

LECTURE 09

USING EARNED VALUE MANAGEMENT

What is Earned Value Management?

- **Earned value management (EVM)** is a way of measuring your performance (and the performance of your project team) at any given date or point in the schedule. As your project progresses, you should take the opportunity to analyze costs/budget, the schedule/time.
- You use the EVM measurements to compare your projected progress with your actual progress on a certain date.

Budget

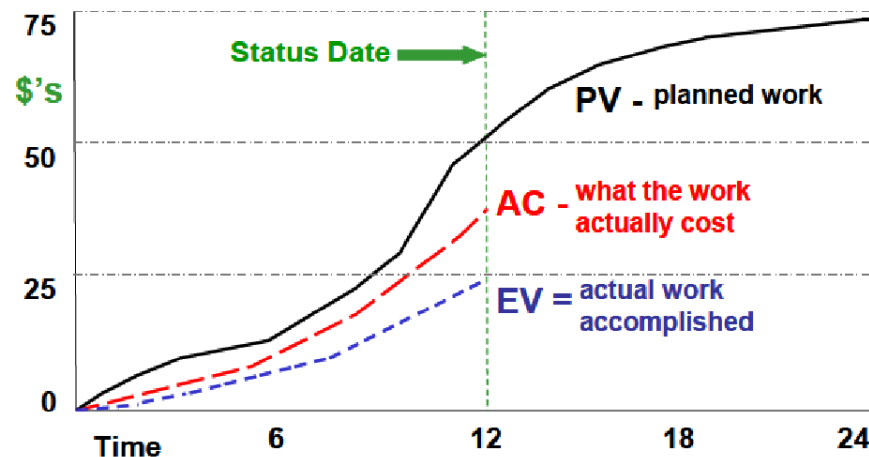
- Under Budget
- Over Budget
- On Budget

Schedule:

- Behind schedule
- Ahead of schedule
- On schedule

Project Total Cost = 6 Lac, Duration = 6 Month

Element of Earned Value Management



Planned Value	The budgeted cost for the work scheduled to be done. This is the portion of the project budget planned to be spent at any given point in time. This is also known as the budgeted cost of Work scheduled.
Actual Costs	The money spent for the work accomplished. This is also known as the actual cost of work performed.
Earned Value	The percent of the total budget actually completed at a point in time. This is also known as the budgeted cost of work performed. EV is calculated by multiplying the budget for an activity by the percent progress for that activity: $EV = \% \text{ complete} \times \text{budget}$

Planned Value (PV)

This is the first element of earned value management. Planned Value is the approved value of the work to be completed in a given time. It is the value that you should have earned as per the schedule.

According to the PMBOK Guide, “Planned Value (PV) is the authorized budget assigned to work to be accomplished for an activity or WBS component.”

You calculate Planned Value before actually doing the work, which also serves as a baseline. Total Planned Value for the project is known as Budget at Completion (BAC).

Planned Value is also called Budgeted Cost of Work Scheduled (BCWS).

Formula for Planned Value (PV)

The formula to calculate Planned Value is simple. Multiply the planned percentage of the completed work by the project budget; it will give you the Planned Value.

Planned Value = (Planned % Complete) X (BAC)

Example of Planned Value (PV)

You have a project to be completed in 12 months. The budget of the project is 100,000 USD. Six months have passed, and the schedule says that 50% of the work should be completed. What is the project's Planned Value (PV)?

Given in the question.

Project duration: 12 months

Project cost (BAC): 100,000 USD

Time elapsed: 6 months Percent complete: 50% (as per the schedule)

Planned Value is the value of the work that should have been completed so far (as per the schedule).

We should have completed 50% of the total work in this scenario.

Planned Value = 50% of the value of the total work

= 50% of BAC

= 50% of 100,000

= (50/100) X 100,000

= (0.5) X 100,000

= 50,000 USD

Therefore, the project's Planned Value (PV) is 50,000 USD.

Application of Planned Value (PV)

Planned Value is used to calculate Schedule Variance and Schedule Performance Index.

Actual Cost (AC)

This is the second element of earned value management. Actual Cost is the total cost incurred for the actual work completed to date. In other words, it is the amount of money you have spent to date.

According to the PMBOK Guide, "Actual Cost (AC) is the total cost actually incurred in accomplishing work performed for an activity or WBS component."

Actual Cost is also known as the Actual Cost of Work Performed (ACWP).

The formula for Actual Cost (AC)

Finding Actual Cost is the simplest of all.

There is no unique formula to calculate Actual Cost. It is an amount that has been spent, and you can find it easily in the question.

Example of Actual Cost (AC)

You have a project to be completed in 12 months. The budget of the project is 100,000 USD. Six months have passed, and 60,000 USD has spent already, but on closer review, you find that only 40% of the work has been completed so far. What is the project's Actual Cost (AC)?

Actual Cost is the amount of money that you have spent so far. In the question, you have spent 60,000 USD on the project so far. Hence, the project's Actual Cost is 60,000 USD.

Application of Actual Cost (AC)

Actual Cost is used to calculate Cost Variance and Cost Performance Index.

Earned Value (EV)

This is the third and last element of earned value management. Earned Value is the value of the work actually completed to date. Earned Value will show you the value that the project has produced if the project is terminated today.

According to the PMBOK Guide, “Earned Value (EV) is the value of work performed expressed in terms of the approved budget assigned to that work for an activity or WBS component.”

Although all three elements have their significance, Earned Value is more useful because it shows you how much value you have earned from the money you have spent to date.

Earned Value is also known as Budgeted Cost of Work Performed (BCWP).

There is a difference between Planned Value and Earned Value. Planned Value shows you how much value you expected to earn in a given time, while Earned Value shows how much value you have actually earned on the project.

Formula for Earned Value (EV)

The formula to calculate the Earned Value is simple. Multiply the actual percentage of the completed work by the project budget; you will get the Earned Value.

Earned Value = % of completed work X BAC (Budget at Completion).

Example of Earned Value (EV)

You have a project to be completed in 12 months. The budget for the project is 100,000 USD. Six months have passed, and 60,000 USD has been spent. On closer review, you find that only 40% of the work has been completed to date. What is the project's Earned Value (EV)?

In the above question, you can see that only 40% of the work is completed, and the definition of Earned Value states that it is the value of the project that has been earned.

Earned Value = 40% of the value of total work

= 40% of BAC

= 40% of 100,000

= 0.4 X 100,000

= 40,000 USD

Therefore, the project's Earned Value (EV) is 40,000 USD.

Application of Earned Value (EV)

Earned Value is used for calculating Schedule Variance, Cost Variance, Schedule Performance Index, Cost Performance Index, Estimate at Completion, and To Complete Performance Index.

Please note that these elements are also called by different names; Planned Value referred to as Budgeted Cost of Work Scheduled (BCWS), Actual Cost as Actual Cost of Work Performed (ACWP), and Earned Value as Budgeted Cost of Work Performed (BCWP).

Schedule Variance (SV)

It is imperative for you to keep your project on schedule. Schedule Variance is a vital analytical tool for you. This tool gives you the information needed to determine if you are ahead of schedule or behind schedule concerning dollars.

The formula for Schedule Variance (SV)

Schedule Variance can be calculated by subtracting planned value from earned value.

Schedule Variance = Earned Value – Planned Value

SV = EV – PV

From the above formula, we can conclude that:

- You are ahead of schedule if Schedule Variance is **positive**.
- You are behind schedule if Schedule Variance is **negative**.
- Schedule you are on schedule if Schedule Variance is **zero**.

Example of Schedule Variance (SV)

You have a project to be completed in 12 months and the budget of the project is 100,000 USD. Six months have passed and 60,000 USD has been spent, but on closer review you find that only 40% of the work has been completed so far. Find the project's Schedule Variance (SV), and determine if you are ahead of schedule or behind schedule.

Given in the question:

Actual Cost (AC) = 60,000USD

Planned Value (PV) = 50% of 100,000

= 50,000 USD

Earned Value (EV) = 40% of 100,000

= 40,000 USD

Now,

Schedule Variance = Earned Value – Planned Value

= 40,000 – 50,000

= – 10,000 USD

The project's Schedule Variance is -10,000 USD. You are behind schedule since it is negative.

Cost Variance (CV)

Cost Variance is as important as Schedule Variance. You must complete your project within the approved budget. Exceeding the planned budget is bad for you and your stakeholders.

It is all about the money, and clients are very cautious about what they are spending. Organizations are sensitive towards it because any deviation from the cost baseline can affect their profit, and, worst case, they may have to put more money into the project to complete it. This is especially detrimental if the contract is a fixed price.

Cost Variance deals with the cost baseline of the project. It provides you with information about whether you are over budget or under budget, concerning dollars. Cost Variance is a measure of cost performance of a project.

The formula for Cost Variance (CV)

Cost Variance can be calculated by subtracting the actual cost from earned value.

Cost Variance = Earned Value – Actual Cost

$$CV = EV - AC$$

We can conclude the following from the above formula:

- You are under budget if Cost Variance is **positive**.
- You are over budget if Cost Variance is **negative**.
- You are on budget if Cost Variance is **zero**.

Example of Cost Variance (CV)

You have a project to be completed in 12 months, and the budget of the project is 100,000 USD. Six months have passed, and 60,000 USD has been spent, but on closer review you find that only 40% of the work has been completed so far. Find the project's Cost Variance (CV), and determine if you are under budget or over budget.

Given in the question:

Actual Cost (AC) = 60,000USD

Earned Value (EV) = 40% of 100,000 USD

= 40,000 USD

Now,

Cost Variance = Earned Value – Actual Cost

$CV = EV - AC$

= 40,000 – 60,000

= -20,000 USD

Hence, the project's Cost Variance is -20,000 USD, and you are over budget since it is negative.

Schedule Performance Index (SPI)

The Schedule Performance Index indicates how efficiently you are actually progressing compared to the planned project schedule.

According to the PMBOK Guide, “The Schedule Performance Index (SPI) is a measure of schedule efficiency, expressed as the ratio of earned value to planned value.”

The Schedule Performance Index gives you information about the schedule performance of the project. It is the efficiency of the time utilized on the project.

The formula for the Schedule Performance Index (SPI)

The Schedule Performance Index can be determined by dividing earned value by planned value.

Schedule Performance Index = (Earned Value) / (Planned Value)

SPI= EV / PV

You can conclude the following with the above formula:

- More work has been completed than the planned work if the SPI is greater than one. In other words, you are ahead of schedule.
- Less work has been completed than the planned work if the SPI is less than one. In other words, you are behind schedule.
- Work is being completed at about the same rate as planned if the SPI is equal to one; you are on time.

Make sure that you consider all tasks while calculating the Schedule Performance Index. Sometimes, you may only consider the tasks on the critical path while ignoring the rest; this will cause an erroneous result.

Therefore, ensure that non-critical activities are included.

Example of Schedule Performance Index (SPI)

You have a project to be completed in 12 months, and the budget of the project is 100,000 USD. Six months have passed, and 60,000 USD has been spent, but on closer review, you find that only 40% of the work has been completed so far. Find the Schedule Performance Index and deduce whether the project is behind or ahead of schedule.

Given in the question:

Actual Cost (AC) = 60,000USD

Planned Value (PV) = 50% of 100,000 USD

=50,000 USD

Earned Value (EV) = 40% of 100,000 USD

= 40,000 USD

Now,

Schedule Performance Index (SPI) = EV / PV

= 40,000 / 50,000

= 0.8

Hence, the Schedule Performance Index is 0.8

You are behind schedule since the Schedule Performance Index is less than one.

Cost Performance Index (CPI)

The Cost Performance Index helps you to analyze the efficiency of the cost utilized by the project. It measures the value of the work completed compared to the actual cost spent on the project.

According to the PMBOK Guide, “The Cost Performance Index (CPI) is a measure of the cost efficiency of budgeted resources, expressed as a ratio of earned value to actual cost.”

The Cost Performance Index specifies how much you are earning for each dollar spent on the project. The Cost Performance Index is an indication of how well the project is remaining on budget.

The formula for the Cost Performance Index (CPI)

The Cost Performance Index can be determined by dividing the earned value by actual cost.

Cost Performance Index = (Earned Value) / (Actual Cost)

CPI = EV / AC

You can conclude the following with the above formula:

- You are earning less than the amount spent if the CPI is less than one. In other words, you're over budget.
- You are earning more than the amount spent if the CPI is greater than one. In other words, you are under budget.
- Earning and spending is equal if the CPI is equal to one. You can say that you are proceeding exactly as per the planned budget spending, although this rarely happens.

Example of Cost Performance Index (CPI)

You have a project to be completed in 12 months, and the budget of the project is 100,000 USD. Six months have passed, and 60,000 USD has been spent, but on closer review, you find that

only 40% of the work has been completed to date. Find the Cost Performance Index for this project and deduce whether you are under budget or over budget.

Given in the question:

Actual Cost (AC) = 60,000USD

Planned Value (PV) = 50% of 100,000 USD

= 50,000 USD

Earned Value (EV) = 40% of 100,000 USD

= 40,000 USD

Now,

Cost Performance Index (CPI) = EV / AC

= 40,000 / 60,000

= 0.67

Hence, the Cost Performance Index is 0.67

This means you are earning 0.67 USD for every 1 USD spent since the Cost Performance Index is less than one. In other words, you are over budget.

If you subtract the CPI from 1, you can see by what percentage you are over or under budget.

Example

You are managing the bathroom renovation project. The project has a budget of \$1500 and is 40% complete. Actual costs to date have been \$900. Find the cost variance and cost performance index?

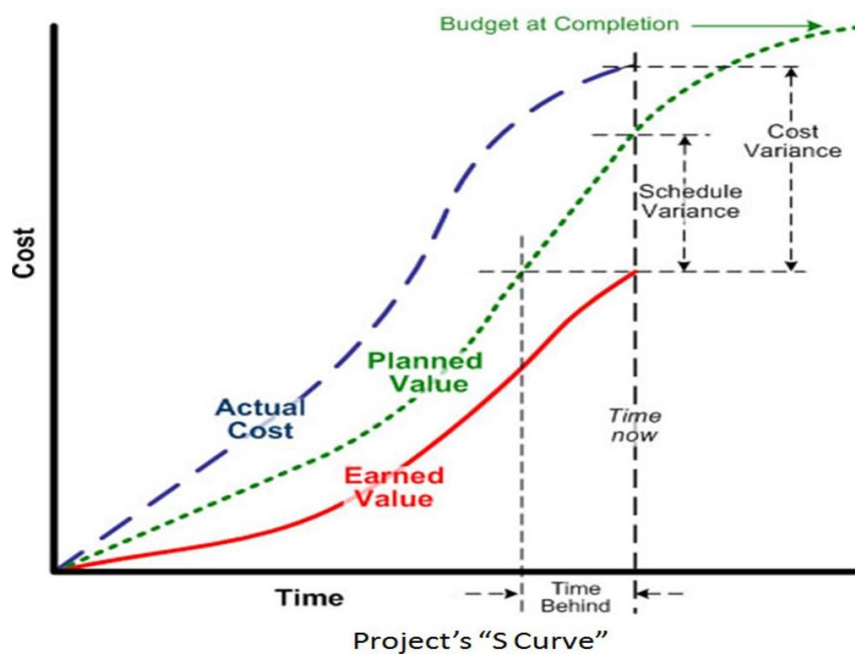
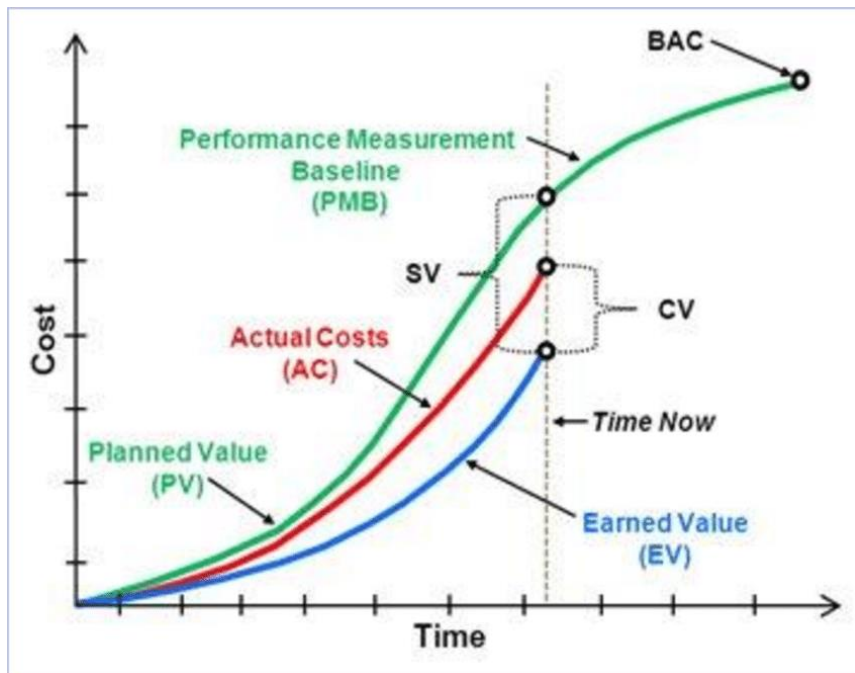
BAC = \$1,500

EV = \$600

AC = \$900

CV = EV – AC = \$600 – \$900 = (\$300) <– That's bad: we are over budget

CPI = EV ÷ AC = 0.67 <– Indicates we are 33% over budget



EVM Performance Measure Interpretation

EVM Performance Measure	Variances			Performance Indices		
	Greater Than Zero (> 0)	Less Than Zero (< 0)	Equal To Zero ($= 0$)	Equal To One ($= 1$)	Less Than One (< 1)	Greater Than One (> 1)
Schedule	Ahead of Schedule	Behind Schedule	On Schedule	On Schedule	Behind Schedule	Ahead of Schedule
Cost	Under Budget	Over Budget	On Budget	On Budget	Over Budget	Under Budget

Question:

Let consider the following table, which show the Plan Value (PV) of each month from January 2021 to December 2021. Actual cost (AC) and Earn Value (EV) of each month from January 2021 to June 2021. Find the Cost variance and Schedule variance on 30th June with interpretation. Amount in term of \$.

	Jan	Feb	March	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
PV	10	15	25	20	25	30	35	40	45	50	55	60
AC	10	20	30	40	50	60						
EV	5	15	25	35	45	55						

Solution:

BAC = Project Cost = Sum of PV from Jan to December = **410**

PV = Sum of PV from Jan to June = 125

AC = Sum of AC from Jan to June = 210

EV = Sum of EV from Jan to June = 170

CV = EV – AC = 170 -210 = - 40 **Over Budget**

SV = EV – PV = 170 -125 = 45 **Ahead of Schedule**

Example:

There are two tasks with IDs 100 and 200 Duration and Budget as follows.
Find the PV of task ID 100 on March 3

ID	Name	Start	End	Budget
100	Set up Database	Mar. 1	Mar. 10	\$10,000
200	Build Application	Mar. 7	Mar. 20	\$15,000
TOTAL				\$25,000

Task ID 100: $PV = 30\% \times 10000 = 0.3 (10000) = 3000$

Example:

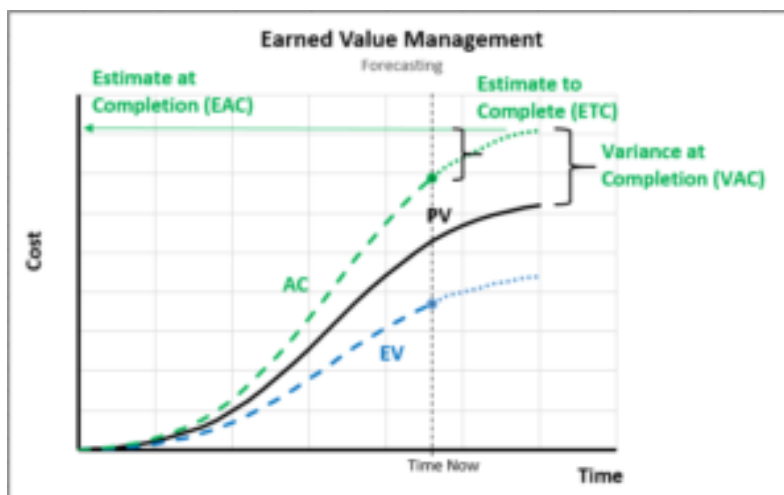
There are two tasks with IDs 100 and 200 Duration and Budget as follows.
Find the PV of project on March 3

ID	Name	Start	End	Budget
100	Set up Database	Mar. 1	Mar. 10	\$10,000
200	Build Application	Mar. 7	Mar. 20	\$15,000
TOTAL				\$25,000

Task_ID 100: $PV = 30\% \times 10000 = 0.3 (10000) = 3000$

Task_ID 200: $PV = 0\% \times 15000 = 0 (15000) = 0$

PV of project = 3000

FORECASTING

There are **four variables**, which **allow** the project manager to **forecast** the **future performance of the project**:

1. Estimate to Complete (ETC)
2. Estimate at Completion (EAC)
3. Variance at Completion (VAC)
4. To Complete Performance Index (TCPI)

Estimate to Complete (ETC)

ETC is the expected cost to finish the remaining work of the project.

It measures only the *future* budget needed to complete the project, not the *entire* budget (that's the EAC, next). It allows the project manager to compare the funding needs to finish the project with funding available.

The ETC can be calculated either for each task or for the whole project. There are two ways to calculate ETC:

1. Based on past project performance:

$$\text{ETC} = (\text{BAC} - \text{EV}) / \text{CPI}$$

2. Based on a new estimate (This is called a Management ETC)

In this ETC can be added to the to-date cost (AC) to determine the final EAC.

$$\text{EAC} = \text{AC} + \text{ETC}$$

Example

You have a project to be completed in 12 months, and the budget of the project is 100,000 USD. Six months have passed, and 60,000 USD has been spent, but on closer review, you find that only 40% of the work has been completed so far. Find the Estimate to Complete (ETC).

Solution:

$$\text{ETC} = (\text{BAC} - \text{EV}) / \text{CPI}$$

$$\text{ETC} = (\$100,000 - \$40,000) / 0.67$$

$$\text{ETC} = \$89,552 \text{ USD}$$

Estimate at Completion (EAC)

EAC is the expected total cost of completing all work for the project. There are multiple ways to calculate it based on how you expect the future of the performance of the project to be:

1. Future performance will be based on the budgeted cost

If you think the existing variance was a unique event and the rest of the project should go according to plan, simply add the remaining project budget to the actual cost incurred to date (AC). This method does not assume the project finishes on budget. Rather it takes into account the one time event and adjusts the whole project plan upward or downward to determine the final result.

$$\text{EAC} = \text{AC} + (\text{BAC} - \text{EV})$$

2. Future cost performance will be based on past cost performance

If you think the past performance is not unusual and there is no reason to expect the project to perform any differently than it already has, you would use this formula.

$$\text{EAC} = \text{AC} + [(\text{BAC} - \text{EV}) / \text{CPI}]$$

3. Future cost performance will be influenced by past schedule performance

since schedule and cost performance are usually related, there could be a reason to adjust the cost performance by the schedule performance. In this case an average of the CPI and SPI are used to extrapolate the final project cost.

$$\text{EAC} = \text{AC} + [(\text{BAC} - \text{EV}) / (\text{CPI} \times \text{SPI})]$$

You could also use a combination of the past schedule or cost performance to extrapolate the final project cost. You could use only the schedule performance (SPI). Or you could figure in a small influence of the schedule performance. In the formula below, 20% of the SPI and 80% of the CPI has been used to determine the final project cost.

$$\text{EAC} = \text{AC} + [(\text{BAC} - \text{EV}) / (0.8 \cdot \text{CPI} \times 0.2 \cdot \text{SPI})]$$

4. A new estimate is produced

In this case a Management ETC can be added to the to-date cost (AC) to determine the final EAC.

$$\text{EAC} = \text{AC} + \text{ETC}$$

Example

You have a project to be completed in 12 months, and the budget of the project is 100,000 USD. Six months have passed, and 60,000 USD has been spent, but on closer review, you find that only 40% of the work has been completed so far. Find the Estimate at Completion (EAC).

Solution:

$$\text{EAC} = \text{AC} + (\text{BAC} - \text{EV})$$

$$\text{EAC} = \$60,000 + (\$100,000 - \$40,000) = \$120,000.$$

Variance at Completion (VAC)

The VAC is a forecast of what the variance, specifically the Cost Variance (CV), will be upon the completion of the project. It is the size of the expected cost overrun or underrun. In many situations the project manager must request additional funding as early as possible, or at least report the potential for an overrun. The VAC represents the size of this request.

The formula is:

$$\text{VAC} = \text{BAC} - \text{EAC} = \text{Old Budget} - \text{New Budget}$$

This one is relatively simple. If you've calculated the EAC you've done the big math already, and the 'new budget' can simply be subtracted from the 'old budget' to determine the cost overrun or underrun.

The Variance at Completion is simply a future projected Cost Variance. It has the same units as CV. It is the same type of element.

We will once again add another column to the table:

Example

You have a project to be completed in 12 months, and the budget of the project is 100,000 USD. Six months have passed, and 60,000 USD has been spent, but on closer review, you find that only 40% of the work has been completed so far. Find the Variance at Completion (VAC).

Solution:

$$\text{VAC} = \text{BAC} - \text{EAC}$$

$$\text{VAC} = \$100,000 - \$120,000 = -\$20,000.$$

To Complete Performance Index (TCPI)

To Complete Performance Index (TCPI) is a forecasting technique of Project Management (PM). It is the cost efficiency required to complete a project within a defined budget.

Difference Between CPI And TCPI

Both CPI and TCPI provide a measure of **Project's cost efficiency**. However there are basic differences between these two figures.

Cost Performance Index (CPI) is defined as ratio of EV and AC (EV / AC). It is project's current cost efficiency on the Control Date.

The project CPI could be any one of the following:

- $\text{CPI} < 1$ – it means that value earned value is less than the money spent. Project is **over budget**.
- $\text{CPI} = 1$ – it means that value earned value is equal to the money spent. Project is going **as per the budget**.
- $\text{CPI} > 1$ – it means that value earned value is more than the money spent. Project is **under budget**.

The main differences between CPI & TCPI, can thus, can be enumerated as:

- **CPI** represents project's current cost efficiency, whereas **TCPI** estimates project's future cost efficiency.
- **CPI** is actual efficiency of the completed project work, whereas **TCPI** is estimated forecast of efficiency of the remaining project work.

The To Complete Performance Index formula will be different in both cases. Let's discuss these two cases.

Case I: You're Under Budget

Example of TCPI: Case-I

You are working on a project to be completed in 24 months. The BAC of the project is 200,000 USD. 12 months have passed, you have spent 110,000 USD, and 60% of the work has been completed. Find the To Complete Performance Index (TCPI) for this project.

Solution:

Given in the question:

Budget at Completion (BAC) = 200,000 USD

Actual Cost (AC) = 110,000 USD

Planned Value (PV) = 50% of 200,000 = 100,000 USD

Earned Value (EV) = 60% of 200,000 = 120,000 USD

Cost Performance Index (CPI) = $EV / AC = 120,000 / 110,000 = 1.1$

Since the Cost Performance Index is 1.1, which is greater than one, you are under budget.

Therefore, you will use the TCPI formula based on the BAC in this case.

$$TCPI = (BAC - EV) / (BAC - AC)$$

$$= (200,000 - 120,000) / (200,000 - 110,000)$$

$$= 80,000 / 90,000$$

$$= 0.89$$

This means that you can continue with a Cost Performance Index of 0.89 to complete the project.

Case II: You're Over Budget**Example of TCPI: Case-II**

You have a project to be completed in 12 months. The budget of the project is 100,000 USD. 6 months have passed, and you have spent 60,000 USD, but on closer examination, you find that only 40% of the work has been completed so far. Find the To Complete Performance Index (TCPI) for this project.

Solution:

Given in the question:

Budget at Completion (BAC) = 100,000 USD

Actual Cost (AC) = 60,000 USD

Planned Value (PV) = 50% of 100,000 = 50,000 USD

Earned Value (EV) = 40% of 100,000 = 40,000 USD

Cost Performance Index (CPI) = $EV / AC = 40,000 / 60,000 = 0.67$

Hence, the Cost Performance Index (CPI) = 0.67

Since the Cost Performance Index is less than one, you are over budget.

Now you will calculate the new Estimate at Completion and use a formula based on the EAC.

Estimate at Completion (EAC) = $BAC / CPI = 100,000 / 0.67 = 149,253.73$ USD

Hence, Estimate at Completion (EAC) = 149,253.73 USD

Now, $TCPI = (BAC - EV) / (EAC - AC)$

$= (100,000 - 40,000) / (149,253.73 - 60,000) = 60,000 / 89,253.73 = 0.67$

TCPI = 0.67

This means that you can continue with a Cost Performance Index of 0.67 to complete the project.

Point to remember about TCPI

- You will calculate the TCPI based on the BAC if you are under budget (Case-I).
- You will calculate the TCPI based on the EAC if you are over budget (Case-II).