EVM.01

Earned Value Analysis – Why it Doesn't Work

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For many companies looking to improve project performance, earned value analysis (EVA) seems a logical technique to use on projects to better understand and manage performance. Procedures are written and some training provided. The project managers are then told to start using earned value, with the management expectation that project results will soon improve. Usually about a year later reality sets in. No improvement is achieved, project management costs are up and people are complaining about all of the 'extra paperwork.'

The company then either decides to drop use of earned value, or brings in a consultant to help figure out what corrective actions should be taken to get earned value 'back on track'. The author has been this consultant for companies, and this paper will cover the 'Dave Letterman' list of the top 10 pitfalls that can make the use of EVA unsuccessful, along with suggested corrective actions that can be applied to projects to counter these hazards.

This paper will first provide a review of earned value terminology, formulas and key metrics to monitor when using earned value analysis. After this review, the common errors encountered in implementing EVA and corrective actions will be covered in detail. By the end of this paper you'll hopefully realize this paper really isn't just about using earned value analysis, but really covers the more important topic of having a complete and integrated project plan in place, which is a cornerstone of earned value management.

EARNED VALUE TERMINOLOGY

Let's start out by clarifying the terminology associated with Earned Value, because many people incorrectly use the terms below interchangeably, and they are distinct and different. The terms are:

- **Earned Value Analysis (EVA)** - a quantitative project management technique for evaluating project performance and predicting final project results, based on comparing the progress and budget of work packages to planned work and actual costs.
- **Earned Value Management (EVM)** – a project management methodology for controlling a project which relies on measuring the performance of work using a Work Breakdown Structure (WBS) and includes an integrated schedule and budget based on the project WBS.
- **Earned Value Management System (EVMS)** – the process, procedures, tools and templates used by an organization to do earned value management.

The point is that you can do earned value analysis calculations on any project, but unless you have complete earned value management in use on your project, it will be extremely difficult to obtain accurate results. In order to easily use EVM, your organization really needs to have an earned value management system in place.

EARNED VALUE DEFINITIONS

Earned value analysis uses three key pieces of project information, which are the planned value, actual cost and earned value, which are shown in figure 1. The first two terms are not new, they are the plan spend curve and the actual cost expenditures curve many project teams have been using for years.

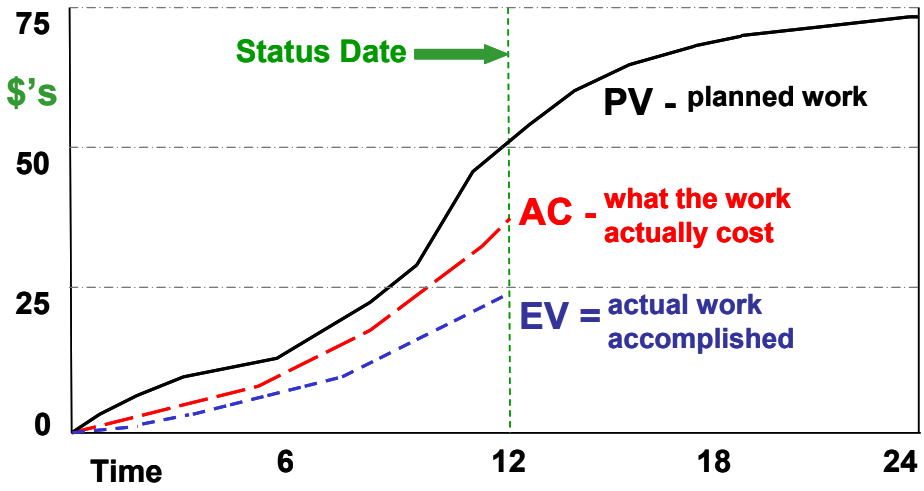

Figure 1–Typical Curve Showing PV, EV and AC

Planned Value (PV) is 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 (BCWS).

Actual Costs (AC) is simply the money spent for the work accomplished. This is also known as the actual cost of work performed (ACWP).

Earned Value (EV) is the percent of the total budget actually completed at a point in time. This is also known as the budgeted cost of work performed (BCWP). EV is calculated by multiplying the budget for an activity by the percent progress for that activity:

EV = % complete x budget

For example, if a work package is the installation of 500 new computers in an office, and 350 computers are installed, the work package progress is 70 percent complete (350/500). If the budget for this work package is $200,000, then the earned value is $140,000 (0.70 x $200,000).

HOW TO MEASURE PROJECT PROGRESS

The example above shows a very simple situation for evaluating progress. On projects, determining realistic progress for work packages (WP) is usually more difficult, but is essential for ensuring the earned value analysis is accurate and meaningful.

So how much work was accomplished? This is a common question project managers ask team members. Too often, progress is reported in a qualitative manner. One frequent expression is "I'm almost there" or I'm 90 percent done." After weeks of hearing that same progress report, the project manager begins to suspect that just maybe the person responsible for the work package really doesn't know how much progress has been made.

Quantitative techniques are obviously much better than qualitative (subjective) techniques for measuring project progress. One thing to keep in mind when measuring project progress is that it's an estimate! Many people spend too much time trying to generate a very exact number especially when using quantitative techniques. The key is to make it "fit for use". Don't spend exorbitant amounts of time determining exact numbers on a small work package. Focus your efforts on the larger value work packages. Remember that measuring progress is an estimate, and that the inherent errors on each work package will tend to cancel out as you roll up the progress numbers to a project level.

Since the types of work packages on a project vary, no single progress reporting method is suitable. The seven most common methods for reporting project progress will now be described.

Quantitative progressing techniques are:

- **Units completed** - tasks that involve repeated production of easily measured pieces of work, when each piece requires *approximately* the same level of effort.
- **Incremental milestones** - work packages (WP) that can easily be divided into a series of tasks handled in sequence. The work is divided into separate, measurable tasks, and completing each task is considered achieving an "incremental milestone". Progress is earned only when reaching each milestone.
- **Start-finish** - low value and/or short duration activities without readily definable intermediate milestones. Either no or some limited progress is "earned" when the activity is started, and 100 percent progress is earned at the completion of the activity.

Qualitative (subjective) progressing techniques are:

- **Level of effort (LOE)** - used when it's very difficult to measure what work was accomplished for the budget spent. LOE assumes the progress is equal to the actual costs divided by the budget. For example, if the project manager's budget on a project is $20,000, and $10,000 has been charged to the project, then the progress is calculated as 50 percent.
- **Individual judgment** - used for complex work not easily measured by other methods. Even though this is subjective, getting multiple opinions on the work accomplished by knowledgeable team members helps determine a more reasonable estimate on progress.

Two other progressing techniques commonly used are listed below. The can be either quantitative and/or qualitative depending on how used. The techniques are:

- **Combination techniques** - good for complex work occurring over a long time period and use two or more of the other progressing techniques. An example would be installing a building foundation. The excavation progress would be units completed (cubic yards of earth removed), the formwork could be incremental milestones and pouring the concrete is start-finish (0 percent/100 percent).
- **Apportioned Relationship -** has a direct intrinsic performance relationship to another discrete work package, which is called the 'measurement base'. For determining progress, the apportioned work package progress is the same value as the measurement base work package.

EARNED VALUE ANALYSIS CALCULATIONS

With the terms PV, EV and AC defined, along with how to determine progress, some key calculations can easily be done and will provide important information on how the project is doing. The formulas for earned value calculations are:

- Cost Variance: **CV = EV – AC**
- Schedule Variance: **SV = EV – PV**
- Cost Performance Index: **CPI = EV / AC**
- Schedule Performance Index: **SPI = EV / PV**

A CPI value of 0.83 implies that for every project dollar spent, only $0.83 in earned value was accomplished. A CPI of less than one and a negative CV indicates project cost performance is below the plan.

A SPI value of 1.05 implies that for every dollar of work the project had planned to accomplish at this point in time, $1.05 worth of work was actually done. A SPI greater than one and a positive SV indicates more work has been accomplished than was planned. Note how this is worded since a SPI > 1.0 does *not* necessarily mean you are ahead of schedule! You can accomplish more work than planned by working on non-critical path work packages. You need to look at project float to determine whether you are ahead, on or behind schedule.

Figure 2 shows the planned value, actual cost and earned value for a project. Note that when the planned spend curve is compared to the actual spent, it shows a variance of +$15. An uneducated observer is likely to conclude the project team is accomplishing the planned work and doing it for less money.

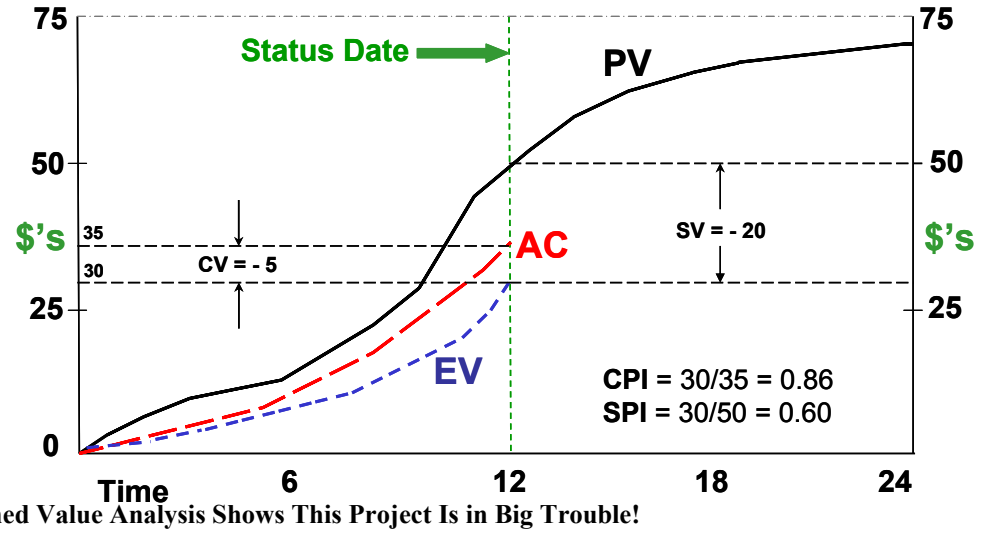

Figure 2–Earned Value Analysis Shows This Project Is in Big Trouble!

However, analyzing the project using earned value gives a different picture. Reading from the graph shows a cost variance of -$5 and a schedule variance of -$20. The project team has accomplished ("earned") $30. However, at this point in time the schedule plan was to accomplish $50 of work. Therefore, the project team is $20 behind in schedule work. In addition, the actual cost for the work accomplished was $35 and the budget for the work accomplished was only $30. This means the project team has overspent for the work done. The bottom line is earned value analysis clearly demonstrates this project is in big trouble!

SPI: A BAROMETER ON SCHEDULE PERFORMANCE

Figure 3 shows a useful graph to use on a project, which is a plot of the project SPI value versus time. A SPI greater than 1.0 implies the team is accomplishing more work than planned, and a SPI less than 1.0 indicates the team is accomplishing less work than planned. You need to be careful using SPI, because you really can't determine the project health without knowing how the team is doing against the critical path in the project schedule. A team can achieve a SPI > 1.0 by working on non-critical path activities. Therefore, it's very possible to have an SPI > 1.0 and be behind schedule! You need to look at the project float to determine complete schedule performance.

Figure 3 is from an actual project, and like many projects the SPI for the first few reporting periods is less than 1.0, since the team is in start-up mode and project activities are just being started. However, if the SPI does not go above 1.0 after the first few reporting periods, it's a good indication there could be schedule problems and it's time to start taking action.

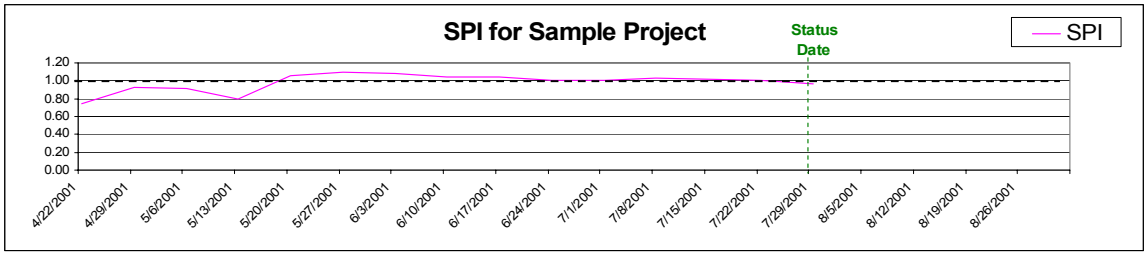

Figure 3–Plotting SPI is a Good Schedule Performance Metric

USING CPI TO DETERMINE FINAL PROJECT COST

The cost performance index is an excellent indicator of the cost efficiency for completed work. The main use of CPI is forecasting the final project cost. Before listing the common formulas used, a few terms need to be defined:

- **Estimate to Complete (ETC)** - the expected *additional* cost needed to complete the project.
- **Estimate at Completion (EAC)** - The expected total cost of the project when the defined scope of work is completed.
- **Budget at Completion (BAC)** - The total approved budget when the scope of the project is completed (including any project contingencies).

Most techniques for forecasting EAC include some adjustment of the original cost estimate based on project performance to date. The three common formulas are:

- **EAC_1 = AC + (BAC - EV)** This formula is called the 'mathematical' or 'overrun to date' formula in some textbooks. However, using the term 'overrun to date' is incorrect because the project could be under on costs and ahead of schedule. This formula assumes the plan will be met for the remaining work (CPI = 1.0), and yields the most optimistic EAC when a project is not doing well.
- **EAC_2 = BAC/CPI** This formula is called the 'cumulative CPI' in some textbooks, and assumes the entire project will be done at the same cost performance (current CPI does not change).
- **EAC_3 = BAC/(CPI x SPI)** This formula considers both cost and schedule impact on the EAC, and usually yields the most pessimistic EAC for a project not doing well.

Figure 4 below shows the relationship of BAC, ETC and EAC. Note that the project cost contingency is not spread as part of the Planned Value curve. Contingency is a provision in the project plan (extra $'s and time) to mitigate the typical (but undefined) unplanned events that happen on projects – to cover 'known unknowns'. When calculating the ETC and EAC, some thought should be given to whether an adjustment is needed for the remaining contingency.

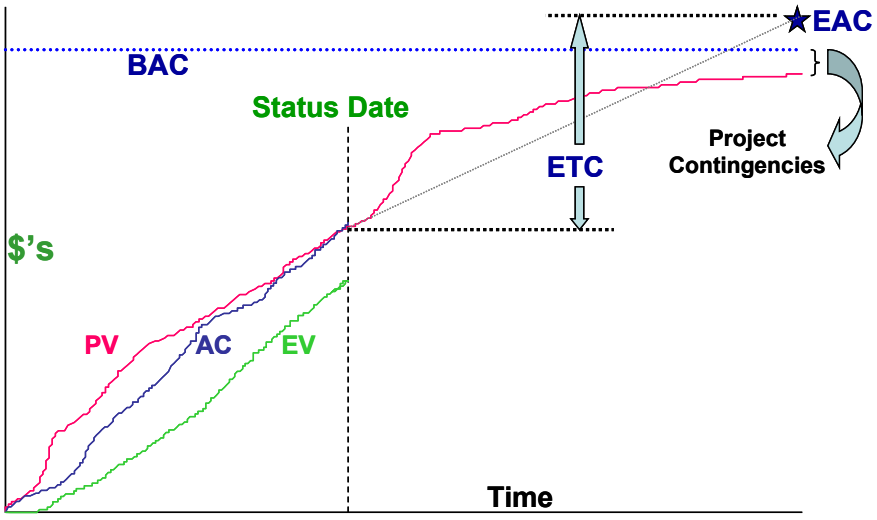

Figure 4 – Displaying ETC, EAC and BAC on the EV graph

TO COMPLETE PERFORMANCE INDEX

Another useful evaluation tool is the '**To Complete Performance Index**' (TCPI), which provides a forecast of the required performance level, expressed as the CPI, which must be achieved on the remaining work in order to meet the project financial goal. The TCPI calculation can look at either the current authorized budget or the current estimate-at-completion.

TCPI provides a sanity check for the project manager on whether the required CPI for the rest of the project is realistically obtainable. Of the two formulas, looking at the CPI required to complete the project based on the estimate-at-completion is probably more meaningful.

The two TCPI formulas are:

$$TCPI_{(BAC)} = \frac{\text{Work Remaining}}{\text{Funds Remaining}} = \frac{(BAC - EV)}{(BAC - AC)}$$

$$TCPI_{(EAC)} = \frac{\text{Work Remaining}}{\text{Funds Remaining}} = \frac{(BAC - EV)}{(EAC - AC)}$$

Figure 5 – TCPI Formulas Based on BAC and EAC

Research has shown the cumulative CPI will stabilize *as early as* the 20 percent completion point of the project, and "researchers found the cumulative CPI does not change by more than 10 percent once a contract is 20 percent complete; in most cases, the cumulative CPI only worsens as a contract proceeds to completion"[1]. This may be too pessimistic, but no later than 30 percent completion, it's reasonable to expect the CPI won't change by more than 10 percent. For example, if the project CPI is 0.80 at 30 percent completion, the best you can expect is a final CPI of 0.88 which means your budget will overrun by at least 13.6 percent (1/0.88).

TOP TEN MISTAKES

There are many project maturity models in use today, and many use a five level format where level 1 is chaos, level 2 is some rudimentary project management techniques in use, but inconsistently across projects, and level 3 is having a process and procedures in use across projects. If your organization is not at least a level 3 maturity level, you should not be using earned value. Here is an analogy. If you are just learning to dive, you would dive off a board close to the water surface to learn the basics. Once you become proficient, you move to a 3 meter diving height, then later to a 10 meter diving height to learn advanced skills. If you're new to diving, you would not start with the 10 meter diving height unless you are looking to fail! The same applies to the use of earned value analysis. If you don't have a project organization with a maturity level of 3 or higher, trying to apply EVA will only lead to failure.

Let's not leave you hanging in suspense. Based on the author's experiences, listed below are the top 10 reasons why Earned Valve Analysis doesn't work:

- no documented requirements;
- incomplete requirements;
- WBS not used or not accepted;
- WBS incomplete;
- plan not integrated (WBS-Schedule-Budget);
- schedule and/or budget incorrect;
- change management not used or ineffective;
- cost collection system inadequate;
- incorrect progress; and
- management influence and/or control.

The remainder of this paper will delve into each of these reasons in more detail, and provide suggestions on how to overcome the specific problems. Let's look at these one at a time.

No Documented Requirements

A project is undertaken to deal with a specific opportunity or problem. Therefore, every project has a specific objective such as 'meet Environmental Protection Agency (EPA) air emission standards'. Requirements define the project product – what will be created and used by the client as a result of doing the project.

Unfortunately, all too often a client starts a project, and engages a project team who immediately starts working with the client to define the scope of the project. For example, a client may hire a project team to install a water spray scrubber to meet an EPA emission rules, and the project team immediately jumps into action and starts the design of equipment, structural supports and ductwork without stepping back to ask the more pertinent question of whether the equipment will really solve the problem. In this case the problem is reducing specific air emissions and

the customer already picked the 'how' (the water spray scrubber), which may not meet the real need since requirements including types of contaminants and final concentration levels were not defined.

No requirements can be a delicate issue and you obviously have to be sensitive in how you broach this subject with the client. As figure 6 below shows, without requirements, the link to developing a quality WBS is broken. In order to help ensure a successful project, the project team must work with and support the client in documenting the project requirements. Some people may object to this, believing that the role of the project team is to deliver the requirements as defined by the client. But keep in mind nobody looks good on a bad project, and that's the probable outcome if the project proceeds without documented requirements.

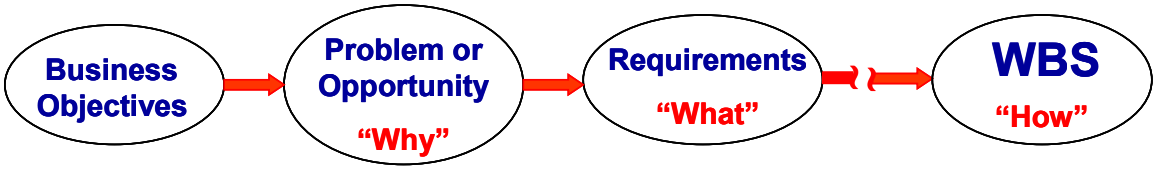

Figure 6 – Requirements Describe 'What' Is Needed

Incomplete Requirements

This is related to reason #1, but in this case the client has defined requirements and issued a request for proposal (RFP) so the project team can deliver the product the client wants. However, in many cases clients do not have project experience, or are too busy with other job assignments to take the time to fully develop requirements. Or the client may list the 'how' instead of the 'what' in the RFP.

For example, stating a 3,000 square feet (SF) cafeteria is needed instead of stating a cafeteria is needed for a peak of 100 people. The danger here is that the project team may deliver the functionality, cost and schedule and still have an unhappy client, who now has a product which really isn't what they need. A 3,000 SF cafeteria probably won't suffice for 100 people. So who do you think will get blamed? The project team has to invest the time to work with the client to ensure the requirements are *completely* captured and accurately reflect what is needed to meet the project objectives.

WBS Not Used or Not Accepted

The WBS is the key project plan document. As shown in figure 7, without a complete WBS, the schedule and budget will not accurately reflect what it will take to successfully complete the project. A good technique when responding to a RFP is including in the proposal scope of services the project WBS. Unfortunately, most often what you see is a long narrative on what the service provider will do for the client. A narrative that provides a detailed description of what will be done can be useful, but it's more important to start with the WBS!

The other issue that can occur is when the project manager prepares a WBS, and the team really doesn't see the value and provides at best minimal cooperation. The project manager must 'talk up' the value of using the WBS and make it clear this will be the 'foundation' document for the project. Otherwise, the WBS won't be maintained and quickly becomes obsolete.

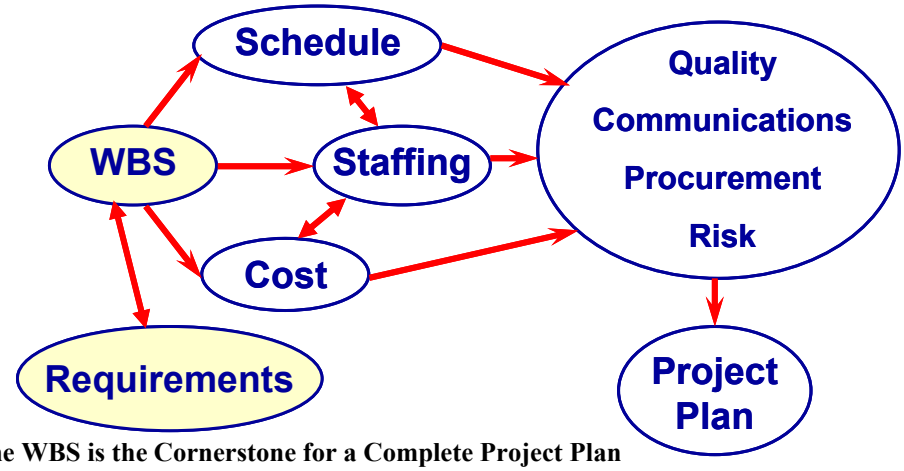

Figure 7 – The WBS is the Cornerstone for a Complete Project Plan

WBS Incomplete

This is related to the #2 problem of having incomplete requirements. Obviously, if you have incomplete requirements, your WBS will also be incomplete, but stakeholders may not realize it. The flip side is having complete requirements, but the WBS isn't checked against the requirements and one or more requirements are missed. The method to avoid this is using a WBS dictionary, and including a field that lists the requirements covered by each WBS element. The WBS should also be checked to see if it includes deliverables that do not relate back to the requirements. If this occurs, the items may not be needed and should be considered for deletion.

Plan Not Integrated

You actually have complete requirements and a fully developed WBS that covers all requirements. The next problem often encountered is the estimator and/or scheduler develops their product and it isn't based on the WBS. The estimator will state that the WBS wasn't developed with his input, and he can't create the estimate to match the WBS – too bad nobody talked to him. The project manager is responsible for making sure the people preparing the schedule and estimate are involved in the WBS preparation and are in alignment with providing the budget and schedule to match the WBS elements.

Once your WBS is established, the project summary schedule is prepared. One frequent problem is the project team creating schedule tasks that do not relate back to the WBS. The project summary schedule should have tasks corresponding to each WBS work package. However, there are a few exceptions to this rule. For example, it does not make sense having a schedule task for ongoing project administrative functions such as administrative support.

The project estimate is also prepared once the WBS is established. By definition, the work package level is where work is authorized, performance monitored and costs collected. The project estimate should have for each work package a statement of work (what's expected) plus an authorized budget. It's also important to have performance responsibility for each work package assigned to just one individual. This makes the project managers job much easier in obtaining status information.

By preparing a project schedule and estimate that matches back to the WBS, you have created a project plan that gives you cost and schedule integration! The next step is to measure how much progress has been accomplished on your project. Once the progress is determined, you will be able to easily perform earned value analysis on your project.

Schedule and/or Budget Incorrect

The author reviews schedules for clients on a frequent basis, and over 90 percent of the time the schedule is incorrect. Common mistakes include hangers, improper relationships, and misuse of constraints. Budget and estimating errors can also happen for numerous reasons including miscommunication, quantity errors or use of wrong rates. The key here is having a quality control process in place, which should include review of project plan deliverables such as the schedule and estimate by experienced project personnel. Everybody makes mistakes, so it's important to have a process in place to catch as many mistakes as possible before the project plan is finalized.

Change Management Not Used or Ineffective

There can be several issues here, the most serious not having a change management process in use for the project. Change management must be addressed in the project plan, and includes the procedure for handling scope and variance changes, the forms to record and evaluate change requests, the review and approval process for changes, and the process to ensure changes are incorporated into the current plan so the earned value calculations remain relevant.

The second potential problem area can be changes that occur but are not recognized. The issue can be design team members who decide to add scope items to 'improve' the final product, and don't realize the added cost or time that will be incurred during execution. The best way to catch this is for the project manager to get out and talk to team members to hear what's going on and where 'extras' might be creeping into project scope.

Most projects include contingencies, which is defined as an allowance for "known unknowns" such as rework, estimating uncertainty, unforeseen events or problems. When you prepare your planned value (PV) spending curve you really don't know when (or if) you will spend the contingencies. Therefore, the PV spending curve for the project should reflect the project sub-total without contingencies or other allowances such as inflation. The change management process should be used to allocate contingencies to project work packages. When a change is approved, the budget for the effected work package is changed:

Current Work Package Budget = Original Budget + Approved Changes

With the computer software available today, making changes to the PV spending curve is very easy. When a change is approved, the plan has changed and the PV spending curve should be modified.

One good method of showing the available project contingencies is to draw a horizontal line for the approved project budget on the cost versus time graph. The difference between this line and the PV spending curve at project completion is the remaining contingencies (refer back to figure 4).

Another good tool to use with change management is the contingency drawdown curve. This gives an indication regarding how much cost and schedule contingency remains. In the example below, extrapolating the schedule and cost contingency indicates the project will use up all of the schedule contingency well before completing the project, but the cost contingency probably will not be completely used based on performance to date.

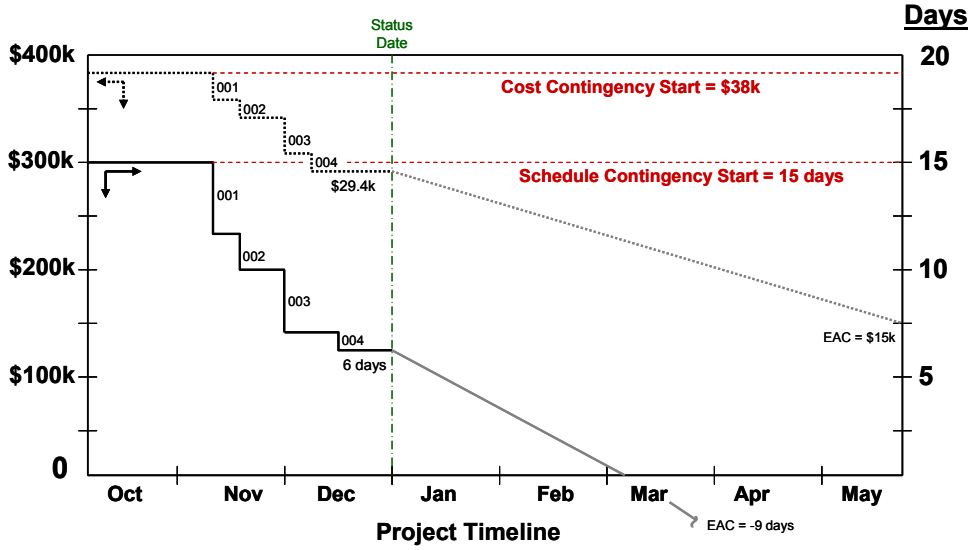

Figure 7 – The Contingency Drawdown Curve is an effective control tool

Cost Collection System inadequate

Earned value will not work unless you can obtain accurate actual costs for your project. Companies with multiple cost systems in use make cost collection and reporting extremely difficult. A limitation of cost systems is that they only show actual costs for invoices received and/or paid. Any work that is contracted and any purchased items will typically have invoices that lag by a month or more from when the work was actually done. Therefore, using information from your cost system for earned value calculations can be very misleading! To get around this problem, use an "adjusted actual cost" column for reporting actual costs (AC). Adjusted actual cost uses the actual cost from your cost system, plus your estimate for outstanding invoices for work accomplished, which are called accruals. The project plan should include the procedure for reporting costs. This includes the frequency of reporting costs, and how 'adjusted actual' costs will be determined and reported.

Incorrect Progress

Earned value is considered a 'quantitative technique' for evaluating project performance. However, it really hinges on how progress is reported. Earlier in this paper the various progressing techniques were described. Earned value works best when the progressing techniques are quantitative, such as units completed or incremental milestones. One important gauge is to look at how much of the project is using the level of effort (LOE) progressing technique. If LOE is 10 percent or more of the total budget, there is a good chance you really are not getting an accurate measurement of the project progress.

Using qualitative techniques for reporting project progress also allows for team bias to creep into the reported progress. Reporting progress that is behind plan brings unwanted attention to a person as being a 'problem'. The obvious easier approach is to make sure your reported progress is on or ahead of plan. However, this may just postpone the inevitable negative news if you really are behind plan.

Management Influence and/or Control

The final potential problem when using earned value can be management pressure to influence the reported results. Management may have various reasons for wanting to influence what is reported. It can be company targets for the quarter that 'must' be met related to project incentives, or just the normal human behavior of trying to avoid 'bad news' in the hope the problem performance can be reversed.

Earned value is the most effective technique for providing information on project performance. It communicates scope, schedule and cost status information to project stakeholders. Properly used, earned value is a flexible process that provides timely information on the project health. Effective use of earned value concepts can provide a competitive edge in successfully delivering projects.

The most common reason given for not using earned value analysis is "I haven't got the time". So here's the good news: if you have prepared your project plan properly, earned value analysis takes essentially no additional effort! The key is having complete requirements and a good project plan, which includes the WBS to fully document scope, and a schedule and cost estimate that is integrated to the WBS. Having these in place means you are using earned value management! On the flip side, if your project does not have these items in place, doing earned value analysis will give you inaccurate and misleading results and won't be worth the time and effort.

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