# Assessing the Impact of Front Loading on the CPI and EAC

*For brevity, this article only discusses the impact of front loading on the CPI and the EAC. Other indices such as SPI and TCPI are not addressed.*

## Background

Since the early 1970's, Earned Value Management Systems (EVMS) have been recognized throughout the project management community as a useful early warning system. The early visibility to cost and schedule variances and concomitant project overruns and schedule slippages, are both friend and foe. A project manager who is conscientious and possesses strategic management skills appreciates the early visibility. A more myopic manager may view the early alert as an enemy that can impact career opportunities and bring about early project cancellation. The potential of early project cancellations is, and always will be, one of the downsides to early cost and schedule information. For some, living with latent unease is better than facing an unpalatable truth.

Part of the problem with an early alert is that customer, stake holder, or upper management reactions to the variances early in the project's cycle are uncertain and often counterproductive, particularly for variances indicating cost overruns. Consequently, project managers and some companies consistently front load the project's budgeted resources profile, the performance measurement baseline (PMB).

In 1993, David S. Christensen, Ph.D., discussed the stability of the cost performance index (CPI) as a critical factor in the accurate prediction of the project's estimate at completion (EAC).[1] Since project customers and stake holders have increased their use of the CPI as an indicator of the cost health of a project and as a prognosis tool, it is essential that the CPI is realistic; i.e., the earned value is based upon objective accomplishment of work. Hugh A. Langford stressed in a 1980 article that all users of performance measurement data should be very knowledgeable of the various subjective earned value practices of some contractors, including booking lag, front loading, 100/0 earned value technique, and misclassified level of effort.[2] All of these practices can overstate earned value, and the CPI significantly.

The CPI can be affected, sometimes dramatically, by front loading, a process of providing a relatively higher proportion of the project resources to the near term activities at the expense of those activities occurring later in the project schedule. Admittedly, the process of estimating needed, but scarce, resources is a very difficult and complex endeavor. Front loading, and especially intentional front loading, is extremely difficult to detect. Analysts at Humphreys & Associates, Inc., have developed a series of topics and questions that may help to identify front loading. Using the answers to these questions, estimators can determine whether managers may have unintentionally front loaded their tasks or projects. If so, the estimates can then be

[1] Christensen, D. S. and Scott R. Heise. "Cost Performance Index Stability." National Contract Management Journal, Spring, 1993, Vol. 25, 7-15.
[2] Langford, Hugh A. "Performance Measurement and Program Management – A Look Ahead." Technical Marketing Society of American Newsletter, February, 1980.

updated with a new forecast. Similarly, analysts at procuring activities can better identify characteristics of intentional and unintentional front loading and can then make mathematical adjustments in EAC calculations that involve the CPI in their formulae.

The CPI is available to those projects that use an EVM System. The CPI is a measure of efficiency. Not absolute efficiency, but efficiency relative to the performance of tasks and the cost of completing those tasks. It is calculated by dividing the output of the system by the input to the system. Earned value, also called the budgeted cost for work performed (BCWP), for the project or for any element or sub-element of a project is the output in the CPI calculation. Actual cost, also called actual cost of work performed (ACWP), is the input. The resulting calculation is sometimes expressed as a percentage and is often interpreted in terms of the value earned for each dollar spent. For example, if a project element has an earned value of $45,000 and an actual cost of $50,000, it could be said that this represents an efficiency of 90%. The project has earned .90 of budgeted value for every dollar spent to complete the work.

The CPI can be used to calculate a mathematical estimate at completion (EAC), which can be used to verify the reality of the EACs determined by other means such as a control account manager's (CAM) estimate. A simplified mathematical EAC can be calculated by dividing the budget at completion (BAC) by the CPI. For example, if a project has been experiencing a CPI of .9 over the first half, it might be reasonable to assume that this efficiency will continue for the remainder of the project. If the BAC were $100,000, the mathematical EAC would be $111,000. The $111,000 would then be compared against the reported EAC and the reporting organization could be challenged to explain any significant differences. Christensen states that after a certain point in the project, the CPI determined EAC is a stable predictor of the final project costs.[3]

It is important to recognize that the CPI must be used judiciously. The underlying assumption of an EAC based on the CPI is that the future can be accurately foretold by that which has taken place in the past. Perhaps this is true, but the nature of the remaining work is a major consideration. If the engineering development phase of a project has been completed with a CPI of .87, is it reasonable to assume that the operations and testing phase will be completed with the same cost effectiveness? Might one argue that what Christensen really uncovered was the CPI-based EAC is a self-fulfilling prophecy? Additionally, as contractors and procuring activities independently groped for the "right" EAC for their under-budgeted projects, the CPI provided a convenient and apparently objective (but often misleading) resolution of the problem: Keep the project alive.

## Front Loading Defined

Front loading may apply to a total contract or to control accounts. Front loading is defined as:

- **Budget front loading.** Budgeting more resources than necessary to the near term work, resulting in significantly less budget available for the far term work.
- **Schedule front loading.** Scheduling more activities to the near term than can be reasonable accomplished in the time available, resulting in significantly fewer activities planned in the far term. Front loaded schedules usually result in front loaded budgets, assuming the resources are in alignment with the activities.

Front loading is a process that some contractors, or individuals such as CAMs, may use in an attempt to make their project or task performance look favorable early in the project life, often to enable them to get far enough into a project to dissuade customer cancellation. This is usually

[3] Christensen, Ibid.

done intentionally and results in extremely favorable performance indices, which are favorable for a period of time and then deteriorate with time until the true performance becomes evident later in the project. However, some other causes and methods of front loading include:

- The proposal schedule and/or cost is front loaded because there is significantly less confidence in the nature of the far term proposed tasks than in the proposed near term tasks.
- There is a decrease in the cost or price during negotiations without a corresponding decrease in scope resulting in the contractor deleting the negotiation loss from the far term work to be able to adequately budget the near term work.
- Reducing budgets from the far term work to increase near term budgets because of significant technical and/or cost uncertainties in the near term.

## What's the Impact on the CPI?

How does front loading impact the CPI calculation? Consider a simple example: A manager has two activities; the second is dependent on the completion of the first. Each activity is 30 days in length, and, in an ideal world where a manager could estimate with perfect accuracy, each activity would require 50 resources. Thus, the project's budget at completion (BAC) would be 100. The BCWS is 50 resources for each activity. The manager then works according to plan and measures performance, the BCWP. Monthly, or more frequently, actual costs are collected, the ACWP. At the completion of the first activity in this ideal world, the project's efforts would be 50% complete and have a BCWS of 50, a BCWP of 50, and an ACWP of 50. The CPI, which is BCWP/ACWP, would equal 1.0 and in most of the mathematical EAC calculations would predict that the manager could be expected to finish the second activity for the budget of 50 with a project EAC of 100. In this ideal world, when the project is completed, the actual cost would be 100.

Suppose, however, the manager assigned a budget of 60 for the first activity and 40 to the second. Consequently, the project would be front loaded. Suppose also that the manager proceeded to accomplish the work at the same pace and for the same cost as in the first example. At the end of the first activity, the work would be 60% complete, but would now have a BCWS of 60, a BCWP of 60, and an ACWP of 50. Now, however, the CPI is a healthy 1.2 (60/50), and most of the mathematical EAC calculations would predict an equally healthy underrun for the total project. In the ideal world, the final cost would still be the originally estimated 100 EAC; but an EAC of 85 (100/1.2) would be projected with the BAC/CPI in our sample EAC formula. There would be no adverse consequences from the front loading, because the project would have finished on cost.

Realistically, the project might have had to face one of the two adverse consequences: First that the corollary to Murphy's Law once again prevails (the expenses always match the amount that was budgeted), and the first activity actually expends 60 to complete (ACWP = 60). Or second, that the funding authority might be swayed enough by the optimistic projections using the CPI of 100% cost effectiveness to reduce funding for the project. Of course, in the real world, front loading should not be a serious concern if there were a properly estimated budget for the total project and that it has been time phased accurately.

Unfortunately, the ideal world is not always populated with managers who can estimate with perfect accuracy because of uncertain or non-specific statements of work and objectives. In addition, not all funding authorities are always fortunate to have adequate funds to underwrite risky programs through project completion. Thus, suppose that the manager had estimated the

project at 90 resources instead of 100; that is, there are two activities with 50 resources worth of work to be done, but have been unknowingly under estimated at 45 each. The new BAC is 90 with 45 budgeted for each activity. Calculating the initial CPI at the completion of the first activity will yield an indicator that will correctly predict an EAC resulting in an overrun of 10.

(BAC = 90, BCWP = 45, ACWP = 50, CPI = .9, EAC = BAC/CPI = 100)

In the previous example of the budgeted resources to accomplish work, the budget was under estimated at 90. An example of front loading would be wherein the manager inadvertently, or unintentionally, budgeted the first activity at 60 and the second at 30. Now the calculation at the completion of the first activity would yield a CPI of 60/50 or 1.2 and an EAC of 90/1.2 or 75. Assume the second activity is having its underlying 50 resources of work accomplished for 50 actual resources. The project ACWP will begin to exceed the mathematical EAC (75) when only half of the second activity (one half of the remaining 50, ACWP = 25) is complete. This sudden "overrun" might be a shocking surprise, one developing too late in the project's life to take any effective corrective action. Thus, the perceived benefit of this approach is that the overrun does not become apparent until well into the project. Many major U.S. DOD and NASA acquisitions have experienced sudden late revelations of this nature.

Another example of the front loading conundrum is where the budgets based on an over-estimate are front loaded. If the manager had estimated 110 resources for the project with an anticipated 100 resources of underlying effort and budgeted the activities at 60 and 50, the CPI would have been 1.2 when the first activity was completed. The resulting mathematical EAC would be approximately 92. Consequently, the project may be more than 80% complete before the rising actual costs will unveil a new estimate. In an over-estimate condition, some over-budgeting is inevitable. But budgeting the activities equally would have resulted in a mid-project EAC of 100. In an over-budget scenario, the front loading is less consequential – unless, of course, Murphy or an alert funding analyst intervenes.

Once again, the message is clear. Without accurate estimating of the total project's cost, widespread front loading can result in serious consequences, all potentially counter-productive to the project's outcome. This reason alone would dictate that projects should err on the side of "back loaded." So, why would anyone wish to front load?

## Is it Unintentional or Intentional?

Some front loading is unintentional. Even the most highly skilled practitioners of estimating can fall victim to the natural human tendency to provide more adequate resources to the better understood activities in the early phases of a project than to the more obscure tasks to be undertaken later. Some of it is intentional. Occasionally practitioners, abetted by analysts and management on both sides of the negotiating table, may front load a project budget in the hope of prolonging the delay in delivering some inevitable bad news. This may include using front loading to demonstrate sufficient early successful project performance to secure a next phase decision or a follow-on effort.

Finally, some front loading may only appear to be. Unless the reviewing analyst understands the risk assessment and mitigation process that the estimator has undertaken, the allocation of more budget to earlier activities may only seem to be front loaded. The key to understanding front loading is in the risk analysis and mitigation.

The customer or the contractor must be careful not to jump to a front loaded conclusion without conducting careful analysis. Some projects are planned the way the planner truly envisions the work will be performed, but the nature of the work might naturally result in schedules and/or budget spreads that appear to be front loaded, when in actuality they are not. Just because a

larger percentage of budget may be spread toward the front end of a project, or control account, does not by itself mean that the budget is artificially front loaded or inappropriate for the project. Some simple examples of valid planning that may appear as front loading include:

- Risk analysis identifies that the majority of the risk will be experienced in the beginning of the contract or control account and will require more resources up front or higher skill grades which means more expensive resources.
- A realistic steep ramp-up of resources in the beginning is planned, including the budget for the majority of the material, based on the receipt of the material.

Evidence of front loading should be examined during the development of the proposal, negotiations, and during and after baseline development. Contractors and customers should carefully evaluate each project, preferably at the control account level, to ensure they understand the type of work that is involved, and what the expectations should be for each type of project or work effort involved. They should try to recognize the characteristics of both normal and front loaded baselines, and rectify any inconsistencies early.

## Testing for Evidence of Front Loading

The following questions are examples of what should be assessed in determining whether a manager or contractor has front loaded a schedule or budget plan. This is a partial list that Humphreys & Associates analysts use to test for potential project front loading.

### Technical/Scope of Work

1. Is the nature of the work consistent with the baseline budget spread? Is the scope of the work and budget correlation feasible? Is the complexity of the scope of work commensurate with the types of resources budgeted?
2. Is there a significant amount of development type work involved? Development type activity is typically worked heavily in the first portion of the project by senior, more expensive personnel, to facilitate the resolution of the technology development problems.
3. Was the division of technical work scope between the prime contractor and subcontractors and the types of subcontracts involved considered? If a large percentage of the work scope is in the form of firm fixed price (FFP) subcontracts, taking the combined FFP and prime contractor cumulative cost performance and applying it to the whole contract is an incorrect use of the CPI. Depending on the percent of the total budget belonging to the FFP subcontractor, the percent complete of the prime and the subcontractor, the mathematical EAC using the CPI will either overstate or understate an overrun and an underrun. Plus, once the FFP subcontract has been completed, the 1.0 CPI will continue to distort the CPI at the contract level.

### Schedule

1. Given the inherent uncertainty and risk of the project, are the contract milestones/delivery dates reasonable? Unreasonable milestone dates could force an early concentration of resources in an attempt to meet these unrealistic expectations. This is driven many times by aggressive customers who achieved project start approval by committing to unrealistic goals (technical/schedule/cost).

2. Is the near term baseline spread, which includes a large amount of critical items, inherent in the nature of the work/contract? Are the activity durations in the schedule for the near term work reasonable? Excessively long planned durations could require more resources than necessary. Such actions can bring about the early application of larger amounts of resources and give the appearance of front loading.
3. Are the milestones identified in the project schedule reasonable and well defined regarding completion criteria? The customer should assess milestones or schedule activities identified early in the schedule (in terms of risk) to determine the concentration of higher risk elements early in the project. And, based on the risks associated with the early activities, determine the appropriateness of the baseline spread. An assessment of the quality of the milestone definitions and dates should have dispelled any front loading concerns in proposal fact finding as well as in contract negotiations.
4. Did early project reviews include a review of the schedule network baseline plan for the entire project? The customer should have evaluated the validity of the project schedule and the achievability of that schedule based on assessment of the risk for each milestone.

## Cost

1. Did the initial project reviews surface concerns about the adequacy of budgets? If front loading were a concern, then a corresponding concern would be whether sufficient budget exists for the remaining far term tasks. Was the budget spread evaluated as part of the source selection or contract negotiations?
2. Was an Integrated Baseline Review (IBR) conducted early in the project to allow the contractor and customer the opportunity to test whether the baseline budget was front loaded? Conducting an IBR provides a means for the contractor and customer to assess the reasonableness of the schedule and budget plan as well as the adequacy of risk identification and planned response.
3. Did the customer's project office identify this front loading concern early in its normal surveillance, project reviews, or data analysis processes? Were the high, medium, or low risk areas of the project and the resources associated with each type of risk and the appropriateness of the spread versus of the risk assessment evaluated? Were the resource requirements against the resource availability for the project assessed, including other projects at the facility, in the evaluation of the baseline?
4. Have surveillance personnel provided reports that include continuing assessment of the quality of the performance measurement baseline (PMB)? Was an assessment made of the budget amounts in management reserve (MR) and undistributed budget (UB) that, once distributed, would shift the loading of budgets more toward out months/out years, leveling the trend on any front loading?

## Earned Value

1. Is the amount of level of effort (LOE) work minimized considering that LOE would have a significant impact on the performance indices?
2. Was the CPI evaluated in conjunction with other information with regard to potential efforts on performance? If the CPI were well above 1.0 for some of the work, it could indicate that the earned value technique for the planned work is largely LOE and/or above average performance is occurring for the discrete effort. However, the condition

may not be consistent with the availability of the staffing estimated on Format 4 of the Contract Performance Report.

3. Was the percentage of LOE versus discrete work early in the project assessed and compared to the same ratio later in the project's life? Was the amount of LOE checked on similar projects?
4. What does the contractor's EVM System Description or procedures indicate about earned value for materials, booking lag avoidance, and what percentage of the contract value is for materials? If earned value for materials is taken at point of receipt, it will naturally front load any plan that has a materials component.

## Conclusion

The questions listed above are examples of what Humphreys & Associates analysts use to evaluate a project baseline. We urge you to create your own questions based upon your unique project environment. Diligent baseline evaluations are an absolute must for early identification of front loading. Just as all airplanes eventually land and bleeding eventually stops, inappropriately front loaded projects, whether intentional or inadvertent, usually shocks and contributes to blindsiding the customer.

When bad news is in the offing, its delay diminishes the credibility of the participants and jeopardizes the project when finally delivering the "unforeseen surprise" to the funding authority. Moreover, the front loaded budget may become a self-fulfilling prophecy; actual costs may rise to meet it. Bad news does not get better with time.