Protecting Earned Value Schedules with Schedule Margin

4/26/2010

Robert C. Newbold, Dr. Charlene S. Budd, and Charles I. Budd

More and more, scheduling experts are recommending schedule margin as a means of proactively allowing for risks and uncertainties in schedules.[1] By acknowledging the existence of variation and managing it explicitly, project managers and their customers achieve better predictability and more control over their projects.

Various mechanisms have been developed for estimating and tracking schedule margin. However, the growing use of schedule margin has raised questions regarding its use with Earned Value Management (EVM). There are two apparent problems, one of which is simple to resolve and the other more complicated.

The first problem is an artifact of the representation of schedule margin: schedule margin often appears in schedules as a discrete entity with no discernable value or cost. When represented this way, this schedule margin or "buffer" raises the question: "How do you assign costs or 'value' to schedule margin, in order to calculate Earned Value?" This is only an apparent problem. Buffers earn no value and should have no costs assigned. Costs should be assigned to the tasks associated with the work.[2]

The more complicated question has to do with when those costs are expected to be incurred, especially as relates to the budgeted cost for work scheduled (BCWS). This can clearly have a significant impact on schedule performance index (SPI). Figure 1 shows a very simple project schedule with two tasks. Schedule margin is represented at the end as a cross-hatched box. The task durations are based on optimistic timing assumptions, which means point X would be an optimistic completion time for the project. Point Y would be a low-risk completion time, based on some amount of schedule margin.

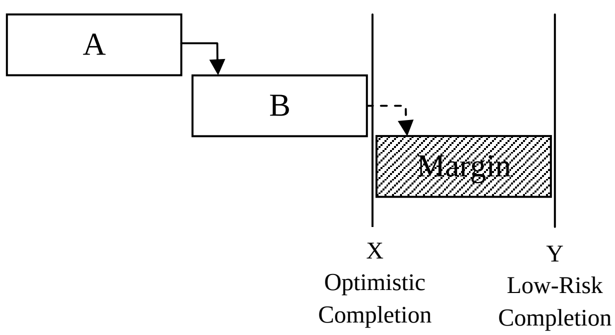

Figure 1: Simple Project

[1] See *inter alia* (GAO, 2009), (NASA, 2010), and (NDIA, 2009). See the Addenda for a discussion of the term "schedule margin."

[2] Note that management or contingency reserve funding (GAO, 2009, p.17) refer to a type of buffer that will often make sense to employ. However, that concept is distinct from schedule margin in numerous significant respects and is not treated in this paper.

If we use these optimistic times for tasks A and B in our BCWS, there is a reasonable chance that we will consume at least some of the schedule margin. In that case, our SPI is likely to indicate a problem, even while the schedule is within the bounds of the margin we have reserved.

Suppose, for example, that the estimated durations for Task A and Task B are 12 days each, and the schedule margin is also 12 days. Based on internal cost calculations of $5,000/day and assuming we'll use all the schedule margin, we have assigned costs of $90,000 each for Task A and Task B. Our BCWS after 12 days would be $90,000; after 24 days $180,000. Now suppose we reach day 11 and have completed 70% of Task A. We will have consumed some schedule margin, but we might be on track. Our BCWS would be 11/12 x $90,000 = $82,500. Our Actual Cost of Work Performed (ACWP) would be 11 x $5,000 = $55,000. Our Budgeted Cost for Work Performed (BCWP) or Earned Value would be .7 x $90,000 = $63,000. This gives us a Cost Performance Index (CPI) of 63,000/55,000 = 1.15, but a Schedule Performance Index (SPI) of 63,000/82,500 = .76. SPI does indeed indicate a problem.

So we need to decide whether or how we should adjust the timing of A and B to accommodate schedule margin when calculating BCWS. Leaving aside our optimism, when might we realistically expect these tasks to be completed?

To answer this question, it's useful to go back to the reasons for schedule margin, and common means for determining the amount to put into the schedule. Schedule margin can help allow for schedule variation of many sorts, including:

- Merge bias
- Inherent variability in time required to perform work
- Specific risks
- Uncertainty of events (weather, deliveries, etc.)

These kinds of variations are typically associated with specific tasks or groups of tasks. Therefore various approaches have been used to estimate schedule margin, such as Monte Carlo simulation, the original PERT technique, and other heuristic approaches. These approaches all have a common assumption: by estimating the potential for variation at the task level, we can estimate the potential for variation at the program level.[3]

This means that for each task, we have some kind of optimistic estimate as well as a low-risk estimate for task completions. When combining those estimates across a project network, whether we use Monte Carlo or some heuristic approach, we also have optimistic and low-risk estimates for project completion.[4] The time between the two estimates for a project endpoint (or other key area to protect) is the schedule margin. This is illustrated in Figure 2.

---

[3] Sometimes estimates must be done for groups of tasks and spread to individual tasks, as for example with merge bias or a risk that a particular capability may not be required. (GAO, 2009, p.170) suggests correcting for such correlated cost elements.

[4] Note that these times may be expressed as probabilities. So, for example, an "optimistic" task or project completion might be expected 50% of the time and a "low-risk" completion 90%.

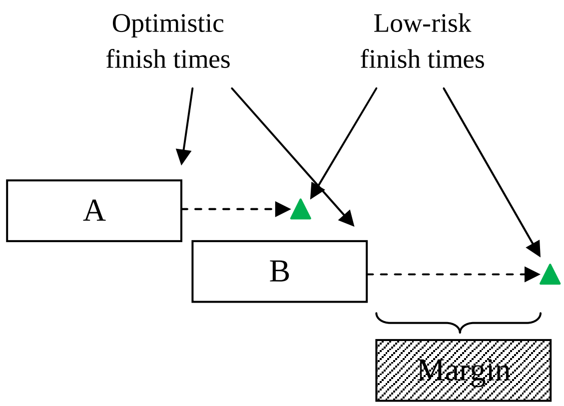

Figure 2: Optimistic and Low-Risk Finishes

Figure 2 suggests a simple approach to calculating task start and finish times to incorporate into BCWS. Go through the network task-by-task, only visiting a task when its predecessors have all been visited. For tasks without predecessors, use the start time associated with the task.[5] For tasks with predecessors, calculate the earliest possible start time, taking into account the finishes of all predecessors.[6] The finish time of a task is its low-risk completion time, as shown by the triangles in Figure 2.

This procedure spreads the schedule margin across all the tasks, in a way that takes into account how the schedule margin was derived in the first place. The result of applying this process to Figure 1 is shown in Figure 3.

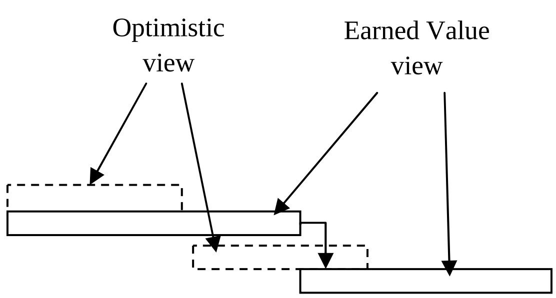

Figure 3: Schedule Margin Spread Over Tasks

Developing further the earlier example, suppose in Figure 3 that the Earned Value view indicates that Task A and Task B are expected take 18 days each, and we are again at the end of day 11 with 70% of Task A completed. ACWP is still $55,000 and BCWP is still $63,000. However, now BCWS changes to be 11/18 x $90,000 = $55,000. That means SPI is now 63,000/55,000 or 1.15, indicating that when we account for schedule margin, we are earning value at an acceptable rate.

[5] This may differ from the earliest-possible or project start date in cases where the task is scheduled to begin later, whether due to resource contention or other considerations.
[6] This must naturally consider any characteristics of links, such as lags, leads, or start-to-start relationships.

This approach raises an important issue: it seems, from Figure 3, as though we have two different schedules. That could be a huge problem; multiple schedules for the same project constitute a recipe for disaster. So it is critically important to note that this calculation results in only one schedule, with a range of possible starts and finishes for tasks and endpoints. Using (for example) a Monte Carlo approach, a supplier could agree with their client on the definition of "optimistic" and "low-risk" in terms of probabilities. "Optimistic" might be the completion time with a 50% probability; "low-risk" could imply a 90% probability. Rather than showing two schedules, Figure 3 shows two views of the same schedule: an optimistic view and a low-risk "Earned Value" view.

The recommended procedure shows how the Earned Value view can be derived from the original "optimistic" view. The "optimistic" view can be derived from the Earned Value one using a similar process, beginning with the start times of tasks without predecessors and applying the original optimistic task durations. In other words, both views are derived from the same basic data.

There are number of necessary conditions for a schedule in order to use this approach:

- Tasks must represent work, and dependent tasks must be linked.[7]
- Overall schedule margin must relate to variation on individual tasks. If, for example, schedule margin is estimated independently of the tasks, you will need an approach for spreading it back to the tasks. Otherwise there is no reasonable adjustment possible for BCWS.
- Information regarding schedule margin, including its importance, must be shared with the customer. Without that, you effectively have two schedules. (It is important to note that this is not always common practice; often, schedule margin is hoarded by individuals in order to protect dates.)
- The schedule must be reasonable to both the supplier and the customer.

With the approach discussed above, SPI will be less than 1 if schedule margin is consumed more rapidly than expected. It will be greater than 1 if schedule margin is not being consumed as quickly as expected.[8] This means it can provide valid Earned Value information about whether work is happening as rapidly as expected. In addition, the credibility and control added by making schedule margin explicit and visible makes all the EVM parameters more credible and therefore more useful.

[7] Note that this is a standard scheduling "best practice."
[8] Of course, SPI should not be used by itself to predict whether or not the project is on track to complete on time. However, explicit tracking of remaining schedule margin over time can be used to evaluate the likelihood of on-time completion. See, for example, (NASA, 2010, p.65).

Addenda

Definition of Schedule Margin

There are several terms used to refer to a block of time used to protect a schedule from the effects of variation and other uncertainties. Schedule reserve, schedule margin, and buffer seem to be the most common. This proliferation of terms has resulted in some confusion. How does schedule margin differ from schedule reserve? Does use of "buffer" mean you are doing Critical Chain scheduling? And so on. It's therefore useful to discuss current usage of this terminology.

The PMBOK Guide (PMI, 2008) does not mention "margin," instead using "reserve." It leaves "buffer" as a synonym and "contingency" as a modifier:

> ***Reserve***. *A provision of the project management plan to mitigate cost and/or schedule risk. Often used with a modifier (e.g., management reserve, contingency reserve) to provide further detail on what types of risk are meant to be mitigated.*[9]

Similarly, GAO uses the term "schedule reserve" in its Cost Guide (GAO, 2009).

In its draft paper on Schedule Margin (NDIA, 2009), NDIA uses the terms "schedule margin" and "schedule reserve" interchangeably, while primarily referring to "schedule margin." Similarly, NASA emphasizes the term "schedule margin" but states:

> *It is a recommended practice that schedule margin, based on risks, duration uncertainty, and historical norms, be clearly identifiable when included within the IMS. Schedule margin may also be referred to as "schedule reserve" or "schedule contingency."*[10]

The IMS description seems to focus on Schedule Margin:

> *2.4.1.22 Schedule Margin. A management method for accommodating schedule contingencies. It is a designated buffer and shall be identified separately and considered part of the baseline. Schedule margin is the difference between contractual milestone date(s) and the contractor's planned date(s) of accomplishment.*[11]

Meanwhile, Critical Chain advocates use the term "buffer" almost exclusively.

---

[9] See (PMI, 2008, p.437). Interestingly, PMI's Practice Standard for Scheduling (Project Management Institute, 2007) omits all these terms from its glossary.
[10] NASA, 2010, p.44.
[11] DoD, 2005, p.5.

In this paper I have used the term "schedule margin," but recommend that the terms schedule margin, schedule reserve, and buffer be used interchangeably, because that seems to be common usage.

Schedule Margin as a Task

In incorporating schedule margin in a schedule, NASA has stated that:

> *The preferred technique for including schedule margin in the IMS is to insert additional tasks that are specifically identified as "Schedule Margin." These tasks should have durations assigned that provide the additional quantity of time deemed necessary to absorb the impacts of unknown schedule risks.* [12]

Similarly, NDIA's Schedule Working Group recommends use of explicit tasks to represent schedule margin.[13]

However, people periodically express reservations regarding the use of buffer tasks because they are "non-value-added" in an Earned Value sense. Some of these reservations may come from (DoD, 2005, p.2) which says: "Every discrete task/activity, work package, and planning package shall be clearly identified and directly related to a control account."

My view is that, on the one hand, tasks representing schedule margin do add value to the schedule and are therefore valid as tasks, even though control accounts may be problematic. In any case, as may be clear from this paper, data describing schedule margin can be associated with the task immediately prior to the schedule margin itself. Therefore either approach could work. By far the more important question is whether variation and uncertainty are to be managed explicitly.

References

Department of Defense (DoD). 2005. *Integrated Master Schedule*. DID DI-MGMT-81650. DoD Policy & Guidance, ACC EVM CoP.
http://www.acq.osd.mil/pm/currentpolicy/cpr_cfsr/IMS%20Final%203-30-05.pdf

Government Accountability Office (GAO). *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs.* March 2009.
www.gao.gov/new.items/d093sp.pdf.

[12] NASA, 2010, p.45.
[13] NDIA, 2009, pp.9-10.

NASA. 2010. *NASA Schedule Management Handbook.* http://evm.nasa.gov/docs/Handbooks/Sched_Mgmt_Jan_10/Special_Publication_NASA_Schedule_Mgmt%20Hdbk_%20Jan%202010.docx .

National Defense Industrial Association (NDIA), Program Management Systems Committee, Schedule Working Group. 2009. "Depicting Schedule Margin in Integrated Master Schedules." http://www.ndia.org/Divisions/Divisions/Procurement/Documents/PMSCommittee/CommitteeDocuments/WhitePapers/NDIAScheduleMarginIssueWhitePaperDraft.pdf .

Project Management Institute (PMI). 2007. *The Practice Standard for Scheduling.* Newtown Square, PA: Project Management Institute.

Project Management Institute (PMI). 2008. *A Guide to the Project Management Body of Knowledge*,
4th ed. Newtown Square, PA: Project Management Institute.

Authors

Robert Newbold, CEO and founder of ProChain Solutions, is a leading expert on Critical Chain scheduling and project management. He is author of the books *Project Management in the Fast Lane* and *The Billion Dollar Solution* and holds degrees from Stanford University, SUNY Stony Brook, and Yale University.

Charlene S. Budd, PhD, CPA, CMA, CFM, and PMP, is Professor Emeritus of Accounting at Baylor University, where she taught graduate accounting and project management courses. With Charles Budd she has co-authored two editions of *A Practical Guide to Earned Value Project Management*.

Charles I. Budd, PMP, is a principal of Budd Management Systems in Atlanta, Georgia. He is certified as a system analyst by the Foundation for Administration Research and is active in the Project Management Institute. He has held executive positions in a number of technology companies and is co-author with Charlene Budd of *A Practical Guide to Earned Value Project Management*.

If you have questions or comments regarding this paper, please contact Rob Newbold at rnewbold@prochain.com.