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RETHINKING EARNED VALUE AND SCHEDULE MANAGEMENT ON CONSTRUCTION PROJECTS

[**Editors' Note:** This article is based on the author's recently published book, *Rethinking Earned Value & Schedule Management on Construction Projects: Solving the World's Construction Performance Problem.*]

The good news for the construction industry is that construction continues to be a major engine of the world's economy. Governments are forecasting the investment of trillions of dollars into infrastructure and other types of construction, and the hope is that this investment will aid in the economic recovery made especially necessary by the desultory effects of COVID-19. The bad news: for at least four decades, productivity in the construction industry has been conspicuously poor relative to other industries. Moreover, projects on average perform very badly versus their contractually stipulated time and price targets, and delayed projects waste dollars and human resources. Should we be concerned? According to the economist Paul Krugman: "*Productivity isn't*

everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker".

Although existing approaches to improving performance have largely failed, there is an escape from the performance doldrums in which the industry is currently mired. It begins with owners, contractors and design professionals actually having reliable contemporaneous knowledge about how their projects are performing, so that when off-trends appear, corrective action can be taken, and the party(s) responsible held to account.

Schedule and Earned Value Management and analysis is supposed to provide such performance information but, despite the expenditure of billions of dollars, neither provide the required actionable intelligence. Among the reasons for this are: schedule practice is grossly deficient; Earned Value (EV) analysis has not been customized for construction and its analytics are flawed, and Critical Path Method (CPM) scheduling has not been fully integrated with EV analytics to provide a complete performance picture. *Rethinking Earned Value & Schedule Management on Construction Projects* provides a field-tested guide to overcoming these obstacles, and advice on developing an effective performance-based system that significantly improves outcomes on construction projects and programs.

Existing Fixes Require Reliable Performance Analysis

Topics like contract delivery and contractual risk allocation get much more attention at construction industry forums than the subject of reliable performance evaluation. This is unfortunate because without the latter, all of the currently-relied-upon fixes for performance problems are unlikely to work.

To illustrate, consider the Public-Private-Partnership (P3) contract delivery approach which is, in some quarters, thought to be a performance panacea. P3 advocates refer to it as a "*performance-based*" system, but what likely attracts many owners is really the idea that all performance risk is *transferred* to the contractor. Based on this understanding, some owners think project performance need not be their concern because the contract fully shields them from performance risk.

However, owner expectations are disappointed when, as often happens, major construction delay and disruption claims arise on their P3 projects. The P3 design-builder asserts that the project was delayed by causes outside of its control, such as undisclosed site conditions or deficient design parameters provided by the owner. When these claims arise, the problem for the owner, and also project performance, is that, because it assumed that performance was the contractor's problem, the owner did not seek to know how the project was actually performing over time. There is often no serious effort to critically review the baseline and monthly schedules submitted by the design-builder. "*Trust but verify*" should be the dictum under all types of contract delivery, but the performance analysis necessary for verification is absent.

Problems with Critical Path Method Schedules and Earned Value

CPM scheduling and EV have the *potential* to be very effective performance analysis and management tools. To achieve their potential, the following problems require correction:

Schedule Problems

Most contracts require the contractor to produce CPM schedules which, if properly prepared, are a valuable performance planning and analysis tool as well as an instrument to resolve delay claims fairly. Unfortunately, most schedules fall far below even a minimum standard of CPM practice.

Even if the practice problem is surmounted, objective analysis of schedule feasibility and performance is limited on most projects because contracts rarely require schedules to be resource loaded. In the absence of information about the resources (inputs) that are required to produce the construction in the required time, schedule is a black box (output) model which must be taken on faith.

Earned Value Problems

Earned Value Management (EVM) is a project management methodology which is *supposed* to integrate schedule, costs, and scope to measure project performance. Despite its avowed purpose, EV does not really integrate with schedule; instead deferring the analysis of project time to CPM schedule analysis.

To evaluate historical performance, it relies on "cost" and "schedule" variance metrics. The cost metrics can be used to measure labour productivity using cumulative Earned and Actual (dollar) values. The schedule metrics measure variances in earned versus planned *progress*. Currently, EV theory posits no connection between the cost and schedule metrics, but there is actually an important causal connection between them that is key to understanding time performance.

EV theory does not currently account for variance in labour resources. This is a significant short-coming because, as discussed below, labour resources, along with productivity, are the *performance factors* which *determine* activity durations and, with activity logic, the overall schedule time.

Example of Flawed Performance Analysis

How do the above problems manifest on projects? Assume a fixed price contract where the contractor is at risk for time and price. The planned schedule (Fig. 1, blue bars) is so simple one might expect performance problems could be easily identified.

Ten days into the project, the contractor submits a schedule update (green bars) which forecasts a three-day delay to completion. The apparent cause of the project delay is the longer duration of the formwork activity: originally planned to require 10 days, but now 13 days.

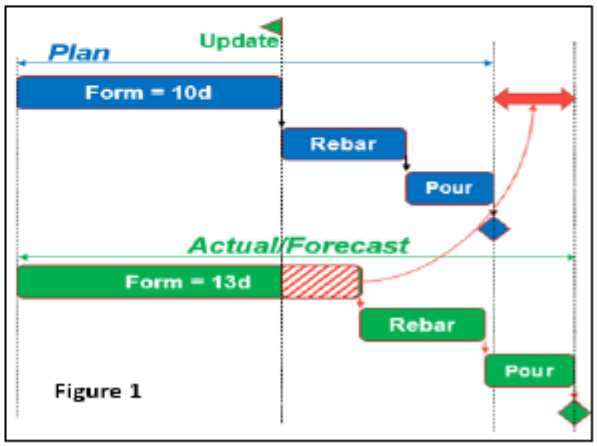

Figure 1

Why is the formwork activity taking longer? The contractor asserts a recently issued contract change order (CO) is the root cause of delay and disruption. It added electrical conduit around which the formwork contractor must work. The contractor alleges the duration increased because the added work reduced crew productivity. Labour was increased as a mitigation effort. The contractor cites empirical studies as proof that the conditions of trade stacking, congested workspace, increased crew size, and re-sequencing — all resulting from the CO — are the root cause of the delay. No productivity data is provided.

In response, the owner's representative asserts contractor performance problems, such as missed deliveries, idle crew time, and so on. After much back-and-forth, no agreement is reached on the time and productivity claims, and the executed CO includes only the direct cost of the work. The contractor reserves its right to claim later for the excluded delay and productivity costs.

This is not good for the prospects of project success. How reliable is the schedule forecast if this and future delay are not accounted for? Have mitigation opportunities been squandered while true root causes go unnoticed? At the end of the project, will performance suffer because energies are focused on contentious claims instead of completing the work? In dispute resolution, will memories have faded, and facts be obscured, by the performance fog that prevails because there are no reliable schedules and performance analysis? Experienced construction people will recognize these as rhetorical questions: time and cost overruns, further exacerbated by the costs of formal dispute and possibly litigation, are the norm.

Enhanced Performance Analysis

CPM Schedules Can be Highly Reliable

The quality of construction schedules is generally so poor that there is widespread skepticism about the value of scheduling. It, therefore, needs to be re-affirmed that a best practice, fully-resource loaded, CPM schedule, based on a fully defined scope of work and sound constructability and resource assumptions, is a highly reliable performance analysis tool. Such a schedule is a bottom-up estimate of time, which aligns with the bottom up estimate of cost, and can be correlated to earned progress reported in the monthly progress billings. With such a schedule, and absent extenuating circumstances, the probability of completing on time can be 80 per cent or greater. On stipulated sum contracts, this level of certainty is sufficient for contractors to contractually commit to a time (and cost) objective. The schedule *should* continue to be a reliable instrument to analyze performance *throughout the project*, but this is rarely the case. Part 3 of the author's book explains how it is possible to obtain such schedules despite widespread industry failure to deliver them.

New EV Analytics

EV analysis requires improvement to provide reliable analysis about time and budget performance and, also, to be fully integrated with CPM schedules. New formulas have been developed (Fig. 2) to correct for these problems and are used to analyze the delayed project discussed above. The contractor argued that formwork experienced lost productivity, and was delayed, because of a CO alleged to have caused conditions of trade stacking, congestion, and other disruptions.

The new formulas are labour based because labour is a controllable performance factor in construction, reflected in the axiom: "*control the hours and control the project*". The new activity duration formula (2nd down) reveals that activity duration (an output) equals the product of the productivity and resource supply inputs. The originally planned duration of the formwork was based on an assumed productivity rate of 10 s.f./hr., and 100 hours/day of labour supply. After 10 days of work, actual labour data reveals that productivity is *exactly as planned! There is no productivity loss*. Moreover, labour was *not* increased to mitigate delay. It turns out the cause of delay is the deficit in the supply of labour (77 hrs./day instead of 100).

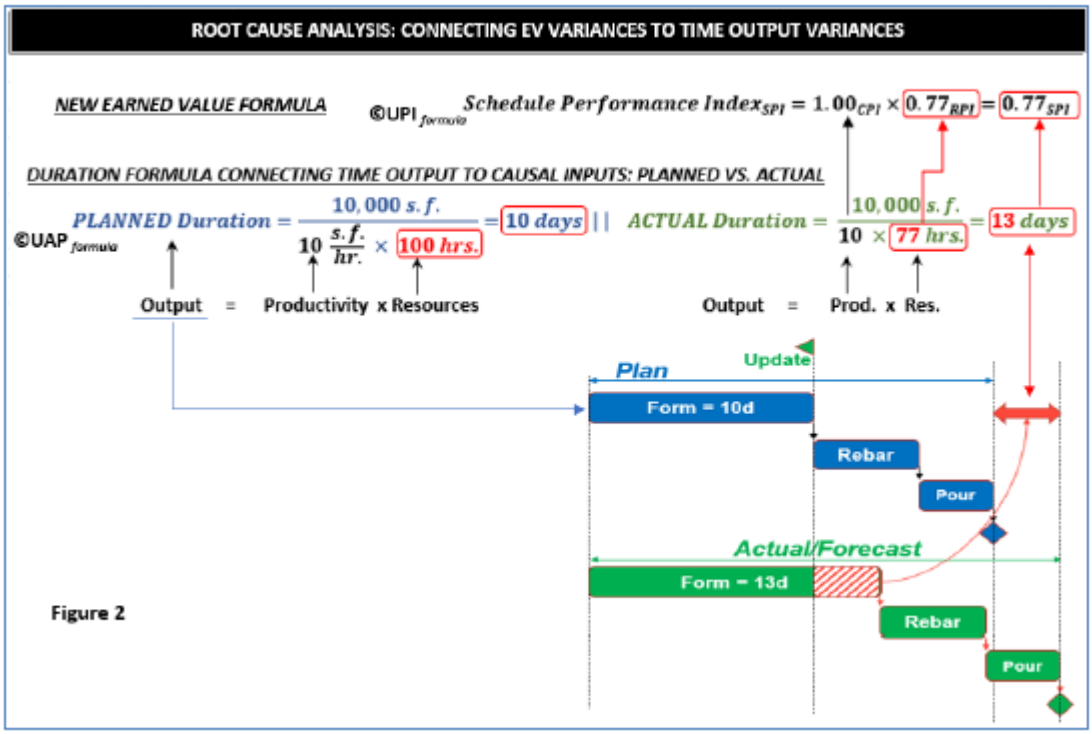

Figure 2

Productivity and the rate of labour supply are "root" causes, by which is meant they are the (input) agency which produces the (time output) effect. If an activity duration lengthens, or starts or finishes later than planned, either one or both of these input factors are the cause. Everything else, such as trade stacking, slow response to Requests for Information, multiple changes, and so on, are secondary causes or conditions, which may have an effect on duration (by affecting productivity or labour resources supply), but not necessarily so. The first time productivity gets attention is usually when a productivity claim is submitted at the end of the project and yet, it should now be understood, productivity (and the rate of resource supply) must be known in order to evaluate delay.

At this point, we should pause to reflect on the countless hours and dollars which have been wasted on projects everywhere because of the absence of causal performance analysis evidenced above. Heads should be shaking over this needless waste. The only reason that planned and actual productivity data are rarely available for contemporaneous performance analysis is that contracts do not require it and, it must be assumed, owners are not interested in getting it. Instead of project-specific, fact-based, causal analysis, there is probabilistic speculation (delay is occurring; condition "x" usually causes delay; condition "x" exists; therefore, condition "x" caused delay) about the reasons for variances in terms only of time output. Moreover, opportunities to effectively mitigate are lost when true root causes are unknown.

The new EV formula (top of figure) uses earned, actual and planned (labour-hour) data to connect output variance, measured by SPI, to the product of productivity (CPI) and (the new) labour supply (©RPI) input variances. If there is an activity time variance, there will be an SPI variance, and SPI variance is causally explained by one or both of CPI and RPI. Earned, actual and planned indices are measured in labour hours. In this case, the CPI is 1.00, which confirms productivity is favourable. However, the RPI is 0.77, indicating that 23 per

cent less labour (77 hours instead of 100) has been provided than originally planned. Finally, SPI, which is the product of RPI and CPI, is 0.77, meaning that 33 per cent less work has been accomplished (equating to the three-day delay) than was planned as of the update.

A salient point for project managers and delay analysts is that the required root cause test for delay is the actual impact on the productivity and labour supply performance factors, as calculated by the new formulas. Without it, analysis of performance and delay is bereft of a factual foundation.

Fully Integrating EV with CPM Schedules

EV and resource data is readily loaded into CPM schedule software. CPM analysis and the new EV analytics can then be combined. Calculations can be performed at an activity level, or wrapped up to a summary level, to analyze overall performance, or that of major trades, and so on.

Space is not adequate to fully convey the superiority of the new performance analytics presented in the author's book. Knowledge of productivity and labour supply enables a causal understanding of time variances which lifts the performance fog. Perhaps electrical activities are, on average, taking longer to complete, and starting and finishing later. This is a concern because float consumption increases the risk of schedule delay. Productivity is low (CPI = 0.80), and the resource supply is below plan (RPI = 0.90). Earned progress is 28 per cent behind plan (SPI = 0.72), (note: when both input factors are unfavourable, their adverse effect is magnified). So how much of a problem is this? The CPM Late curve provides a threshold for the Schedule Variance beyond which critical delay would be expected, and the earned curve is perilously close to this limit. The next construction meeting begins with an uncommon declaration:

> *We know that time slippage is occurring. We know that is because both productivity and resources are in deficit. What is the reason for these deficits? If productivity remains constant, the crew size needs to increase by 25 percent. Is that the plan for time recovery?*

These questions set the stage for a meaningful performance discussion and action plan to improve the chances of timely completion. Even if delay occurs, reliable schedules and contemporaneous performance analysis form the basis for lessons-learned and effective dispute resolution.

Conclusion

The new analytical theories, practices and project management approaches advanced here have had a transformational effect in terms of improved delivery of the cost and schedule objectives and have been successfully implemented on all types and sizes of construction and different contract delivery types, often at a lesser cost than the flawed approaches which currently predominate.

Buyers of construction control the rules of the game and so can dictate change. Now armed with comprehensive EV analytics customized for construction, as well as instruction on how to fully integrate the same with meaningful CPM schedules, and proven project management methods and strategy to meet the implementation challenge, the gauntlet is thrown down to owners. The paramount question for buyers of construction—government and private—is: Do you fully commit to a performance-based system, and do you have the will and determination to follow it through?