Crosswind Learning

Version 6.1 Updated for the 2021
Project Management Professional (PMP)® Exam

Crosswind Success Series: PMP® Exam Bootcamp Manual

www.crosswindpm.com
Tony Johnson, MBA, CAPM, PMP, PgMP, PfMP

Version 6.1 aligned with the Project Management Institute, *A Guide to the Project Management Body of Knowledge, (PMBOK® Guide)* - Sixth Edition, Project Management Institute Inc., 2017

12.14.1. Earned Value Management (EVM)

Know the characteristics and formulas related to earned value management (EVM), cost variance (CV), cost performance index (CPI), to-complete performance index (TCPI), schedule variance (SV), and schedule performance index (SPI).

Earned value management (EVM) is a technique for measuring the progress of a project by looking at its scope, schedule, and cost in an integrated manner. If the initial focus is on the relationships between the components, rather than on the formulas, determining earned value is not complicated.

To understand EVM and Cost Analysis, the components and formulas should be considered within the context of a home building project.

To determine earned value and perform cost and schedule analysis, the total project value and, at a distinct point in time, the completion percentage, the amount of work that should have been completed, and the amount that has been spent must be known.

The value of the project is $100,000 (BAC) as of the end of today (a specific point in time):

- The house is 40% completed, thus $40,000 of work has been done
- The amount of work that should have been completed is $60,000
- The amount that has been spent is $80,000

Determining Earned Value

Component	Definition	Calculation/Amount
Budget at Completion (BAC) *aka Performance Baseline*	The amount the project is expected to cost	Total the costs of each project activity without regard to completion status: $100,000
Planned Value (PV) *aka Budgeted Cost of Work Scheduled (BCWS)*	The value of the work that should have been completed at a specific point in time, **excluding any work started ahead of schedule**	Total the value of each project activity scheduled for completion at a specific point in time: $60,000
Actual Cost (AC) *aka Actual Cost of Work Performed (ACWP)*	The cost of the work that has been completed at a specific point in time, **including any work started ahead of schedule**	Total all the project costs at a specific point in time: $80,000
Earned Value (EV) *aka Budgeted Cost of Work Performed (BCWP)*	A measurement of the project's progress and the basis for cost analysis, **including any work started ahead of schedule**	BAC or PV multiplied by percentage complete (**40%**): $40,000

Schedule analysis is comparing the amount of work completed versus the amount of work that should have been done. Using planned value (PV) and earned value (EV), the SPI and SV can be determined.

Performing Schedule Analysis		
Index/Variance	Formula/Result	Result Interpretation
Schedule Performance Index (SPI)	EV / PV $40,000 / $60,000 **= .67** Be able to calculate EV or PV if given SPI and EV or PV. For example: PV x SPI = EV or EV / SPI = PV	An efficiency indicator that denotes the amount of work done at a single point in time. If the result is **1.0**, the amount of work done on the project at a single point in time is **on track**. If the result is **greater than 1.0**, the amount of work done on the project at a single point in time is **better than expected**. If the result is **less than 1.0**, the amount of work done on the project at a single point in time is **less than expected**. In this case, the result is .67; therefore only ***67% of the work scheduled to be done has been done.***
Schedule Variance (SV)	EV - PV $40,000 - $60,000 = -**$20,000** Be able to calculate EV or PV if given SV and EV or PV. For example: PV + SV = EV or EV – SV = PV	A variance indicator that denotes the difference between the value of the work completed and the value of the work that should have been completed. If the result is **0**, the project is **on track**. If the result is **greater than 0**, the project is **ahead of schedule**. If the result is **less than 0**, the project is **behind schedule**. In this case, the result is less than 0; therefore **the project is behind schedule by $20,000**.

Cost analysis, at its most basic, is determining progress in terms of the amount of work completed (EV) versus what was paid to complete the work (AC). Using budget at completion, planned value, actual cost, and earned value, the CPI, CV, and TCPI can be determined.

Performing Cost Analysis

Index/Variance	Formula/Result	Result Interpretation
Cost Performance Index (CPI)	EV / AC $40,000 / $80,000 = **.5** Be able to calculate EV or AC if given CPI and EV or AC. For example: AC x CPI = EV or EV / CPI = AC	An efficiency indicator that denotes the return on each dollar spent at a single point in time. If the result is **1.0**, the return on the project at a single point in time is **on track**. If the result is **greater than 1.0**, the return on the project at a single point in time is **under budget**. If the result is **less than 1.0**, the return on the project at a single point in time is **over budget**. A CPI of .5 means that **50 cents of project work is completed for every dollar spent**.
Cost Variance (CV)	EV-AC $40,000 - $80,000 = **-$40,000** Be able to calculate EV or AC if given CV and EV or AC. For example: AC + CV = EV or EV – CV = AC	A variance indicator that denotes the difference between the value of the work completed and the cost of the work completed. If the result is **0**, the project is **on track.** If the result is **greater than 0**, the project is **under budget**. If the result is **less than 0**, the project is **over budget**. In this case, the result is less than 0; therefore **the project is over budget by $40,000**.

12.14.2. Calculating the Basics of Earned Value Management (EVM)

Memorize the earned value management triangle.

Figure 12-7: Earned Value Management Triangle shows the relationship of earned value concepts.

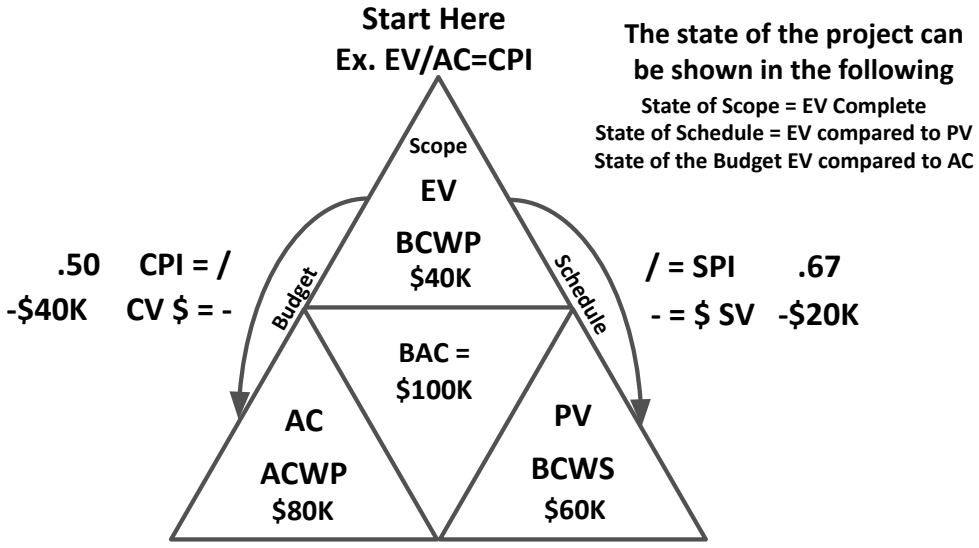


Figure 12-7: Earned Value Management Triangle

The earned value management triangle is ideal to memorize because it depicts the calculation of (cost or schedule) variances or performance indices. To interpret the graphic, start with EV and follow the arrows. For example EV divided (÷) by PV equals SPI or EV minus AC equals CV.

The following table contains keys to memorizing the earned value management triangle.

Performance Indices (CPI, SPI)	Variances (CV, SV)
Listed first (vertically)	Listed last (vertically)
Calculated by division	Calculated by subtraction
If less than one (<1), project is behind schedule or over budget	If negative, project is behind schedule or over budget
If greater than one (>1), project is ahead of schedule or under budget	If positive, project is ahead of schedule or under budget

NOTE: The AC (ACWP), EV (BCWP), and PV (BCWS) are listed alphabetically (horizontally). Although the values for actual cost (AC), earned value (EV), and planned value (PV) are generally provided, you may have to calculate them. The details that follow describe how to calculate planned value (PV), actual cost (AC) and earned value (EV) at the activity level.

Planned Value (PV or BCWS)	Determine the date or "complete through" level. **Add the planned values of activities that should have occurred as of the date or "complete through" level.** Do not add the planned value of activities that have started ahead of schedule. For example, today is June 6th, and there are two activities that should not start until June 8th but have already started. If an activity should be partially complete at the point you are measuring, the percent (%) complete will have to be provided or assumed. For example, a four-day activity is generally considered to be 50% done two days into the work.
Actual Cost (AC or ACWP)	Add all "actual costs" related to the project. In the case of an activity, add the cost regardless of its completion status (1% to 100%), even if the activity was started ahead of schedule.
Earned Value (EV or BCWP)	1. List the planned value (PV) of all the following types of activities: • The activities that should have started and haven't started yet • The activities that should have started and have actually started • The activities that shouldn't have started, but have (ahead of schedule) 2. Determine the % complete of each activity listed in step 1. 3. Multiply planned value (PV) by the % complete for each activity, giving the earned value of an individual activity. 4. **Add all the earned value measurements** (calculated in step 3) from each activity to get the total earned value for the project or situation.

Activity Name	Planned Day	Actual Cost ($)	Earned Value ($)†	% Complete	Planned Value ($)
		(AC)	(EV)		(PV)
Activity A	Day 1	$300	$300	100%	$300
Activity B	Day 2	$200	$150	100%	$150
Activity C	Day 2	$150	$100	100%	$100
Activity D	Day 3	$225	$200	100%	$200
Activity E	Day 3	$100	$100	100%	$100
Activity F	Day 3	$300	$150	60%	$250
Activity G	Day 4	$140*	$130*	65%	$200
Activity H	Day 4	$100*	$80*	20%	$400
Activity I	Day 5	$0	$0	0%	$300
Activity J	Day 5	$0	$0	0%	$200

(The bolded line between Activities F and G represents the measuring point for the analysis.)

† PV x % complete

*These activities started ahead of schedule and their progress must be included.

Using the previous table, perform earned value analysis as of the end of day three (the horizontal line in the previous table indicates that the information above the line represents days one, two, and three).

Budget at Completion (BAC)	BAC is calculated by totaling the planned values for all the project activities. The total budget at completion is **$2,200**.
Planned Value (PV)	Planned value is calculated by **adding up the planned value for each activity through day three. The total is $1,100**. This value represents the planned value or the value of the work that should be completed through day three. Note that, even though some work is ahead of schedule, only the work that should have been done through day three is considered.
Actual Cost (AC)	Actual cost is calculated by totaling the amounts spent through day three. A**ll costs**, even for work that was started ahead of schedule, must be considered. The actual cost is $1,515.
Earned Value (EV)	The earned value (EV) for an activity is calculated by multiplying its planned value (**regardless if it should have started yet or not**) by the percentage complete (%). The earned value for the project is calculated by totaling the earned values for each activity (**regardless if it should have started yet or not**). The earned value (EV) for the project, which is equal to the budgeted cost of work performed (BCWP), is $1,210.
Interpretation	**Through day three**, $1,100 worth of work should have been done and Activities A through F should have been completed. In actuality, $1,515 has been spent, but the earned value for the project (the value of the work completed) is only $1,210.

Based on the above table, the project metrics are:

CPI:	0.8	=	$1,210 / $1,515	CV:	-$305	=	$1,210 - $1,515
SPI:	1.1	=	$1,210 / $1,100	SV:	$110	=	$1,210 - $1,100

The CPI indicates that the project realizes $.80 in value for every dollar spent. The CV indicates the project is presently $305 over budget. The SPI indicates that the project is progressing at 110% of the rate planned and the SV indicates that the project has accomplished $110 more in work than was scheduled. The project is ahead of schedule, but over budget.

Based on the forecasting table in section 7.14.3, the project metrics are:

EAC:	$2,750	=	$2,200 / .8	VAC:	-$550	=	$2,200 - $2,750
ETC:	$1,235	=	$2,750 - $1,515				

The EAC indicates that the project is expected to cost $2,750 at the current rate of spending and progress. The ETC indicates that the remaining amount to complete the project is expected to cost $1,235. The VAC indicates that, based on current spending, the project is expected to be $550 over budget when complete.

12.14.3. Forecasts

Forecasts are estimates or predictions of the future state of the project based on past performance and expected future performance. The forecasts in the following table are based on the EVM table in section 12.14.2.

Cost Forecast	Description	Formula*
Estimate at Completion (EAC)	The estimate at completion (EAC) represents the current, projected final cost based on the current spending efficiency (CPI). If the CPI is greater than one (>1), the number will be less than the BAC; therefore, the project will likely finish under budget. If the CPI is less than one (<1), the number will be greater than the BAC; therefore, the project will likely finish over budget. If the CPI equals 1, the number will be equal to the BAC; therefore, the project will likely finish on budget. **EAC:** $200,000; therefore, the project is on pace to come in over the BAC of $100,000.	EAC = BAC / CPI Or $100,000 / .5 = $200,000
Estimate to Complete (ETC)	The estimate to complete (ETC) represents the amount needed to finish the project based on the current spending efficiency of the project. This figure is the EAC without the actual cost to date. **ETC:** $120,000; therefore, the project is on pace to exceed the BAC amount after factoring in what has already been spent.	ETC = EAC - AC Or $200,000 - $80,000 = $120,000
Variance at Completion (VAC)	The variance at completion (VAC) is the difference between the budget at completion (BAC) and the estimate at completion (EAC). This difference indicates the amount the completed project is expected to be over or under budget. **VAC:** -$100,000; therefore, the project is on pace to be completed over budget based on its current spending efficiency.	VAC = BAC - EAC Or $100,000 - $200,000 = -$100,000

Cost Forecast	Description	Formula*
To-complete Performance Index (TCPI)	The to-complete performance index (TCPI) is an efficiency indicator that denotes the efficiency needed from the remaining resources to meet the cost goals of the project and finish the project on budget.	TCPI = (BAC -EV) / (BAC - AC) Or ($100k - $40k) / ($100k - $80k) = 3.0

* Variations of these formulas are listed in the Cost Formulas and Variables section. It is important to be become familiar with all the Estimate At Completion (EAC) formulas and related situations.

Figure 12-8: Earned Value Forecast Table, is formatted as a tic-tac-toe grid and contains the formulas for EAC, ETC, and VAC. Note that connecting the instances of EAC results in a diagonal line.

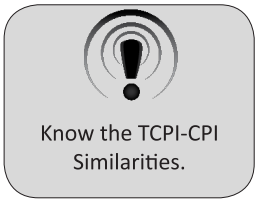
This table can be used as a quick reference for the exam.

Earned Value Forecast Table

EAC $200K	BAC $100K	/ CPI .5
ETC $120K	EAC $200K	AC $80K
VAC -$100K	BAC $100K	EAC $200K

Figure 12-8: Earned Value Forecast Table

Figure 12-9: TCPI - CPI Similarities , illustrates the similarities of the to-complete performance index and the cost performance index.



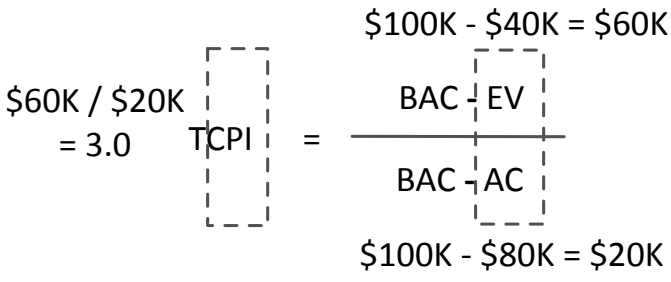


Figure 12-9: TCPI - CPI Similarities

12.14.4. Calculating the Basics of Earned Value Management (EVM) at the Project Level

The sunroom project detailed in the table below illustrates Earned Value Management at the project level. The sunroom is projected to be complete in five days at a cost of $2,000 per day. At the end of day three, the project is 40% complete and $5,000 has been spent.

Variable	Formula/Description	Value
Actual Cost (AC)	Sum of Actual Costs	$5,000
Earned Value (EV)	% Complete of Project	$4,000
Planned Value (PV)	Value of Scheduled Work	$6,000
Budget at Completion (BAC)	Total Budget	$10,000
Cost Performance Index (CPI)	EV/AC	0.8
Cost Variance (CV)	EV-AC	-$1,000
Schedule Performance Index (SPI)	EV/PV	0.667
Schedule Variance (SV)	EV-PV	-$2,000
Estimate at Completion (EAC)	BAC/CPI	$12,500
Estimate to Complete (ETC)	EAC-AC	$7,500
Variance at Completion (VAC)	BAC-EAC	-$2,500
To-Complete Performance Index (TCPI)	Rem. Wk./Rem. $	1.2

12.14.5. S Curve

An S Curve is a graphical representation of earned value management. The classic S Curve shows the interaction between scope, cost, and time over the life of the project.

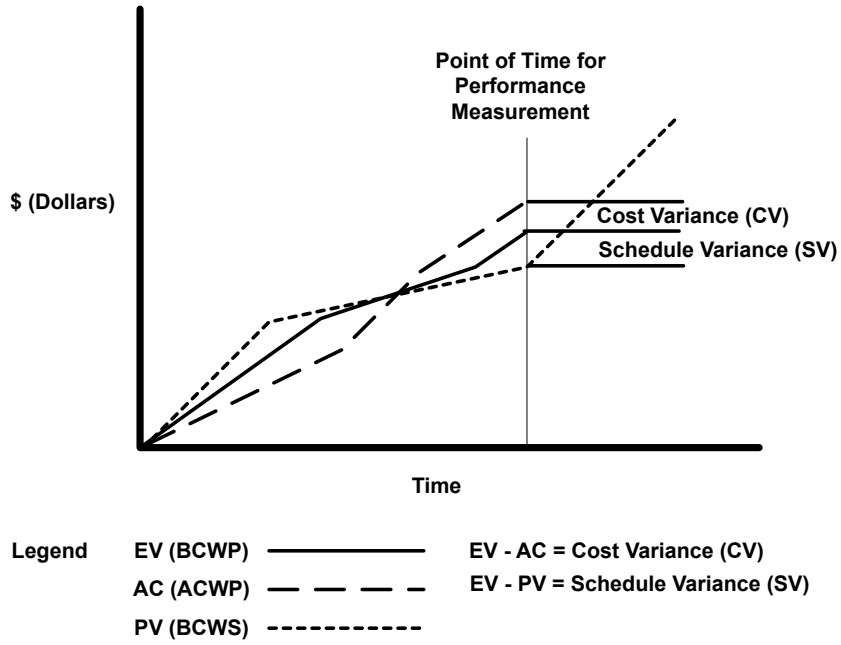


Figure 12-10: S Curve

The source for the above figure is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Figure 7-9, Page 255

Figure 12-10: S Curve illustrates that the project, at a specific point in time, is over budget (the cost variance indicates more was spent on the work than budgeted) and ahead of schedule (the schedule variance indicates more work was completed than scheduled). The closely dotted line represents planned value (PV). The uninterrupted line represents earned value (EV). The widely dotted line represents actual costs (AC).

One of the most common misunderstandings in performance reporting is that schedule, cost, and progress are directly related: for example, people commonly assume that a twelve month project that started on January 1st should be 50% complete on July 1st (halfway through the duration). The direct relationship only occurs if time is utilized and costs are paid at a consistent rate calculated to reach 100% of cost or schedule at the completion of the project.

It's important to remember that each project will have its own unique S Curve based on the amount of work expected to be accomplished over time. In a perfect world, an S-Curve would have three lines (AC, EV and PV) and they would all be on top of each other. This would mean everything went as planned on the project. Since this rarely occurs, three separate lines are typical.

The source for the above text is the Project Management Institute, *A Guide to the Project Management Body of Knowledge*, (*PMBOK® Guide*) – Sixth Edition, Project Management Institute Inc., 2017, Pages 257-270