Almost everyone in the planning and scheduling profession has an opinion regarding the use of negative lags in schedule preparation. This article will explore the pluses and minuses of using these lags in a schedule. To lag or not to lag is not the question. The question: Is the use of negative lags proper scheduling?

Don’t miss this exciting session. This lively debate will provide an opportunity for audience participation to express an opinion after both presenters have expressed their opinions on each issue. The pros and cons of using negative lags will be presented by experienced schedulers who are equally convinced that their negative lag position is the only correct approach.

BACKGROUND

When the arrow diagram method was developed, it allowed for only finish-to-start relationships. With the development of the precedence diagram scheduling method, the start-to-start, finish-to-finish and start-to-finish relationships were created. In addition to the added types of relationships, lag time was created. A lag is the number of time units from the start or finish of an activity to the start or finish of its successor.

PRO

A Lag can be a positive or negative value. An example of a positive lag is sometimes used to delay the start of an activity after pouring concrete. The pour is performed and a seven day lag is used to delay the start of an activity until the concrete is adequately cured.

Negative lags have been used to forecast when an activity will start prior to the finish of a precedent activity. An example of this is the start of check-out activities. A start up supervisor may say “I will start my check out two weeks prior to the project being complete” meaning that two weeks prior to when the project will obtain mechanical completion, he will mobilize his start up personnel to check out the facility.

The use of negative lags is supported by logical reasoning in that they mirror expressions of construction supervisors. An electrician will say, “I’ll start my rough-in work on that floor a week prior to the stud installer being complete.” A drywall installer will say, “I will start putting up drywall on the floor when the electrician and the plumber are a week from being complete with their rough-in.” Negative lags parallel contractor’s thinking and assists in their understanding schedule network? Let us look at an example of a traditional network with finish-to-start logic and no lag.

In figure 1, roof deck, studs, rough-in and finishes were divided into two activities in order to allow for an overlap of the work. The above schedule using a normal five-day work week calculates a project completion on April 17th.

Many contractors today develop schedules which do not use the traditional finish-to-start with no lag. A popular method is a start-to-start with a positive lag. In this manner the contractor is able to schedule the project with overlap of activities but with fewer activities in his schedule. In figure 2, network has fewer activities and still calculates a completion date of April 17th 2006.

Another method to develop a comparable network is to use finish-to-start relationships with a negative lag. A purist may say that a finish-to-start with a negative lag is an unacceptable relationship. However, the method is very effective in eliminating numerous activities that would have to be added into a schedule in order to eliminate the negative lag relationship. These numerous activities make the schedule less understandable and less economical to update. In addition, the theory of CPM states that all activities should represent actual, measurable work.

Figure 3 schedules all correctly calculated as planned completions date, however the real question is, as the schedules are updated, do positive lag or negative lag schedules correctly calculate the impacted completion date?

In the figures 4, 5 and 6, we have updated the schedule based on a Feb. 4 data date at which time all schedule activities were proceeding as scheduled with the exception of the roof deck installation. Roof deck installation started as scheduled on Jan. 31 but only achieved one day of progress by Feb. 4. We have recalculated the three types of schedules based on the actual progress. The traditional schedule calculates a project completion date of April 20.

Using the same criteria, the start-to-start with a positive lag schedule network was updated and the calculated completion date was April 17. The schedule did not reflect the delay which had occurred after the start of metal deck because the relationship was tied only into the actual start date of Jan. 31.
The criteria again were used on a finish-to-start with a negative lag. This network calculated a completion date of April 20 which is the same as the traditional schedule model. The calculation reflected the traditional model because the logic path went to the completion of the roof deck installation which was delayed.

The finish-to-start with negative lag allows schedule activities to be overlapped but still restrained by the completion of the predecessor activity. If we examine a step farther and update our schedule as of April 4, with the following schedule deviation, the installation of studs for Area A is completed in 11 work days and Area B is completed in nine work days. The overall duration of stud work is still 20 days as scheduled; however, the beginning work is delayed but is recovered in Area B.

The actual progress on the traditional network (figure 7) results in a completion date of April 21. This additional one-day delay is a result of the sequence of activities through area A studs, rough-in, and finish, to area B finish. Using the same criteria in a finish-to-start with a negative lag (figure 8), the one-day delay in the beginning of stud wall installation does not result in a change in the network. The completion date of April 20 of the finish-to-start with negative lag network is unchanged.

The question that cannot be answered by these theoretical calculations is, “What was the actual project completion date?” The traditional method may or may not calculate the correct completion date.

PRO CONCLUSIONS

Networks with finish-to-start relationships with a negative lag provide a reasonable calculation for the completion date of a project. The schedules using finish-to-start relationships with a negative lag can effectively overlap work activities without adding numerous schedule activities which complicate and increase the cost of developing schedules. Although traditional methods may be the best solution, negative lag is a reasonable method to create workable schedules.
Most scheduling software programs do allow the use of lags and they can be used as either positive or negative, however that does not mean that the use of negative lags is an acceptable approach to producing a good project schedule. The major problem with the use of any lag, whether it be positive or negative, is that in most instances of use the person who prepared the schedule is truly the only person that actually knows the definition of all of the lags within his schedule. A positive lag utilized in concrete placement, as described by Mr. Calvey, is one of the more obvious uses of lags. Most experienced construction supervisors understand this particular use of a lag. However, many lags used in scheduling today completely lack that transparency and have to be translated to the user of the schedule, by the scheduler. For example, if you are building a house and are scheduling the plumber and electrician work you might have an activity that says:

- Rough-in plumbing and heating—second floor (10 days original duration)
- Rough-in electrical—second floor (15 days original duration)
Most schedulers would choose to have the electrical activity be a successor to the plumbing and heating activity due to much of the plumber's work involving rigid pipe versus the electrician's work involving easily bendable conduit and wire. Many of today's scheduler's would choose the logic of these tasks with the electric activity having a start-to-start successor relationship with a five day positive lag, as shown in figure 9.

The problem with this approach to scheduling is that the start of the electrical work is not based on the completion of any known scope of plumbing and heating work, instead it is based on the assumption that after five days of plumbing and heating work there will be enough work completed to create open space where the electrician can work productively. In this case the five day lag is not based the completion of some known event such as a concrete pour, but instead is based on the scheduler's assumption that the plumber will sufficiently progress his work so that one of the second floor rooms will be sufficiently open for the electrician to work. This lag is not nearly as transparent as the concrete cure lag because it is not based on the completion of a known scope of work. A fundamental element of any schedule is to communicate...
the work plan; and using lags of any kind make that communication more difficult. The use of the positive lag has eliminated detail from the schedule that communicates the work plan and this lack of communication can add a level of inefficiency to a project.

The introduction of negative lags equally decreases the amount of transparency in the schedule. If we use the same two activities mentioned above, but this time have the logic be based on the electrical activity having a finish-to-start relationship with a negative five day lag, the planned start and completion dates for the electrical work would be identical the planned start date based on the positive lag, as shown in figure 10.

Contrary to the opinion of Mr. Calvey, construction supervisors do not think in terms of negative lags. Mr. Calvey stated above that: An electrician will say, “I'll start my rough-in work on that floor a week prior to the stud installer being complete.” This is simply incorrect! A good electrician will actually say, “I'll start my rough-in work on that floor after the stud installer has completed three out of the four exterior walls.” Mr. Calvey also stated: A drywall installer will say, “I will start putting up drywall on the floor when the electrician and the plumber are a week from being complete with their rough-in.” This is also incorrect! A good drywall

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**Figure 9**

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<th>Activity ID</th>
<th>Activity Description</th>
<th>Orig Dur</th>
<th>Early Start</th>
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<td>10 03APR06*</td>
<td>14APR06</td>
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<tr>
<td>110</td>
<td>Rough-In Electrical - Second Floor</td>
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**Figure 10**

<table>
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<td>10 03APR06*</td>
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**Figure 11**

<table>
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<th>Activity Description</th>
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<th>Early Finish</th>
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The problem with this approach is that now the start of the electrical work is based on backing up a week from the planned completion date of the plumber’s scope of work. What if after the work actually starts, the plumber is unproductive and behind schedule? In figure 10, the electrician is scheduled to show up based on the plumbers planned completion of work and an assumption that by the time he, the electrician, shows up there will be a space available where he can work productivity. The electrician’s start of work is again not based on the completion of a scope of work. The use of the negative lag has eliminated detail from the schedule that communicates the work plan and this lack of communication can add a level of inefficiency to a project.
installer will actually say, “I will start putting up drywall on the floor when the plumbers are complete on that floor and the electricians have completed their work in two out of the four rooms.” This approach bases the plan on completed events and makes sure that there are not too many different craft types competing for limited space.

Although it is true that the precedence diagram method does in fact allow a schedule to be produced that will have less activities and finish on the same completion date as a more detailed schedule, it does so at a cost. Less activities, by definition, creates activities with more work scope taking place within those activities and that masks the project’s work plan and additionally complicates the ability to accurately status the work.

In Mr. Calvey’s figure 1, above, the carpenters know when they are supposed to be working on the area A and area B stud walls. Conversely, in figure 2, the carpenters are not communicated the work plan of when they are supposed to be working in each area. If one of these areas has more rough-in related work than the other, it may be beneficial to complete that area first and make that work area available to the plumbers and electricians as soon as possible. This level of scheduling in figure 2 will not communicate that type of information.

Additionally, in figure 1, the scheduler can examine the work status of the area A and area B stud walls independently of each other and estimate a remaining duration of work for each area with reasonable accuracy. In figure 2, the scheduler has to examine the work status of all stud wall work combined and estimate a remaining duration of that combined work. Examining the work status in smaller increments of work almost always produces greater accuracy of total work completion status.

Mr. Calvey makes the statement that having more activities makes a schedule less understandable. This is fundamentally inaccurate! Clearly, figure 11 shows that just the opposite is true. Figure 11 compares Mr. Calvey’s approach to a more detailed approach. In both his activity, and the more detailed version the stud work starts and completes on the same day. However, what does one stud work activity tell the person reading the schedule? It only communicates that the stud work is scheduled to start on April 3 and finish on April 28. That’s all! The more detailed version breaks out the work by the North, South, East and West exterior walls and the interior stud walls. This version is much more understandable in terms of the project work plan than a schedule with only one activity for all of this work. What else does this detail tell the reader? It shows that the north and south walls are erected concurrently which suggests there are two carpenter crews on the project. It shows the planned completion date of all four exterior walls allowing the plumber to understand when there should be enough walls erected for him to be efficient in his work. It also shows him the planned completion date of the interior walls. This added transparency of the work plan will allow all craft supervisors to better understand which specific areas they will be working in a given timeframe so that they can have the exact materials for performing that work. This can be very important to some craft, such as the plumbers and electricians, because of installation sequences. For example, most modern bath and shower units have to be placed in a bathroom by the plumbers prior to the carpenter’s completion of the interior stud walls. This knowledge of when to have that unit on site can greatly add to their productivity. A lack of this detailed work plan communication requires a project supervisor on site at all times to perform that guidance that the schedule does not communicate.

Mr. Calvey’s statement that “the theory of CPM states that all activities should represent actual, measurable work,” seems to be intended to show that lags are required for any schedule for it to meet the theory of CPM scheduling. That is simply not true. The arrow diagramming used dummy activities to show logic restraints. These activities had no measurable work. If a schedule had an activity that was solely for the curing of concrete that activity is actual and measurable. The curing is actually taking place after the concrete has been placed and it is completely measurable. It just does not require any project resources during the curing timeframe.

Figure 8, attempts to make a case that using negative lags makes realistic completion date calculations. He even tries to show how the negative lags, might actually give a better calculation. There is no doubt that with the utilization of positive and negative lags it is possible to accurately calculate a project’s completion date. However, in his example cited above, the difference in the calculated project completion date between the two schedules is due to the actual start date assigned to the Area A rough-in activity in figure 7 versus the rough-in activity in figure 8. This example is fundamentally flawed! A schedule’s logic is used to produce planned start and completion dates for work activities. These planned start and completion dates are merely guidelines. If an activity is capable of being started on any given date, it is capable of being started on that date regardless of the logic utilized to calculate the planned dates, so to show a different actual start date based on schedule logic and lags is inherently incorrect.

CON - CONCLUSIONS

Networks utilizing finish-to-start relationships with a negative lag can absolutely provide a reasonable calculation for the completion date of a project. However, schedules using this approach to overlap work activities, by definition, eliminate many schedule activities that would otherwise be included within the CPM network. This elimination process also can eliminate the transparency of the project work plan as well, and the resulting lack of transparency can substantially add to project labor inefficiencies. This added inefficiency can be much more expensive than the cost of updating a few more schedule activities per week or month depending on the update frequency. The two biggest concerns of all, regarding negative lags, were not even discussed by my counterpart. They are:

1. The look of confusion on a senior manager’s face when you show him a critical path analysis that has a negative lag within the schedule logic. Many people, such as senior VPs and CEOs do not have a good grasp for scheduling to begin with, and having to explain negative lags can confuse them even more.

2. The first memories that many older schedulers have regarding negative lags was having a subcontractor insert them into finish-to-start relationships of their critical path activities in
order to keep their work off the project's critical path on large projects. This early use of negative lags has associated their use with cooking the books and made many people shy away from using them at all.

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