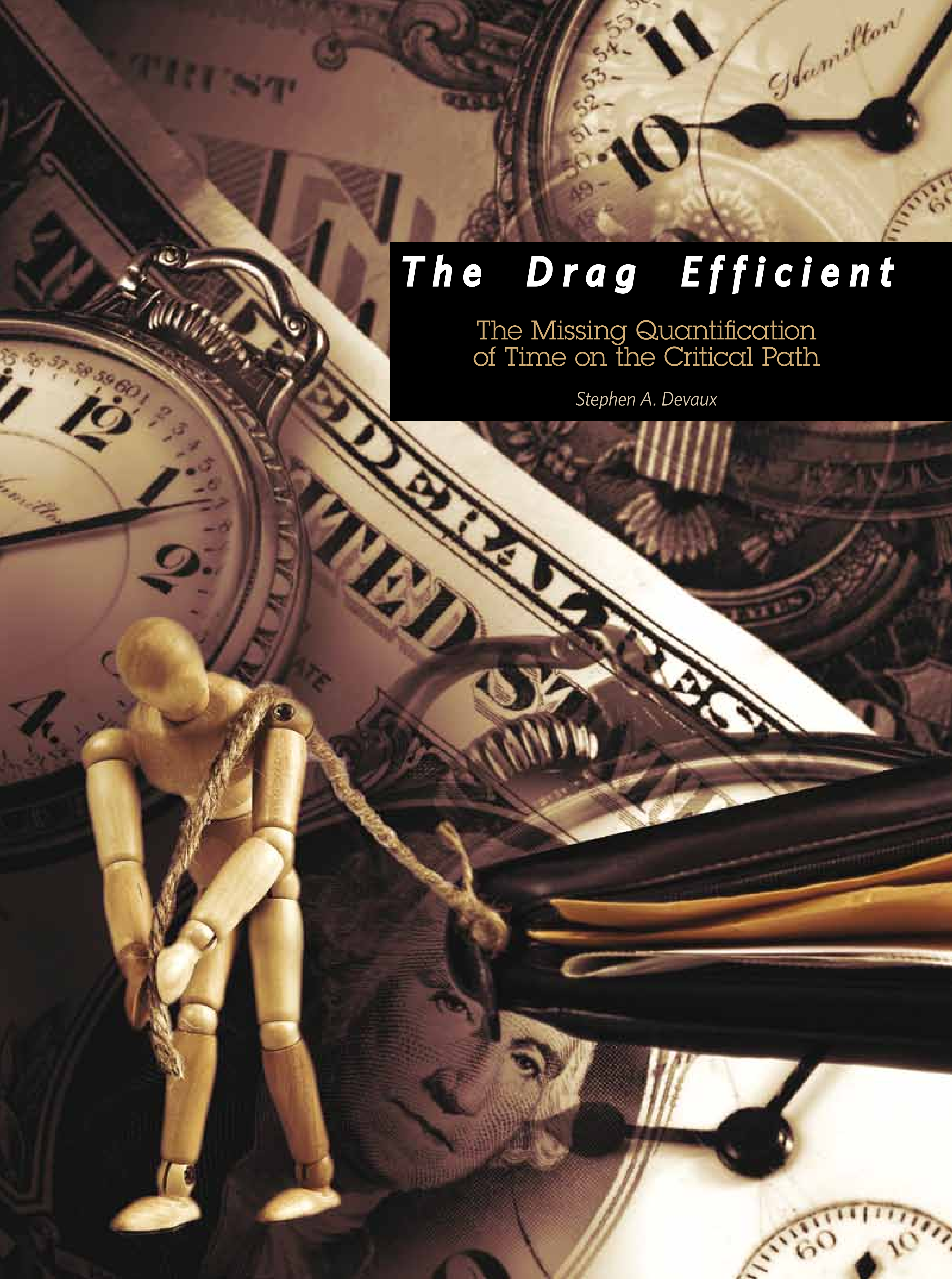

The Drag Efficient

The Missing Quantification of Time on the Critical Path

Stephen A. Devaux

Critical path analysis has been around for more than half a century. An argument can be made that no project management technique is more important. Yet in project management theory and in scheduling software, there is the significant omission of two vital critical path metrics: *drag* and *drag cost*.

Critical path drag is a key metric in the planning and scheduling of a project. It measures how much a critical path item is delaying project completion. Its greatest value is to the contractor who must manage the schedule. But it is also crucial for the customer to know that the

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project team is using this metric both to generate an efficient schedule and to target the most appropriate work packages when slippage occurs.

The drag cost of an activity has even greater implications for the customer; it is the amount of value that the project is losing due to delivery being delayed by that activity's critical path drag. Unfortunately, financial analysis of project work tends to focus almost exclusively on budget. Benjamin Franklin wrote that time is money. Every customer knows that the time required for a project comes at great cost. Those funding projects often would willingly pay significantly more to accelerate deployment of a mission-critical system. Since it is exclusively critical path activities that are delaying project completion, the cost of delay is an invisible and expensive cost of critical path work.

The problem is the inability to identify which critical path activities are costing the time and money—i.e., their drag and drag cost. This article will show that the use of these concepts is vital to on-time delivery, schedule recovery, and the generation of maximum customer value.

Impact of Critical Path on Project Investment

All projects, without exception, are investments, undertaken to create greater value than the cost of the required resources. No customer or sponsor would ever *knowingly* invest $5 million worth of resources if the total value from the final product, from all sources, was only expected to be $4.9 million. The difference between the value of the final product and the cost of producing it, what we might call *project profit,* should be a key metric for project performance (as it is for all other investments!). The cost of a project investment is always carefully tracked—but the return, or the *expected monetary value* (EMV) of the scope is little analyzed and often ignored.

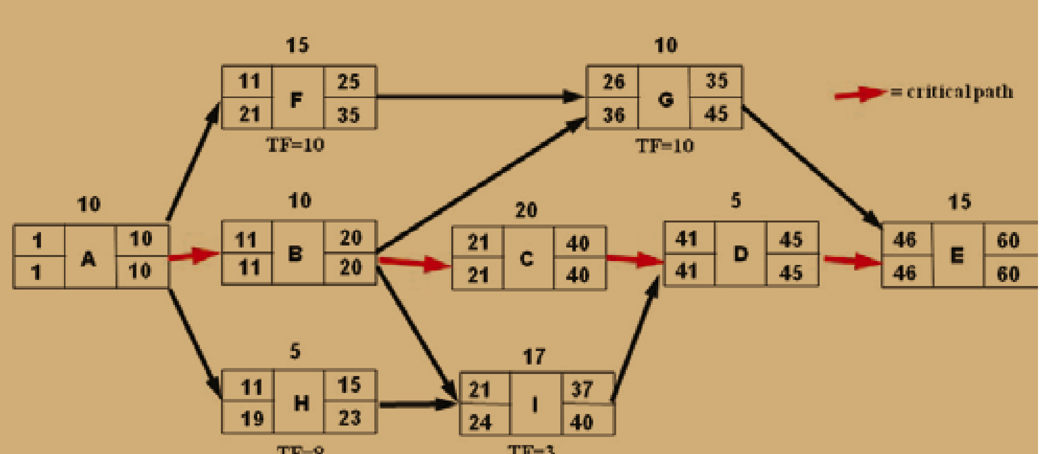
One of the main factors that can affect the EMV of a project is changes in delivery date. It is usually the case that the earlier the delivery date, the greater the value of the project investment. Delivery date is always determined by the project's longest, or critical, path. This may start as a planned critical path, but will finish as the actual longest path, or what the construction industry terms the "as-built critical path" (ABCP). The project manager should recognize the overwhelming importance of this path, and manage it. During project postmortem, the ABCP and the changes from plan that may have generated it should be a vital artifact and a generator of lessons learned.

Gaps in traditional critical path data

Whether dealing with the planned critical path or the ABCP, it is important to recognize that both the gods and the devils are in the details. Good schedule management requires knowing the contribution of each activity (as well as technical difficulties, scope changes, resource insufficiencies, schedule constraints, etc.) that contributes time to the length of the path. And here, unfortunately, we enter an area in which critical path theory, as beneficial and vital as it is, is silent.

What does critical path analysis tell us about each activity in our project? If an activity is not on the critical path, both critical path theory and traditional program management software quantify something called either *total float* or *total slack* (depending on the software): the maximum amount of time that

Figure 1: A Simple Network Logic Diagram, Showing Forward and Backward Passes and Total Float



Drag Cost in Human Lives

Benjamin Franklin's dictum that time is money sometimes understates the case: on some projects, time can be measured in human suffering and death. Examples can be found in pharmaceutical development, hospital systems, emergency response—any endeavor in which projects are undertaken to save lives.

Deployment of homeland security and defense systems are prime examples of efforts where human lives are often on the line. To identify just one example, earlier deployment of a countermeasure to defend against MANPADS (man-portable air-defense systems) could protect aircraft in a combat zone and save many American lives. If the annual loss of life in a combat zone due to MANPADS is determined to be 50, and a planned countermeasure deployment would reduce that number by half, then decreasing the drag of *any critical path activity* by 2 weeks would eliminate an estimated drag cost, over and above the dollars, of the death of an American soldier.

an activity can be delayed without making its path the longest in the project.

Figure 1 shows a simple network logic diagram of a project with the earliest and latest dates for each activity filled in on top and at bottom respectively. Let's assume that this is the schedule of a project with a 45-day deadline, with each additional day reducing investment value by $10,000.

As the network shows, the critical path is A, C, E, H, I, and the project duration would be 60 days. The total floats of the non-critical activities would be:

F = 10
G = 10
H = 8
I = 3

But since total float quantification is all *off* the critical path, this gives us little help in knowing where to compress the schedule. And unfortunately, no similar quantification is performed for activities that are *on* the critical path! For each critical path activity, the software (and all traditional PM theory, including the *PMBOK Guide*) simply says zero—that its total float is zero.

Of course, project schedules are much more complex than the simple example shown in Figure 1. But no matter how large or complex the schedule, the project manager's approach should always be to make the project schedule as efficient as possible, providing the customer with the greatest value for the least cost.

The trouble is that most traditional project management metrics are silent about what we all know is really important: the critical path. What we need to know is:

1. Of all the activities on the critical path, which are adding the most time to project duration and offer the greatest "bang for the buck" if shortened?
2. How much money is each activity's added time costing, and how much would it cost to compress it?

The first metric that addresses this issue is not float—it's the much more important metric, critical path drag (as introduced in my book *Total Project Control: A Manager's Guide to Project Planning, Measuring and Tracking*, published in 1999 by John Wiley & Sons). Just as drag is what slows down a submarine or an airplane, critical path drag is the

A Historical Example of Drag Cost in Human Lives

In 1991, during the first Gulf War, it was discovered that a software bug in the radar of the Patriot anti-missile system was causing the timing system to lose a small fraction of a second for every hour that a battery had been operational. Quoting from the February 4, 1992, report of the Information Management and Technology Division of the United States General Accounting Office (http://www.fas.org/spp/starwars/gao/im92026.htm):

> On February 21, 1991, the Patriot Project Office sent a message to Patriot users stating that very long run times could cause a shift in the range gate, resulting in the target being offset. The message also said a software change was being sent that would improve the system's targeting. However, the message did not specify what constitutes very long run times...
>
> ...Alpha Battery, the battery in question, was to protect the Dhahran Air Base. On February 25, Alpha Battery had been in operation for over 100 consecutive hours. Because the system had been on so long, the resulting inaccuracy in the time calculation caused the range gate to shift so much that the system could not track the incoming Scud. Consequently, Alpha Battery did not engage the Scud, which then struck an Army barracks and killed 28 American soldiers.
>
> On February 26, the next day, the modified software, which compensated for the inaccurate time calculation, arrived in Dhahran. According to Army officials, the delay in distributing the software from the United States to all Patriot locations was due to the time it took to arrange for air and ground transportation in a wartime environment.

Although there is always a strong tendency to blame the last few activities (i.e., "the time it took to arrange for air and ground transportation") for a late delivery, the fact is that every critical path activity contributes to the project's duration. In this case, every activity that had drag of 1 day or more, *and that might somehow have been shortened through additional resources or expense*, could have saved the lives of those 28 soldiers.

Figure 2: A Simple Network Logic Diagram with Drag Computed

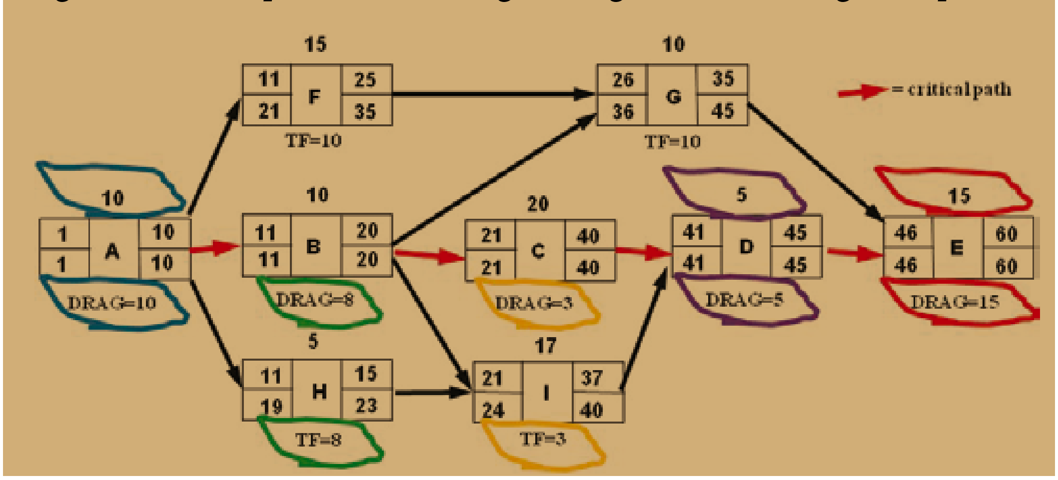


Figure 3: A Simple Network Logic Diagram with Drag Cost Computed at $10,000/Day

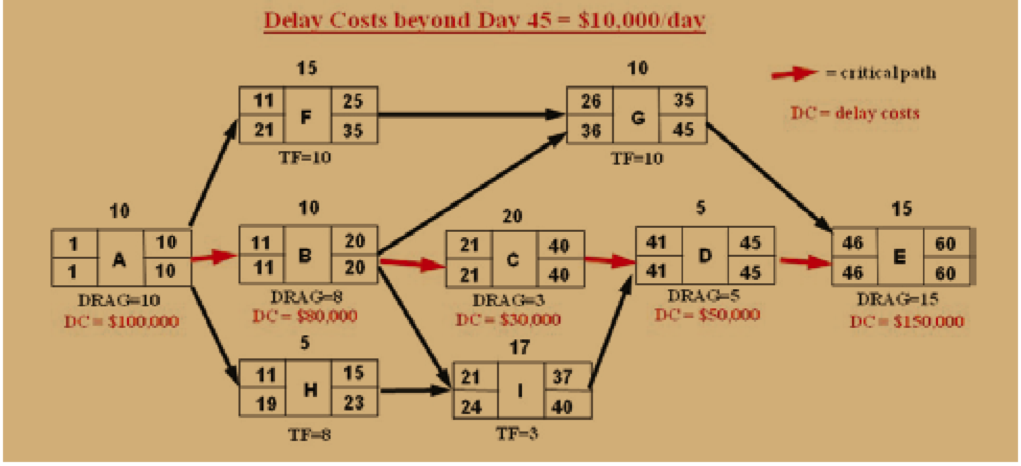
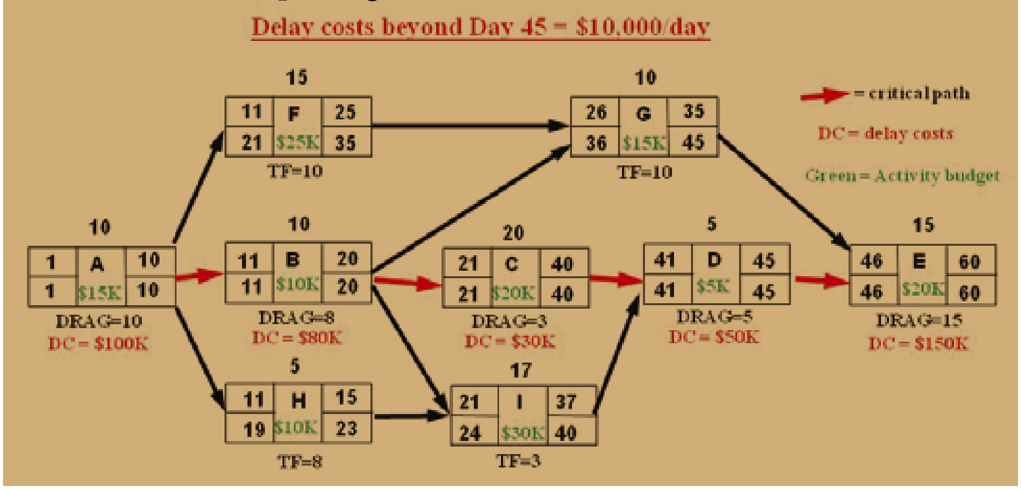


Figure 4: A Simple Network Logic Diagram with both Drag Cost and Activity Budgets



- Step 1: Only critical path activities have drag.
- Step 2: If an activity has nothing else in parallel (e.g., A and E above), its drag equals its duration.
- Step 3: If a critical path activity has other activities in parallel, its drag is *whichever is less*: the total float of the parallel activity with the LEAST total float (B and C above), OR its own duration (D, whose duration of 5 days is LESS than the 10 days of total float in each of the parallel activities F and G).

Today, three software packages compute drag:

- Project Optimizer from Sumatra.com (an MSProject 2007 add-on)
- PlanontheNet.com
- Spider Project

Of course, there is more to schedule optimization than drag computation. Just because Activity E has drag of 15 and Activity B's drag is only 8 does not necessarily mean that you can shorten E more than B.

- Some activities are less "resource-elastic" than others, i.e., adding resources may do little to shorten their durations.
- Shortening some activities may increase risk unacceptably, decrease quality, or otherwise reduce project value and profit.
- The resources needed to reduce one activity by each unit of time may be much more costly than those needed for an equal or greater reduction on a different activity.

However, when trying to shorten the project duration (either up front during planning, or during execution when schedule slippage may leave the project manager seeking alternatives), we may be searching through a network of not five activities but 500 or 5,000! Then there needs to be a way of focusing the process of schedule reduction onto those candidates which will provide the greatest reward. These are almost always the activities with the greatest drag.

In Figure 2, even though Activity C has a duration of 20 days, it is only adding 3 days to the project schedule. By contrast,

amount of time by which a critical path activity is slowing down the project. *And it is vital information for any project manager to know about the activities in her project!*

- Float is always off the critical path, whereas drag is always on critical activities.
- Float usually does not cost the project time and money, whereas drag almost invariably does!

There is an old saying: "What is measured is what is emphasized." As a result of the standard CPM metric of total float, the emphasis winds up being on precisely the wrong things—the work that's not on the critical path! What the project manager needs to know is: *how much time is each critical path activity adding to my project duration so that I can target the best tasks for compression.* This is critical path drag. In Figure 2, we show the drag totals on the critical path activities:

Although "manual" drag computation in a large network with complex dependencies (Six Sigma, lag, etc.) can be intimidating and time-consuming, it is relatively easy in a simple network such as the one above:

The *USS Monitor*: A Happy Story of Limiting Drag Cost

When news reached the U.S. Navy in late 1861 that the Confederate Navy was working to convert the former *USS Merrimack* into an ironclad warship, an emergency order went out for the design of a Union ironclad. John Ericsson's model of "a cheesebox on a raft" was selected, and on October 4, 1861, Continental Iron Works and DeLamater Iron Works, both of New York, were contracted to build the Union ironclad.

Ericsson had no project management software, and had never read an article about critical path drag. But he was an engineering genius managing an urgent project. Under his direction, the *USS Monitor* was launched in Brooklyn and began preparations for combat on January 30, 1862, just 118 days after the Navy's order was submitted.

On March 6, the process of towing *Monitor* down the Atlantic Coast to Chesapeake Bay began. Late on March 8, the former *Merrimack*, now rebuilt into the ironclad *CSS Virginia*, attacked the Union squadron blockading Hampton Roads and sank *USS Cumberland* and *USS Congress.* At dusk, the *Virginia* returned to port, intending to finish the job the next morning. But that night the *Monitor* arrived, and on March 9 the two ironclads fought their famous battle to a draw, leaving the Union blockade in place.

The cost of the one extra day it took for *Monitor* to arrive was high, but two days would have cost far more! Had Ericsson had software to help him eliminate one more day on his critical path, the lives lost on the two Union warships might have been saved. Conversely, had he not so brilliantly shortened the project schedule as much as he did, the blockade would probably have been broken and the Union might have lost the war.

even though Activity D has a duration of just 5 days, it's adding 2 more days to the critical path than is Activity C. And, all else being equal, Activity E may offer the greatest opportunity with 15 days of drag.

Computing the Drag Cost of an Activity

Ben Franklin's statement that "Time is money!" is never more accurate than when applied to projects. The key is to tie the cost of project delay to each individual activity generating the delay. The cost of this delay is caused by the activity's critical path drag, and is the activity's drag cost.

Drag cost represents the synthesis of the concept of project profit with a truly scope/cost/schedule-integrated plan. It is the reduction in the net value of the project because of the delay in project completion due to the time impact of each activity's drag. It may be caused either because the delay reduces the project's expected monetary value, or because the delay increases the indirect costs (overhead and opportunity costs).

Figure 3 computes the drag cost of each activity if the cost of delay beyond 45 days is $10,000 per day.

Drag cost assigns the cost of project time to the individual critical path activities that are adding that time to the schedule. Suddenly, not only does Ben Franklin's dictum apply to projects—it now applies to individual work items in the project, and to the resources performing that work. This allows the project manager to assess the relative cost of each work item, and to target additional resources to reduce the drag cost.

Computing the True Cost of an Activity

Although finance departments have taught us to identify the cost of work with the price of the resources doing that work, this is simply not true of work performed on the critical path of a project! A week's work by a minimum-wage laborer can be much more costly than a week's work by a Nobel laureate physicist—if the physicist's work has float while the laborer's work is on the critical path with lots of drag cost! The *true cost* of project work is the sum of the resource cost and the drag cost (which of course is zero if the work is not on the critical path).

In Figure 4, we have provided the budget for each activity's resources. Even though most financial analysis would determine that Activity I is the most costly work (with a budget of $30,000) since it has no drag cost, it's actually not even close. Since Activity I is not on the critical path, its true cost is only its resources. Conversely, Activity E's true cost is the sum of its $20,000 budget and its $150,000 of drag cost, or $170,000. The true cost of each activity is as follows:

A = $15,000 + $100,000 = $115,000
B = $10,000 + $80,000 = $90,000
C = $20,000 + $30,000 = $50,000
D = $5,000 + $50,000 = $55,000
E = $20,000 + $150,000 = $170,000
F = $25,000
G = $15,000
H = $10,000
I = $30,000

Computing the true cost of an activity can provide huge benefit to the customer, the project manager, and to the organization performing the project.

Additional resources can be targeted to the activities with large true cost. For example, if doubling the daily resources on Activity E reduced its duration and drag from 15 days to 10 days, its budget would increase from $20,000 to $26,700, but its drag cost would be reduced by $50,000 and its new true cost would be only $126,700 ($26,700 +100,000), or $43,300 less.

Some optional activities ("nice-to-haves" rather than "must-haves") often wind up delaying a project by more than they are worth. Drag cost computation would allow both the customer and the project manager to recognize the true cost of optional

Using Drag to Accelerate the Schedule of a Subdeliverable

A few years ago, a client called to see if I could help with a scheduling issue on a large project: the customer had requested that delivery of a certain component be accelerated by 5 weeks. Part of the problem was that the component was not on the critical path of the 3 year project; it had over 200 days of float. The earliest it could be completed, according to the master schedule, was 5 weeks later than the customer now needed it. And the program manager didn't know where to start.

In such cases, it is crucial to have a "clean" schedule: with up-to-date progress information, correct dependency links, and no activities performed out-of-sequence (the bane of schedule analysis!). It took a while to "scrub" the data. After 3 or 4 hours, we felt that we had an accurate schedule from the current date forward. Then:

1. We targeted the component delivery, making it our last or "sink" activity.
2. We identified the target's "ancestors," i.e., all earlier activities on the same logical path: predecessors, predecessors' predecessors, etc.
3. Next we eliminated all activities that were NOT ancestors to get a subset of only those activities that were ancestors of the targeted activity.
4. We identified the critical path to the targeted activity, and computed the drags.
5. Finally, we pulled in the component's delivery date just as we would the end of a project, by fast tracking or crashing the durations of those activities with the most drag, recalculating activity drags as the critical path changed.

The adjustments made the component's desired delivery date achievable.

work when it migrates to the critical path and determine if it is of sufficient value or whether it should be jettisoned. (This analysis should be performed any time that the critical path changes, loading a new set of activities with drag cost during project performance.)

Any organization in the business of performing multiple simultaneous projects should conduct quarterly assessments of the true cost of specific resource types (mechanical engineer, programmer, etc.) and create Pareto charts highlighting those that have the greatest true cost. Increases in such resources will usually result in decreases in the drag cost component of their summed true costs.

A Concluding Anecdote

A few years ago, while teaching the concept of drag in a seminar, an engineer who worked with a large defense contractor told an illuminating story. The customer had requested that a specific deliverable that was not part of the project's critical path be pulled in by 6 weeks. The transcontinental team all flew to a central site and spent a full day suggesting the changes they thought would meet the new scheduling needs. When they were finished, they incorporated the changes into the master schedule—and the deliverable came in by 1 day! The team then spent the rest of the week engaged in pure trial-and-error: "What if we could do this in 8 days instead of 12? Nope, no change." "What if we made this 5 days instead of 14? Okay, we gained 3 days!" The engineer told me: "If we'd understood the concept of drag, we'd never have even left our offices. We could have accomplished our goal in a half-hour conference call."

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From the Managing Editor

It's well known to the readers of this magazine that with the challenges facing the federal budget, the leaders of the Department of Defense and of DAU have called on all of us to look for ways to reduce costs while maintaining value. As with most publications, two of the largest costs of publishing *Defense AT&L* are printing and postage. And so, after much consideration and collaboration, we begin our transition to being a largely online entity. This issue of *Defense AT&L* will be one of the last to be printed and mailed to our full roster of U.S.-based subscribers.

As unfamiliar as this change might be to some readers, it does bring new opportunities. We will soon provide a version of the magazine for e-reader devices, along with a smartphone application via the DAU web portal. Not to mention the full-color PDFs always available on our website. A quick e-mail to **datlonline@dau.mil** will get you automatic updates when new issues come out. And as an incentive to share your knowledge, contributing authors will still receive the few printed and bound copies.

Change sometimes takes getting used to. It's the earnest hope of everyone who works on this magazine that this change will allow us to bring you acquisition knowledge even more efficiently and conveniently.

Thanks to all our readers for your continued support and contributions—and your service to this great nation.

John Bell
Managing Editor