



## PS.08

# Let's Scrap the Precedence Diagramming Method

Earl T. Glenwright Jr.

### THE STATE OF CONSTRUCTION SCHEDULING PRACTICES AND SCHEDULES

### WHY PRECEDENCE DIAGRAMMING WAS DEVELOPED

**C**ontemporary construction schedules are for the most part invalid and misleading. This is due to some of the following reasons.

Abuse of the Precedence Diagramming Method by using excessive start-start and finish-finish dependencies, lag and lead values, and constraint dates.

Inadequate or the lack of schedule planning prior to schedule development.

Untrained scheduling personnel and their lack of construction experience.

Insufficient time for schedule planning and development between contract award or notice-to-proceed for the contractor's staff to prepare a well-planned schedule prior to its required submittal.

Low status and pay of the scheduling member of the contractor's field staff.

Compromising of the contract provisions by both owners and contractors.

Improper scheduling of construction resources.

Overly verbose and complicated schedule specifications that are out of date and do not truly specify what is needed for effective construction management.

Construction scheduling has three sequential phases: planning, development, and monitoring. Schedule planning is the most time and effort consuming phase yet is it the most important part.

The total effort is approximately: 60% planning, 20% development, and 20% monitoring. There is of course some overlap between planning and development due to constraints that arise during the development phase that necessitate some re-planning. Such is normal.

There is an interesting parallel between the evolution of computer hardware and software, and the increasing sophistication of project management tools and techniques. In the period from the mid-1950s to the beginning of the 1970s the desired results and utility of Project Management Information Systems (PMIS) were severely limited by computer capabilities that dictated their use and took the form of faux rules. For instance, only one resource could be assigned to an activity. This led to creation of the "ladder-feed" diagram for linear projects such as pipelines, highways, and canals where each activity represented one type of work and therefore one resource. To properly diagram these projects one had to use many "dummy" dependencies to avoid the classical "wagon wheel" and "waterfall" dependency errors. (See **The Use of CPM in Construction** page 34.)

Because of the above limitations, the U.S. Navy contracted with Dr. John Fondahl at Stanford University to develop a hand method of CPM computations that would also solve the use of "dummy" dependencies. Dr. Fondahl reversed the traditional Activity-on-Arrow diagramming method to a Activity-on-Node diagramming method. There were only Finish-to-Start relationships. Dr. Fondahl's proposal was published circa 1977 in **Western Construction**.

The precedence diagram is actually a throwback to the bar chart. Sometimes even the activities are time scaled and a calendar placed at the top; this of course is a schedule not a logic diagram, which is neither time-scaled nor has a calendar line.

As computer capabilities expanded in the 1980-2000 period many additional attributes were added to the basic PDM network analysis programs, such as multiple types of relationships, lag and lead time values on the dependencies, multiple calendars, and multiple resources on activities. The correct use of these functions requires a high level of training and experience in scheduling construction projects.

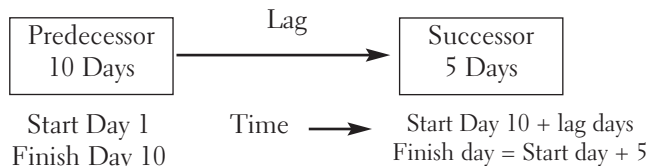
However, using these complex tools can create the illusion that the Contractor has developed a detailed and logical plan and schedule, when actually one does not exist. The main issue that plagues schedule planning and development is not doing the hard work of planning out the details of the contract execution and documenting that plan in a clear and understandable way. This

includes a clear Work Breakdown Structure of the organization of the contract deliverables and sub-deliverables, resource definition and estimates, and activity resource and earnings (not cost) loading.

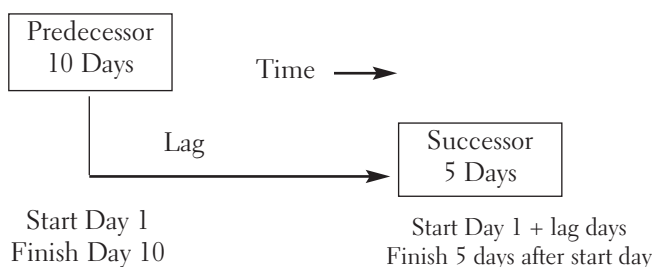
**HOW ACTIVITY STARTS AND FINISHES ARE COMPUTED WITH PDM RELATIONSHIPS**

Assuming that no constraint dates are used and there are unlimited resources:

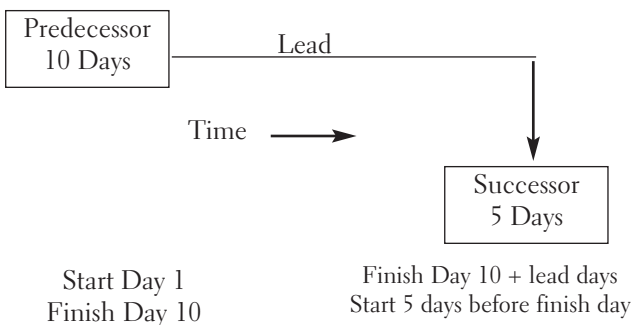
Case A: Finish – Start



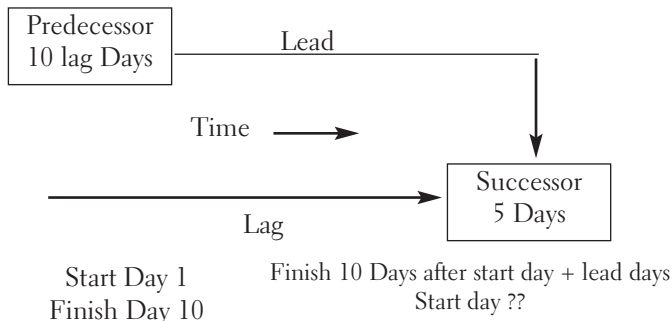
Case B: Start-Start



Case C: Finish-Finish



Case D: Start-Start and Finish-Finish



Depending on the Lag and Lead values, inconsistent and different successor activity Start Days will be computed by various CPM software programs, and/or the duration of the successor activity may be extended.

The above are the very simplest variations of these four possible dependency relationships. When many Start-Start and Finish-Finish and lag and/or lead durations are used very confusing results occur. Add to this the impact of resource allocations and the use of constraint dates and we can see that the resulting planned schedule will be almost impossible to understand.

Hence, the Precedence Diagramming Method has many pitfalls for the novice or untrained project scheduler. The addition of the requirement to input every dependency into the scheduling program adds a significant burden on the user of the Precedence Diagramming Method. Only one missed dependency will invalidate the results.

**A COMPARISON BETWEEN THE PRECEDENCE AND ARROW DIAGRAMMING METHODS**

To illustrate compare these two diagramming methods of only 12 activities, see Figures 1 and 2.

**DO WE REALLY WANT TO SCRAP THE PRECEDENCE DIAGRAMMING METHOD?**

Of course not, although with the sophistication of our PMIS software one might ask “Do we still need it.” Claims have been made that PDM is the bane of construction schedules, and it is the root of the poor schedules now being prepared. Why is this? Let’s review the 8 causes given at the beginning.

Excessive use of the S-S and F-F logic relationships: there must be a valid reason for using these relationships. Generally, this indicates a lack of understanding of what they mean. They are not a substitute for resource allocation.

If the purpose is to provide a preferred sequence of execution of the work (and there is usually one), a constraint date is a better way to handle this. Dates are easy to change whereas logic changes will upset the network analysis.

**LACK OF ADEQUATE EFFORT IN THE PLANNING PHASE**

Many scheduling planning tasks can be accomplished during the final design phase. For instance: preparation of the upper levels of the Work Breakdown Structure, Defining the construction activities in accordance with the work to be contracted, identifying the sequence of these activities, and estimation of the type and amount of all resources needed for each activity.

Unqualified personnel: industry practice is to hire a cost engineer and assign them the schedule development and monitoring tasks. These are usually very young persons with little or no scheduling experience or training.

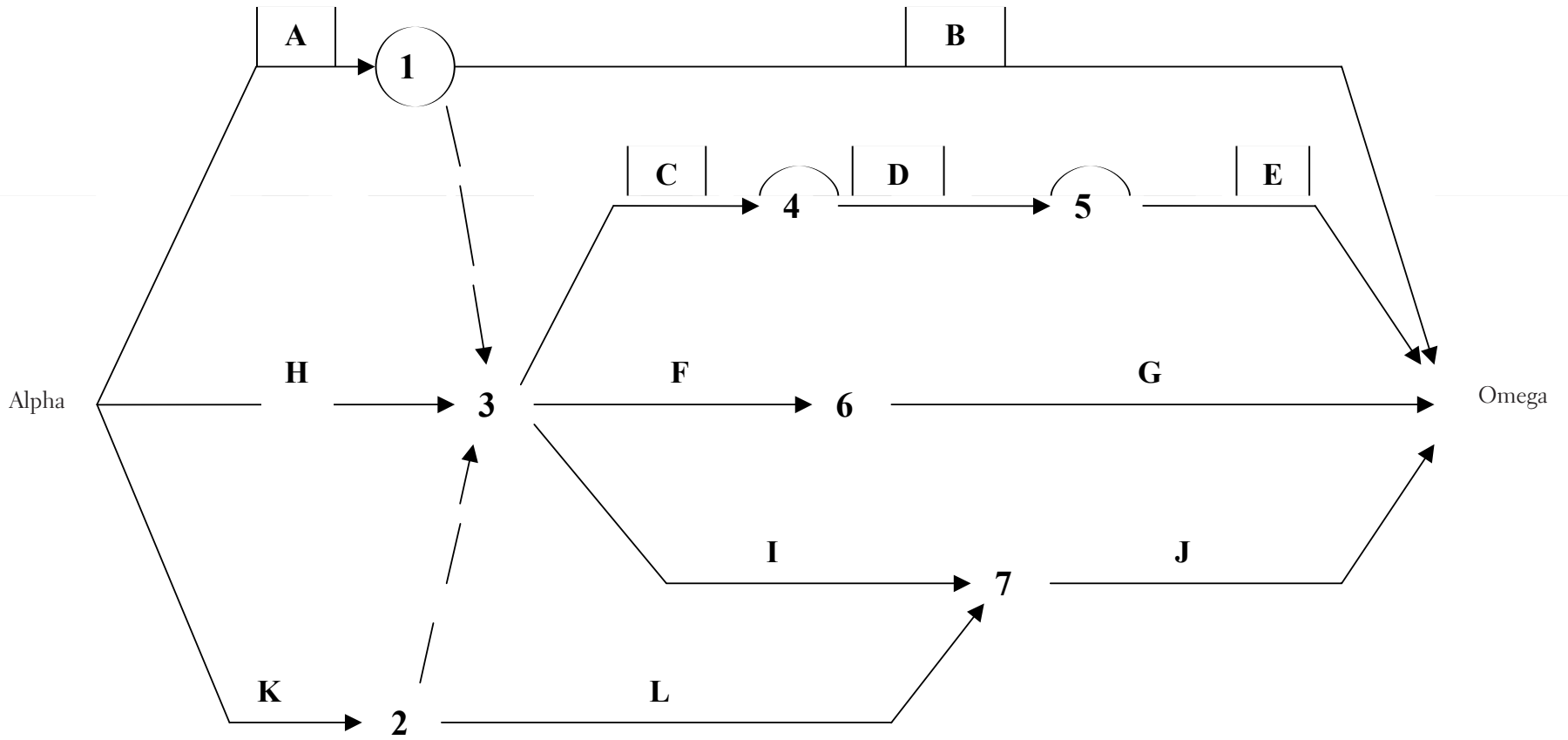
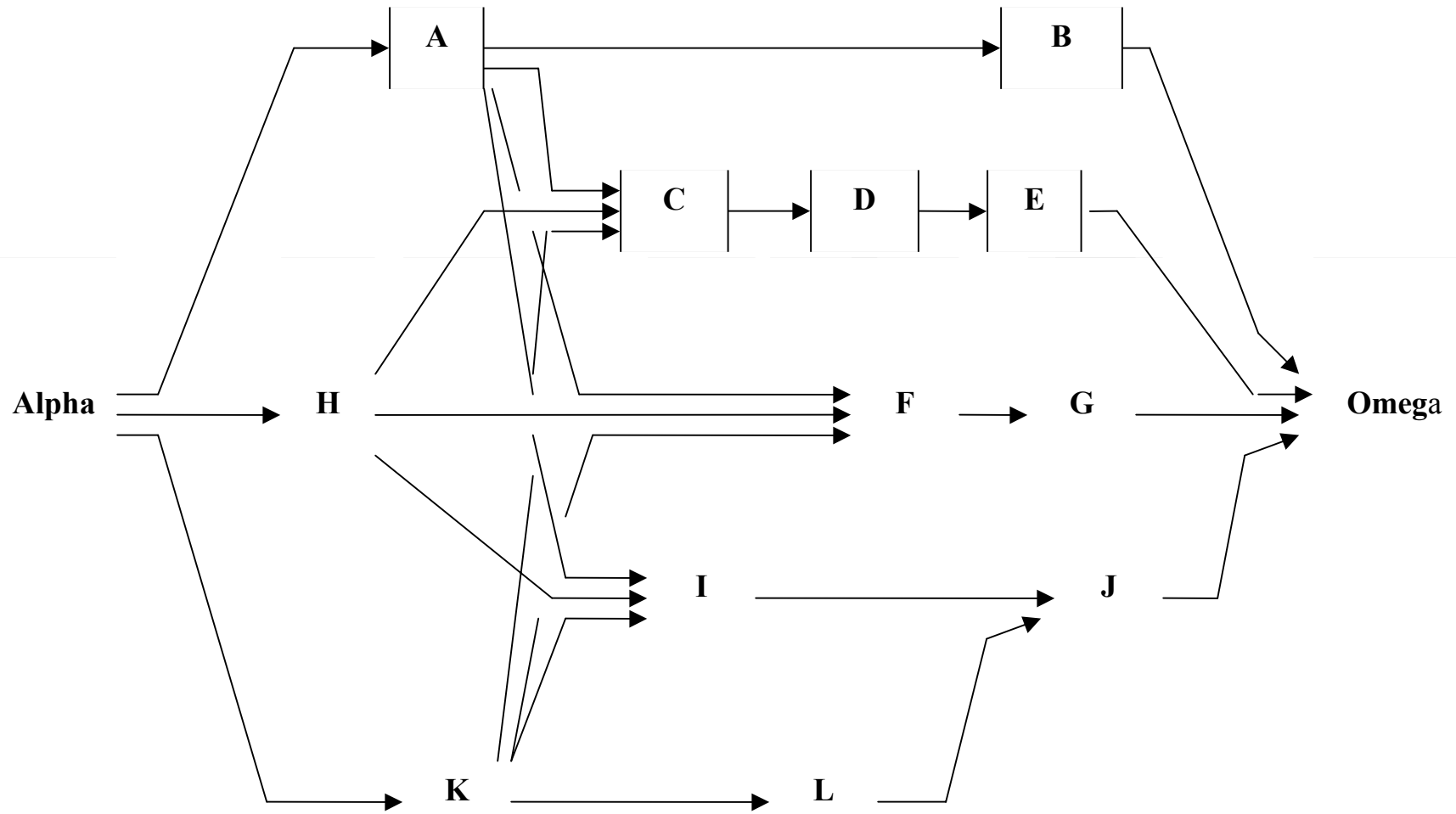


Figure 1

# PRECEDENCE NETWORK

12 Activities

23 Dependencies



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Figure 2

The contractor's and owner/client's scheduling engineers must be accepted as qualified by some certification process by each other.

Insufficient time for the contractor to do both Planning and Development after award or Notice-to-Proceed is given. The usual 60-day period is far too short to Plan and Develop a valid and realistic schedule. The Planning phase itself will usually take 3 or 4 months. Schedule Development will usually take 6 or more weeks as alternative operational plans are tested.

Poor pay and status of the scheduling member of the field team. The low pay and status of the cost/schedule engineer does not encourage those persons to fill this position any longer than necessary. Hence there are very few qualified scheduling engineers and most of them are in other positions in the contractor's home office or are employed in consulting firms.

Owners subvert their own scheduling requirements and approval. Most contracts have a non-payment for progress until the schedule is approved clause. Yet, most often this is not enforced as the contractor continues to put construction in place and must either be paid or shut down their operations. Hence the owner is in a "catch-22" situation.

Rudimentary if any handling of resources that are the real basis for any schedule. Quite often contractors do not do an adequate job of resource planning, at least not in terms of the network activities. Garbage in, garbage out.

When the dominant or pacing resources are allocated by a leveling process in a forward pass, the results must be analyzed for these and all other resources as to their viability.

In addition a backward allocation pass must also be made to ensure that resource requirements do not stack up towards the end of the contract.

Inappropriate schedule specifications: many schedule specifications discuss in extensive detail what is required, and what is required is not what either the contractor or the owner needs.

The desired output is a planned schedule, a work sequence plan, and the quantity of resources required in each time period. But that is not what is asked for.

Terminology such as "early start," "float," and "costs" are not germane to the output. Provided to the owner/client.

"Float" is used by the scheduler to smooth out the peaks and valleys of each resource that is limited or not readily available. The result of this is the planned schedule, not one that is the "early start/late finish" from the mathematical analysis of the activity network which is simply the time framework for scheduling activities by allocating resources.

Contractors do not "cost load" the project activity network as costs are internal information and not provided to the owner/client. What is placed on the activities are the "earnings" assigned to each activity for payment is due.

### IS THERE AN ALTERNATIVE OR SOLUTION TO THIS DILEMMA?

Of course. Remedying these problems would go a long way towards a solution. However, some of them will take time depending on each contractor's and owner's commitment to and understanding of the proper scheduling techniques and the bene-

fits that each will derive from having and using valid schedules as a management tool. Let's explore some possible approaches.

Precedence Diagramming can be characterized as two levels, basic and complex. In the basic application only Finish-to-Start relationships would be used. Use of constraint or "plug" dates are minimized. No lags or leads are used.

Use of the complex PDM would be limited to those contractors who can show that they fully understand the ramifications of using the advanced attributes of PDM software and have a qualified, certified (AACE International or CMAA), and experienced scheduling person on the jobsite. Development and monitoring the schedule is their sole function.

Assign the responsibility of the planning task to either the design firm or a construction management firm that would work with the design firm during final design. This would be especially effective for design-build contracts.

In this way the groundwork and supporting structure of the schedule will be available to the construction contractor. The contractor can modify this model as they wish. Then the construction contractor can apply their resource levels and preferred sequences and concentrate their efforts on resource planning and scheduling.

If the owner is not going to abide by their own contract specifications, then that clause should be deleted to avoid the ensuing hassle. An alternative approach might be to withhold  $x\%$  (i.e., 50%) of the earnings until a schedule is approved. The owner may also consider approving only those activities for which they are responsible such as furnished materials and equipment and submittal approvals.

**T**he state of construction scheduling is in dire need of improvement. Among the causes of this situation are the misuse and abuse of the precedence diagramming method.

Contemporary project scheduling software falls into two extremes: too sophisticated on the one hand and too limited on the other.

The above suggestions could be implemented immediately with little expense, if any.

The use of the basic PDM will solve many of the inconsistencies that occur when the complex PDM is used by inexperienced persons.

Owners should add to the design and design-build contracts the requirement that pre-construction schedule planning be done during final design and this information provided to the construction contractor as part of the contract. The contractor would have the option of using this information or not as they so choose.

Owners must resolve the subjugation of the schedule approval before making progress payments requirement.

A program of training and certification should be undertaken to improve the level of construction scheduling understanding and ascertaining the competency of scheduling personnel at all levels of both the design and construction firms.

A recognized career path should be formulated so that the body of experienced scheduling personnel is enlarged. Along with this the status of the scheduling person on the construction site

must be raised, compensation improved accordingly, and the schedule be used to manage the construction process.

Finally, the schedule specification clauses must be overhauled, simplified, and be consistent with what is really wanted of the developed schedule.

The bottom line is always profit. The only justification for expending the time, effort, and costs of the planning, development, and monitoring of the project schedule is to enhance the probability of successfully completing the contract on time, with a minimization of costs, at the required quality, and a reasonable profit. Good schedule planning and development are essential ingredients of that success. What is profit? The result of planning resources, operations, facilities, and interfaces together.

Earl T. Glenwright Jr.  
PO Box 3305  
Eagle, CO 81631  
E-mail: assist\_bg@yahoo.com