How to Manage a Program Effectively

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Abstract:
This paper will describe the importance of cost estimating to Program Control. Specifically, it will consider the policy for Earned Vale Management (EVM) and the need to consider the deviation from the baseline program in an EVM System (EVMS). Through the integration of a parametric model with an EVMS application, on based upon frequent re-evaluation of the baseline, it is possible to increase the confidence in the EVM metrics.

The paper will elaborate on Chapter 7 of the "Systems Cost Engineering" book published by Gower and edited by Dale Shermon. It will consider how EVM can be applied using the TruePlanning® cost models. After a simple example, to explain the principles behind this parametric solution, the paper will elaborate on this application of the hardware, software and IT parametric cost models with a practical example of a program baseline being monitored against earned value.

The technique is transferable and equally applicable to all government procurement agencies or customer initiatives where program management needs to be monitored and reviewed. With the application of a parametric methodology this is a realistic proposition with limited resources.

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Cost control on a project is the discipline of reconciling planned cost or man-effort to actual cost or man-effort while considering the achievement of the project. This combination of planned, actual and achieved provides the basis of Earned Value Management (EVM).

I drive to the office when necessary to attend meetings, teach classes or meet customers. This trip involves the M4 motorway and a series of A-class roads. The distance is 81 miles and will take 1 hour and 20 minutes. Why is this relevant to project cost control?

Before we start to look closely at EVM and my journey to work, it is worth briefly mentioning other methods of cost monitoring and control. Cash flow management is the discipline of accountancy which ensures that liquid capital is available to the working of the organization. It is of little interest to the average employee that a project has accrued a healthy income. The average employee cannot buy their weekly groceries with accruals. Cash into an organization is its life blood; it enables the organization to survive. Many profitable companies have been dissolved due to lack of cash flow.

A consistent cash flow is a time-driven indicator that the project is running acceptably. It is also important that milestones are met to enable milestone payments to be claimed. These are event driven achievements and form the basis of a cost management process. These milestones need to be tangible and well defined; Cost Engineering can often identify solid achievements which would make good milestones.

The Baseline

It is critical to the successful and fruitful outcome of a project to determine the baseline correctly. The customer will normally provide a Statement of Work (SOW) which indicates the general direction of the project in its broadest form and desired outcome. The Work Breakdown Structure (WBS) created during the proposal will identify the activities that need to be successfully accomplished to enable a technical well-engineered solution to be the end result. These activities can be grouped into convenient Work Packages. They are normally assigned to technical leaders responsible for the work and may not correspond to a milestone. Therefore, it is the project manager's responsibility to manage the work in such a way that payments are received regularly and that technical progress is made.

The Work Packages containing the activities will have resources allocated to them. These resources are part of the Organization Breakdown Structure (OBS) of a company. They consist of the labour, material and other direct costs that will be consumed during the conduct of the project. The intersection of the WBS and the OBS is a Control Account (see Figure 7.1).

Establishing a cost baseline for this project will result from the proposal estimate. It will be necessary to take the winning proposal and possibly rearrange the cost estimate into the Control Accounts if the customer structure for the proposal was not aligned to the originator's OBS and WBS natural structure.

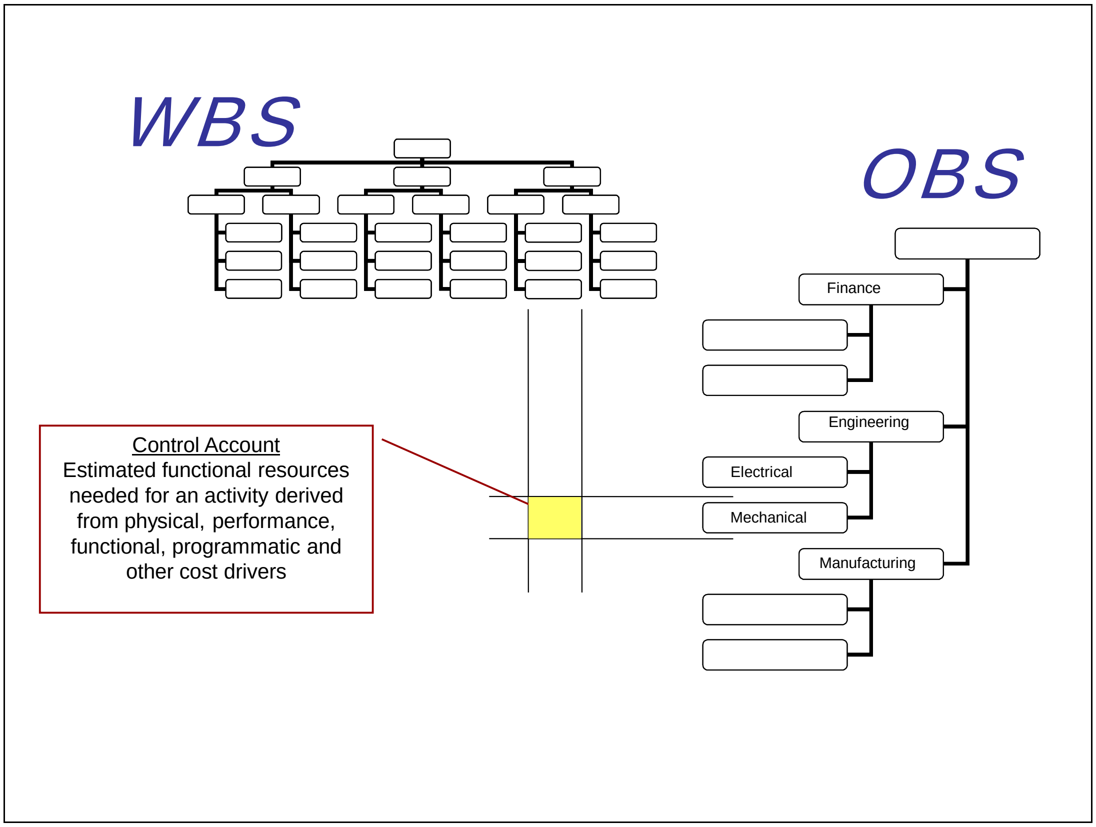

Figure 7.1 Definition of a Control Account

Earned Value Management (EVM)

Having determined the baseline resources for the Control Accounts, the project can begin. Tracking time is easy: days pass and weeks pass when difficult technical problems need to be solved. Accounts departments with timesheets ensure that costs are gathered and religiously allocated to the correct Control Accounts. But what about performance?

Figure 7.2 is generally recognized as the time, cost, performance triangle of projects. The three elements each have an influence upon the others. What is required is a technique to assess the performance of a project. Earned Value allows us to do that. It also enables organizations to forecast the cost and time to completion, but unfortunately not performance.

There have been many books written about the Earned Value Management (EVM) project control technique. It is not my intention to detail the theory here, but to consider the basic principles, then to explore the advantages of integrating EVM with parametrics.

Earned Value is also known as the Budgeted Cost of Work Performed (BCWP). The BCWP needs to be determined accurately to ensure that any performance indices that are calculated to enable future projections are accurate. It is therefore important at the outset of a project to spend considerable time and effort establishing credible BCWP values from the proposal that technical leaders are prepared to commit to. It can take weeks of effort to determine the correct baseline, and maintaining this baseline can be very time consuming. In some cases, armies of staff have been employed on projects to maintain this baseline.

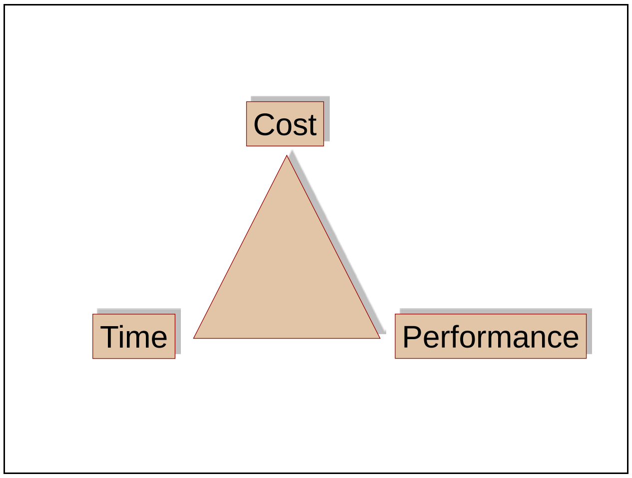

Figure 7.2 The time, cost, performance triangle

Once the project is underway the Actual Cost of Work Performed (ACWP) can be monitored. This represents the actual cost of completing the work itself in any given period of time. From these two pieces of information it is possible to determine cost variances which are the difference between the Earned Value and Actual Cost. The cost variance is the BCWP less the ACWP. If the outcome is positive, we have an efficient project and if it is negative then action needs to be taken.

For my journey to work the Budgeted Cost at Completion (BAC) is 1 hour and 20 minutes or 80 minutes. The Membury service station on the motorway marks the half way point to work. (It is next to the 500 foot Membury transmitting station for broadcasting and telecommunications, which I find hard to miss even on the earliest of mornings.) I know that my Budgeted Cost of Work Performed (BCWP) at this point needs to be 40 minutes.

If I manage this first part of the journey in 45 minutes, the journey variance would be the Earned Value (40) less the Actual Cost (45), resulting in 5 minutes – not good progress. Rather than a variance, EVM systems would also determine a performance index which is given as a ratio of the Earned Value divided by the Actual Cost, or 40/45, which is 0.88. A performance index of less than one is not good and a performance index of greater than one would indicate good performance. Either calculation is beginning to indicate that I might be late for work. A similar calculation can be conducted for the schedule of projects.

It is useful having the parameters and indices of past performance, as these can be used to estimate the project outcome assuming the same performance to the completion of the project. My Budgeted Cost at Completion (BAC) has not changed at 80 minutes; if I use the cost variance, my absolute variance is the best progress I can make, or BAC + Cost variance at present = 80 + 5 = 85 minutes. This assumes that matters will not get any worse for my journey.

If I utilize the cost performance index, I can get 80/0.88 = 90.9 minutes. This assumes that performance will be the same for the second part of the journey as for the first part. So why do I set a satellite navigation system in my car every morning? I drive the same route to work and I have never missed the Junction 11 turning from the M4. The answer is that the journey is never the same each day. The satellite navigation system is integrated into the car and has been preset with the legal speed limit on the various roads. As a result, when I start my journey it confidently predicts that I will arrive at the other end in 1 hour and 20 minutes. Using a map and a calculator would enable me to calculate the same BAC.

However, compared to a BAC calculated from a map, the satellite BAC is constantly updated. Traffic information is fed to the unit by radio signal to enable the computer to provide alternative routes, thus avoiding accidents and queues. Hence, my Cost Performance Indicator (CPI) might be 0.88 halfway through my project to transport me to work, but if the satellite navigation systems have adjusted the BAC to take into consideration a diversion or queue, it would be a mistake to phone the boss to tell him I will be only 10 minutes late for work. If the BAC has been altered to 100 minutes, the CPI could get me fired.

This is all fun, but it has a serious point. The baseline for a program needs to be monitored continuously to ensure that the estimate at completion is taking due consideration of the changing environment in which the project is being conducted. The problem, as stated earlier, is that constant monitoring of the technical baseline takes time and effort. Therefore, many projects will neglect the baseline or BAC and will continue to calculate the Estimate at Completion (EAC) on false assumptions. This is done with good intentions to keep down the perceived overhead of periodically re-establishing the baseline for the project.

Parametric Estimating and EVM

The need for parametric estimating to be the source of the baseline project is as convincing as my use of the satellite navigation system each morning to travel to work. Parametric models provide the cost, schedule, performance triangle described above. Their Cost Drivers, which are used to generate the cost and schedule estimates, are indicative of the performance and provide an excellent Earned Value progress measurement system.

Firstly, parametrics will ensure that the baseline is constructed logically and consistently, without the prejudice that can arise just because a department needs more work or is currently under-utilized. The estimating technique requires fewer resources and is quicker than bottom-up estimating, thus ensuring that more resources are spent scrutinizing the project. This also applies to reestablishing the baseline of the project, which will require a simple update of the Cost Drivers from the technical changes to the project, rather than a pause in project progress while the team updates their estimates.

Once the project is underway, monitoring the technical solution against the solution that was originally proposed will provide early detection and assessment of problems leading from the technical solution. This early visibility, like the SatNav will enable projects to steer towards success.

Parametric estimating engages many disciplines from an organization including engineering, accounting, schedule control, manufacturing and others. This naturally leads to an improved decision-making process from a holistic viewpoint, rather than the disciplines only considering the best solution for themselves. An integrated situation throughout the program, as shown in Figure 7.3, will lead to a better Estimate at Completion (EAC), using technical inputs rather than cost variances determined from a baseline which is constantly changing.

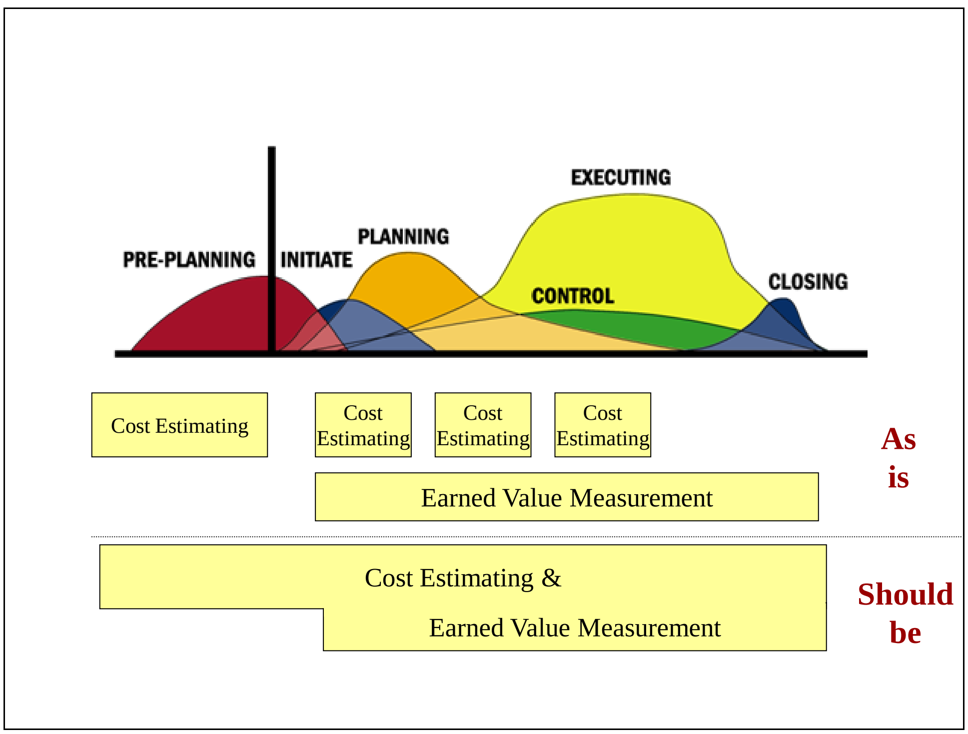

Figure 7.3 Integrated EVM and estimating system

Predictive EVM

PEVM is Predictive Earned Value Management – the 'marriage' of EVM project control with parametric estimating. By monitoring the technical changes to the baseline configuration the parametric model will create cost and schedule estimates continuously. This progressive scrutinizing of the technical solution which is being generated will have a direct bearing on the resulting cost and schedule of the baseline of the project.

Third generation parametric cost models are based on activity-based estimating methodology, which naturally lends itself to this project control technique. These parametric cost models have the ability to estimate to activity level and the resources required within those activities. In essence, the parametric model will estimate to the Control Account, a fundamental need of the EVM philosophy.

Using calibration facilities within the parametric models it is possible to monitor the health of the project in terms of its productivity. The Earned Value of the project can be calibrated in the parametric model and the productivity of the project established at that point of the project. This ensures that the EVM performance measurement baseline is synchronized with the actual achievement of the project to date. This then leads to the utilization of non-cost to cost relationships in the Estimate at Completion (EAC), which can be predicted using past performance data. The technical performance and measurements of the project are integrated, in PEVM, with cost and schedule through functional and physical parameter descriptions modelled in a parametric model.

Finally, the result of the combination of parametrics and project control through PEVM is more than the sum of two powerful techniques in themselves. PEVM adds analytical features that are unique, but proven as reliable, with the combination of linking performance, cost and schedule. This enables quick assessment for the Project Manager of cause and effect for their project, enabling real-time access to 'what if?' style question-solving.

Parametrics and EVM Tools

The interface between parametric estimating and EVM tools has already been demonstrated in a real-life example. The solution handled large-scale capital planning and management issues. The customer involved clearly understood that this solution would have a fundamental and far-reaching impact on the way they do their business. During the task, the program planning and control/ EVM function was explored, together with how the solution could collect and report both contractor and 'organic' EVM data within a common framework.

Figure 7.4 provides a clear indication of the PEVM data flow. The flow of data through an integrated system reduces the resources needed to manipulate the data. It also ensures that there are no typographical errors. The unique part of this integration is steps 7, 8 and 9. While it is normal for the EVM systems to have external data automatically fed into them from the accounts systems, it is unusual for the estimate to be calibrated from the EVM systems. An Enterprise Version of a third generation parametric model enables users to link seamlessly the power of parametric tools to other software tools using web services. This linkage connects the powerful forecasting tools of parametrics to widely used software applications.

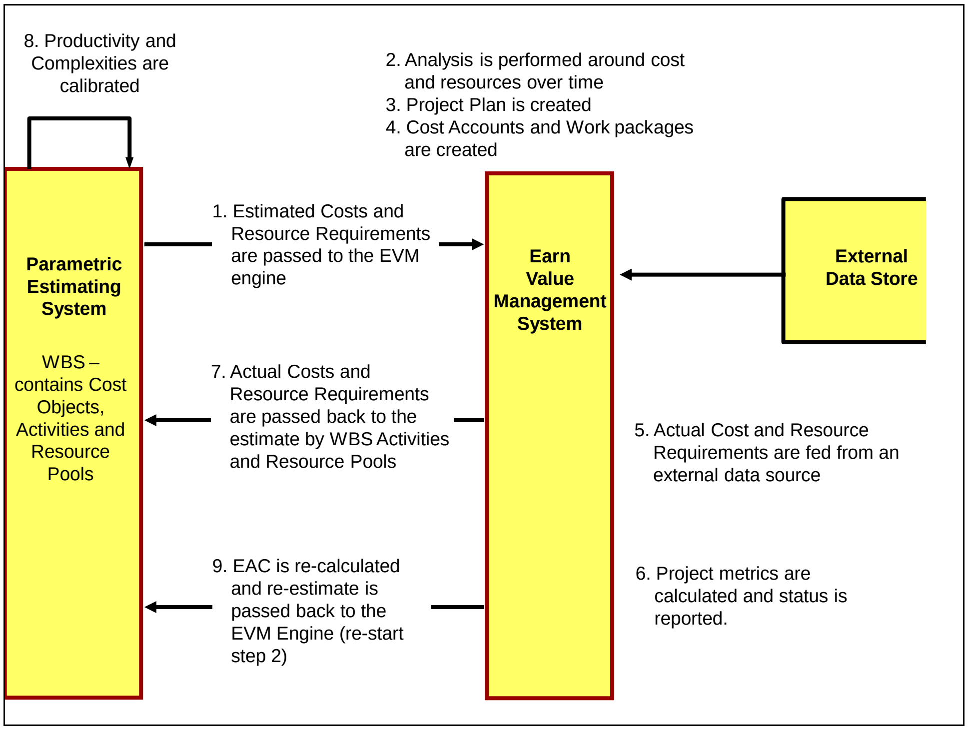

Figure 7.4 Predictive EVM Integration

EVM Software Case Study

This case study will consider the application of parametrics to an EVM problem. The case study starts with the development of a simple COBOL product developed in the early 1990s. This is a simple Management Information System (MIS) – it contains a single Computer Software Configuration Item (CSCI) with 183,887 lines of code and an Organizational Productivity of 1.462 (somewhat more productive than the industry standard).

At the beginning of the project the baseline description is estimated using a parametric model and the budgetary estimate (baseline) of about $10.1m is set (Figure 7.5). The estimate, being based on activities and resources, will be used as the basis of the Cost Account.

As the program begins work, actual labour is recorded together with the progress. After the first seven months the program was expected to have spent $1.0m; but in reality the budget is exceeded by approximately $250k.

As a result it is possible to reflect this productivity by calibrating on the baseline model through determining the productivity factor that would yield a figure of $1.0m for the first seven months. The result is a productivity of 1.1, versus the 1.462 used to produce the budget. The conclusion is that we are not as productive with this project as we thought we would be (about 25 per cent less productive).

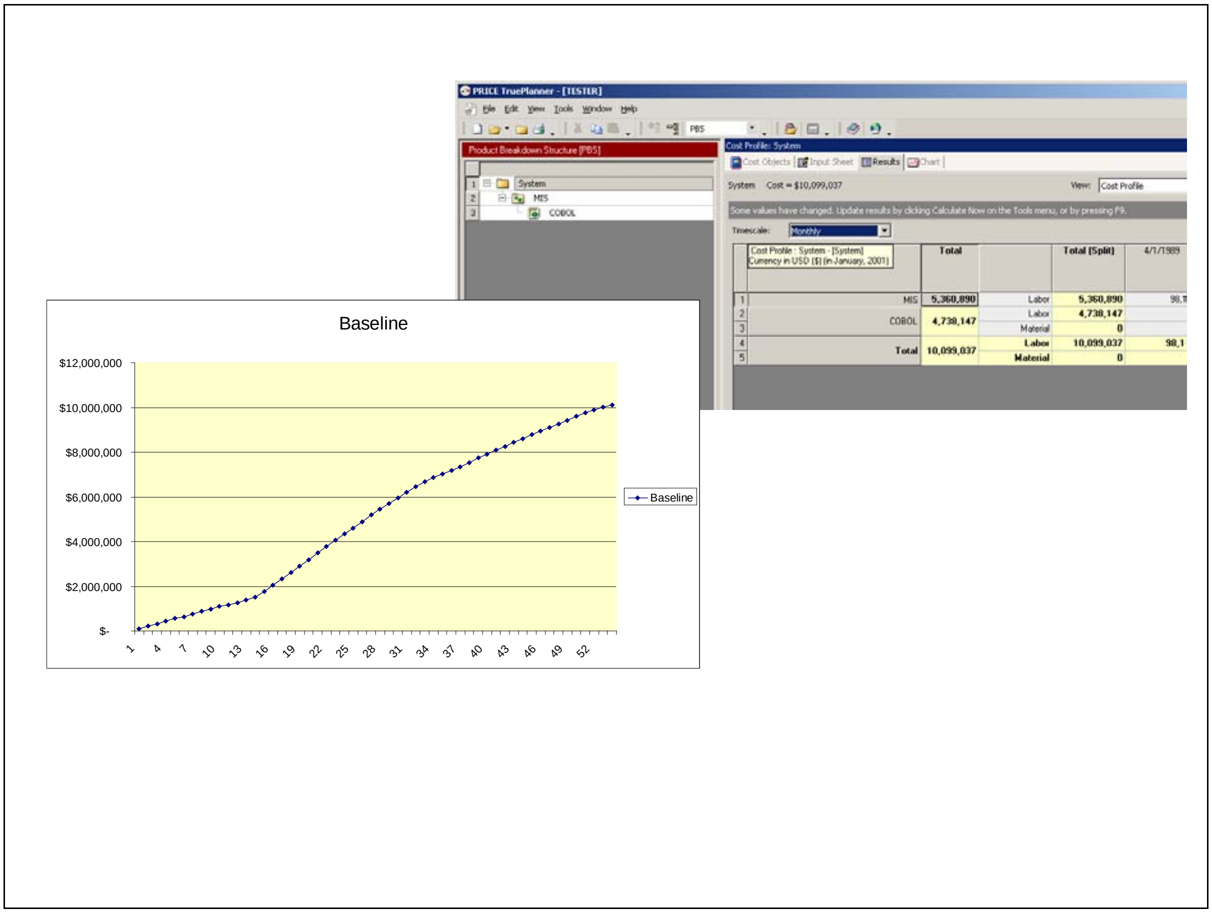

Figure 7.5 Initial Baseline Estimate

Following the productivity review at seven months, the recalibrated Organizational Productivity is applied to the baseline parametric model to estimate the cost to complete the project; this emulates what traditional EVM tools would produce since the productivity calibration to seven months Actual Costs serves as the Earned Value gauge – a lower than original productivity, as we have here, means less value earned than budgeted.

The Estimate to Completion (ETC) is approximately $12.3m, hence the Estimate at Completion (EAC), including the sunk £1.0m cost, will be a total project cost of $13.3m (see Figure 7.6).

When linking a parametric cost and schedule estimating model with an EVM tool the result is different. The Predictive EVM approach at the seven month review would determine a different analysis. There are three initial project conditions that have changed after the first seven months of the project. Firstly, the target computer has changed from one that has been in use for over a year to one that, while fairly well known, is actually new to the developers. Secondly, a better understanding of requirements has changed the initial estimate of new size (Source Lines of Code) needed from 183,000 to 300,000.

Finally, a clearer definition of interfaces has identified the need to include a COTS software package of 50K Source Lines of Code (SLOC) in the system.

These changes are captured as changes to the baseline software model.

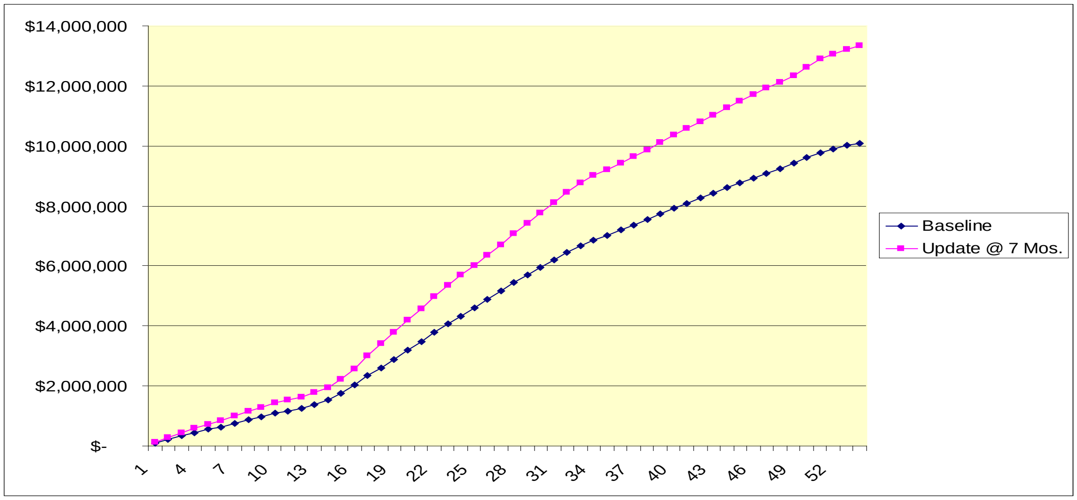

Figure 7.6 Progress at seven months

Again, calibrating the productivity factor to the $1m incurred to date, after Figure 7.6 Progress at seven months making the technical parameter changes to match the changed conditions, results in a higher realized productivity (1.58) than that used to produce the original project budget. Therefore, the conclusions at this stage of the project are:

- the project is larger than thought at the start;
- the project is over budget because it is larger than planned;
- the developers are actually performing more productively than planned

With a Predictive EVM analysis the results of the seven-month review would be different, because of what has been learnt. The higher productivity is applied to the changed baseline in the parametric model to estimate the cost to complete the project; this predicts the Earned Value at project end on the basis of effort to date after it is aligned to the project conditions known at month seven.

In this case the ETC is approximately $15.5m, or a $16.5m total project cost (see Figure 7.7).

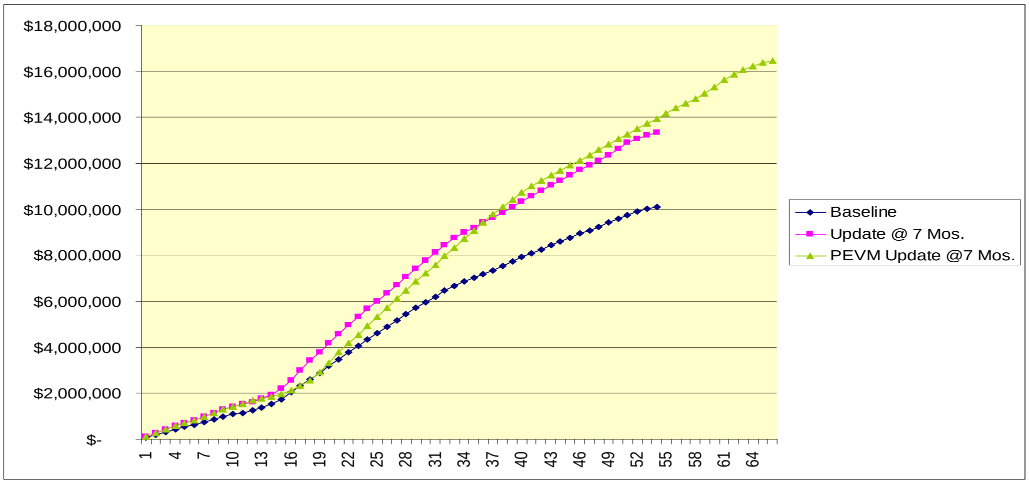

Figure 7.7 Predictive EVM Predictions

In addition to the cost estimate the parametric model has a predicted schedule estimate. The changes to the productivity and technical parameters will add 12 months to the predicted baseline; it predicts that the project will overrun its schedule by approximately one year.

In this case study the estimates were produced with a parametric software model, but this is applicable to all aspects of systems, hardware, software, service and IT estimates. Calibration was accomplished by iterating on the model productivity factor until the costs for the first seven months were $1m, the Actual Cost for the first seven months.

Summary

Conclusions drawn from the PEVM analysis would resonate with most software project professionals. That is, that the project failure is the result of underestimating the size and scope of the project leading to significant schedule slippage being a more likely reason than the team being less productive than initially planned.

PEVM is the incorporation of updates to cost model drivers into traditional EVM to predict the cost at completion of a project. Because it is based upon the most current information about the project, as well as effort spent on it to date, it will produce the most credible prediction possible. The benefits of Predictive Earned Value Management can be summarized as follows:

- the ability to predict the EAC using non-cost past performance productivity;
- a baseline which is always current;
- project's information stored in a knowledge base for future projects to increase accuracy;

- project success based on both the most current technical information and the current productivity of the organization;
- Engineering Change Proposal evaluation is an extension of normal supplier assessment analysis;
- enhanced variance analysis diagnostic capability – impacts related to non-Cost Drivers, size and complexity by deliverable end-items, Organization Productivity analysis;
- improved Independent Baseline Review (IBR) results – better risk assessments, better confidence levels;
- improved communication – cost and schedule performance actively linked to requirements and technical performance;
- ability to derive quantified contractor productivity;
- better ability to assess cost impact of schedule variances.