Earned Value Management

Mitigating the Risks Associated with Construction Projects

QUENTIN W. FLEMING • JOEL M. KOPPELMAN

Everyone knows certain "truths" about Earned Value management. Such knowledge is often based on what we may have heard others say about the technique. For example:

"Earned Value is useful only on large government-funded contracts." • *"Earned Value is useful only on cost-reimbursable-type projects."* • *"Earned Value has no utility in the management of lump-sum or firm fixed-price work."* • *"Earned Value does nothing for construction projects."*

Respectfully, we take exception to these "truths" and would like to present a case for the employment of a *simple* form of Earned Value on all projects—large or small, cost-type and fixed-price—it really doesn't matter. The basic utility of Earned Value is to contain the cost risks associated with projects. Bad news never gets better with time. The earlier you know that you have a problem on your project, the better chance you will have to mitigate that problem.

While we believe you can, and perhaps should employ some minimal form of Earned Value on any project, as a way of facilitating this discussion we will cover using Earned Value on a *specific* type of project—a construction project. We will discuss the use of Earned Value on construction projects while employing either the Design-Bid-Build concept, or the Design-Build approach. Surprisingly, much of the basic Earned Value data is already available on most construction jobs. We will also make six

Fleming is a private consultant in project management, Tustin, Calif. Koppelman is the co-founder and President of Primavera Systems, Inc., Bala Cynwyd, Pa.

specific *recommendations* for using Earned Value management to mitigate project risks.

What is Earned Value Management?

An interesting phenomenon exists in the construction industry. The industry probably uses parts of Earned Value management about as well as any industry. But, what makes it interesting is that in construction work, practitioners rarely use the term "Earned Value." Often, they do not even realize that they are in fact using a form of Earned Value. Anytime the construction cost engineers put a project baseline plan in place, *this* is Earned Value in its purest form. But ask cost engineers if they use Earned Value management and often you will get a blank stare.

A typical project baseline plan would consist of: 1) a detailed schedule containing all of the authorized work; 2) schedules containing the authorized resources to conduct the work; and 3) payments by the cost engineer to contractors based on their physical accomplished work, together with the original authorized budget for the work.

Earned Value management is a technique that can be applied, at least in part, to the management of *all* capital projects, in *any* industry, while employing *any* contracting approach. The employment of Earned Value requires a three-dimensional measurement of project performance, ideally from as early as possible—perhaps as early as 15 percent complete, up to 100 percent final completion. However, two of the three dimensions of Earned Value—the baseline plan and the physical performance measurement—will apply to *all* capital projects, in *any* industry, using *any* contracting method.

Point: People sometimes get "hung up" on precise terminology. The ardent proponents of Earned Value will often use specific terms with exact meanings. Most construction managers may not use the Earned Value terms "Planned Value" or even "Earned Value," but the process they go through to establish their baseline plans and then to measure performance against their plans is exactly the same. Only the jargon may be different.

To understand the concept, we must understand the following three dimensions of Earned Value:

- *Planned Value*, which consists of the authorized work, along with the authorized budget, within the authorized time-frame, which in total forms the project baseline.
- *Earned Value*, which is the authorized work that has been completed, plus the original budget for the work.
- *Actual Costs*, which are the actual costs incurred to convert the Planned Value into the Earned Value.

Both the Planned Value and the Earned Value dimensions will apply to all construction projects. Only Actual Costs are sometimes unknown in construction, particularly on fixed-price or lump-sum jobs. In the discussion covering progress payments later in this article, we offer a few recommendations to help better manage the process.

What is the Design-Bid-Build Concept (or Engineer-Procure-Construct Method)?

The more traditional, established approach to construction is called the Design-Bid-Build concept, or, sometimes also referred to as the Engineer-Procure-Construct method. This approach takes a new construction project and breaks it into three distinctive but sequential phases:

- The complete design of the new item.
- The execution of a competitive solicitation, bidding, and construction contract award process.
- The actual construction of the new facility.

Today, construction work is most likely accomplished under the Design-Bid-Build approach.

To start Design-Bid-Build, a selection is made of an architectural or design firm to capture the thoughts of the owner of the new project. Because this broad conceptual direction is often subject to changes as the design solidifies, such work is often (but not always) done on a soft or cost-reimbursable contract basis. The owners often start out by describing what they envision as a final product, but will often change directions to the architect as the design evolves. The design firm, taking directions from the owner, then completes the definition up to what

is described as the 100 percent complete design point.

Next, the owner will take the final 100 percent construction design and, often with the professional assistance of others—perhaps a project manager, sometimes a construction manager, or sometimes both—will prepare a solicitation package to request firm quotes from multiple construction firms. The final design will take the form of drawings and specifications sufficient to the extent that an experienced independent constructor can bid on a new job with precision and confidence. This is the bid or competition phase of the project, which will often take several months to complete, depending on the size and complexity of the project. Often, but not always, the original design firm is also retained and used in conducting the process.

Once a contractor is selected, a contract is awarded to the successful construction firm—quite often to the lowest responsible bidding firm. The physical construction work will be started. As discussed earlier, once final construction work begins, a common practice is to retain the original design firm to assist the project manager, construction manager, or both with the interpretation of design requirements. Typically, design contracts will be cost-type, while the construction work is most likely lump-sum. But there are exceptions.

From the start of design through the bidding and selection process through construction, the final product will be built and delivered; and the team will then be dismantled and sent on to the next project. Sometimes, however, open items called construction claims will remain to be settled. These open items will eventually be settled and the project completed.

Under Design-Bid-Build, the ultimate construction contractor is *not* a part of the original design team. Thus, the designers will not gain valuable input from the people who will do the final construction work and will be spending the majority (perhaps more than 90 percent) of the project dollars. Some believe this is an important opportunity that is needlessly lost.

One last important point on the three-phased Design-Bid-Build process. Some maintain it contains opportunities for construction claims to proliferate. The final settlement of the costs of construction claims can easily exceed the original costs of the design. Many owners suspect that the original 100 percent designs, completed without valuable inputs from the physical constructors, may contribute directly to construction claims.

Undoubtedly, the Design-Bid-Build approach is the most popular approach in construction. But performing the work in three distinct sequential phases takes time. Hence, someone came up with the idea of a faster approach. Enter the "Design-Build" concept.

What is the Design-Build Concept (or Design-Construct Method)?

While the Design-Build concept has been practiced in Europe since the 18th century, only recently have most project owners accepted its broad use. Under the Design-Build concept, a *single* contractor assumes complete responsibility for both completion of the final design and the resulting construction effort. Hence, the final design effort will have inputs from the ultimate constructor.

The owner starts the process by authorizing what is called the "preliminary design" for the project. The owner will contract with an independent design firm to create a design definition sufficient to allow a Design-Build firm to bid on the total remaining effort, including both the final design work and construction work.

Just what constitutes a preliminary design will vary from project to project. But the preliminary design is typically described as representing the 20 to 35 percent point in the design process. Some projects increase or decrease these percentage values, and the exact point is an arbitrary one at best.

Once the designated preliminary design point is reached, the owner will typically issue a formal Request for Qualifications response from firms with experience in Design-Build contracting. Prospective firms in Design-Build—often construction firms—will either complete the final design themselves or subcontract outside for the completed design. Or, many experienced Design-Build firms will employ some combination of participation from designers and constructors. Most critical, however, is the fact that the Design-Build firms have a proven track record in this type of construction. The assumed savings in both time and money to the owner come from assigning a single point of responsibility with the use of Design-Build.

An initial "big-list" of potential Design-Build contractors will be evaluated based on their responses, and then reduced down to a "short-list" of only qualified contractors. From the short-list, the owner will solicit formal bids with a Request for Proposal. The short-list of final contractors will represent perhaps only three or four contenders. Because this final bidding process places a financial burden on the qualified prospective bidders, and to keep all of them in the bidding process, an accepted practice emerging in some quarters is for the owner of the project to grant a small "honorarium" to the short-list of final contractors. Such honoraria simply defray some of the costs of bidding. The owner will then make a final selection, awarding a single contract to a firm to complete the final design and perform all of the construction effort on the project. Design-Build begins.

Proponents of Design-Build suggest that this approach provides substantial benefits to the owner. Among the described advantages are:

- A single point of responsibility for both the final design work and the construction.
- A shortened time-table for overall project completion.
- Total project costs known at the outset.

- Higher quality.
- Innovations in the construction process, which are then incorporated into the final design.

Perhaps one of the most important benefits is the potential *reduction* of final construction claims that have resulted from the "professional" differences of opinion between the architects and designers vs. the constructors. If this point is in fact true, claim reductions alone could save considerably in the overall final costs to the owner.

One last point—the final Design-Build contract can take several contract forms, which will vary the risks to the owner. Three contract types are typically used in Design-Build relationships:

- Fixed-Price/Lump-Sum
- Cost-Reimbursable
- Cost-Reimbursable with a Guaranteed Maximum Price.

Some owners will separate the design from the construction phases and use a different contract type for each phase—a cost-type for the design phase and a lump-sum for the construction phase. Others will issue a single contract type for both the design and construction effort. Each of these three types carries its own unique risks, which we cover later in this article.

Monitoring and Analyzing Earned Value Project Metrics

Using Earned Value metrics, any project can accurately monitor and measure the performance of projects against a firm baseline. Measurement will take place at regular intervals—certainly monthly, but oftentimes weekly—where, as of a given point in time, the project will be determining: its Planned Value, its Earned Value, and the Actual Costs incurred. These three dimensions provide a wealth of data reflecting the true health of projects.

Using the three dimensions of Earned Value, the project management teams can at all times monitor both the cost and the schedule performance status of their projects.

To determine schedule status, we must first determine the Earned Value measurement. Remember, Earned Value represents two elements:

- The authorized work that has been completed.
- The original budget authorized to perform the completed work.

To determine the schedule position, we must take the Earned Value and subtract the Planned Value for the period being measured. A negative value indicates that the project is behind in its planned schedule position.

Falling behind our planned schedule is one of the first indicators that the project is experiencing problems. However, the Earned Value schedule position is best used in conjunction with critical path methodology. If the late tasks are on or near the critical path, they are important. If the late tasks have lots of float or slack and low risk, they are only interesting and merely indicate that we are behind our original plan.

To determine our cost position, we must also start with our measured Earned Value, but now we subtract the Actual Costs incurred to accomplish the Earned Value. A negative value indicates that we are overrunning our costs. Cost overruns are very serious in that they are rarely (if ever) subsequently recovered by the project. Keep in mind that our best planning, scheduling, and budgets will be front-loaded into the early phases of the project. Thus, if we overrun the early phases of the project, how can we expect to recover the overrun in the latter phases when the plans, schedules, and budgets are more uncertain?

Earned Value metric data can also be converted into efficiency factors so we can compare the efficiency rates of one project against all other projects in the organization. Earned Value data are also excellent for managing a portfolio of projects.

For example, if we take the Earned Value achieved and divide it by the Planned Value, we determine the schedule efficiency factor, which we call the Schedule Performance Index (SPI). Any SPI value less than 1.0 indicates that we are running behind with our planned schedule. If our SPI is .84, this condition indicates that for every dollar of work we planned to do, we only did 84 cents of work. The SPI provides a quantified metric.

Most important, however, is the cost efficiency we are achieving. Cost overruns are more serious than falling behind our planned schedule, only because in the end the schedule will eventually be recovered, whereas the cost overruns are rarely (if ever) fully recovered.

We determine our cost efficiency rate—the Cost Performance Index (CPI)—by dividing the Earned Value by Actual Costs incurred. Any resulting value less than 1.0 indicates that we are overrunning our costs. For example, a CPI of .82 indicates that for every dollar we incurred in expenses, we only accomplished 82 cents of value. Thus, we are overrunning our costs.

The significance of the CPI metric is empirically proven (with over 700 DoD projects studied) to stabilize at the 20 percent completion point of a project. Also, the CPI metric becomes progressively more stable as the project continues toward the 100 percent completion point. Thus, the CPI can be used to forecast the final project costs from as early as 20 percent into the project. To forecast total final costs, the total authorized project budget (Budget at Completion) is divided by the cumulative CPI. Thus, you can continually monitor and forecast the final required costs to complete your project. It is as simple as that.

Using Earned Value to Make Progress Payments on Construction Projects

Owners of all projects (including construction projects) must take care to never place themselves in a position of overpaying their suppliers for the work they complete. Stated another way, the very quickest way to increase the risks on any project is to overpay suppliers

for their completed work. Cost-type arrangements have inherent risks because some owners simply focus on the actual expenses incurred, without also closely monitoring the actual work accomplished for the monies spent. Earned Value management can help in this process.

Likely, the best way to mitigate construction risks on fixed-price or lump-sum work is to accurately measure the value of the work completed, together with the original budget authorized for the completed work, and then only pay for the actual work accomplished, less any withholds or retentions as may be allowed by the contract. Earned Value management can also help with this process.

Payments on "Cost-Type" and "Fixed-Price-Type" Contracts

Today, the two broad contractual environments prevalent throughout DoD are cost-type and fixed-price-type. Both need to be addressed separately—both represent separate issues.

Cost-Type Contracts

Cost-type contracts are sometimes (perhaps often) used in construction projects to cover the initial design work—both the preliminary and final design—in both Design-Bid-Build and Design-Build approaches. Additionally, on selected other projects that are considered to be inherently high risk for the constructor (for example, nuclear energy construction), cost-type contracts are sometimes used for all phases—both the design work and the construction effort.

Under a cost-reimbursable-type arrangement, the suppliers will be reimbursed each month for their actual costs incurred on the project, subject to the terms of their agreement. Payments of fees are normally withheld until specific deliverable objectives have been met. But all incurred costs (without fee) are submitted by the supplier to the owner, and are then paid by the owner. Sometimes on cost-type arrangements, where the process is not watched closely, there can be a wide disparity between the physical work done and the dollars spent. Thus, the risks to the owner escalate. We offer four recommendations to mitigate the risks with cost-type contracts. All owners on cost-reimbursable-type contracts should:

Recommendation No. 1

Require that the performing supplier (the designer or constructor) provide a *time-phased* "Schedule of Values" in which the sum of the line items will add up to the total contract value. A time-phased Schedule of Values provides the owner with a simple form of Planned Value against which performance throughout the life of the project may be monitored and measured.

Recommendation No. 2

Each month, as the suppliers submit their invoices reflecting the actual costs incurred, require that all contractors update their Schedule of Values reflecting a percent complete position, i.e., the Earned Value for the project. Thus, the owner of the project will have the means to monitor performance by comparing the Earned Value less the Planned Value to determine schedule variance, and also Earned Value less Actual Costs to determine the cost variance.

Recommendation No. 3

Always monitor performance of both the cumulative SPI and CPI to compare results of one project to all other projects in the enterprise.

Recommendation No. 4

Continuously forecast the likely final costs on the project using a simple but accurate estimating technique (the total project budget divided by the cumulative CPI) to provide assurances that the project will be completed within acceptable cost risks to the owner. Unacceptable risks would be any forecasted final position that exceeds the owner's available funds, or penetrates the Guaranteed Maximum Price.

Fixed-Price-Type or Lump-Sum Contracts

Under a fixed-price-type arrangement, the suppliers are typically given progress payments based on their demonstrated percentage of work completed, together with the authorized budget for the completed work. Again—pure and simple—this is Earned Value at its *finest*, as typically employed on most construction projects. One can easily establish the Earned Value baseline or Planned Value using one of two methods: "Schedule of Values" or "Critical Path Method (CPM) Schedule."

Schedule of Values

Just as we recommended for cost-type work, the Earned Value baseline, or Planned Value can be created with use of a Schedule of Values," which is time-phased. The Schedule of Values can be updated monthly to reflect the measured Earned Value and used to authorize payments to the constructor.

Critical Path Method (CPM) Schedule

Another very effective method to establish an Earned Value baseline would be to require that the performing supplier create and submit a "Critical Path Method (CPM) Schedule" with resources embedded into the CPM network—the sum of which must add up to 100 percent of the contract value. Assuming that your schedule software package has the ability to freeze this baseline, you will have in place the equivalent of a Planned Value baseline. Payments to suppliers will be made each month based on their reflected percentage completion—their Earned Value. (Note that the resource-loaded CPM schedule will work nicely on either cost-type or fixed-price work.)

Typically missing with fixed-price or lump-sum work, however, are the Actual Costs related to the Earned Value being measured. Without the Actual Costs related to the Earned Value achieved, we lack the ability to determine the cost performance efficiency factors—the CPIs—which are likely the most important metric in Earned Value management. However, there may be a way to get the information needed to bring owner risks down to acceptable levels, without invading the sacred cost ledgers of our performing fixed-price suppliers.

Whenever performing suppliers accept a fixed-price job, they are often highly reluctant (they adamantly refuse) to disclose to the owner how much profit they are making on a given job.

Question: Do we really care if our suppliers make a profit on our jobs, even a *big* profit? We don't think so.

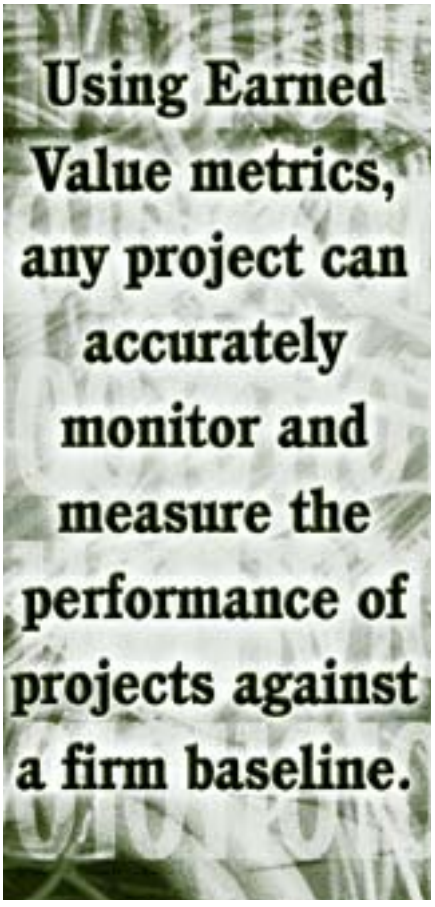
It's only when suppliers start incurring a loss, particularly a *big* loss, that we should really be concerned. The bigger the loss, the more likelihood the supplier may not complete the job. To mitigate risks to the owners, we need to know about, and to quantify potential supplier losses as early as possible.

Recommendation No. 5

Require that all fixed-price suppliers provide a financial projection of their anticipated costs incurred, to accompany their Planned Value projections contained within either the time-phased Schedule of Values or their resource-loaded CPM networks. Such costs-incurred forecasts should typically resemble what is commonly called an "S" shaped curve, or sometimes referred to as "one-half a bell shaped curve." Such financial curves typically will project a slow beginning, a fast acceleration in the middle, and then a slow close-down to completion. Unless extenuating circumstances exist, all project expenditure profiles should resemble an "S" shaped curve. Anything other than an "S" curve might indicate that the cost projections may be front-loaded. Always watch out for front-loaded project baselines.

Recommendation No. 6

As a condition to making monthly payments to fixed-price suppliers, require also that the Chief Financial Officer (CFOs) for your suppliers "certify" each month that they have *not* exceeded their own financial forecast of costs incurred. However, if they have exceeded their own forecasted values, require that they also disclose the *amount* of their costs incurred, so that you can compare it to the Earned Value and quickly determine the amount of loss the contractors are experiencing.



By closely monitoring the relationship between Earned Value and Actual Costs incurred, even on fixed-price jobs, owners may use these data to monitor supplier performance and take action early enough to mitigate the financial risks of projects. Although you may not eliminate such risks, possibly you may bring them down to acceptable levels.

Making Our Case

For this article, we have tried to make the case for using at least a simple form of Earned Value to mitigate the costs risks on all construction projects, either Design-Bid-Build projects or Design-Build concepts. Most of the data for using Earned Value is already in place on most construction projects. Only the performance efficiency factors and forecasting methods are typically not generated in construction work. But they certainly could be.

We believe the six specific recommendations offered in this article could help in this process. Likely, many project managers may believe that they do not need to have their performance monitored this closely, particularly when they are performing under a fixed-price or lump-sum arrangement. However, the risks of cost increases (called overruns) and potential project failures ultimately rest with the project's owner, and sometimes also with the surety companies underwriting construction performance bonds. Owners and sureties may well have different thoughts on the benefits of using Earned Value management to monitor construction project performance.

In our opinion, Earned Value management should have an important place in the management of any type of construction project.

Editor's Note: The authors welcome questions or comments on this article. Contact Fleming at *quentinf@msn.com;* Koppelman at *JKoppelman@Primavera.com*.

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