PDHonline Course P104C (8 PDH)

Project Cost Management

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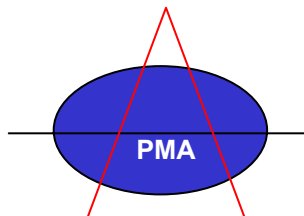
Presents

Project Cost Management

Via

WEB BASED LEARNING

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Module 4
Project Cost Management

Overview

Projects in the business world invariably have a specific financial objective; this is the *Project Outcome*. Project cost management involves the techniques required to meet the desired project outcome. It is important to understand when project cost management starts, what factors have controlling effects on project outcome, and when project cost management ends.

➢ Cost management starts during the planning phase of a project, *NOT* after the project has been approved to commence. For those of you, who don't quite believe this; just let your sales force sell a project or product 25% below market value. Now, you execute the project or manufacture the product. Get the drift?

➢ During the execution phase of a project, the three overriding factors that affect project outcome are:
  1. Performance / Quality
  2. Schedule
  3. Costs of Work
  And, keep in mind that these factors are listed in order of importance. If you take nothing else away from this course, please remember this one.

➢ After project completion, cost management continues through the application of lessons learned to the planning phases of subsequent projects. So, while project cost management may end for the given project, it should be regarded as a cyclical management process in any project-based organization.

Resource Planning

Prior to estimating the costs associated with any project, we must first identify what resources will be required for successful execution of the work. This process of identification is known as resource planning.

➢ *Resource Planning* is the determination of what resources must be used and in what quantities must they be used in order to accomplish the project objectives.

➢ Types / Examples of Resources:
  1. People – Our greatest project resource: welders, programmers, administrative assistants, engineers, functional managers, etc.
  2. Tools & Equipment – Anything from a welding machine to a new software package that is used to execute the tasks at hand.
  3. Materials – Any physical materials consumed in the execution of project tasks. For instance, structural steel in a building.

4. Services – Subcontracted services used to execute specific tasks, for instance, the use of an outside consultant or a subcontractor to install foundations.

➤ Application of the W5H2 questions is of great use in resource planning.
   Recall the W5H2 questions:
   1. *Why?* Task Identification
      Why perform this task? Is it really necessary, or is there an alternate way to accomplish the same objective?
   2. *What?* Task Identification
      What tasks are vital to completion of the project?
   3. *Who?* Labor Resources
      Who will be responsible for the work?
   4. *Where?* Location / Facility Resources
      Where will the work be performed?
   5. *When?* Availability of Resources
      When must task items be accomplished? And, are the appropriate resources available at such times?
   6. *How?* Definition of work to complete tasks
      How will the work be done?
   7. *How Much?* Quantity of Resources
      How much of the various resources will be required? How much labor? How much of a given material or service?

➤ Requirements for Resource Planning:
   1. Clear project objectives – To effectively plan resources, we must have a clear scope of supply and clear project objectives. Fuzziness on the front end usually leads to failure on the back end.
   2. An accurate and effective *Work Breakdown Structure* (WBS) – Since resource planning lends itself to a bottom-up analysis, development of a Work Breakdown Structure is critical to the accuracy of our resource plan.
   3. Buy-in from project team members – It cannot be overstated that people are our most important project resource. Once accountability for a given task has been determined, who could possibly be better to plan resources for the task than the people who will execute the task? Collaboration between pre-contract personnel and post-contract personnel is always desirable. Buy-in during the initial planning phase usually leads to success on the back end.
   4. Working knowledge of the resource pool – We must have knowledge of the resources available for project use. Extra resources may be required for project execution (for example, staffing up or purchasing new equipment).
   5. Experience – Where would we be without it? Historical information from similar projects as well as personal experiences are invaluable.

Cost Estimating / Budgeting

Some years ago, I worked for an air pollution control systems company. We went through some lean years when the market was in a down cycle, profit margins were slim, and competition was fierce. And I remember joking with one of my colleagues that whenever we got a new job in house, the first question that came to my mind was, "I wonder what we left out of our estimate?" It wasn't long before we found out.

The cost estimating and budgeting phase of cost management bridges the gap from planning to execution. Accuracy here can make or break projects. While estimating and budgeting are different activities technically speaking, they are very closely related for most projects.

➢ ***Cost Estimating*** is the process of developing estimated costs for all resources required to complete the project. This process attaches an anticipated approximate cost to each resource identified in the planning phase
➢ ***Cost Budgeting*** is the process of allocating cost estimates to specific cost items that account for the work necessary to complete the project. Budgeting establishes a cost baseline against which project performance is measured.

Who is involved in Cost Estimating?

1. Pre-contract personnel (for client projects) – Before any project is sold to an outside client, cost estimating is performed. Such financial analysis is critical for management to approve submitting a quotation to an outside client.
2. Project sponsors (for internal projects) – Likewise, a financial analysis is necessary for management to approve an internal project. So, typically, project sponsors have had estimates prepared in order to show the financial impact to the company.
3. Project managers – These poor folks will ultimately be accountable for project outcome performance and, hence, must be involved in developing cost estimates (even if only on a review basis).
4. Project team members and functional managers – Again, the ones who will be doing the work are the most appropriate ones to estimate how much the work will cost. Buy-in leads to project success. And project success makes the PM's and the sales force both look good.

Who is involved in Cost Budgeting?

1. Project managers – PM's are definitely players here. Since the project manager is going to be held accountable for the financial performance of the overall project, he must certainly be involved in preparation of the project budget.
2. Accounting – The conversion of an idea or quotation to an actual project requires that the project finances be put into the company's accounting system. Cost codes are assigned to budgeted cost items. Cost baselines are established to allow performance measurement. The accounting department then integrates the project into the company's operations.

3. Upper management – Company management are involved here as the project budget is a cost component of the company's operations as a whole.

What Data is Required in Cost Estimating and Budgeting?

1. Clear project scope of supply – Project objectives and exact scope must be well defined by this point.
2. Work Breakdown Structure – The WBS is used to organize cost items and insure that all cost items are included in the estimates and budgets.
3. Resource Requirements – All resources identified in the planning phase are transferred into estimates and budgets so that cost items can be applied.
4. Units of Cost for Various Resources – Unit cost data multiplied by individual resource need yields a specific cost item in an estimate or budget.
5. Historical Data – Used for comparative and iterative treatment of cost items. Lessons applied are lessons learned. Lessons not applied are just plain negligence.
6. Accounting Codes – Project estimates and budget items must be assigned to the correct accounting categories. Cost codes should be used to bring cost items into the company's financial analysis and reporting system.

What Methods are used for Cost estimating and budgeting?

1. Analogous (Top-down) estimating – Estimating that is based on the use of actual costs from a similar project that has been successfully executed. The degree of similarity between the projects has great influence on the accuracy of the estimate. With adequate similarities, this method can be quite useful since it is quicker and easier than bottom-up estimating, but use great care to make sure that you are comparing apples to apples.

2. Parametric Estimating – Estimating based on a scalable, mathematical model of work to be performed on a project. For example, the cost to construct a reinforced concrete foundation may be estimated based on a standard cost per yard of finished concrete. Similarly, installation of carpet and padding in a building can generally be estimated based on the area to be carpeted. Although the individual cost items are not estimated and summed, the unit cost should include representative portions of the individual items. This method also should be used only with great care, and hopefully with a big dose of experience.

3. Summation (Bottom-up) Estimating – Estimating the costs of all individual work items in the project (from the WBS) and summing the costs to reach the total estimated cost for the project. Although this method is very accurate, it also is much more time consuming. Also, individual cost items must be treated with great accuracy as padding of many small items could cause the total to be completely bloated.

4. Computer-aided estimating – Packaged computer programs as well as custom-developed programs can greatly streamline the estimating process.

Every effort should be made to utilize the latest tools that technology provides.

The Estimating Exercise

In this exercise, you will estimate the total sales price of carpeting a house based on each of three different methods: analogous, parametric, and summation.

1. What is the estimated price using each method?
2. What method is the easiest? Quickest? Most accurate?
3. What are potential risks to each method?

Use the following data to determine your estimates.

➢ The area to be carpeted is measured and found to be 1,800 square feet. There are two stairwells to be carpeted as well. Each stairwell has 14 steps and one landing.

➢ As a general rule, your company targets a Gross Margin of 20% of sales price for carpet installation projects.

➢ In the past six months, your company has carpeted two houses in the same neighborhood with a similar product. The sales prices for these two jobs were $5,700 and $6,100. The gross margins were 23% and 25% respectively.

➢ Your company uses the following estimating formula for houses less than 2,800 square feet when the unit carpet cost is between $12 and $15 per square yard. This formula yields the sales price including installation of the new carpet, removal of the old carpet, and disposal of the old carpet.

Sales Price = Measured Area (sq yd) x Carpet Price ($/sq yd) x 2.1

➢ Individual cost items are as follows. Cost items are based on the measured area (square yardage) plus 5% overage (to account for waste).

1. Carpet	$12.45 / sq yd
2. Padding	$ 2.10 / sq yd
3. Installation – base charge	$ 3.75 / sq yd
4. Installation – stair premium	$ 8 / stair
5. Installation – landing premium	$ 15 / landing
6. Removal of old carpet	$ 0.60 / sq yd
7. Disposal of old carpet	$ 0.50 / sq yd

➢ 1 square yard = 9 square feet

Develop your solutions now!

The Solution to the Estimating Exercise

Analogous (Top-Down) Method:

Option 1: The sales price can be estimated as the average of the sales prices of the two recent and similar jobs. This result is $5,900. Although this is the easiest and quickest method, it produces the least accurate estimate for the new work.

Option 2: The sales price can be estimated by applying the target Gross Margin to the actual costs of the two recent and similar jobs. Taking into account the executed gross margins of the two jobs yields actual costs for those jobs of $4,389 and $4,575. The average of these costs is $4,482. Including the 20% margin gives us a sales price of $5,602.50.

Parametric Method:

Area (sq yd) = 1800 sq ft x $\frac{1 \text{ sq yd}}{9 \text{ sq ft}}$ = 200 sq yd

Sales Price = 200 sq yd x $12.45/sq yd x 2.1 = $5,229.00

Summation (Bottom-Up) Method:

Basis Area = Measured Area + 5% Overage = 210 sq yd

Cost Item		Est. Cost
Carpet	= 210 x 12.45 =	2,614.50
Padding	= 210 x 2.10 =	441.00
Base Install	= 210 x 3.75 =	787.50
Stairs	= 28 x 8.00 =	224.00
Landings	= 2 x 15.00 =	30.00
Removal	= 210 x 0.60 =	126.00
Disposal	= 210 x 0.50 =	105.00
	Total Estimated Cost =	4,328.00

Sales Price = $\frac{\$4,328}{0.80}$ = $5,410.00

➢ Most Accurate: Summation
➢ Least Accurate: Analogous

- ➢ Quickest: Analogous
- ➢ Slowest: Summation
- ➢ Risks: Analogous estimates (both options) are high; the primary risk is not getting the job. Parametric estimate is slightly low (possibly due to the house having two stairwells); the primary risk is falling short of target Gross Margin. The risks associated with the summation estimate are minimal.

Cost Monitoring

Monitoring is the continuous process of data collection in order to identify the state of project tasks at a given point in time during the project. In short, what has happened to date? And, more importantly, how much has it cost?

Types of Data to Be Monitored

1. Earned Value
2. Labor (Internal Project Team Members)
3. External Labor (Contract Workers, Consultants, etc.)
4. Committed Costs
5. Incurred Costs
6. Estimates of % Completion for Individual Tasks
7. Material Usage
8. Equipment Usage
9. Resource Utilization

Crucial Characteristics of Data / Input

1. The data must be accurate. No excuses. No bull. A clear picture is imperative to successfully manage project cost.
2. The data must be timely. Out-of-date measurements can doom even the best of project managers.
3. The data must be relevant. Wading through reports with too much information or the wrong information is a waste of time. And in the now legendary words of Benjamin Franklin, "Remember that time is money."

Sources of Project Data

1. Accounting
2. Project Team Members (Internal and External)
3. Functional Managers

Project Data from Accounting

1. Internal Labor Reports
2. Cost reports (for materials, supplies, equipment, etc.)

3. Committed Costs
4. Incurred Costs
5. Cash Out to Date / Payables Open
6. Receipts to Date / Receivables
7. These reports should be in real time and periodic. Typically, monthly or weekly. But, such reports should be available upon request at any time should the need arise.

Project Input from Project Team Members

1. Unlike data from accounting, which comes to the project manager automatically, the PM must seek input from team members.
2. Data (or input) from team members is generally much more nebulous than that from accounting.
3. Such input from team members almost never has dollar values attached to it. But this input is no less important than all the "dollar data" from accounting.
4. Examples of data from project team members:
   ➤ Which tasks are completed?
   ➤ Which tasks remain not started?
   ➤ Of tasks in process, how much time, materials, equipment, expenses remain to reach completion?
   ➤ Any possible project risks that have arisen? And possible suggestions for averting such risks.
   ➤ Any possible opportunities that may have arisen? And possible suggestions for taking advantage of them.
5. Remember that your project team members are invaluable. Their expertise and efforts can determine the project's chances of success. But how well the PM integrates these efforts can ensure project success or failure.

Project Input from Functional Managers

1. Similar to input from project team members, but more related to how your specific project fits into the company's other projects and operations.
2. Changes in availability of company resources that may affect your project execution. For Instance:
   ➤ Company cash flow might impact your management of project receivables and payables.
   ➤ Another ailing project may require labor to be pulled from your project.
3. New tools (computer software or construction equipment) may improve the possible efficiency of some project tasks.

Results (Cost Tracking Reports)

   ➤ All relevant cost data should be organized into a single report (the cost tracking report) that allows real-time analysis of the monitored costs.
   ➤ The project manager typically maintains cost tracking reports.
   ➤ They generally track cost items (tasks or purchases) as budgeted.

➢ They are bottom-up reports. In other words, they include all cost items in the project that roll up into overall project cost.

Basic Format for a Cost Tracking Report

➢ Project Identification (number, title, etc.)
➢ Project Manager
➢ Date (prepared, updated, printed, etc.)
➢ Project Value (Contract Value for outside projects)
➢ Budgeted Cost
➢ Budgeted Gross Margin
➢ EAC Cost
➢ EAC Gross Margin
➢ Analysis of each cost item (task, labor, purchase, etc.):
  1. Cost Code
  2. Item Description
  3. Resource (or Vendor for purchases and subcontracts)
  4. P. O. Number (if applicable)
  5. Budgeted Cost
  6. Cost Committed
  7. Cost to Date
  8. Open P.O. Cost
  9. ETC (Estimated Cost to Complete)
  10. EAC (Estimated Cost at Completion)
  11. Variance
➢ Rolled-up Analysis (summation of all cost items)

Example of a Project Cost Tracking Report

The following page shows a fairly detailed project cost tracking report for a half-million dollar project. This report contains all of the basic information categories listed above with a few additions.

➢ Two columns are included for the budgeted cost, one for the original budgeted cost and one for the current budgeted cost. The latter takes into account booked changes to the contract.
➢ A column specifically for freight cost appears in this report. Tracking freight cost in this way was helpful for this specific project but need not be done as a general rule.
➢ Two variance columns are shown, one in $ and one in %. While the dollar variance is helpful from a total project standpoint, the percent variance helps to identify cost problems on specific items.
➢ For material purchases, three columns are used to check whether items have been purchased, received, and paid.

Such reports will vary from company to company and from project to project. The emphasis is not on the exact format, rather that all of the necessary information is included and that the format *WORKS*.

"Project Cost Tracking Worksheet" (EXCEL)

Explanation of Cost Tracking Report Example

1. General project information is in the top left corner of the report:
   - ➤ Project Name
   - ➤ Project No.
   - ➤ Date
   - ➤ Project Manager

2. This project has four major cost categories:
   - ➤ Internal Labor
   - ➤ Purchased Materials
   - ➤ Fabrication
   - ➤ Other

3. All critical information is shown for each cost item.
   - ➤ Cost Code
   - ➤ Description
   - ➤ P.O. No. (if applicable)
   - ➤ Budgeted Costs (Original and Current)
   - ➤ Cost Committed (Labor Posted, Purchase Orders, and Sub-Contracts)
   - ➤ Cost to Date (Labor Posted and Payables to Suppliers)
   - ➤ Freight Cost
   - ➤ Open P.O. Cost (Cost Committed - Cost to Date)
   - ➤ ETC (Estimated Cost to Complete) – Values determined by the Project Manager
   - ➤ EAC (Estimated Cost at Completion)
     EAC = Cost to Date + Freight + Open P.O. Cost + ETC
   - ➤ Variance ($) = Current Budgeted Cost - EAC Cost
   - ➤ Variance (%) = Variance / Current Budgeted Cost * 100

4. Rolled-up data are presented.
   - ➤ Overall analysis at top of report
   - ➤ Column summations for each of the four major cost categories
   - ➤ Column summations for project totals

5. Variances are clearly shown.
   - ➤ Negative variances are shown in parentheses (and in color)
   - ➤ Although variances for the whole project and even the four broad cost categories are small, some variances on individual cost items can be enormous

What do We do with all of this Data?

1. Update project budget reports
2. Update project schedule
3. Compare actual progress with plan
4. Update our *Earned Value Analysis*. Our what? *(MORE ON THAT BELOW)*

Cost Analysis and Control

You have received a mountain of cost information from accounting. You have discussed project status with team members. You have fought tooth and nail over company resources with functional managers. You know exactly where you are and where you're going. Right?

Before you answer too quickly, let's consider the most powerful cost analysis tool available to the project manager, the *Earned Value Analysis (EVA)*.

The *Earned Value Analysis (or EVA)* measures project performance by comparing the amount of work actually completed with the amount of work that should be completed according to the project plan. EVA is also sometimes referred to as a *Variance Analysis*.

Before we delve further into the actual technique, let's review the terms used.

EVA Definitions

1. **BCWS**
   Budgeted Cost of Work Scheduled – This is the budgeted cost associated with the amount of work that was to be accomplished during a given period of time according to the original plan.

2. **BCWP**
   Budgeted Cost of Work Performed – This is the budgeted cost associated with the amount of work that was actually accomplished during the given period of time. BCWP is also known as *Earned Value (EV)*.

3. **ACWP**
   Actual Cost of Work Performed – This is the actual cost associated with the amount of work that was accomplished during the given period of time.

4. **CVAR**   **CVAR = BCWP - ACWP**
   Cost Variance – This is the difference between actual cost and budgeted cost of the work that has been performed for the given period.

5. **SVAR**   **SVAR = BCWP – BCWS**
   Schedule Variance – This is the difference between the amount of work that was performed and the amount of work that was planned for the given period.

6. **BAC**
   Budget at Completion – This is the total budgeted cost at completion of a task, group of tasks, or project.

7. **ETC**   **ETC = (BAC-BCWP) / CPI**
   Estimate to Complete – This is the estimated additional cost required to complete a task, group of tasks, or project.

8. **EAC**   **EAC = ACWP + ETC**
   Estimate at Completion – This is the estimated total cost of a task, group of tasks, or project at completion.

9. **CPI**   **CPI = BCWP/ACWP**
   Cost Performance Index – This is the ratio of budgeted costs to actual costs for work that has been performed.

10. **SPI**   **SPI = BCWP/BCWS**
    Schedule Performance Index – This is the ratio of work performed to work scheduled to have been performed.

For BCWS, BCWP, and ACWP, other work units may be used as an alternative to cost. For example, we may use labor figures (man-hours or man-weeks) or other task-specific work units that accurately track progress (yards of reinforced concrete, lines of computer code, etc). However, one must keep in mind how these alternative work units are related to project cost in general.

In cases where BCWP is greater than ACWP, the cost variance, CVAR, is positive. This indicates that the project or task is under budget. Or, in other words, the actual cost is lower than the budgeted cost for the work that has been accomplished to date. Conversely, a negative value for CVAR indicates that the project or task is over budget.

In cases where BCWP is greater than BCWS, the schedule variance, SVAR is positive. This indicates that the project or task is ahead of schedule. In essence, more work has been performed than was originally scheduled. Conversely, a negative value for SVAR indicates that the project or task is behind schedule.

For CVAR and SVAR, positive values are good; and negative values are bad. While this information is of use, these values do not inherently give us an idea of the degree of the variance. CPI and SPI, however, not only tell us good or bad, but also by what degree. Let's review the formulas for CPI and SPI.

$$CPI = \frac{BCWP}{ACWP} \qquad and \qquad SPI = \frac{BCWP}{BCWS}$$

A value of 1.0 for CPI indicates that the project is being executed on budget (costs are being incurred according to the original plan). A value less than 1.0 indicates an over-budget condition, and a value greater than 1.0 indicates an under-budget condition.

A value of 1.0 for SPI indicates that the project is being executed on schedule. A value less than 1.0 indicates that the project is behind schedule. A value greater than 1.0 indicates that the project is ahead of schedule.

In addition, since we have a baseline of 1.0, these values for CPI and SPI also give us a feel for the degree of the variance. For instance, a CPI of 1.12 shows not only that the project is under budget, but further that it is under budget by about 11%. A CPI of 1.45 would indicate that the project is grossly under budget; a value this far out of line should be questioned with great skepticism.

Now, let's look at some graphical examples of the Earned Value Analysis technique.

Earned Value Analysis Examples

Consider the following examples. These examples may reflect the analysis of a complete project, or more likely, the analysis of a task or group of tasks within a larger project. The budgeted cost at completion is $24,000. The work is scheduled to be complete in 15 days. The examples show project status at the end of day 10.

Example 1: Project on Budget and On Schedule

EVA - Case 1
Project On Budget and On Schedule
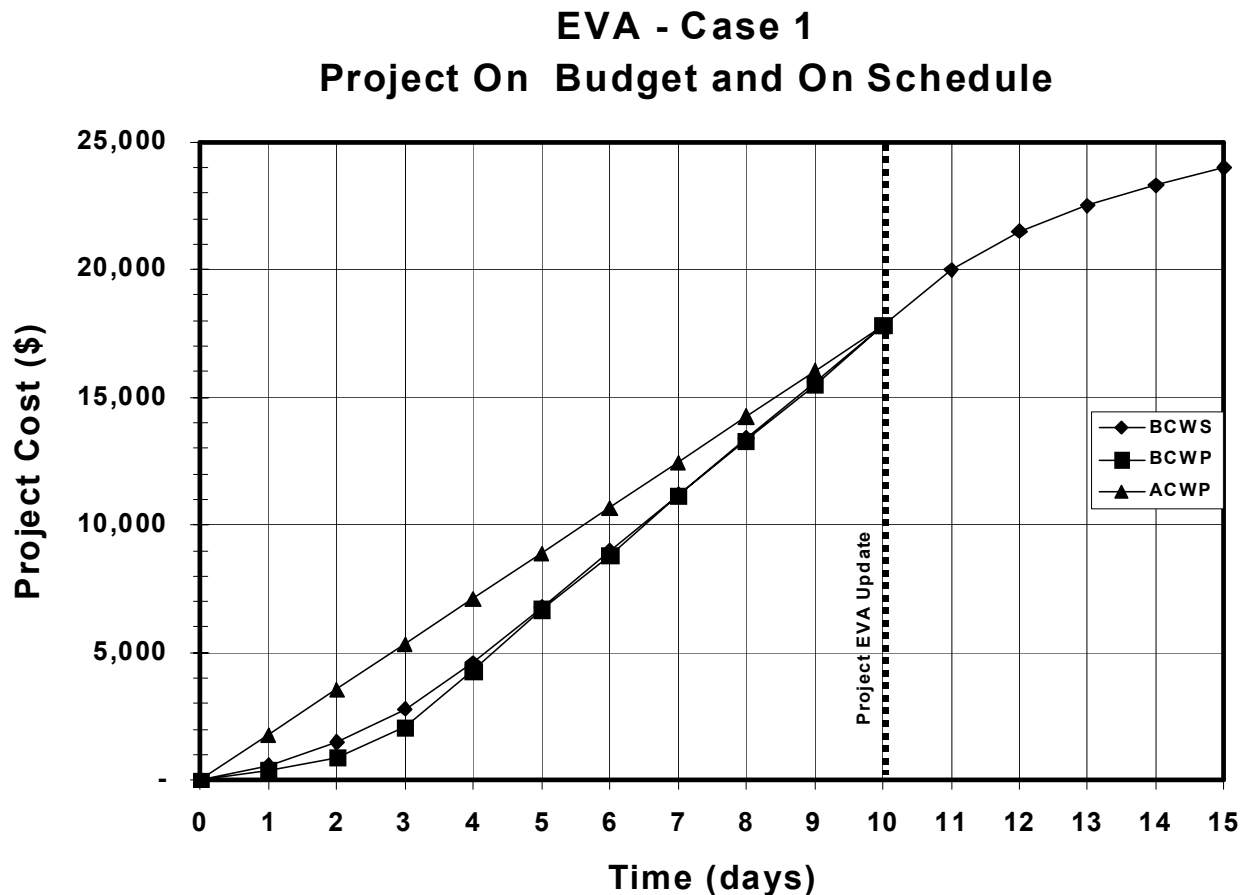
CVAR = 17,800 – 17,800 = 0   CPI = 17,800/17,800 = 1.000

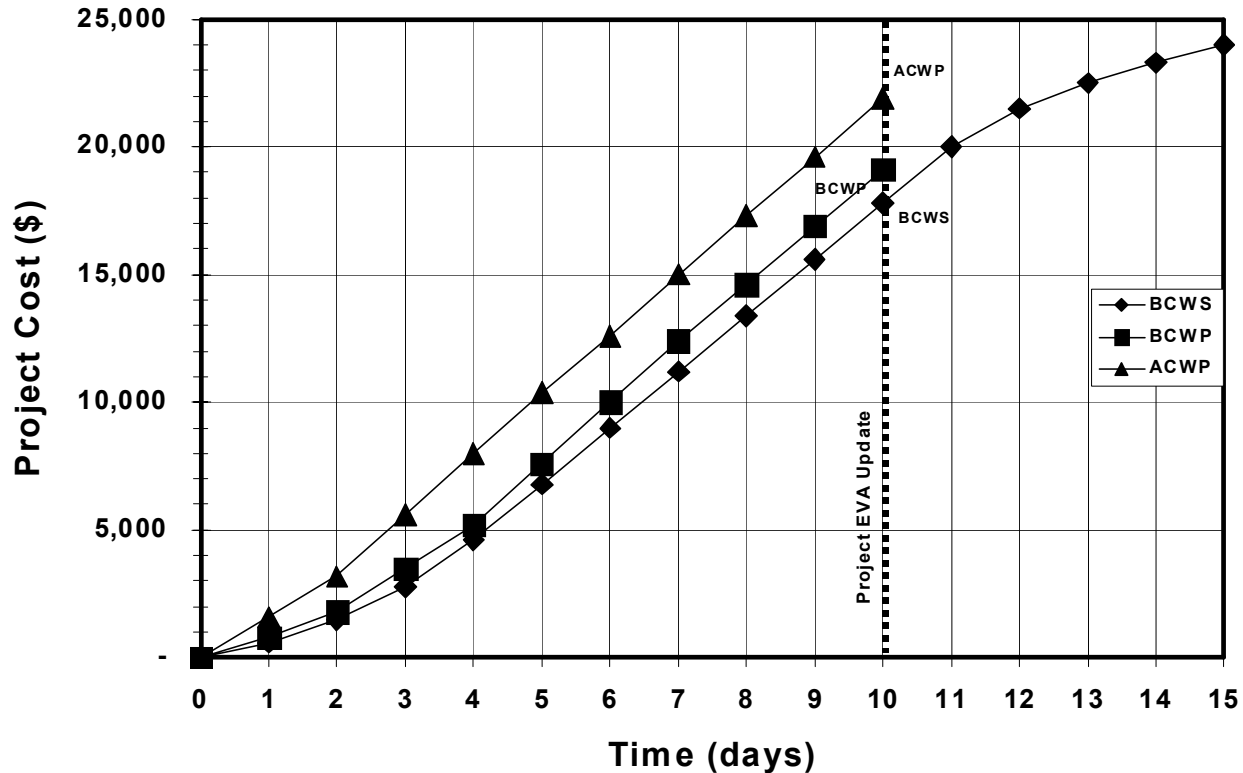SVAR = 17,100 – 17,800 = 0   SPI = 17,800/17,800 = 1.000

It is clear that this project is progressing according to plan. Two-thirds of the way through the planned duration of the work, the project is on budget and on schedule. Obviously, this case is the exception rather than the rule. Subsequent examples are more indicative of real-world scenarios.

Example 2: Over Budget, Ahead of Schedule

EVA - Case 2
Project Over Budget but Ahead of Schedule

CVAR = 19,100 – 21,900 = -2,800   CPI = 19,100/21,900 = 0.872

SVAR = 19,100 – 17,800 = 1,300   SPI = 19,100/17,800 = 1.073

- ➤ The negative CVAR and CPI less than 1.0 show us that this project is currently over budget.
- ➤ For many purposes, CPI < 0.9 should raise a red flag, indicating a serious cost overrun.
- ➤ The positive SVAR and SPI greater than 1.0 show us that this project is ahead of schedule.
- ➤ Further, the SPI of 1.073 indicates that we are only slightly ahead of schedule – not great cause for excitement.
- ➤ An example of this scenario is a project in which more resources are being allocated to the work than originally planned. Although the work is being accomplished ahead of schedule, the work is not being done as efficiently as planned. This may be due to too many resources working in the same area as in the case of stacked labor.

Example 3: Under Budget, Behind Schedule

EVA - Case 3
Project Under Budget but Behind Schedule
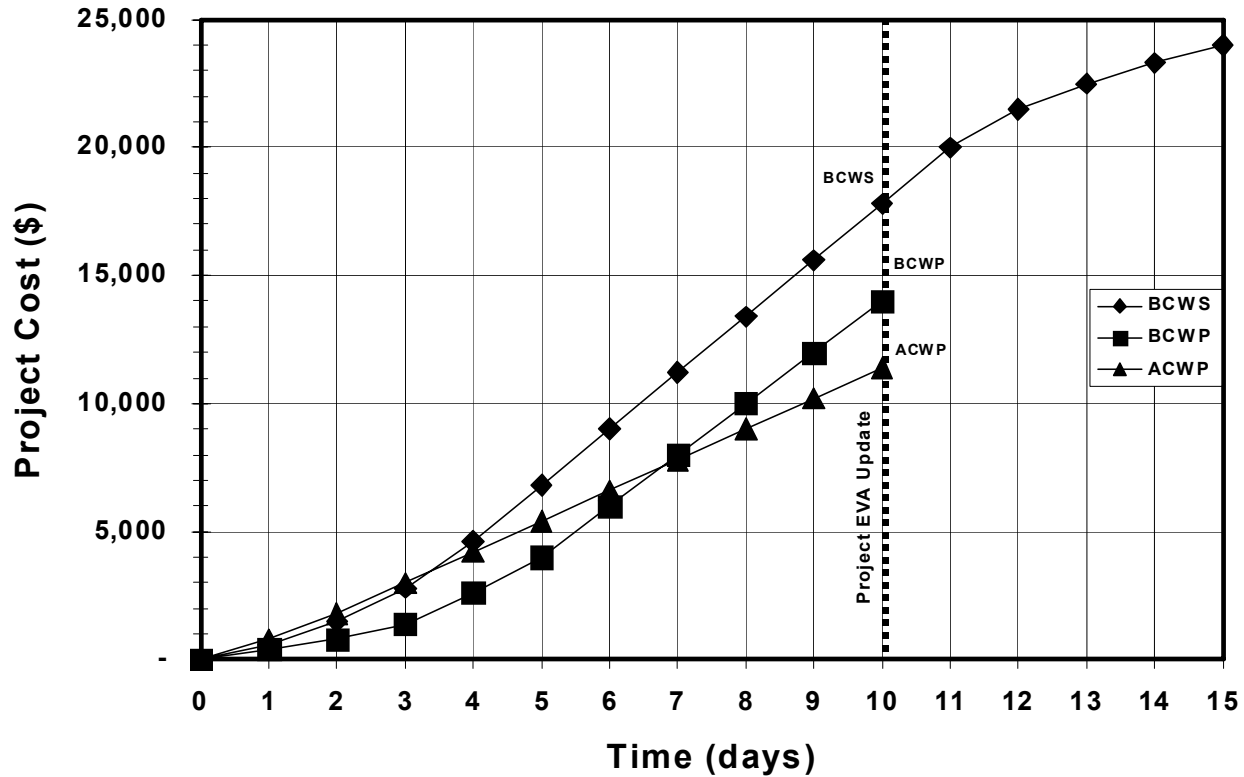
CVAR = 14,000 – 11,400 = 2,600   CPI = 14,000/11,400 = 1.228

SVAR = 14,000 – 17,800 = -3,800   SPI = 14,000/17,800 = 0.787

➢ Values for CVAR and CPI indicate that the project is under budget.
➢ CPI shows a significant cost variance. The project is well below budget, and such a large variance warrants further investigation.
➢ Values for SVAR and SPI indicate that the project is behind schedule.
➢ SPI of 0.787 shows a significant schedule problem, with the implication that recovery may be difficult.
➢ This scenario is typical of a lack of adequate resources to execute the project on time.
➢ While CVAR is positive, SVAR is very negative. Unless corrective actions are taken, this project will likely be over budget as well as late. As we will see later, CVAR and SVAR do not tell the whole story.

Example 4: Under Budget, Ahead of Schedule

EVA - Case 4
Project Under Budget and Ahead of Schedule
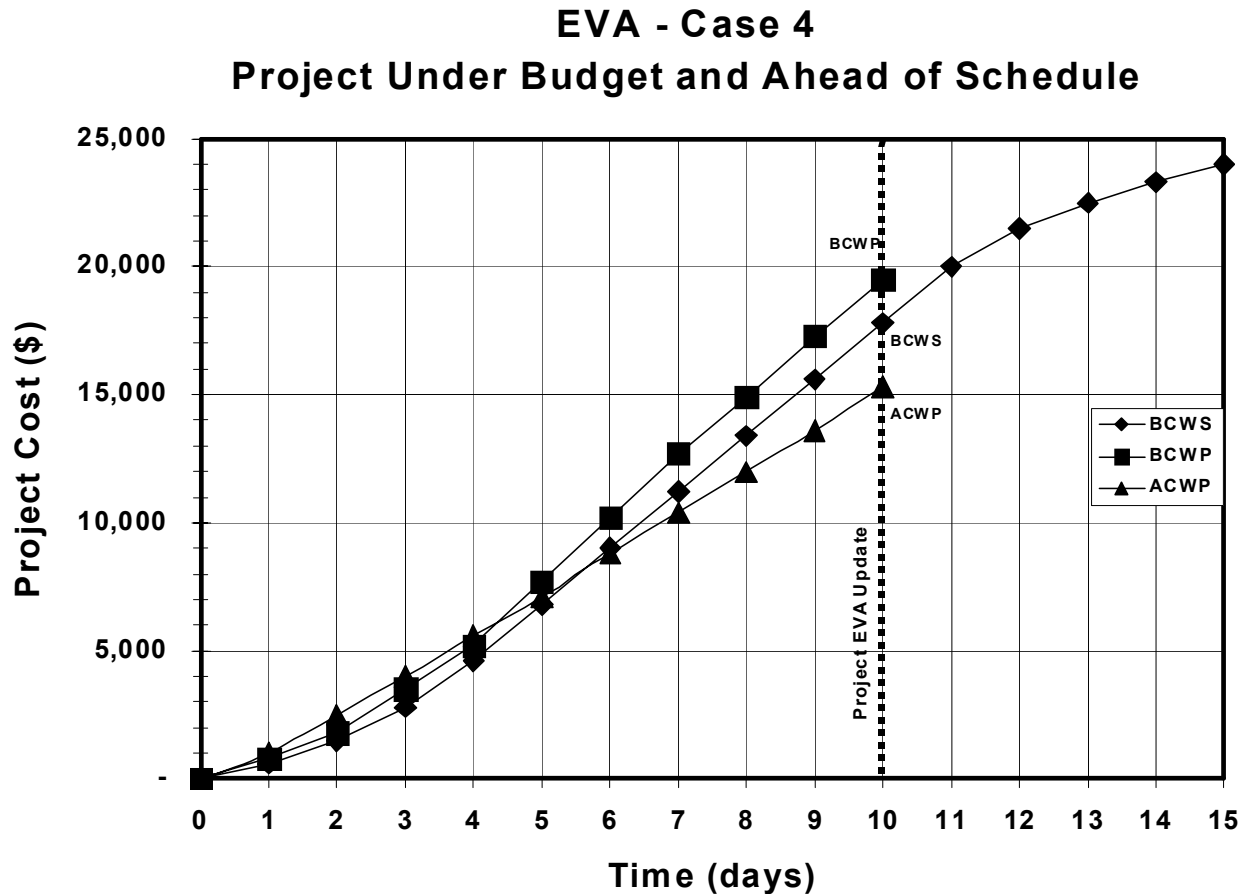
CVAR = 19,500 − 15,300 = 4,200

CPI = 19,500/15,300 = 1.275

SVAR = 19,500 − 17,800 = 1,700

SPI = 19,500/17,800 = 1.096

- ➢ Values for CVAR and CPI show that the project is under budget.
- ➢ CPI of 1.275 is unusually high and should be investigated. Maybe the work is simply being done very efficiently. Or perhaps the original cost estimates were low. Regardless, such a high CPI should raise a red flag.
- ➢ Values for SVAR and SPI show that the project is ahead of schedule.
- ➢ This scenario is indicative of a project that is being executed significantly better than the original plan. Although performance is wonderful, the large variances need to be addressed to determine if they could be problematic.
- ➢ For instance, the schedule variance may be the result of resources applied to this project that could be better used elsewhere. Or, the cost variances may be the result of cheaper labor that may have the downside risk of increased quality problems.

Example 5: Over Budget, Behind Schedule (Worst of the Worst)

EVA - Case 5
Project Over Budget and Behind Schedule
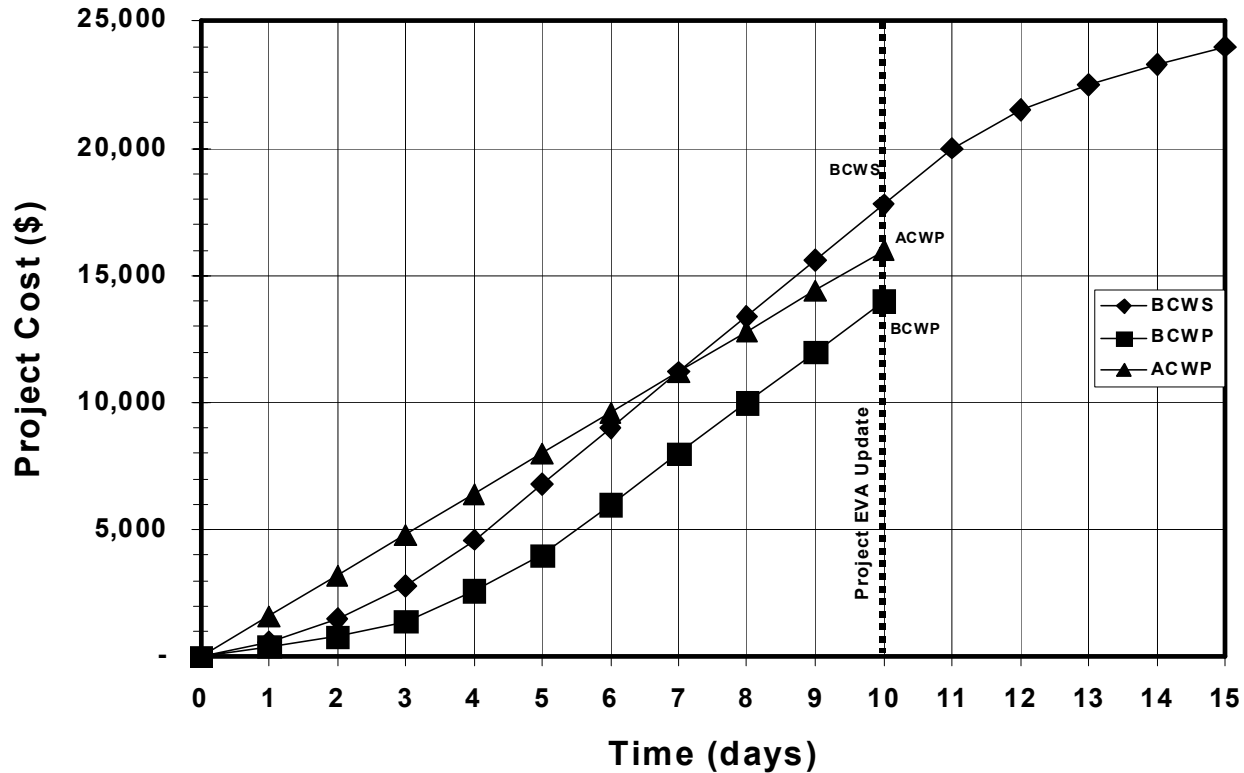
$$CVAR = 14,000 - 16,000 = -2,000 \qquad CPI = 14,000/16,000 = 0.875$$

$$SVAR = 14,000 - 17,800 = -3,800 \qquad SPI = 14,000/17,800 = 0.787$$

➢ The variances on this project show that the cost performance is bad and that the schedule performance is even worse.

➢ CPI of 0.875 indicates the cost overrun.

➢ SPI of 0.787 indicates a serious schedule problem.

➢ Investigation of these variances is an *absolute must*. The causes for such variances must be identified so that decisions can be made to bring the project back on course.

➢ Possible causes of this situation are numerous, and include: poor estimating, poor definition of scope or project objectives, poor quality leading to rework, lack of appropriate resources, and many more. Like most things, there are many ways to do it wrong, but very few ways to do it right.

Estimate to Complete and Estimate at Completion

A further application of the Earned Value Analysis is extrapolation to project completion. ETC (Estimate to Complete) reflects the estimated cost to carry the project from the current status to completion. EAC (Estimate at Completion) reflects the estimated total cost at project completion. Obviously, the EAC provides a useful comparison to the BAC (Budget at Completion). BAC minus EAC yields the variance at completion (VAC). Again, these principles apply to individual tasks and task groups as well as to the project as a whole.

Recall that: $ETC = \dfrac{BAC\text{-}BCWP}{CPI}$

And: $EAC = ACWP + ETC$

Consider the following example:

EVA – Case 6

In this example, we will look at a group of tasks involved in a larger project. The specifics are as follows:

- ➢ The group of tasks is estimated to be complete in 10 days.
- ➢ The budgeted cost for this group of tasks is $5,000. Each day is worth $500.
- ➢ At the end of day six, reports from project team members detailing the status of various tasks indicate that 48% of the work has been completed. As such, the BCWP is $2,400.
- ➢ A labor report is pulled from the accounting system at the end of day six. This report shows actual cost to date of $2,700. This is the ACWP.

We wish to answer the following questions.
1. Is the task group on schedule?
2. Is the task group under budget or over budget?
3. Based on performance as of day six, what is the estimated cost at completion?
4. When do we estimate that these tasks will be complete?

Our EVA reveals the following information.
1. SPI = BCWP/BCWS = 2,400/3,000 = 0.800
   SPI < 1.0
   Therefore, the project is behind schedule.

2. CPI = BCWP/ACWP = 2,400/2,700 = 0.889
   CPI < 1.0
   Therefore, the project is over budget.
3. EAC = ACWP + (BAC – BCWP) = 2,700 + (5,000 – 2,400) = $5,625

| | CPI | 0.889 |

So, the estimated cost at completion (EAC) is $5,625.

4. To determine when the tasks will be completed, let's look at the graphical representation below.
   - Since completion is reached when BCWP = BCWS, the BCWP line is extended until it reaches the BAC Cost, or $5,000.
   - At this point, a vertical line can be dropped to the x-axis (time). This is the estimated schedule for completion of the tasks. This line is denoted as the EAC Schedule line. The value is 12 ½ days.
   - Also note that the ACWP line can be extended until it reaches the vertical EAC Schedule line. At this point of interModule (remember that this is at project completion), the value on the y-axis is the EAC Cost. A horizontal line denoted EAC Cost shows this value.
   - Based on a simple straight-line analysis, we could also find the EAC Schedule with the formula:
   EAC (Schedule) = BAC (Schedule) / SPI = 10 days / 0.800 = 12.5 days

EVA - Case 6
Determination of EAC
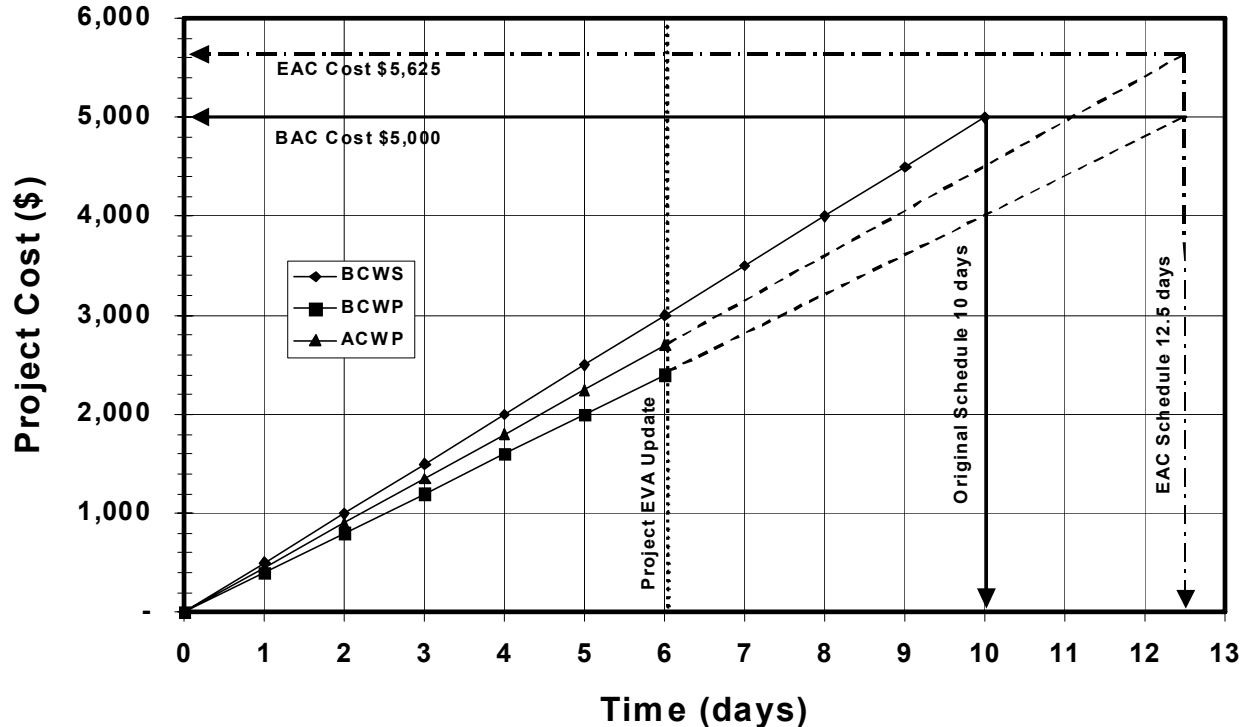
The Earned Value Analysis Exercise

The design phase of a chemical storage and metering system is broken into three different task groups: mechanical design, structural design, and electrical design. Once the mechanical design has been completed, the design package goes to both the structural and electrical design groups. The project schedule allows 10 days for completion of the design phase.

The following table shows a schedule of values for the system design.

Task	Data	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Mechanical Design	BCWS	500	500	500	500						
	BCWP	300	400	700	600						
	ACWP	500	500	800	700						
Structural Design	BCWS					500	500	500			
	BCWP					700					
	ACWP					800					
Electrical Design	BCWS					500	500	500	500	500	500
	BCWP					500					
	ACWP					500					

Data for actual work performed (BCWP) and actual cost incurred (ACWP) have been updated as of the end of day 5 of the design phase.

Your boss has scheduled a meeting on the morning of Day 6 in order to review progress on the project. As a minimum, you must be prepared to answer the following questions. Now, impress the boss!

1. a. Is the design phase ahead of schedule or behind schedule?
    b. By what %?
2. a. Is the design phase under budget or over budget?
    b. By how much ($ and %)?
3. Based on performance to date, what is the ETC?
4. What is the resulting EAC?
5. Will the design phase come in under budget?
6. Based on performance to date, will the design be completed on time?

The Solution to The Earned Value Analysis Exercise

Before performing the necessary calculations, it is helpful to organize the data into the following format. The values within each category are simply summed.

Task	BAC	Through Day 5		
		BCWS	BCWP	ACWP
Mechanical Design	2,000	2,000	2,000	2,500
Structural Design	1,500	500	700	800
Electrical Design	3,000	500	500	500
Totals	6,500	3,000	3,200	3,800

1. Either SVAR or SPI may be used to determine design is **ahead of schedule**.

   SVAR = BCWP – BCWS = 3,200 – 3,000 = 200
   SVAR is positive; therefore, design is ahead of schedule

   SPI = BCWP / BCWS = 3,200 / 3,000 = 1.0667
   SPI is greater than 1.0; therefore, design is ahead of schedule

   %SVAR = $\dfrac{\text{SVAR} \times 100}{\text{BCWS}}$ = $\dfrac{200 \times 100}{3,000}$ = **6.67% ahead of schedule**

2. Either CVAR or CPI may be used to determine design is **over budget**.

   CVAR = BCWP – ACWP = 3,200 – 3,800 = -600
   CVAR is negative; therefore, design is over budget.
   CVAR = -600; therefore, design is **over budget by $600**.

   CPI = BCWP / ACWP = 3,200 / 3,800 = 0.8421
   CPI is less that 1.0; therefore, design is over budget.

   %CVAR = $\dfrac{\text{CVAR} \times 100}{\text{BCWP}}$ = $\dfrac{-600 \times 100}{3,200}$ = **18.75% over budget**

3. ETC = $\dfrac{\text{BAC} - \text{BCWP}}{\text{CPI}}$ = $\dfrac{6,500 - 3,200}{0.8421}$ = **$3,919 is the ETC**.

4. EAC = ACWP + ETC = 3,800 + 3,919 = **$7,719 is the EAC**.

5. **No**. Since EAC > BAC, we do not expect the design phase to finish under budget. Further, the variance at completion would be $1,219 over budget.

6. **Yes**. Estimate = BAC (time) / SPI = 10 days / 1.0667 = 9.375 days

Limitations of ETC and EAC Calculations

1. <u>Assumption of Constant Performance</u>

ETC and EAC calculations outlined above are based on the performance indices, CPI and SPI. Accordingly, these calculations assume the same level of performance for tasks that have been completed in the past for tasks that are to be completed in the future.

Remember, the "E" stands for *ESTIMATE*. Sometimes, you, the project manager must modify this approach when estimating future work on your project.

For instance, consider the previous EVA Exercise, but with the following ideas:
  ➢ The structural design group was uncertain about several aspects of the mechanical design. This was the primary cause for structural design being over budget on day 5. With clarification from the lead mechanical engineer, the structural group reports that they can improve their performance on days 6 and 7 and actually meet the BCWS.
  ➢ Historically, the electrical design group has performed at or better than budget on similar projects. Day 5 data gives you further confidence that the electrical design group can perform to plan.

Now, what is your EAC cost for the project?
  ➢ Optimistic: Structural and Electrical both finish on budget. EAC = $7,000 Only the $500 overrun from Mechanical impacts the design cost.
  ➢ Pessimistic: Structural does not improve, but maintains $100 overrun while Electrical finishes 5% over budget (at worst). EAC = $7,250
  ➢ EVA based on data only: EAC = $7,719
  ➢ You must decide.

2. <u>Dependence on Resource Types</u>

When dealing with tasks or projects involving different resource types, the ETC and EAC values should be handled separately as the confidence levels of estimates generally vary as follows.

  ➢ Labor – Generally the lowest confidence level. Application of CPI and SPI are appropriate.
  ➢ Materials – Generally a higher degree of confidence than labor. CPI and SPI do not generally apply.
  ➢ Subcontracts – These are typically tied to deliverables and hence have a very high degree of confidence.

As you can see, the knowledge and strategies employed by the project manager are vital to project financial success. Cost analysis models are like computers – they are every bit as ignorant as they are useful. Communication with team members, process and/or product knowledge, awareness of priorities and many other characteristics are required for effective project cost management.

Corrective Action

The Wrong Turn Analogy

Have you ever used directions to drive to a certain place for the first time? Probably, all of us have. Under such circumstances, have you ever made a wrong turn along the way? Again (though depending on our gender, we may not admit it) probably all of us have. How did you know? And, more importantly, what did you do about it? How many of you decided to keep going down the wrong road until you reached your desired destination?

How did you know you made a wrong turn? Although you may not have realized it, you did so by constantly monitoring where you were and by performing a variance analysis.

The directions indicated that 1.5 miles after you made the last left turn, you should pass a small lake before seeing the entrance to the recreation area. But, you've now driven 2 miles, and all you see are cornfields. To make matters worse, you have a schedule dilemma. It's 12:35 in the afternoon – you're significant other is hungry. And unless you get back on the right course quickly, you're going to be late for the picnic. At this point, you have discovered the need for corrective action.

The Need for Corrective Action

➢ Executing a project without monitoring is like driving while blindfolded; you're going to crash. It's not a matter of 'if'; it's a matter of 'when?' and 'how bad is the crash going to be?'
➢ Without a variance analysis, monitoring your current situation is of little actual value. You may know where you've been and even where you are. But, where in the world are you going?
➢ And, without corrective action, the super-slick earned value analysis will only approximate by how much you will miss your planned objective.

When to Take Corrective Action

➢ Corrective actions should be taken in response to variances. It's a good thing we learned how to do an earned value analysis. This shows us where the variances are and how big the variances are.
➢ Thresholds on variances should be set. For instance, CPI < 0.9 or CPI > 1.2 may be the trigger for investigation and possible corrective action.
➢ Most attention is given to negative variances. As a result, negative variances should have lower thresholds than positive variances.

General Rules of Thumb for Corrective Action Triggers

➢ CPI < 0.95 – Cost overruns should be identified as early as possible and handled with great concern. Don't wait for the CPI to degrade too far for corrective actions to be effective.
  - o What was the cause(s) of the cost overrun?
  - o The 80/20 rule should be applied if a multitude of cost items are involved.
  - o Was schedule a factor?
  - o Was quality a factor?
  - o Can costs be recovered? Negotiated?

➢ SPI < 0.95 – Like cost, negative schedule variances should be addressed while it's still possible to get back on track. A 5% variance is much easier to overcome than a 10% or 20% variance.
  - o Why is the project behind schedule?
  - o Is efficiency a problem? Is it due to outside influences such as weather or labor issues?
  - o Was quality a factor? Rework?
  - o Is schedule recovery feasible? What resources will be required for recovery?

➢ CPI > 1.10 – Under-budget situations are good in general; however, large variances of this nature must be investigated and corrected in order to improve project (and company) performance.
  - o Were estimates accurate? Or does the estimating model need to be revised?
  - o Was this variance caused by a unique event that will not likely apply to similar future projects?
  - o Can the savings be dropped to contingency?
  - o Can the savings be dropped to gross margin?

➢ SPI > 1.10 – Ahead of schedule is a great place to be. Identification of positive schedule variances can allow optimization of resource utilization.
  - o Again, the original estimate should be questioned?
  - o Was it a unique event?
  - o Have resources been used intelligently? Effectively?
  - o Can resources be reduced without putting the project schedule in jeopardy? This is especially useful if other projects in the company are in need of these resources.

Application of Corrective Action

➢ First, you must understand the three overriding factors that affect project outcome.
➢ You must understand the relationships among these factors. Further, you must anticipate the collateral effects of corrective actions based on these relationships.
➢ Corrective actions should be made with primary consideration to the project outcome and secondary consideration to task outcome. It is typical that

corrective actions negatively may impact the cost of a task, while positively impacting the economic outcome of the project.

➢ Corrective action almost always requires teamwork. Project team members are not only the ones to implement corrective actions; they are typically the best source for corrective action ideas.

➢ Don't confuse corrective action with original plans or biases. Corrective actions are deviations from the original plan for purposes beneficial to project outcome. This may involve efforts to return to the original plan or efforts to develop and employ a new plan.

The 3 Major Factors Affecting Project Outcome

1. PERFORMANCE / QUALITY
   Performance / Quality is the number one priority. If the project deliverables (systems, services, facilities, products, or whatever) do not work or do not perform as well as or better than expectations, then nothing else will matter. Schedule and cost are no longer important, because it doesn't work. If the rocket can't make it off the launch pad, it doesn't matter how far ahead of schedule or how much under budget the rocket program was.

2. SCHEDULE
   Schedule and plan are almost synonymous. Managing the schedule **_is_** managing the project. Assuming that the deliverables meet expectations, the next most important thing is that they are delivered on time.

3. COST
   If the deliverables meet expectations and are delivered on time, then the project has necessarily been executed according to plan. It is likely in this event that the budget results will be acceptable even without extraordinary cost control. Cost is very important in project execution and should not be overlooked.

Relationships among the Big Three

1. Quality v. Schedule

   ➢ The proper level of quality should not adversely impact schedule. If so, then there is something wrong with the plan.
   ➢ Acceleration of schedule increases the possibility of quality problems, in some cases actually causing a likelihood of quality problems.
   ➢ Quality problems must be overcome – generally through revisions to plan, redesign, or rework to the deliverable. These situations invariably lead to schedule delays.

2. Quality v. Cost

   ➤ The proper level of quality should not adversely impact project cost. Rather, project cost planning and estimating should incorporate the appropriate level of quality.
   ➤ Cost reductions (without a high degree of prudence) can lead to lower quality. We have all seen examples of this. Don't be penny-wise and pound-foolish. Know the difference between cheap and inexpensive.
   ➤ Quality problems ***always*** lead to increased cost. The cost of rework is a loss of profit.

3. Schedule v. Cost

   ➤ Schedule and cost go hand in hand. Optimal cost management is only possible in conjunction with execution according to project schedule.
   ➤ Acceleration of project schedule is generally accomplished only with an increase in project costs due to greater resource allocation.
   ➤ Also, delays to project schedule generally cause an increase in project costs due the effects of extended labor.
   ➤ Schedule recovery is *COSTLY*. As my grandfather taught me many years ago, "It's much easier to get ahead and stay ahead than to get behind and catch up!"

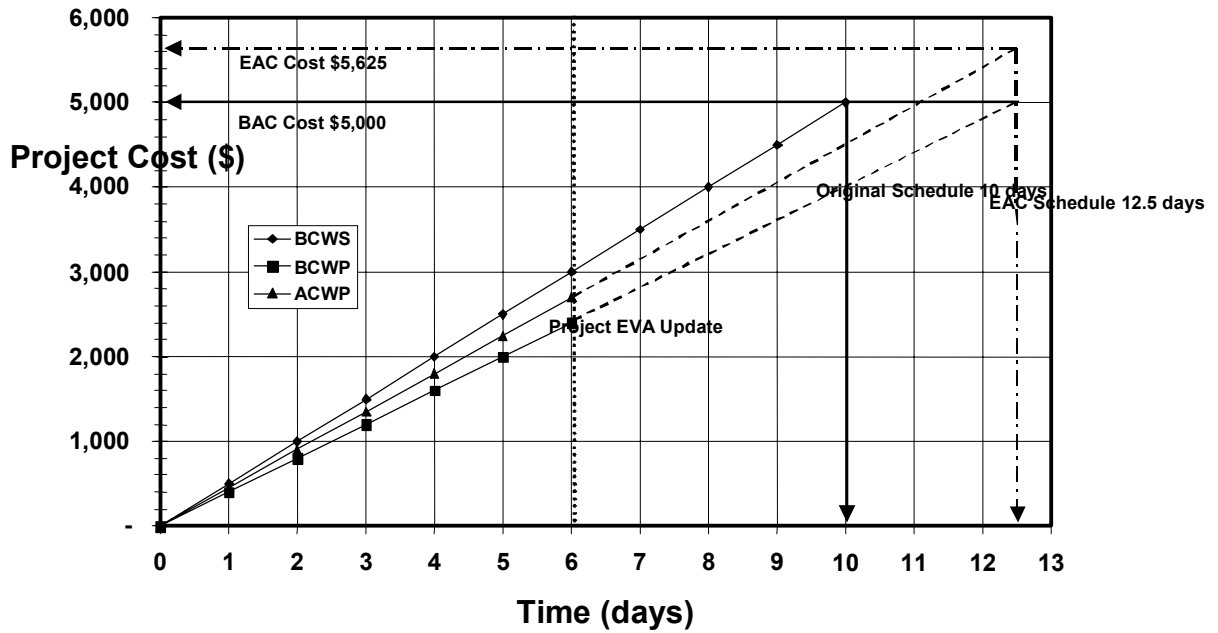## **Examples of Corrective Action**

Example 1: Schedule Recovery with Additional Resources

Recall EVA Case 6. The group of tasks is behind schedule and over budget. It is important to know how this task group fits into the overall project. If on-time completion of this task group were vital to overall project success, then a likely corrective action would be to apply additional resources to the task group in order to accelerate the schedule. Such corrective action will likely result in increasing the EAC, perhaps due to overtime labor costs. Along with schedule acceleration, special care should be paid to quality of work in order to avoid a catastrophe.
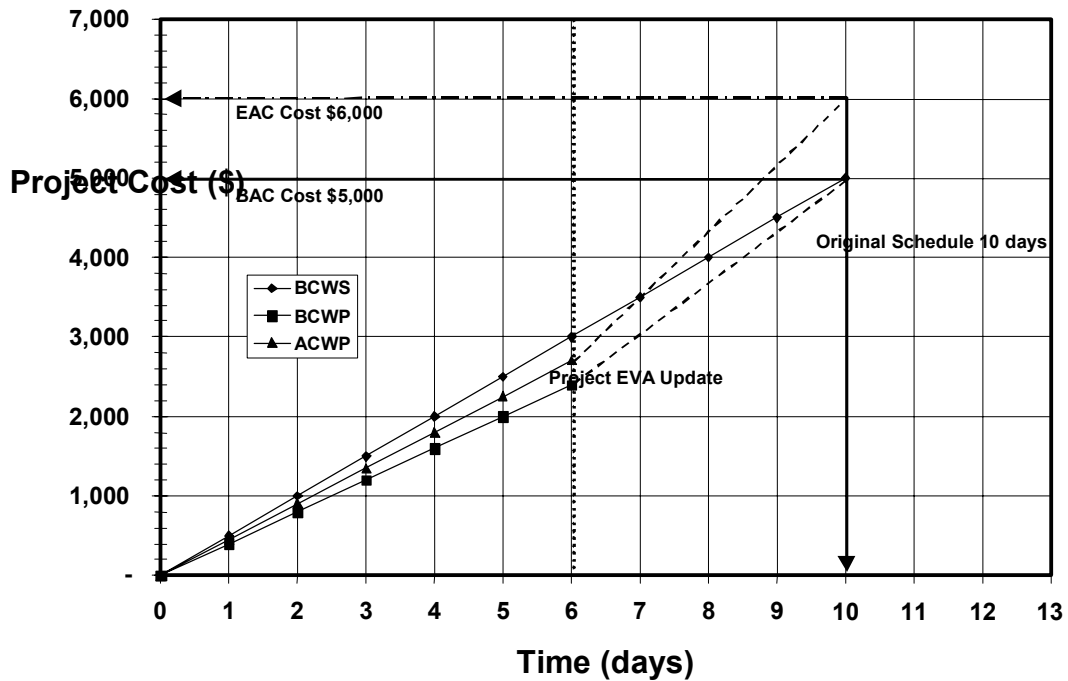
A graphical comparison of this corrective action versus no corrective action is shown below.

Corrective Action – Example 1

(EVA - Case 6)
No Corrective Action Taken

(EVA - Case 6)
Corrective Action - Schedule Acceleration

30

Example 2: Cost Mitigation

EVA Case 7 is shown below. This project is ahead of schedule but over budget. This situation is often the case when slow business allows too much labor to be applied to the project. Oversupply of labor resources generally leads to lower productivity. Therefore, although the project is ahead of schedule due to the increased resource loading, the cost of completing tasks is at a higher rate than planned.

 As of the EVA update after day 6, CVAR = -$600. In this case the project manager has discussed labor reallocation with functional managers and has convinced them to reduce labor to levels more appropriate to the plan. The result is that ACWP more accurately tracks BCWP for the remainder of the project.

Note that the -$600 variance is maintained through the end of the project. Had these labor costs remained unchecked, the variance at completion would have been -$833. Although the project still finishes over budget, a savings of $233 has been realized.

While the numbers in this example are small, the improvement on a percentage basis is certainly worthwhile especially if executed on a larger project.
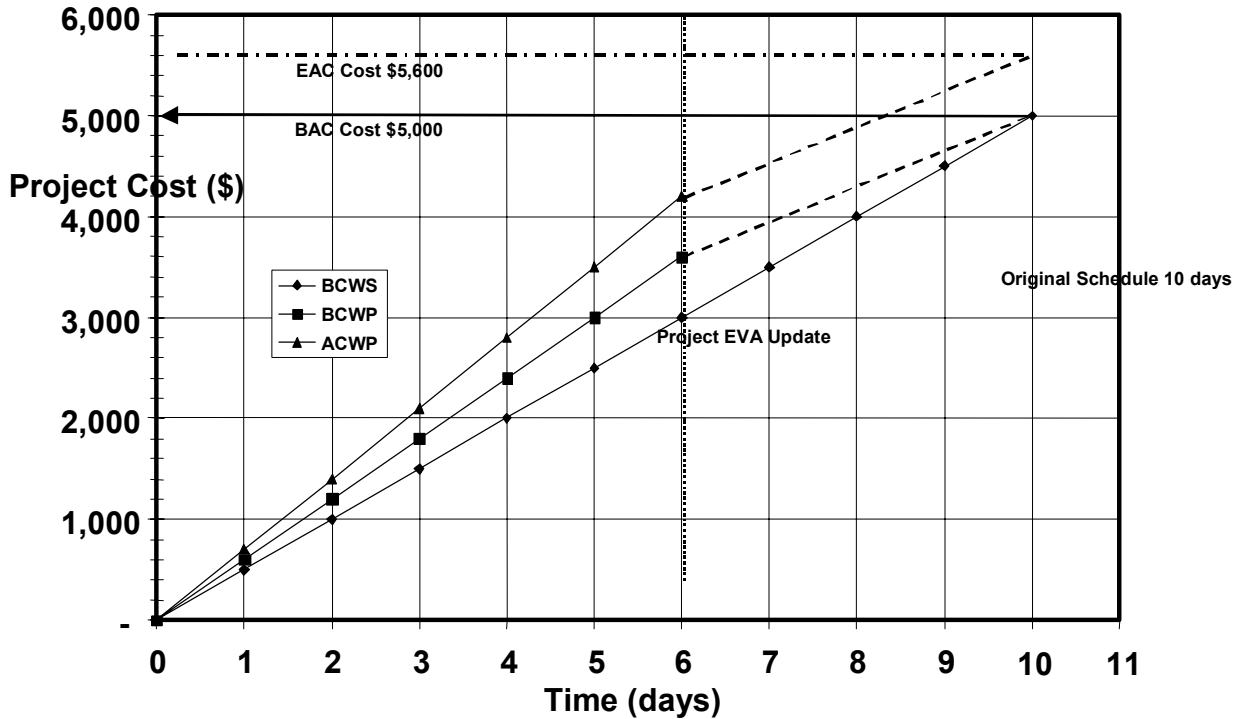
% Improvement = $\underline{233 \text{ x } 100}$ = 4.0% based on original EAC Cost of $5,833
                         5,833

Corrective Action – Example 2

(EVA - Case 7)
No Corrective Action Taken
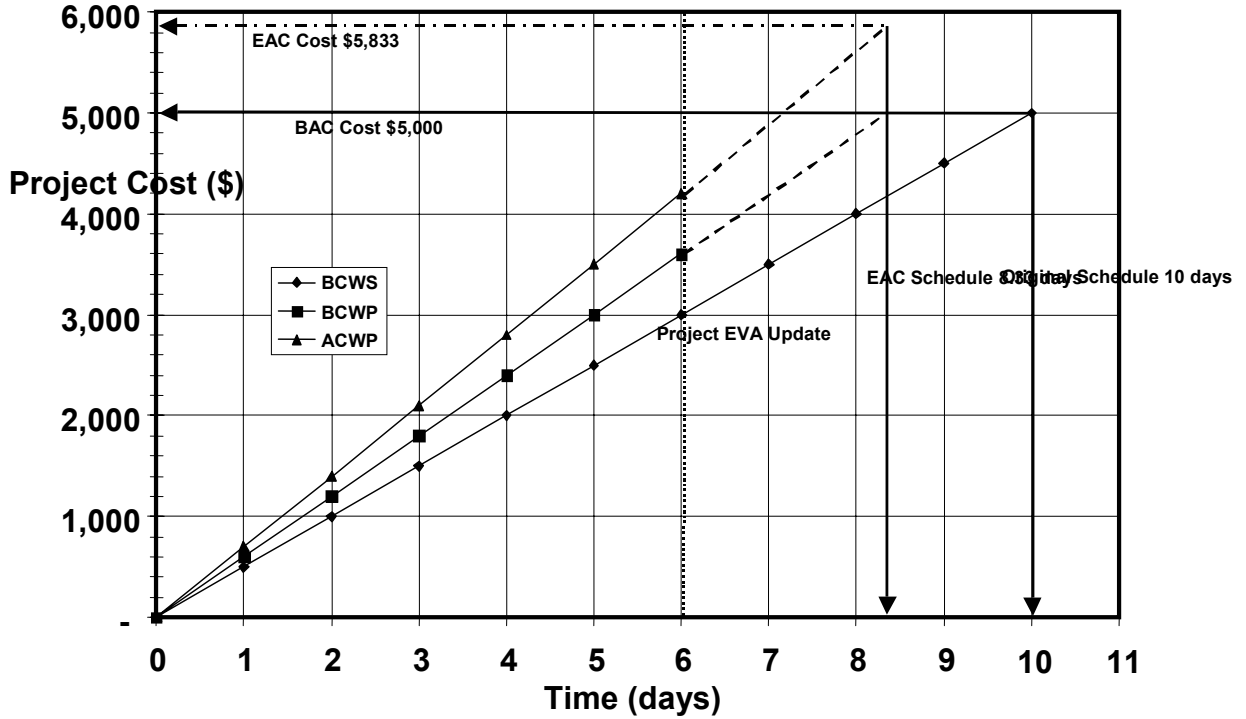
(EVA - Case 7)
Corrective Action - Mitigation of Costs

Example 3: Too Good to Be True

EVA Case 8 is shown below. This project has actually been completed – some 20% ahead of schedule and 32% below budget. Everything looks great, so is there any need for corrective action?

Positive variances of this magnitude are rarely due to aspects of project execution. Most likely, the cost estimating process was flawed. The bottom line is that the actual costs are no where near the planned costs. If these estimates are used to price similar future projects in competitive bid situations, there is a good chance that this project will be the last.

So, the corrective actions here should include review and probably modifications to the project-estimating model.

And, perhaps some of the proceeds should be used to celebrate the superior project results – you've got to keep the team members happy!

Corrective Action – Example 3

(EVA - Case 8)
Well Ahead of Schedule and Well Under Budget