

EARNED VALUE MANAGEMENT. CASE STUDY USING MICROSOFT PROJECT*

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Abstract: A formalism and a corresponding notation for earned value analysis are presented. With compact, consistent, mnemonic notation, earned value calculations become more transparent and flexible, leading to insights about standard quantities and advances through new measures. As an example of the notation's utility, it is used to generate a modified earned value approach that weights quantities according to their position in a project's timeline.

JEL classification: M15, M10

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1. INTRODUCTION

“If you can't measure it, you can't manage it”. Whether one trusts the validity of this common phrase most of the time or all of the time, measuring the true progress of a project presents a formidable task. Given a baseline plan, projects typically report a measure of the completed work and compare it to that scheduled. Similarly, most projects can and do measure the current cost and compare it to the planned spending. But for a more comprehensive view, how does one measure the progress of a project against the triple constraint of cost, schedule, and scope? The two simple measures above separate schedule and cost and include scope only indirectly, as a function of schedule.

In this framework, the mere contemplation of the budgeted cost of work performed cries out for an immediate comparison to the actual cost. Earned value analysis next brings the schedule into this common comparison basis by asking how much spending should have occurred, i.e., according to a project's schedule, at the specific time of any comparison.

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2. OBJECTIVES

The aim is to demonstrate that Earned Value Management (EVM) is a program management technique that integrates technical performance requirements, resource planning, with schedules, while taking risk into consideration (Fig. 1). 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 [1]. This data is in turn used for determining product-oriented contract status, and projecting future performance based on trends to date. In addition, EVM allows better and more effective management decision making to minimize adverse impacts to the project.

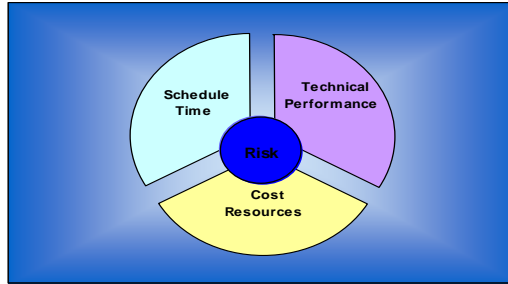


Figure no. 1 Project management component circle

3. METHODOLOGY

Earned value provides an objective measurement of how much work has been accomplished on a project. Using the earned value process, the management team can readily compare how much work has actually been completed against the amount of work planned to be accomplished. All work is planned, budgeted, and scheduled in time-phased "planned value" increments constituting a Performance Measurement Baseline (PMB).

Here are other definitions for Earned value:

- Englert and Associates, Inc define it as, "A method for measuring project performance. It compares the amount of work that was planned with what was actually accomplished to determine if cost and schedule performance is as planned."
- Project Management Institute defines it as, "A methodology used to measure and communicate the real physical progress of a project taking into account the work complete, the time taken and the costs incurred to complete that work" [5].
- The user guide for Microsoft Project 2003 defines Earned Value as, "a method for measuring project performance. It indicates how much of the budget should have been spent, in view of the amount of work done so far and the baseline cost for the task, assignment, or resources" [2].
- NASA defines it as, "An integrated management control system for assessing, understanding and quantifying what a contractor or field activity is achieving with program dollars. EVM provides project management with objective, accurate and timely data for effective decision making" [6].

Earned Value differs from the usual budget versus actual costs incurred model, in that it requires the cost of work in progress to be quantified. This allows the project manager to compare how much work has been completed against how much he expected to be completed at a given point.

Earned Value is also known as Performance Measurement, Management by Objectives, Budgeted Cost of Work Performed and Cost Schedule Control Systems.

Earned value (EV) is one of the most sophisticated and accurate methods for measuring and controlling project schedules and budgets. Earned value has been used extensively in large projects, especially in government projects. Project Management Institute is a strong supporter of the earned value approach because of its ability to accurately monitor the schedule and cost variances for complex projects [5].

Although it is sophisticated, earned value can be scaled to be appropriate for any size of project. The key is in the project planning.

There are three primary advantages to using earned value:

1. Accuracy in reporting.
2. Ability to deal with the uneven rate of project expenditures and work.
3. The early warning it provides project managers, allowing them to take the necessary corrective action should the project be spending more money than it is physically accomplishing.

Earned Value Management (EVM) is a project management technique that objectively tracks physical accomplishment of work and more [4]:

- Earn Value Management (EVM) technique used to track the Progress and Status of a Project & Forecast the likely future performance of the Project.
- EVM technique integrates the scope, schedule and cost of a project.
- EVM technique answers a lot of questions to the stakeholders in a project related to the performance of the project.
- EVM technique can be used to show past performance of the project, current performance of the project and predict the future performance of the project by use of statistical techniques.
- Good planning coupled with effective use of the EVM technique will reduce a large amount of issues arising out of schedule and cost overruns.

There are following three basic elements of EVM:

- Planned Value (PV)
- Actual Cost (AC)
- Earned Value (EV).

All the three elements are captured on a regular basis as of a reporting date.

Planned Value (PV). This is also referred to as Budgeted Cost of Work Scheduled (BCWS). Planned Value (PV) or BCWS is the total cost of the work scheduled /Planned as of a reporting date. This is calculated as in (1):

$$PV \text{ or } BCWS = \text{Hourly Rate} * \text{Total Hours Planned or Scheduled} \quad (1)$$

Actual Cost (AC). This is also referred to as Actual Cost of Work Performed (ACWP). Actual Cost (AC) or ACWP is the total cost taken to complete the work as of a reporting date. This is calculated as in (2):

$$AC \text{ or } ACWP = \text{Hourly Rate} * \text{Total Hours Spent} \quad (2)$$

Earned Value (EV). This is also referred to as Budgeted Cost of Work Performed (BCWP). Earned Value (EV) or BCWP is the total cost of the work completed/performed as of a reporting date. This is calculated as in (3):

$$EV \text{ or } BCWP = \text{Baselined Cost} * \% \text{ Complete Actual} \quad (3)$$

All these three elements can be derived from Work Breakdown Structure by associating the costs to each of the tasks. For a big project it will be a tedious task to calculate these elements manually. Scheduling Softwares like Microsoft Project is used to calculate these three elements.

Cost Variance (CV) is very important factor to measure project performance. Cost Variance (CV) indicates how much over or under budget the project is. Cost Variance can be calculated as in (4):

$$\text{Cost Variance (CV)} = \text{Earned Value (EV)} - \text{Actual Cost (AC)} = \text{BCWP} - \text{ACWP} \quad (4)$$

- The formula mentioned above gives the variance in terms of cost which will indicate how less or more cost has been to complete the work as of date.
- Positive Cost Variance Indicates the project is under budget.
- Negative Cost Variance Indicates the project is over budget.

Cost Variance % indicates how much over or under budget the project is in terms of percentage. Cost Variance % can be calculated as in (5):

$$\text{CV \%} = \text{Cost Variance (CV)} / \text{Earned Value (EV)} = \text{CV} / \text{BCWP} \quad (5)$$

- The formula mentioned above gives the variance in terms of percentage which will indicate how much less or more money has been used to complete the work as planned in terms of percentage.
- Positive Variance % indicates % under Budget.
- Negative Variance % indicates % over Budget.

Cost Performance Indicator (CPI). Cost Performance Indicator is an index showing the efficiency of the utilization of the resources on the project. Cost Performance Indicator can be calculated as in (6):

$$\text{CPI} = \text{Earned Value (EV)} / \text{Actual Cost (AC)} = \text{BCWP} / \text{ACWP} \quad (6)$$

- The formula mentioned above gives the efficiency of the utilization of the resources allocated to the project.
- CPI value above 1 indicates efficiency in utilizing the resources allocated to the project is good.
- CPI value below 1 indicates efficiency in utilizing the resources allocated to the project is not good.

To Complete Cost Performance Indicator (TCPI). To complete Cost Performance Indicator is an index showing the efficiency at which the resources on the project should be utilized for the remainder of the project. This can be calculated as in (7):

$$\text{TCPI} = (\text{Total Budget} - \text{EV}) / (\text{Total Budget} - \text{AC}) = (\text{Total Budget} - \text{BCWP}) / (\text{Total Budget} - \text{ACWP}) \quad (7)$$

- The formula mentioned above gives the efficiency at which the project team should be utilized for the remainder of the project.
- TCPI value above 1 indicates utilization of the project team for the remainder of the project can be stringent.
- TCPI value below 1 indicates utilization of the project team for the remainder of the project should be lenient.

Schedule Variance (SV) indicates how much ahead or behind schedule the project is. Schedule Variance can be calculated as in (8):

$$\text{Schedule Variance (SV)} = \text{Earned Value (EV)} - \text{Planned Value (PV)} = \text{BCWP} - \text{BCWS} \quad (8)$$

- The formula mentioned above gives the variance in terms of cost which will indicate how much cost of the work is yet to be completed as per schedule or how much cost of work has been completed over and above the scheduled cost.
- Positive Schedule Variance Indicates we are ahead of schedule.
- Negative Schedule Variance Indicates we are behind of schedule.

Schedule Variance %. Schedule Variance % indicates how much ahead or behind schedule the project is in terms of percentage. Schedule Variance % can be calculated as in (9):

$$SV \% = \text{Schedule Variance (SV)} / \text{Planned Value (PV)} = SV / BCWS \quad (9)$$

- The formula mentioned above gives the variance in terms of percentage which will indicate how much percentage of work is yet to be completed as per schedule or how much percentage of work has been completed over and above the scheduled cost.
- Positive Variance % indicates % ahead of schedule.
- Negative Variance % indicates % behind of schedule.

Schedule Performance Indicator (SPI). Schedule Performance Indicator is an index showing the efficiency of the time utilized on the project. Schedule Performance Indicator can be calculated as in (10):

$$SPI = \text{Earned Value (EV)} / \text{Planned Value (PV)} = BCWP / BCWS \quad (10)$$

- The formula mentioned above gives the efficiency of the project team in utilizing the time allocated for the project.
- SPI value above 1 indicates project team is very efficient in utilizing the time allocated to the project.
- SPI value below 1 indicates project team is less efficient in utilizing the time allocated to the project.

To Complete Schedule Performance Indicator (TSPI). To Complete Schedule Performance Indicator is an index showing the efficiency at which the remaining time on the project should be utilized. This can be calculated as in (11):

$$TSPI = (\text{Total Budget} - EV) / (\text{Total Budget} - PV) = (\text{Total Budget} - BCWP) / (\text{Total Budget} - BCWS) \quad (11)$$

- The formula mentioned above gives the efficiency at which the project team should utilize the remaining time allocated for the project.
- TSPI value above 1 indicates project team can be lenient in utilizing the remaining time allocated to the project.
- TSPI value below 1 indicates project team needs to work harder in utilizing the remaining time allocated to the project.

Budget At Completion (BAC). Budget At Completion (BAC) is the total budget allocated to the project.

- Budget At Completion (BAC) is generally plotted over time. Say like periods of reporting (Monthly, Weekly etc).
- BAC is used to compute the Estimate At Completion (EAC), explained in next section.
- BAC is also used to compute the TCPI and TSPI.

BAC is calculated as in (12):

$$BAC = \text{Baselined Effort-hours} * \text{Hourly Rate} \quad (12)$$

Estimate To Complete (ETC):

- Estimate To Complete (ETC) is the estimated cost required to complete the remainder of the project.
- Estimate To Complete (ETC) is calculated and applied when the past estimating assumptions become invalid and a need for fresh estimates arises.
- ETC is used to compute the Estimation at Completion (EAC).

Estimate At Completion (EAC):

- Estimate At Completion (EAC) is the estimated cost of the project at the end of the project.

- There are three methods to calculate EAC [1]:
 - Variances are Typical - This method is used when the variances at the current stage are typical and are not expected to occur in the future.
 - Past Estimating Assumptions are not valid - This method is used when the past estimating assumptions are not valid and fresh estimates are applied to the project.
 - Variances will be present in the future - This method is used when the assumption is that the current variances will be continue to be present in the future.
- The formula for calculation of the three methods are as given below:
 - $AC + (BAC - EV)$
 - $AC + ETC$ (Estimate to complete)
 - $AC + (BAC - EV) / CPI$.

Variance At Completion (VAC) is the variance on the total budget at the end of the project. This is the difference between what the project was originally expected (baselined) to cost, versus what the it is now expected to cost. VAC is calculated as in (13):

$$VAC = BAC - EAC \quad (13)$$

% Completed Planned. The percentage of work which was planned to be completed by the Reporting Date. This is calculated as in 14:

$$\% \text{ Completed Planned} = PV / BAC \quad (14)$$

% Completed Actual. The percentage of work which was actually completed by the Reporting Date. This is calculated as in (15):

$$\% \text{ Completed Actual} = AC / EAC \quad (15)$$

4. ANALYSES. CASE STUDY – USING MICROSOFT PROJECT FOR EARNED VALUE MANAGEMENT

Microsoft Project is a great tool to track project performance using Earned Value. The following steps are required to get the EV values of the project plan [8]:

Step 1: Create project plan

We have a project plan called “Baselineproject”. This project contains just two tasks called “User Interface” and “Database design”. We create the project plan with following scenario or similar (Fig. 2).

- Estimated total duration to complete project: 10 days
- Sam and Tom are the resources working on this project (Fig. 3)
- Sam’s hourly rate is \$12 per hour; Tom’s hourly rate is \$8
- Estimated work: 160 hours (80 hours for User Interface task; 80 hours for Database design task)
- Sam will be working on User Interface task; Tom will be working on Database design task
- Sam and Tom will work max. 8 hours per day
- Both tasks will be start on 01/02/2010 and end on 12/02/2010.

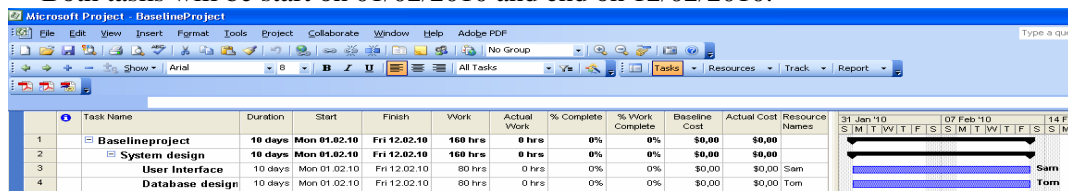


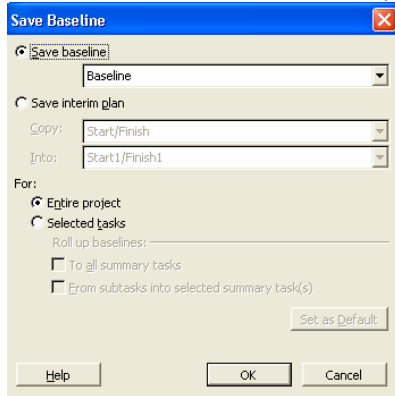
Figure no. 2 Gantt Chart

	Resource Name	Type	Material Label	Initials	Group	Max. Units	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar	Code
1	Sam	Work		S		100%	\$12,00/hr	\$0,00/hr	\$0,00	Prorated	Standard	
2	Tom	Work		T		100%	\$8,00/hr	\$0,00/hr	\$0,00	Prorated	Standard	

Figure no. 3 Resource Sheet

Step 2 : Save Baseline

Steps are: On Tools menu -> Tracking -> Save Baseline; Click Save Baseline and then click the baseline; Press OK to save your baseline; Save Project Plan (Fig. 4); Verify the baseline information on Project Statistics window (on Project menu -> choose Project Information -> click on Statistics) (Fig. 5).



	Start	Finish
Current	Mon 01.02.10	Fri 12.02.10
Baseline	Mon 01.02.10	Fri 12.02.10
Actual	NA	NA
Variance	0d	0d

	Duration	Work	Cost
Current	10d	160h	\$1.600,00
Baseline	10d	160h	\$1.600,00
Actual	0d	0h	\$0,00
Remaining	10d	160h	\$1.600,00

Percent complete:
Duration: 0% Work: 0%

Figure no. 4 Save Baseline

Figure no. 5 Project Statistics

Step 3 : Update project plan

Once we saved the baseline, project has been started and entered into execution phase. Now this project is ready to track the progress. Sam and Tom started working on their tasks and worked for 5 days and he submitted the actual work as follows:

Actual work done by Sam:

- 01/02/2010 (Monday): 8 hours
- 02/02/2010 (Tuesday): 8 hours
- 03/02/2010 (Wednesday): 2 hours
- 04/02/2010 (Thursday): 6 hours
- 05/02/2010 (Friday): 8 hours.

Total Actual Work by Sam: 32 hours.

Actual work done by Tom:

- 01/02/2010 (Monday): 8 hours
- 02/02/2010 (Tuesday): 8 hours
- 03/02/2010 (Wednesday): 8 hours
- 04/02/2010 (Thursday): 8 hours
- 05/02/2010 (Friday): 8 hours

Total Actual Work by Tom: 40 hours.

We update the project plan with above actuals depends on the update method we chosen (Fig. 6) and we are choosing the Resource Usage view to update the actual hours in

the project plan. Steps are: View -> Resource Usage view; Make sure that time scale window shows 31 Jan '10; Enter the actual hours against task; Save Project Plan.

Resource Name	Work	Actual work	31 Jan '10							07 Feb '10							14 Feb '10		
			S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	
1 Sam	80 hrs	32 hrs	Work		8h	8h	2h	8h	8h				8h	8h	8h	8h			8h
			Act. W		8h	8h	2h	8h	8h				8h	8h	8h	8h			8h
User Interface	80 hrs	32 hrs	Work		8h	8h	2h	8h	8h				8h	8h	8h	8h			8h
			Act. W		8h	8h	2h	8h	8h				8h	8h	8h	8h			8h
2 Tom	80 hrs	40 hrs	Work		8h	8h	8h	8h	8h				8h	8h	8h	8h			
			Act. W		8h	8h	8h	8h	8h				8h	8h	8h	8h			
Database design	80 hrs	40 hrs	Work		8h	8h	8h	8h	8h				8h	8h	8h	8h			
			Act. W		8h	8h	8h	8h	8h				8h	8h	8h	8h			

Figure no. 6 Resource Usage view

Step 4 : Set status date

Status Date: Status date may be current date, a date in the past, or a date in the future. Setting the status date to the date you last updated project progress is always the best practice. In this example, 05/02/2010 is the status date of the project (Fig. 7). Steps are:

- On Project menu, choose Project Information
- Select Status Date as 05/02/2010 and click OK
- Save Project Plan.

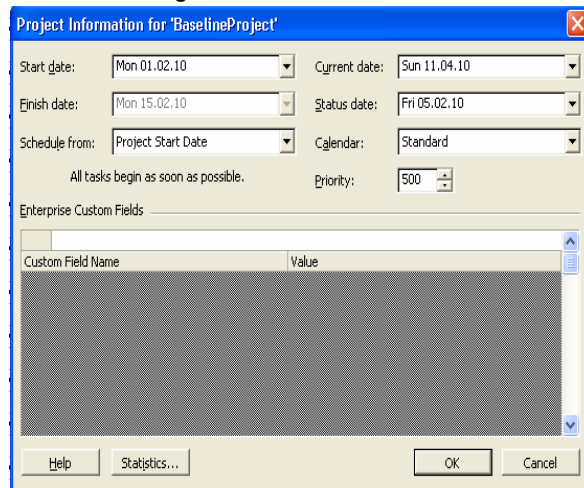


Figure no. 7 Set status date

Earned value calculations also based on following settings on Microsoft Project (Fig. 8).

- Baseline Number
- EV Calculation Method.

To get the accurate EV numbers, we need to specify the EV calculation method MS Project Plan.

Baseline Number: If we have multiple baselines saved for our project, you have a option to specify which baseline that you want to consider for EV Calculations. In this example, we are using Baseline for calculations.

EV Calculation Method: Earned value calculations always based on % Complete or Physical % Complete. Steps are: Under Tools menu, choose Options; Click on Calculation tab and Click on Earned Value; Choose Default task Earned Value method and Baseline for Earned Value calculations from dropdown and click OK; Save Project Plan.

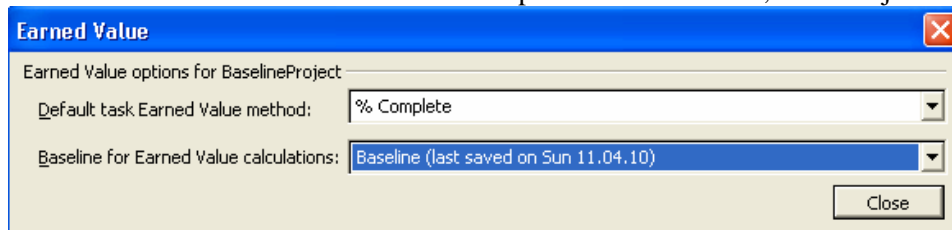


Figure no. 8 Settings for EV calculation method

Step 5: Analyze EV Values

Gantt chart, we will see the following values (Fig. 9).

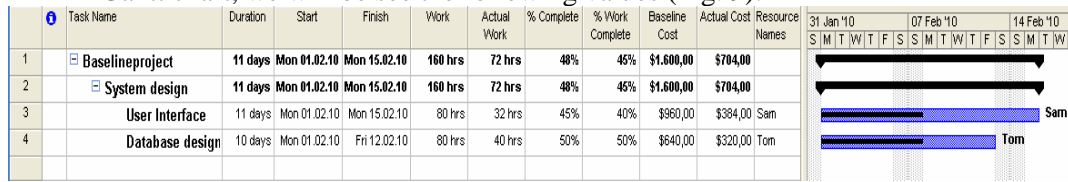


Figure no. 9 Gantt chart for analyze EV values

Analysis of Values in Gantt Chart:

% Complete:

- a) % complete of User Interface task: 45 %

% complete is always related to duration. User Interface task was originally scheduled to complete in 10 days. Due to less actual hours done for this task by Sam, now this task is required 11 days to complete. Out of 11 days, task had been completed 5 days duration. It means, 45% of task had been completed till now. i.e. $5 * 100/11 = 45.4545 = 45\%$

- b) % complete of Database Design task: 50 %

Database design was originally scheduled to complete in 10 days. Out of 10 days of duration, task had been completed 5 days duration. It means, 50% of task had been completed till now.

% Work Complete:

- a) % Work complete of User Interface task: 40 %

Original estimation is 80 hours of work. Out of 80 hours of planned work; 32 hours of task actually completed. i.e. 40% . i.e. $100 * 32/80 = 40\%$

- b) % Work complete of Database Design task: 50 %

Original estimation is 80 hours of work. Out of 80 hours of planned work; 40 hours of task actually completed. i.e. 50%

To view Earned value, we have to apply the Earned value table to tracking gantt. Steps are: On View menu -> Choose Tracking Gantt; View -> Tables -> More Tables -> Earned Value -> Apply. We must insert additional columns as below. Tracking Gantt Chart will look like in Fig. 10:

Task Name	Baseline Cost	% Complete	% Work Complete	Actual Cost	Planned Value-BCWS	Earned Value-BCWP	Actual Cost-ACWP	Schedule Variance-SV	Cost Variance-CV	Estimate At Completion-EAC	Budget At Completion-BAC	Variance At Completion-VAC	CPI-Cost Performance Indicator
Baselineproject	\$1,600,00	48%	45%	\$704,00	\$800,00	\$756,36	\$704,00	-\$43,64	\$52,36	\$1,489,24	\$1,600,00	\$110,76	1,07
System design	\$1,600,00	48%	45%	\$704,00	\$800,00	\$756,36	\$704,00	-\$43,64	\$52,36	\$1,489,24	\$1,600,00	\$110,76	1,07
User Interface	\$960,00	45%	40%	\$384,00	\$480,00	\$436,36	\$384,00	-\$43,64	\$52,36	\$844,81	\$960,00	\$115,19	1,14
Database design	\$640,00	50%	50%	\$320,00	\$320,00	\$320,00	\$320,00	\$0,00	\$0,00	\$640,00	\$640,00	\$0,00	1

Figure no. 10 Earned Value in Tracking Gantt Chart

Baseline Cost or BAC: The Baseline Cost fields show the total planned cost for a task, a resource for all assigned tasks, or for work to be performed by a resource on a task. Baseline cost is also referred to as budget at completion (BAC), an earned value field.

BAC for User Interface is \$ 960 (i.e. total 80 hours of the task was planned at rate of \$12). BAC for Database design task is \$640 (i.e. total 80 hours of the task was planned at rate of \$8).

◆ BAC for project plan is total cost of User Interface task and Database design task: \$1600

BCWS: The BCWS (budgeted cost of work scheduled) fields contain the cumulative time phased baseline costs up to the status date or today's date.

BCWS for User Interface task: Status Date of the project: 05/02/2010; Planned Hours (Budgeted hours) for User Interface task till 05/02/2010: 40 hours; Resource assigned to User Interface task: Sam; Sam Hourly Rate: \$12. Planned Cost (Budgeted Cost) for User Interface task till 05/02/2010: $40 * 12 = \$480$. BCWS for Database Design task: Status Date of the project: 05/02/2010; Planned Hours (Budgeted hours) for Database Design task till 05/02/2010: 40 hours; Resource assigned to User Interface task: Tom; Tom Hourly Rate: \$8; Planned Cost (Budgeted Cost) for Database Design task till 05/02/2010: $40 * 8 = \$320$.

◆ BCWS for System Design task (Summary task) and project plan: \$800 (i.e. \$480 + \$320)

BCWP: The BCWP (budgeted cost of work performed) fields contain the cumulative value of the task's, resource's, or assignments's percent complete multiplied by the timephased baseline costs. BCWP is calculated up to the status date or today's date. BCWP value also known as earned value.

Earned value: A measure of the cost of work performed up to the status date or current date. Earned value uses your original cost estimates saved with a baseline and your actual work to date to show whether the actual costs incurred are on budget.).

i.e. $BCWP = \% \text{ complete} * \text{Baseline Cost till Status Date}$

Explanation of BCWP values in above example:

User Interface task's BCWP: % complete till status date: 45.4545%; Baseline cost for User Interface task: \$960; BCWP value = 45 % of \$960 = \$436.36. Database design task's BCWP: % complete till status date: 50%; Baseline cost for Database design task: \$640; BCWP value = 50 % of \$640 = \$320.

◆ BCWP for project plan: Cumulative cost of BCWP values of User Interface task and Database design task: \$436.36 + \$320 = \$756.36

ACWP: The ACWP (actual cost of work performed) fields show cost already done on a task, up to the status date. i.e. ACWP values actual cost incurred till status date.

Explanation of ACWP values in above example:

ACWP of User Interface task: Actual hours done till status date: 32 hours; Resource (Sam) hourly rate: \$12 Actual cost till status date: $32 * 12 = \$384$. ACWP of Database design task: Actual hours done till status date: 40 hours; Resource (Tom) hourly rate: \$8; Actual cost till status date: $40 * 8 = \$320$.

◆ ACWP for project plan is actual cost incurred: \$384 + \$320 = \$704

Schedule Variance (SV): The SV (earned value schedule variance) field shows the difference in cost terms between the current progress and the baseline plan of a task, all assigned tasks of a resource, or for an assignment up to the status date or today's date. We can use SV to check costs to determine whether tasks or assignments are on schedule. SV is the difference between budgeted cost of work performed (BCWP) and budgeted cost of work scheduled (BCWS). SV is expressed in currency units. Microsoft Office Project calculates the SV as follows: $SV = BCWP - BCWS$. If the SV is positive, the task is currently ahead of schedule in cost terms. If the SV is negative, the task is currently behind schedule in cost terms. If the SV is zero, the task is on schedule in cost terms.

◆ Explanation of SV values in above example: SV of the User Interface task: \$436.36 - \$480 = -\$43.64; SV of the Database design task: \$320 - \$320 = \$0.

Cost Variance (CV): The CV (earned value cost variance) fields show the difference between how much it should have cost and how much it has actually cost to achieve the current level of completion up to the status date or today's date. We can use CV to check whether you're under, over, or exactly within your budget for a task. We

might find this useful when assessing budgetary performance in the project to date. CV is the difference between the task's BCWP (budgeted cost of work performed) and ACWP (actual cost of work performed). Microsoft Office Project calculates the CV for a task as follows: $CV = BCWP - ACWP$. If the cost variance is positive, the cost for the task is currently under the budgeted, or baseline, amount, and your actual costs are less than your baseline costs for the current level of completion on the task. If the cost variance is negative, the cost for the assignment is currently over budget, and your actual costs are more than your baseline costs for the current level of completion on the task.

◆ Explanation of CV values in above example: CV of User Interface task: $\$436.36 - \$384.00 = \$52.36$ (i.e. we spent less cost than planned till status date on this task.). CV of Database design task: $\$320.00 - \$320.00 = \$0$ (i.e no cost variance found between planned and actual).

SPI: The SPI (schedule performance index) field shows the ratio of the budgeted cost of work performed to the budgeted cost of work scheduled (BCWP/BCWS). SPI is often used to estimate the project completion date. $SPI = BCWP/BCWS$. An SPI ratio greater than 1 indicates that you're ahead of schedule. An SPI ratio less than 1 indicates that you're behind schedule.

◆ Explanation of SPI in above example: SPI of User Interface task: $\$436.36/\$480.00 = 0.91$; SPI of Database Design task: $\$320.00/\$320.00 = 1$; SPI of project is $(0.91 + 1.00) / 2 = 0.95$.

CPI: The CPI (cost performance index) fields show the ratio of budgeted (or baseline) costs of work performed to actual costs of work performed, up to the project status date or today's date. CPI is the ratio of BCWP (budgeted cost of work performed) to ACWP (actual cost of work performed). $CPI = BCWP / ACWP$ this value indicates whether you are over or under budget as of the status date. An CPI ratio greater than 1 indicates that you're under budgeted. An CPI ratio less than 1 indicates that you're over budgeted.

◆ Explanation of CPI in above example: CPI of User Interface task: $\$436.36/\$384.00 = 1.14$; CPI of Database design task: $\$320.00/\$320.00 = 1.00$; CPI for Project is average values of User Interface task and Database design task: $(1.14 + 1.00)/2 = 1.07$

EAC: The EAC (estimate at completion) field shows the expected total cost of a task based on performance up to the status date. $EAC = ACWP + (Baseline\ cost - BCWP) / CPI$.

◆ Explanation of EAC values in above example: EAC for User Interface task: $\$384 + (\$960 - \$436.36)/1.14 = \$384 + \$523.64/1.14 = \$384 + \$453.33333 = \844.81

TCPI: The TCPI (to complete performance index) field shows the ratio of the work remaining to be done to funds remaining to be spent, as of the status date. $TCPI = (BAC - BCWP) / (BAC - ACWP)$. A TCPI value greater than 1 indicates a need for increased performance for the remaining work of the project in order to stay within budget (so you may need to give up some quality). A TCPI value less than 1 indicates performance can decrease to stay within budget, thus creating opportunities to increase quality or profit.

◆ Explanation of TCPI values in above example: TCPI for User Interface task: $(\$960.00 - \$436.36)/(\$960.00 - \$384.00) = 523.64/576.00 = 0.90909722$; TCPI for Project is average values of User Interface task and Database design task: $(0.90909722 + 1.00)/2 = 0.94$

5. CONCLUSIONS

Earned value improves on the "normally used" spend plan concept (budget versus actual incurred cost) by requiring the work in process to be quantified. The planned value, earned value, and actual cost data provides an **objective, quantifiable measurement** of performance, enabling trend analysis and evaluation of any cost estimate at completion within multiple levels of the project. EVM is a valuable 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, EVM provides valuable quantifiable performance metrics for forecasting at-completion cost and schedule for their project.

With the above presentation, we have explored the What, Why and How of Earned Value. We have seen that Earned Value is a tool for improving the performance analysis of a project, by: providing a uniform unit of measure for project progress, enforcing a consistent method for analysis and providing a basis for cost performance analysis of the project [4]. The reason for using Earned Value is tied closely to what Earned Value is. While the manipulation of the vast amount of data that is involved may seem daunting, the use of available computer tools designed for the purpose, make the implementation a relatively simple "cookbook" procedure. If the reader takes one thing away from this paper, it should be that Earned Value simply represents the budgeted value of the completed work and is directly related to the per cent complete of the activity or WBS element under consideration.

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