM); Schedule Variance (SV); Schedule Performance Index (SPI); Forecasting and Cost Control.

INTRODUCTION

The main objective of cost control of a project is to gain the maximum profit within the designated period within the budget. In other meaning, to monitor and control actual expenditure against the estimated project budget. It is necessary to decide which control level is required and amount of detail that will be in entered into the construction stage to decide which method of cost control to be applied. Ashraf F. El-deeb, (2006), stated the most common cost control methods as follows: (1) Cost trend analysis, (2) Management exception reporting, (3) Range estimating, (4) Cost Management Planning Support System (COMPASS), (5) Forecasting unit costs, and (6) Earned value system. Each of these methods except the COMPASS method identify cost problems once they have manifested and are reactionary vice anticipatory to potential cost problems. A comparison between those methods is shown in table (1).

Table 1. Comparison Between Cost Control Methods.

Methods	Advantages	Disadvantages
1.Cost Trend Analysis	Graphical view of trends	Ignore critical path activities.
2.Management Exception Reporting	- Simplest form cost control. -Used at least in some form by most of the industry.	Cost variances discovered too late, no schedule link, can become cumbersome on large projects.

3.Range Estimating	Applies simple probability to the most critical items.	Data acquisition may be difficult, useful planning tool but not suited for controlling cost.
4.COMPASS	Provides diagnosis of cost problem.	Requires extensive effort to develop and apply.
5.Forecasting Unit Costs	Simple unit costs are developed that are easily compared to actual.	Does not include effects of the schedule.
6.Earned Value System	Compares cost and schedule in similar items, results show both cost and schedule variances.	EAC approximated by straight line, analysis ignores critical path.

EARNED VALUE MANAGEMENT

The concept of earned value management became a fundamental approach to program management in 1966 when the United States Air Force mandated earned value in conjunction with the other planning and controlling requirements on Air Force programs. The requirement was entitled the Cost/Schedule Planning Control Specification (C/SPCS). Over the decades, the concept and its requirements have remained basically unchanged. It has had periodic updates to its title: Cost/Schedule Control System Criteria (C/SCSC), Earned Value Management Systems Criteria (EVMSC), and the current 32 guidelines in the EIA-748 Standard for Earned Value Management Systems (EVMS) EVM is a project management methodology for measuring financial and project performance. A basic form of EVM can be traced back to industrial engineers on the factory floor in the late 1800s. In 1967, EVM was introduced by the U.S. federal government as an integral part of the Cost/Schedule Control System Criteria (C/SCSC) to understand the financial aspects of programs and to be used in large acquisition programs in an attempt to establish a consistent methodology based on best practices. The construction industry was an early commercial adopter of EVM. Closer integration of EVM with the practice of project management accelerated in the 1990s. In 1999, the Performance Management Association merged with the Project Management Institute (PMI) to become PMI's first college, the College of Performance Management. The United States Office of Management and Budget began to mandate the use of EVM across all government agencies, and, for the first time, for certain internally managed projects (not just for contractors). EVM also received greater attention by publicly traded companies in response to the Sarbanes-Oxley Act of 2002.

CONCEPT OF EVM

Earned Value analysis is a method of performance measurement. Earned Value is a program management technique that uses "work in progress" to indicate what will happen to work in the future. Earned Value is an enhancement over traditional accounting progress measures. Traditional methods focus on planned accomplishment (expenditure) and actual costs. Earned Value goes one step further and examines actual accomplishment. This gives managers greater insight into potential risk areas. With clearer picture, managers can create risk mitigation plans based on actual cost, schedule and technical progress of the work. It is an "early warning" program/project management tool that enables managers to identify and control problems before they become insurmountable. It allows projects to be managed better on time, on budget. Earned Value Management System is not a specific system or tool set, but rather, a set of guidelines that guide a company's management control system.

THE FUNDEMENTAL PRINCIBLES OF EVM

In 2002, The ANSI/EIA-748 EVMS stated the EVM seven fundamental principles as follows:

1. Plan all work scope to completion
2. Break down the work scope into finite pieces that can be assigned to a responsible person
3. Integrate the work scope, schedule, and cost objectives into a performance measurement baseline against which accomplishments can be measured. Control changes to the baseline.
4. Use actual cost incurred and recorded in accomplishing the work performed
5. Objectively assess accomplishments at the work performance level
6. Analyze variances from the plan, forecast impacts, and prepare an estimate at completion

7. Use the earned value information in the management process

EVM TECHNIQUES

In 2010, PMI (Project Management Institute) defined six techniques to measure EV as follows:

1. Weighted milestone.
2. Weighted milestone with Percent Complete.
3. Subjective Percent Complete.
4. Level of effort.
5. Apportioned Effort.
6. Fixed Formula.

Table (2) Summary of advantages and disadvantages of EVM techniques

Technique	Advantages	Disadvantages
Weighted Milestones	Requires objective, measurable milestones, which most customer and project managers prefer.	Does not allow partial credit for in- process work and requires detailed milestone planning.
Weighted Milestones with Percent Complete	Requires objective, measurable milestones, which most customers prefer; allows for partial credit against milestone.	Requires a Control Account Manager's assessment of the percentage complete for each milestone and requires documentation of the assessment methodology.
Subjective Percent Complete	This is one of the more subjective methods, in which Earned Value is based on the CAM's assessment of the work package progress. Detailed planning at the milestone level is not required.	Customer satisfaction may be low due to the subjectivity involved and the lack of detailed planning. However, CAMs are required to provide the customer with their assessment methodology.
Level of Effort	Trivial to implement and is appropriate for sustaining tasks such as Program Management.	Offers no benefit over simple planned vs. actual comparisons. The LOE method should be kept to a minimal portion of the project planned value to avoid distortion of the project level metrics.
Apportioned Effort	Provided a measure to "immeasurable" work	Applying to a large-value work package where the basis for the apportioning is a significantly smaller value work package can distort measure.
Fixed Formula	Works well for short term work packages and requires minimal effort to determine status.	No significant disadvantages for short term, low value work packages. Not very effective for longer term work packages.

STEPS FOR MAKING A STRONG EVM PLAN

According to an early publication from the APM's Earned Value Specific Interest Group (EV SIG) "Earned Value Management is the measurement and monitoring of project progress in terms of cost, time and technical/physical achievement against a defined scope of work". The EV SIG implies that all you need to do to carry out EVM is follow these 10 easy steps:

1. Develop a Work Breakdown Structure (WBS) for the project that covers its agreed scope.
2. Develop an Organizational Breakdown Structure (OBS) that aligns to the WBS that ensures responsibility for work accomplished.
3. Distribute the project's total budget (or resource effort) across elements of the WBS (at a consistent level in the breakdown structure).
4. Schedule the work contained in the WBS and thus spread the budget over the project's schedule/duration.
5. Identify a method to measure achievement.
6. Baseline the plan.
7. Record all costs (actual costs plus accruals or effort expended).
8. Collect and analyze performance data (using the method that should have been identified in 5 above!).
9. Produce forecasts for remaining work.
10. Incorporate authorized changes in a timely manner.

TERMS USED IN EVM

The terms used in EVM can be classified into three groups; performance measurement group, performance analysis group and performance forecasting group.

1- PERFORMANCE MEASUREMENT GROUP

Three quantities form the basis for cost performance measurement using Earned Value Management. They are Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV), Budgeted Cost of Work Performed (BCWP) or Earned Value (EV) and Actual Cost of Work Performed (ACWP) or Actual Cost (AC).

1- Budgeted Cost of Works Scheduled (BCWS)

The BCWS is the baseline budget calculated from the approved, resource-loaded baseline schedule and is represented in terms of budgeted pounds per month. It represents the estimated value of the work scheduled. The (BCWS) or (PV) is calculated as the sum of the product of the scheduled quantities (Qs) and the estimated cost (Cs) for the assigned resources at the Data Date (DD) as follows:

$$BCWS = PV = SUM\ (Q_s * C_s)\ \text{at the DD} \quad (1)$$

2- Actual Cost of Work Performed (ACWP)

According to PMBOK Guide (2008) the (ACWP) is known as actual cost (AC) .Actual Cost (AC) is an indication of the level of resources that have been expended to achieve the actual work performed to date (or in a given time period).

$$ACWP = AC = SUM\ (Q_A * C_A)\ \text{at the DD} \quad (2)$$

3- Budgeted Cost of Work Performed (BCWP)

The **(BCWP)** represents the progress completed against planned and scheduled work. Earned value is the estimated pound value of the work performed in relation to the baseline budget or (**BCWS)**.The (BCWP) or (EV) is calculated as the sum of the product of the actual quantities (QA) and the estimated cost (Cs) for the assigned resources at the Data Date as follows:

$$BCWP = EV = SUM\ (Q_A * C_S)\ \text{at the DD} \quad (3)$$

2- PERFORMANCE ANALYSIS GROUP

1- Schedule Variance (SV):

The Schedule Variance is the difference between value of work performed and work scheduled. The Schedule Variance (SV) determines whether a project is ahead of or behind schedule. It is calculated by subtracting the Planned Value (PV) from the Earned Value (EV).

$$SV = EV–PV \quad (4)$$

2- Schedule Performance Index:
The Schedule Performance Index (**SPI**) is the value of work performed against work scheduled, are usually used to measure schedule efficiency. The Schedule Performance Index (**SPI**) indicates how efficiently the project team is using its time. **SPI** is calculated by dividing the Earned Value (**EV**) by the Planned Value (**PV**) for a Project:

$$SPI = EV/PV \quad (5)$$

3- Cost Variance (CV):
Cost variances represent the difference between the budgeted value of the work completed (BCWP) and the actual cost (ACWP). They provide trend information and serve as a useful indicator of the accuracy of the baseline budget estimate.

$$CV = EV–AC \quad (6)$$

4- Cost Performance Index (CPI):
Cost Performance Index (CPI) is one of the clearest indicators of the cumulative cost efficiency of a project. (CPI) shows how efficiently the project resources are used. It is determined by dividing the Earned Value (EV) by the Actual Cost (AC). In regards to any Project, the (CPI) is:

$$CPI = EV/AC \quad (7)$$

3-FORECASTING GROUP

1- Estimate To Complete (ETC)
Project Management Institute, (2005) defined The Estimate to Complete (**ETC**) as the estimated future costs- to complete the authorized remaining work. The Estimate to Complete (**ETC**), which shows what the remaining work will cost, based on an analysis of the remaining work and is calculated as follows:

$$ETC = BAC–EV \quad (8)$$

2- Estimate At Completion (EAC):
Project Management Institute, (2005) defined the Estimate at Completion as the estimate of total cost to complete authorized work at the end of the project. Assuming that the future cost performance will be the same as all past cost performance.

$$EAC = BAC/CPI \quad (9)$$

3- Time Estimate At Completion (TEAC):
The time estimate at completion is the expected project duration of completing project work. The (TEAC) is calculated as the project duration over the schedule performance index as follows:

$$TEAC = T/SPI \quad (10)$$

4- Variance At Completion (VAC)
Variance at Completion (**VAC**) is the difference between what the project was originally expected to cost versus what is now expected to cost. It shows whether the project will finish under or over budget, by subtracting the (**EAC)** from the (**BAC**).

$$VAC = BAC–EAC \quad (11)$$

5- To Complete Performance Index (TCPI):
To-Complete Performance Index (**TCPI**) helps the team determine the efficiency that must be achieved on the remaining work for a project to meet a specified endpoint, such as the Budget at Completion (**BAC**) or the team's

revised Estimate at Completion (**EAC**). The (**TCPI**) for achieving the (**BAC**) is calculated by dividing the work remaining by the budget remaining as follows:

$$TCPI = (BAC–EV)/ (BAC–AC) \quad (12)$$

Figure 1. Shows a Graphical explanation of EVM Terms

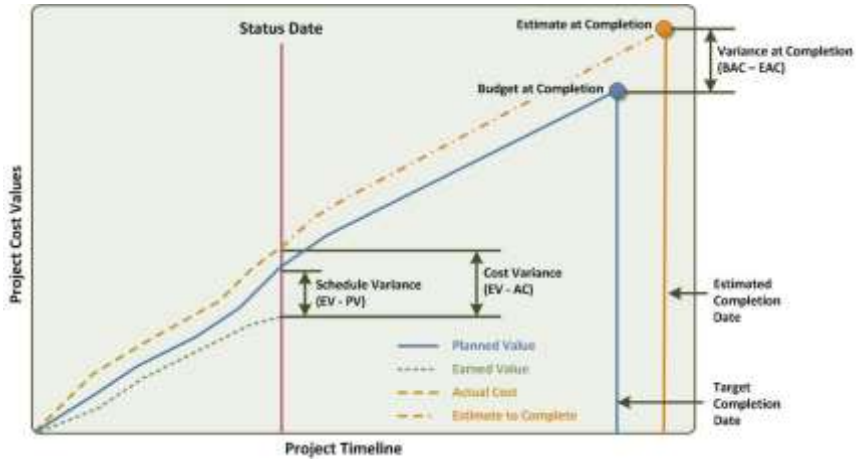

Figure 1. Graphical Explanation of EVM Terms

EVM RESULTS ANALYSIS

Reading of EVM results is the first step to project performance judgment to answer the following questions:

1- do we have any problem with project cost
2- do we have any problem with project schedule
3- do we need to take any corrective actions

According to the previously discussed variances and indices of EVM, the possible cases for schedule and cost variances and indices can be illustrated in table (3):

Table (3) Summary of cases of EVM variances and indices

SV			CV		
+ve	zero	-ve	+ve	zero	-ve
Ahead of Schedule	On Time	Behind Schedule	Under cost	Within Budget	Over cost
SPI			CPI		
>1	=1	<1	>1	=1	<1
Ahead of Schedule	On Time	Behind Schedule	Under cost	Within Budget	Over cost

DISADVANTAGES OF EVM

Earlier we saw what Earned Value Management is, and calculations in Earned Value Analysis. In project management, we use the concept of earned value to measure and predict the progress in the on-going project. It has become very popular now days as a performance measuring method. We need to discuss the disadvantages of

project Earned Value Analysis (EVA) / Management (EVM), trying to reach an improved methodology to be applied. According to Katia Rizkallah, (2012), disadvantages of EVMS can be summarized in the following points:

1. This method is not efficient in the case of low level work breakdown structure (WBS).
2. Performance level at an initial stage may not remain the same throughout the project.
3. While doing earned value analysis, we don't take quality into consideration.
4. In EVM, we take planned value as the baseline, using which we do our calculations and we make predictions. But there is always an element of uncertainty involved while doing any predictions.
5. Costly and Time Consuming Implementation.
6. Unreliable Schedule Indicators.
7. Does not distinguish between critical and non-critical activities.
8. Humble Commercial Awareness of the EV technique.

WHY EVM IS NOT GOOD FOR TIME MANAGEMENT

The main objective of project performance analysis is to tell as how the project is performing related to three principal project factors: scope (size), cost and time. It has to indicate how our process of product development is performing, are we delivering our product (scope) on time and within planned costs. We are practically measuring the effectiveness of our process by measuring its attributes, cost and time. We are measuring how are we delivering the product (instead in product scope, which is often very difficult to measure when the process is in progress, a product is expressed in its other attribute, its value, either planned or earned) comparing to the attributes of process – costs (cost performance analysis) and time (schedule performance analysis). The fundamentals of EVM are based on this concept. EVM is supposed to indicate how our process (project) is performing by measuring and comparing the costs (actual costs-AC) and the time spent in order to produce a certain amount of a product (earned value-EV). While the EVM works well when calculating cost performance, it is much more different when we talk about schedule performance . The EVM concept is graphically presented on two-dimension diagram. The planned as well as the earned value of the product is presented as a curve, for which each point is determined by the corresponding points on a vertical (cost) axis and on a horizontal (time) axis. Cost performance indicators are based on the difference between earned value and actual costs at a given time. All this is projected on a vertical (cost) axis. Following this logic, time (schedule) performance should be calculated by measuring the value of product delivered at a given time (earned value) and by comparing this time to the time when this value was supposed (planned) to be delivered. The difference (called schedule variance) should be presented on a horizontal (time) axis. But, for some reason, the conventional EVM calculates schedule performance by comparing EV delivered at a given time to the value planned to be delivered at the same time. Instead of calculating and expressing the results as the amount of time and presenting them on a horizontal (time) axis, the conventional EVM expresses the result as value and presents it on a vertical (cost) axis as we see in figure(2). This fundamental mistake is not just semantic. It has important implications not just on the unit of measure in which results are expressed (in measure of value instead of measure of time), but more importantly, it influences the schedule performance indicators in a way that make them practically useless and often even misleading. The first EVM indicator, the schedule variance (SV), is expressed in product value and it is not of a great use for project managers. If you say to a project manager that his project is $500 000 late, you can expect a question: Yes, but how many months or days is it? Classical EVM cannot provide a valid response. The second EVM indicator, the schedule performance indicator (SPI), is a ratio between EV and PV and at the end of the project, if the project has delivered all what was planned, EV and PV must be equal. This characteristic makes SPI useless after the planned end of the project because it tends to be 1 near to the project end. After the planned end of the project, planned value remains constant while the earned value is supposed to grow until the real end of the project. If your project is planned to be finished in 10 months, for example, and your EV after 10 months is 70%, you are obviously 30 % behind schedule. But, when you continue your project (you have to finish it eventually), and for some reason you do nothing for three months, your schedule performance will remain the same! At the end of the project your EV will be equal to your PV which, according to EVM, means that you have finished your project on time even though you are couple of months late. Great, isn't it? But I don't think that the client will share your enthusiasm.

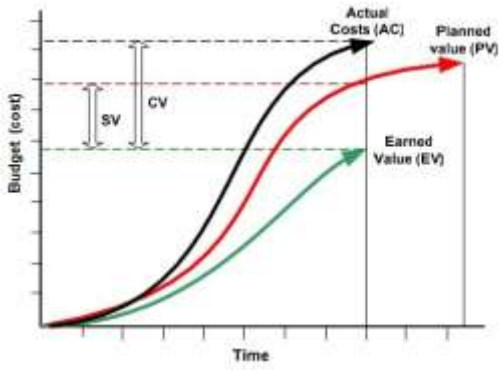

Figure (2) Conventional EVM approach

This weakness of EVM is already very well explained by many authors (Fleming and Koppelman, Lipke, Henderson, Vandevoorde&Vanhoucke) and even included in PMI Practice Standard of EVM. Most of them argue that the EVM is not a reliable predictor of project duration and even recommend that EVM, relating to project schedule performance, should be used just as warning mechanism and not as a real tool to analyze how the project is performing in time.

IMPORTANCE OF SCHEDULE PERFORMANCE ANALYSIS

The original phrase "Time is money" was first posed by Antiphon (Greek writer and educator around 430 BC). "The most costly outlay is time". This statement was ahead of its time! In 2006, Dr. Steve Gumley, CEO Defense Materiel Organization (Australia) stated "We need to maintain our attention on schedule delivery. Data tells us that since July 2003, real cost increase in projects accounted for less than 3 percent of the total cost growth. Therefore, our problem is not cost, it is SCHEDULE." So schedule calculations based on money as in conventional EVM equations can lead to wrong decisions, these wrong decisions mean more cost. We should try to find another way to control project schedule and forecast project delivery date.

THE NEW MODIFICATION CONEPT

For more than 30 years earned value management has been providing valuable insight into project cost and schedule status during project execution. A study of more than 700 completed major programs over three decades has shown that earned value provides insight into the project health when as little as 15 percent of the work is complete. However, while traditional earned value management did an excellent job of estimating the final cost of the project, it failed to do the same for estimating the completion date. Recently, new work in the application of earned value management principles has created novel approaches to obtain schedule information from the application of earned value management, and have resulted in means to predict the project completion date.

In March 2003, Walter Lipke published a paper in The Measurable News that introduced an extension of earned value management that tracked program schedule in units of time rather than traditional EVM units of budget, called earned schedule (Lipke, 2003). It was developed in response to the noted deficiency in using EVM cost-based indicators to effectively evaluate program schedule performance. Schedule performance is important because if a product is not delivered on time there can be serious repercussions. In addition to the likelihood of increased project costs, the customer, internal or external, is deprived of using the product, consequently preventing the delivery of their product or service (Lipke, 2009). The basis for the earned schedule concept is straightforward. Identify the time at which the amount of earned value (EV) accrued should have been earned. By determining this time, time-based indicators can be formed to provide schedule variance and performance efficiency management information (Earned Schedule, 2012). At any point during the execution of a project, we have three earned value management parameters to evaluate planned value, earned value, and actual cost. For a simple project with BAC of 5 million $ and 18 months duration. (See figure 3) Comparing the planned value to the earned value at a point in time provides schedule information. For example, if, at a point in time our planned value is $5 million but our earned value is only

$4 million then clearly there is work valued at $1 million that has not been completed. If, at this point in time our actual cost is $5 million then we have a cost overrun as well. Why? While we planned to complete $5 million (planned value) of work at a cost $5M (actual cost), we only really completed $4 million of work (earned value). So we've spent $5 million to get $4 million of work done. Note that without earned value management, we would compare our planned expenditure of $5 million to our actual costs of $5 million and reached the erroneous and dangerous conclusion that we are right on budget! The SPI must be 1.0 at the end of the project regardless of how early or late the project completes. Thus, the SPI is an unreliable parameter to compute an estimated completion date. At some point around 2/3 into the project the SPI begins to become meaningless. This requires the definition of a few more terms. Earned schedule (ES) is the point in time when the current earned value was to be accomplished. In other words, at what point in time was the project planned value supposed to equal the current earned value? To do this, we find the point on the planned value line that equals the current Earned Value and note when it was to occur. This date is the earned schedule. The other new parameter is the actual time (AT) that has expired since the project started. The linear interpolation method used to determine ES is represented in figure (4)

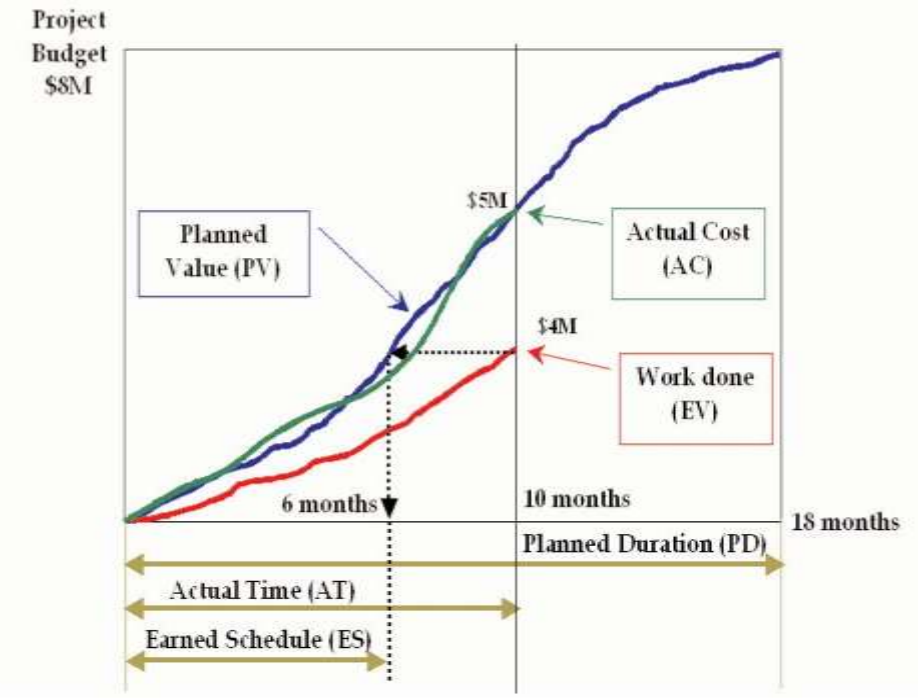

Figure 3.Schedule Performance Index

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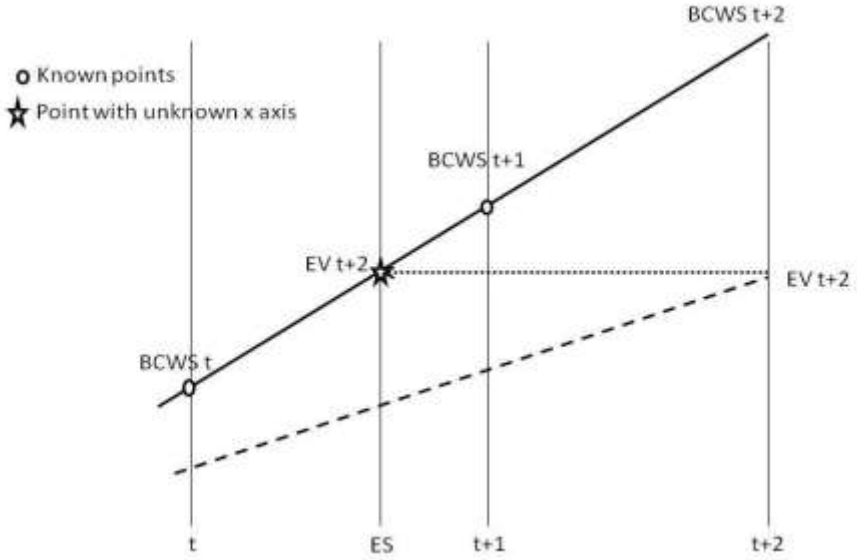

Figure 4.Linear Interpolation Method to Calculate ES

$$ES = t + ((EV_{t+2} - BCWS_t)/(BCWS_{t+1} - BCWS_t)) \quad (13)$$

$$SV = t - ES \quad (14)$$

The important performance metric that can be derived from the ES is the program's schedule performance index, SPI (t).

$$SPI(t) = ES/ATE \quad \text{(Where ATE is Actual Time Expended} \quad (15)$$

$$(T')\ EAC(t) = PD/SPI(t) \quad (16)$$

Most of the EVM authors (PMI Standard proposes the same) think that the future project performance (cost or schedule) is, to some extent, influenced by its past performance. Therefore, EAC may be calculated from the following equation

EAC (t) = Actual Time + (Planned Project Duration – Earned Schedule) *Cf

Cf is an adjustment factor representing the degree by which the past performance is supposed to affect project performance in the remaining time.

CASE STUDY

This case study is a tourist village located in North Cost in Egypt. The project overlay an area of 100,000 M2 consisting of 12 units of type A buildings, 10 units of type B buildings, 2 units of type C buildings and one hotel building.

Project Start Date : 01/04/2012
Project Completion Date: 31/01/2015 (Total project Duration = 34 months)
Delay penalty : 4% of Budget cost monthly with max total penalty of 10% till 31/7/2015 then the contract shall be cancelled.

Figure 5. Project Perspective of Case Study.

APPLICATION OF EVM AND MODIFIED TECHNIQUES

1. Taking November 2013 as a Status Date.
2. BCWS, BCWP, ACWP values have been collected monthly from April. 2012 to November. 2013 According to the project monthly progress report.
3. Table (4) showing conventional Earned Value Management calculation,
4. Basics for Earned Value Analysis calculated as:
   a. BAC = 320,000,000 EGP.
   b. T = 34 Months.
5. Basic variances and indices are calculated and showing in table 4,
6. Forecasting Future Performance Trends are informed in table 5, and
7. Modification equation applied in table 6.

Table 4. Conventional EVM Calculations for Case Study.

Time	BCWS (PV)	BCWP (EV)	ACWP (AC)	SV	SPI	Project Schedule Status	CV $*10^6$	CPI	Project Cost Status
April-2012	12720000	12720000	12720000	0	1.00	On schedule	0.00	1.00	within budget
May-2012	19632000	17212800	17527296	-2419200	0.88	Behind schedule	-0.31	0.98	Over budget
June-2012	26544000	24124800	25835520	-2419200	0.91	Behind schedule	-1.71	0.93	Over budget
July-2012	33456000	29308800	33124224	-4147200	0.88	Behind schedule	-3.82	0.88	Over budget
Aug-2012	42886733	38079091	39159572	-4807642	0.89	Behind schedule	-1.08	0.97	Over budget
Sep-2012	55597901	42977004	44386486	-1.3E+07	0.77	Behind schedule	-1.41	0.97	Over budget
Oct-2012	72280168	56566984	58530062	-1.6E+07	0.78	Behind schedule	-1.96	0.97	Over budget
Nov-2012	66883883	66883883	69171408	-1.6E+07	0.80	Behind schedule	-2.29	0.97	Over budget
Dec-2012	100823230	77091154	78674865	-2.4E+07	0.76	Behind schedule	-1.58	0.98	Over budget
Jan-2013	113178634	97260247	100536817	-1.6E+07	0.86	Behind schedule	-3.28	0.97	Over budget
Feb-2013	129754524	107725476	108525262	-2.2E+07	0.83	Behind schedule	-0.80	0.99	Over budget
Mar-2013	147232121	127937957	128592659	-1.9E+07	0.87	Behind schedule	-0.65	0.99	Over budget
April2013	164142639	144770628	143686602	-1.9E+07	0.88	Behind schedule	1.08	1.01	Under budget
May2013	179421656	159544009	159340705	-2E+07	0.89	Behind schedule	0.20	1.00	Under budget
June2013	198894156	180045917	179297399	-1.9E+07	0.91	Behind schedule	0.75	1.00	Under budget
July 2013	210779936	196224031	195353065	-1.5E+07	0.93	Behind schedule	0.87	1.00	Under budget
Aug 2013	219856976	210524156	210913029	-9332820	0.96	Behind schedule	-0.39	1.00	Under budget
Sep-2013	232106656	220653256	220940755	-1.1E+07	0.95	Behind schedule	-0.29	1.00	Under budget
Oct-2013	238483456	235697056	231381283	-2786400	0.99	Behind schedule	4.32	1.02	Under budget
Nov-2013	244910656	241763656	238323247	-3147000	0.99	Behind schedule	3.44	1.01	Under budget

Table 5. Forecasting Future Performance for Case Study According to Conventional EVM.

Time	EV	AC	SPI	CPI	ETC *10^6	EAC *10^6	VAC *10^6	TCPI	T'
Apr-2012	12720000	12720000	1.00	1.00	307.28	320	0	1.00	34.00
May-2012	17212800	17527296	0.88	0.98	302.7872	325.8467	-5.84674	1.00	38.78
June-2012	24124800	25835520	0.91	0.93	295.8752	342.6916	-22.6916	1.01	37.41
July-2012	29308800	33124224	0.88	0.88	290.6912	361.6576	-41.6576	1.01	38.81
Aug-2012	38079091	39159572	0.89	0.97	281.9209	329.0799	-9.07988	1.00	38.29
Sep-2012	42977004	44386486	0.77	0.97	277.023	330.4948	-10.4948	1.01	43.98
Oct-2012	56566984	58530062	0.78	0.97	263.433	331.1052	-11.1052	1.01	43.44
Nov-2012	66883883	69171408	0.80	0.97	253.1161	330.9445	-10.9445	1.01	42.30
Dec-2012	77091154	78674865	0.76	0.98	242.9088	326.5739	-6.57387	1.01	44.47
Jan-2013	97260247	100536817	0.86	0.97	222.7398	330.7804	-10.7804	1.01	39.56
Feb-2013	107725476	108525262	0.83	0.99	212.2745	322.3758	-2.37578	1.00	40.95
Mars-2013	127937957	128592659	0.87	0.99	192.062	321.6375	-1.63755	1.00	39.13
April-2013	144770628	143686602	0.88	1.01	175.2294	317.6039	2.396123	0.99	38.55
May-2013	159544009	159340705	0.89	1.00	160.456	319.5922	0.407769	1.00	38.24
June2013	180045917	179297399	0.91	1.00	139.9541	318.6696	1.33036	0.99	37.56
July-2013	196224031	195353065	0.93	1.00	123.776	318.5796	1.420362	0.99	36.52
Aug-2013	210524156	210913029	0.96	1.00	109.4758	320.5911	-0.59109	1.00	35.51
Sep-2013	220653256	220940755	0.95	1.00	99.34674	320.4169	-0.41694	1.00	35.76
Oct-2013	235697056	231381283	0.99	1.02	84.30294	314.1406	5.859417	0.95	34.40
Nov-2013	241763656	238323247	0.99	1.01	78.23634	315.4463	4.553749	0.96	34.44

Table 6. Modified Technique Calculations for Case Study.

Time	EV	PV	SV(t)	ES	SPI(t)	T'
April2012	12720000	12720000	0.00	1	1.00	34.00
May2012	19632000	17212800	-0.35	2.00	0.88	38.49
June2012	26544000	24124800	-0.35	2.65	0.91	37.26
July 2012	33456000	29308800	-0.60	3.65	0.88	38.64
Aug-2012	42886733	38079091	-0.51	4.40	0.92	37.16
Sep-2012	55597901	42977004	-0.99	5.49	0.86	39.62
Oct-2012	72280168	56566984	-0.94	6.01	0.88	38.54
Nov-2012	66883883	66883883	-1.32	7.06	0.85	39.86
Dec-2012	100823230	77091154	-1.56	7.68	0.85	39.86
Jan-2013	113178634	97260247	-1.20	8.44	0.89	38.17
Feb-2013	129754524	107725476	-1.44	9.80	0.88	38.64
Mars2013	147232121	127937957	-1.11	10.56	0.91	37.17
April2013	164142639	144770628	-1.14	11.89	0.92	37.02
May2013	179421656	159544009	-1.27	12.86	0.92	37.15
June2013	198894156	180045917	-0.97	13.73	0.94	36.19
July2013	210779936	196224031	-1.14	15.03	0.93	36.44
Aug 2013	219856976	210524156	-1.02	15.86	0.94	36.05
Sep-2013	232106656	220653256	-0.93	16.98	0.95	35.76
Oct-2013	238483456	235697056	-0.44	18.07	0.98	34.76
Nov-2013	244910656	241763656	-0.49	19.56	0.98	34.81

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Table 7. Comparison between EVM and modified technique results for Case

Month	SPI	SPI (t)	T' (EVM)	T' (ES)
April2012	1.00	1.00	34.00	34.00
May2012	0.88	0.88	38.78	38.49
June2012	0.91	0.91	37.41	37.26
July 2012	0.88	0.88	38.81	38.64
Aug-2012	0.89	0.92	38.29	37.16
Sep-2012	0.77	0.86	43.98	39.62
Oct-2012	0.78	0.88	43.44	38.54
Nov-2012	0.80	0.85	42.30	39.86
Dec-2012	0.76	0.85	44.47	39.86
Jan-2013	0.86	0.89	39.56	38.17
Feb-2013	0.83	0.88	40.95	38.64
Mars2013	0.87	0.91	39.13	37.17
April2013	0.88	0.92	38.55	37.02
May2013	0.89	0.92	38.24	37.15
June2013	0.91	0.94	37.56	36.19
July2013	0.93	0.93	36.52	36.44
Aug 2013	0.96	0.94	35.51	36.05
Sep-2013	0.95	0.95	35.76	35.76
Oct-2013	0.99	0.98	34.40	34.76
Nov-2013	0.99	0.98	34.44	34.81

Figure 6. SPI and SPI (t) of Case Study

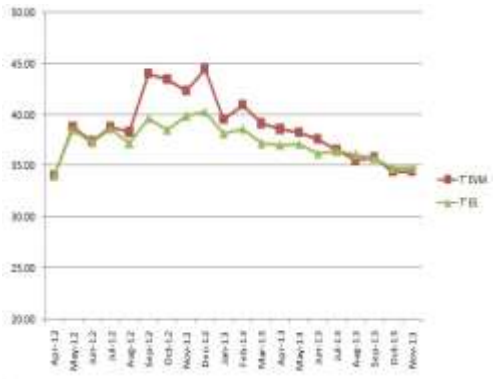

Figure 7. forecasted duration T' of Case Study

COMMENTS ON THE RESULTS

1- According to project cost performance index, there was no cost problem, the difference between budgeted cost and actual cost doesn't exceed 6%, and the real problem in this case is time.
2- The project is behind schedule, according to the type of the project, the investment is related to time because it's an operation profit project, so the wrong schedule performance indicators here are very dangerous.
3- In April, 2014, ES gives us a schedule performance with a much less values than EVM does, but in Jun-2014, SPI calculated by EVM is less than the SPI calculated by the modified technique, this reversed indication leads to reversed corrective actions and completely wrong decisions taken by top management.

From the above results and comments we can conclude that:

1. SPI (t) gives more reliable and realistic indication of project performance in time.
2. As earlier the right corrective actions taken as the cost control process is more effective.
3. True performance indicators mean suitable corrective actions.
4. False indicators of the conventional EVM technique can lead to catastrophic results according to wrong corrective actions.

The paper shows that schedule performance indicators calculated with traditional EVM are not just less precise, they are totally wrong and we cannot depend on.

On the other side, Earned Schedule gives us a clear realistic picture of project performance to the schedule and how are we using time, it also indicates the project delay in time units which is very important to control project schedule.
EVM equations should be modified to contain ES equation reaching an integrated, reliable cost control tool that we can depend on in both time and cost management.

CONCLUSION

The main conclusion drawn from this paper is: (1) every organization should implement a suitable and effective cost control method to get an early warning tool for its projects performance. (2) EVM is the most effective project management tool to be adopted for monitoring and controlling projects performance it gives a clear picture of project performance. (3) A realistic baseline plan is an important factor to ensure right implementation of any cost control method, especially EVM. The main concept of any cost control method is to compare the real performance to the baseline whether in cost or time. (4) EVM has a remarkable problem, it expresses the schedule variance in money units it compares the earned value (money) to planned value (money) which is totally wrong and could lead to wrong decisions and wrong corrective actions. And in the end of the project schedule variance will be zero even the project had a schedule delay. (5) ES gives an accurate indicator for schedule performance (SPIt) and expresses schedule variance in time units. This could give reliable information for decision maker to take further steps and corrective actions based on these indicators. EVM rules and standards related to schedule performance should be changed and established according to the proposed modification which will lead to an integrated tool for cost control that enables projects managers taking right decisions and keeping the project on the right path.

REFERENCES

1. Kwak Y., and Anbari T. (2012) " History, Practices, and Future of Earned Value Management in Government: Perspectives from NASA", Project Management Journal, pp 78-90.
2. Christensen S. (1998) "The Costs and Benefits of the Earned Value Management Process", College of Business Southern, Utah University.
3. Burke R. (2006) "Project Management. Planning and Control Techniques" John Wiley & Sons.
4. Project Management Institute, (2005) "Practice Standard for Earned Value Management", Project Management Institute.
5. Lukas J. (2008) "Earned Value Analysis: Why It Doesn't Work" AACE International Transactions, Vol. (EVM.01), pp. 1-10.
6. Varges R. (2003) "Earned Value Analysis in the Control of Projects: Success or Failure?" Association for Advancement of Cost Engineering (AACE), Orland, Florida, and PMI Collage of Performance Management Measurable News Magazine, Arlington, Virginia.
7. Lipke W. and Henderson K. (2006) "Earned Schedule - an emerging enhancement to EVM", the journal of Defense Software Engineering, 26-30.
8. Vandevoorde S., Vanhoucke M. (2006) "A comparison of different project duration forecasting methods using earned value metrics", International Journal of Project Management, Volume 24, Issue 4, May 2006, pp.289–302.
9. Lipke W. (2011) "Earned Schedule Application to Small Projects" PM World Today (Vol. XIII, Issue IV) pp. 1-12.
10. El-Deeb A.,(2006),"Cost Control during construction phases" thesis submitted to the Architectural Engineering Department, Alexandria University, in partial fulfillment of the requirements for the degree of Master of Science in Architectural Engineering.
11. Mohamed Abbas, (2012). "Improving Measurement Of Project Performance In Earned Value Management" thesis submitted to the Civil Engineering Department, Alexandria University, in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering
12. Mohamed Aly Shaban, (2013), "Methods Of Cost Control " thesis submitted to the Civil Engineering Department, Alexandria University, in partial fulfillment of the requirements for the degree of Master of Engineering in Civil Engineering
13. Liang K.W.,(2005), "Cost Control In Construction Project Of The Site" report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of civil Engineering (Construction Management) – University Technology Malaysia.
14. http:// www.earnedschedule.com/
15. http:// www.watkinsmeegan.com/
16. http:// www.logikalprojects.co.uk
17. http:// www.pmknowledgecenter.com