Chapter

33

Delay Analysis

The principal dimension measured by schedules is time. And when a project is not completed on time, it is the CPM logic plan and calculated schedule that must be used to measure delay. In the past, delays in construction used to be a mutually accepted condition. Courts, on occasion, even recognized that delay was a normal situation in the construction process. Today, however, delay is a very problematic area because owners have tighter budgets and contractors who stay on a job longer than planned incur real costs.

When delays occur during construction, the parties involved attempt to shift the costs that result onto one another. If litigation results after negotiations fail, the lawsuits are between two or more losers, all of whom are attempting to mitigate their losses. There are no winners in delay. To the private owner, delay can mean a loss of revenue through the resulting lack of production facilities and rentable space, as well as through a continuing dependence on present facilities. To the public owner, it can mean that a building or facility is not available for use at the proper time. The service revenues lost through delay can never be recovered. To the contractor, delay means higher overhead costs resulting from the longer construction period, higher prices for materials because of inflation, and escalation costs due to labor cost increases. Further, working capital and bonding capacity are so tied up that other projects cannot be undertaken.

33.1 Delay versus Disruption

Another reason why courts traditionally did not recognize delays is the confusion over terminology, distinguishing delay from disruption. During the course of the project, not every delay to a specific task is going to result in a delay to the project. In fact, the majority of delays to specific tasks will not delay the project as a whole. A court facing competing claims of major delays to electrical installation due to alleged understaffing and millwork installation due to owner indecision might well throw up its hands. Thus, parties to a dispute may paper the file with numerous claims of such instances for the very purpose of confusing the court.

The introduction of the CPM process, distinguishing those activities that are "critical" from those having "float," has provided the courts with a new means to separate the complaints into those causing delay from those merely causing a disruption to the flow of work. As noted previously, courts have recognized that a certain level of disruption is to be expected in the construction process, but they also understand that unreasonable levels of disruption can have their own cost and even contribute to the responsibility for a delay to the project by diverting resources from critical activities.

33.2 Responsibility/Types/Force Majeure

The assignment of responsibility for delay after the fact is difficult, and courts have often remarked that delay should be anticipated in any construction project. Traditionally, the courts have protected owners more than contractors. In recent years, no-damage-for-delay clauses have often been enforced in many states, with contractors receiving only time extensions when delays occurred. However, granting time extensions evades another owner-oriented remedy for problems connected with delay: liquidated damages. Even when courts are inclined to consider recovery of damages for owner-caused delays, the burden is on the contractor to prove active interference on the part of the owner to receive a favorable decision.

There are four general categories of responsibility:

1. Owner (or owner's agent) is responsible.
2. Contractor or subcontractors are responsible.
3. Neither contractual party is responsible.
4. Both contractual parties are responsible.

When the owner or owner's agents have caused the delay, the courts may find that the language of the contract, in the form of the typical no-damage-for-delay clause, protects the owner from having to pay damages but requires a compensatory time extension to protect the contractor from having to pay liquidated damages. If the owner can be proved guilty of interfering with the contractor's progress on the project or has committed a breach of contract, however, the contractor can probably recover damages from the owner. If the contractor or subcontractors cause the delay, the contract language does not generally offer the protection against litigation on the part of the owner to recover damages. If the delay is caused by forces beyond the control of either party to the contract, the finding generally is that each party must bear the brunt of its own damages. If both parties to the contract contribute to the delay or cause concurrent delays, the usual finding is that the delays offset one another. An exception would be instances in which the damages can be clearly and distinctly separated.

There are three basic types of delay: classic, concurrent, and serial. Classic delay occurs when a period of idleness and/or uselessness is imposed on the contracted-for work. In *Grand Investment Co. v. United States,* 102 Ct. Cl. U.S. 40 (1944), the government issued a stop order by telegraph to the contractor that resulted in a work stoppage of 109 days. The contractor sued for damages caused by the delay, basing the suit on a claim of breach of contract.

The court allowed, among other things, damage due to the loss of utilization of equipment on the jobsite, finding inability to use equipment on the jobsite, and stating, "When the government in breach of its contract, in effect, condemned a contractor's valuable and useful machines for a period of idleness and uselessness . . . it should make compensation comparable to what would be required if it took the machines for use for a temporary period."

Johnson v. Fenestra, 305 F. 2d 179, 181 (3d Cir. 1962), also involved a classic delay. Workers were idled by the failure of the general contractor to supply materials. That type of delay, to be legally recognized as such, must be substantial, must involve an essential segment of the work to be done, and must remain a problem for an unreasonable amount of time. Generally, if two parties claim concurrent delays, the court will not try to unravel the factors involved and will disallow the claims by both parties. In *United States v. Citizens and Southern National Bank*, 367 F. 2d 473 (1966), a subcontractor was able to show delay damages caused by the general contractor. However, the general contractor, in turn, was able to demonstrate that portions of the damages were caused by factors for which he was not responsible. In the absence of clear evidence separating the two claims, the court rejected both claims, stating, "As the evidence does not provide any reasonable basis for allocating the additional costs among those contributing factors, we conclude that the entire claim should have been rejected."

Similarly, in *Lichter v. Mellon-Stuart*, 305 F. 216 (3d Cir. 1962), the court found that the facts supported evidence of delay imposed on a subcontractor by a general contractor. It also found that the work had been delayed by a number of other factors including change orders, delays caused by other trades, and strikes. The subcontractor had based its claim for damages solely on the delay imposed by the general contractor, and both the trial court and the appeals court rejected the claim on the basis that "Even if one could find from the evidence that one or more of the interfering contingencies was a wrongful act on the part of the defendant, no basis appears for even an educated guess as to the increased costs . . . due to that particular breach . . . as distinguished from those causes from which defendant is contractually exempt."

Note that in recent decisions, the courts increasingly have demonstrated a willingness to allocate responsibility for concurrent delays. Serial delay is a linkage of delays (or sometimes of different causes of a delay). Thus, the effects of one delay might be amplified by a later delay. For instance, if an owner's representative delays reviewing shop drawings and the resulting delay causes the project to drift into a strike or a period of severe weather resulting in further delays, then a court might find the owner liable for the total serial delay resulting from the initial incremental delay.

Force majeure causes include "acts of God." The general contract usually provides a list of such events: fires, strikes, earthquakes, tornadoes, floods, and so on. Should such an event occur, the contract provides for a mutual relief from demands for damages that are due to delay, and the owner is obligated to provide a reasonable (usually a day-for-day) time extension.

In the case of weather-related delays, usually only the occurrences shown to be beyond the average weather conditions expected for the area based on past records can be considered a reason for time extensions. That can, however, vary with the contract language. A number of states and cities allow a day-for-day time extension (noncompensable) for all bad weather.

Many contracts have clauses stating the time extensions for delay caused by acts of God shall be granted only to the portions of the projects that are specifically affected by such events. Thus, a severe downpour after a site has been graded and drained and the building closed in may cause no actual delay, so that claims for time extensions because of it would not be accepted even though it would qualify under other methods of evaluation as a force majeure act.

33.3 As-Planned Logic Network

The first step in preparing an analysis to determine responsibility for delay to a project is to locate or otherwise acquire the as-planned logic network. This may be, but often is not, the submitted and approved baseline schedule. The key factor in determining if a "baseline" is the proper starting point is whether it includes information known after the start of the project. A proper as-planned logic network will not include any information known after the start of the project, although there may be some leniency relating to the period of time between submission of the bid and Notice to Proceed (NTP).

The rationale for this rule is based upon the concept of contract. In the rush to bid a project, a contractor rarely has sufficient time to carefully plan all the details of how he or she will perform the work and often does not have the input from all project team members who will supervise such work. However, the contractor does anticipate that once a bid is won, the project team will carefully review the project drawings and specifications and choose one of many possible "plans of execution" to effectuate performance in what it deems the most expedient and cost-efficient manner. This thought pattern, however expressed and recorded, is the basis of the as-planned logic network.

The CPM as initially submitted may be rejected for real or imagined flaws. If technical flaws are in the submitted CPM, they must be corrected, and it is not uncommon for there to be several submittals and rejections over a period of months until a proper CPM is approved. However, during this period it is important that neither party use the approval process to modify the initial plan of execution to account for later unanticipated events. From the viewpoint of a proper analysis, the maneuvering of the parties over acceptance of the CPM submittal should be ignored. Thus, an acceptance too hastily made should not bind the owner, and an improper resubmittal required by an owner should not bind the contractor.

In *Edwin J. Dobson, Jr. Inc. v. Rutgers* (157 N.J. Super. 357, 384A. 2d 1121 [1978]), the Court found that the schedule was not complete enough to use to measure delay until the third update. In *Dobson v. Rutgers*, the Court also held that the schedule does not have to be formally accepted by the owner or agent to be accepted as the basis for delay analysis.

Once a proper as-planned logic network has been chosen, the CPM can be useful in establishing the facts and also the intentions of the parties to a contract. The network can be used by the owner to demonstrate areas of failure on the part of the contractor, and it can be used by the contractor to demonstrate points of interference on the part of the owner or owner's agents.

A project involving regular (usually monthly) reviews or updates of the CPM plan should provide a good basis, through the CPM reports, for evaluating the progress of the work done on it. Unfortunately, many such projects have only a collection of CPM diagrams and computer runs to show for the reviews. The CPM reports are far more valuable if each update is accompanied by a comprehensive narrative. The narratives, which should be normal portions of the project documentation, are prepared in the normal order of business and, therefore, can be accepted later at face value, with due weight given to their origins.

33.4 As-Should-Have-Been CPM Network

While it is best to start with an as-planned logic network, there are situations where a good as-planned network did not exist or the one used was flawed or inadequate. In this case, an as-should-have-been network can be produced. Obviously, what is desired here is to re-create the plan of execution envisioned by the project team at the time the work was starting and not to utilize "Monday morning quarterbacking" to create a CPM of how the work should have been planned. If the matter is in dispute, the urge for one party to submit a plan that exaggerates the impact of faults of the other party and sidesteps its own faults may be large. Obviously, it is here that the question of the credibility of the scheduler will come into play. Thus, it is also important to document the sources of information used to re-create the as-should-have-been to become the as-planned CPM.

Thus the terminology means "as-should-have-been-submitted," not "as-should-have-been-planned." In the event that the contractor's CPM is missing some portion of the scope of work (such as installation of a pipe below a foundation), this is to be treated the same as when the engineer's drawings are missing an existing condition (such as a buried pipe) or necessary scope of work requiring a change order. In either case, the work additional to the contractor's original plan will be added to the as-impacted network, as described in Section 33.9.

In some cases, the preparer of the as-should-have-been network has a bar graph to utilize as a guideline. In other cases other contemporaneous documents must be used as primary source material, or to bolster and validate interviews with key staff members on how they planned to perform the project. In one major project, the new Library of Congress building (James Madison Memorial Library), it was recognized by both the owner, the architect of the Capitol, and the contractor, Bateson Construction Co., that there would be delay claims as a result of certain delay problems in the project. It was mutually agreed that it would be advantageous to convert the contractual as-planned bar graph to a CPM network, which would prove more useful in evaluating the effects of delay impacts.

The contractor's scheduling consultant, A. James Waldron, converted the network to a CPM diagram and printout. This was reviewed for the architect of the Capitol by O'Brien-Kreitzberg & Associates (OKA), and after some adjustments, a mutually agreed upon baseline was stipulated. The network was useful to both sides in determining the responsibility for delays and the resulting costs. Often, an as-should-have-been network is more of an uphill situation. If both parties do not agree to a previously approved as-planned network, whoever produces the as-should-have-been network must be able to provide a foundation for it and to justify its use.

In one such application, the New Jersey Department of Transportation specification had an elaborate narrative description of the sequencing required for implementing a project. At that time, the state did not use CPM planning, and the contractor, a major heavy construction contractor, submitted a totally inadequate bar graph that used fewer than 25 activities to describe the work to be accomplished. The contractor also worked in such a fashion that he produced a large amount of excavation soil, which was to be used on and/or sold to other projects. The economic plan made sense, but the logic did not. OKA used experienced highway engineers to develop an in-depth, as-should-have-been network, 24 pages long in its logic and made up of more than 4000 activities. The computer run demonstrated the impropriety of the contractor's initial actions and illustrated a lack of planning in regard to the project.

33.5 As-Planned Schedule

Emphasis in the prior section has been placed on calling the CPM the as-planned logic network to distinguish it from the as-planned schedule. The purpose of this emphasis on terminology is to stress that the logic will be the basis for further steps of the analysis and that, at this point of the analysis, schedule dates are mostly irrelevant. A quick calculation of the schedule from the as-planned logic network may allow the team to determine if some of the logic is missing or incorrect. A schedule showing pouring of concrete in northern latitudes during the winter may indicate some adjustment is necessary. But the flip side is not necessarily true; that is, an otherwise good logic network may neglect to include many of the assumptions therein. Bumping the start date of the CPM by 3 months and rescheduling and reviewing the output may point out some of this missing logic. So it remains for the careful and detailed review of the as-planned logic network to provide assurance that each activity is preceded by a physical restraint to some physical object, and is also preceded by a resource restraint for each necessary resource (crew, equipment, forms, etc.) that will be needed for a proper analysis. An as-planned schedule may exclude assumptions that may be ignored so long as the project is going smoothly. An as-planned logic network for analysis of delay requires that these assumptions be stated within the logic.

33.6 Validation of the As-Planned Logic Network and Calculated Schedule

Again we must emphasize the importance of the as-planned logic network and calculated schedule as the mathematical basis of an analysis of delay. A review and acceptance by the owner of a CPM prepared by the contractor may be prima facie evidence of a "good" schedule, but may still be rebutted for purposes of a claim. It must be understood that the initial submittal was required to assure the owner that the contractor had a workable plan. It was not and is not the role of the owner to challenge the contractor's honest estimates of duration. Acceptance of erroneous estimates of duration no more impacts the owner's rights in challenging an analysis of delay than it creates a right for the contractor to claim extra compensation for the actual versus underreported labor expended.

If the contractor manipulates the as-planned logic network or schedule, it can be disregarded as the basis for comparison with the as-built. In *Hensel*

Phelps v. U.S. (ASBCA No. 49, 270, 99-2), Hensel Phelps, the general contractor, prepared the CPM. The mechanical subcontractor estimated 8 work-weeks each for the duct line work for 12 process exhaust fans, for a total of 96 weeks. In the CPM schedule, Hensel Phelps reduced the estimate to 3 weeks each, for a total of 36 weeks. The subcontractor was not given a copy of the completed CPM as-planned schedule. The as-planned CPM was rejected as the basis for a delay claim because the general contractor had manipulated the as-planned schedule duration estimates.

Similarly, if an owner manipulates the as-planned logic network or schedule, perhaps through the review process, it can be disregarded for purposes of delay analysis. In many instances, an "accepted" CPM is required before progress payments may be processed. This may provide an improper leverage to require the contractor to include post-NTP events as part of the CPM logic. Where post-NTP events are clearly driving the early logic of the network, and to the detriment of a contractor's claims of disruption and delay, the earlier drafts of the CPM logic should be considered as more correct.

This recommendation is partially in agreement and partially contrary to that provided in the Validation section (2.1) of AACEi's 29RP-03. There the following is stated:

> Note that validation for forensic purposes may be fundamentally different from validation for purposes of project controls. What may be adequate for project controls may not be adequate for forensic scheduling, and vice versa. Thus, the initial focus here is in assuring the functional utility of the CPM baseline schedule for purpose of analysis as opposed to assuring the reasonableness of the information that is represented by the data or optimization of the schedule logic.

However, the specific recommended protocol covers much of what is required to validate the submittal for approval.

An exception is the 29RP-03 (2.1) suggestion that "The validation of activity durations against quantity estimates is probably not something that would be performed as part of this protocol." We suggest this is the purpose of validation, to avoid or detect the issue of a manipulated initial as-planned submittal, as with the Hensel Phelps example cited above. We agree that rectification to address such issues is fraught with the danger of challenge and should be avoided to the extent possible. And so we agree with 29RP-03's conclusion on this issue: "The test is that if it is possible to build the project in the manner indicated in the schedule and still be in compliance with the contract, then do not make any *subjective* [emphasis added] changes to improve it or make it more reasonable." The key word of the prohibition is *subjective*. A protocol for an analysis to be used in preparing a claim should be kept as free as possible from subjective determinations or changes upon which reasonable practitioners may differ.

33.7 As-Built Schedule

When the activities on the as-planned network have been identified, work can start on an as-built schedule. A copy should be made of the as-planned logic network and renamed the as-built schedule. The second schedule should include the same activities as the first, for comparison purposes, but should be based on actual performance dates. Those dates are researched from the updates of the original CPM plan, the progress reports, and any other documentation available. Sparse or faulty project documentation may make development of an accurate as-built schedule difficult.

For that reason, CPM updates should plug in actual dates for all activities as they start and as they are completed. However, often erroneous dates are entered when two activity descriptions are similar or when the contractor has performed general condition work not on the CPM and yet desired to record progress to something. In such cases it may be necessary to research other contemporaneous project records, such as daily diaries or job photos, to determine a correct actual start and finish dates. It is important to note where such changes have been made and to footnote the source of replacement data in such cases.

For a quick review, the as-planned and as-built schedules can be plotted side by side to the same time scale for a rough comparison. This review can assist in highlighting where the two schedules diverge and help determine where further research is desired. But it is certainly not sufficient in itself to document a claim as neither the causes for variances nor the criticality of activities before and after impact is yet determined. The work involved in preparing the two schedules will vary with the input information available, its organization, and the information on the levels of the work provided by the client and/or the client's attorney. Two to five people will be needed to work on them over a period of several months. The work should be under the direction of a CPM scheduling professional who is qualified to testify in regard to the final products.

Preston-Brady Co. v. U.S. (VABCA Nos. 1892, 1991, 2555 87-1) states, "[A] general statement that disruption or impact occurred, absent any showing through use of updated CPM schedules, Logs or credible and specific data or testimony, will not suffice to meet that burden . . . of proving the extent of any delay which it claims. . . . This is particularly so where, as here, the Logs, when contrasted to the as-planned CPM schedule, show minimal delay to the very trades most directly involved in the change order at issue."

33.8 Validation of the As-Built Schedule

We have stated that the logic of the network becomes part of the definition of each activity. If an activity is preceded by a Fnish-to-Start (FS) restraint, part of the definition is that "such as may be performed only after 100% of the predecessor has been completed." If an activity is succeeded by FS restraint, part of the definition is that "such as must be performed prior to the start of the successor." See Figure 3.1.1 where prefabrication of a rebar cage to be lifted into a completed form is not the start of the rebar activity (which here is shorthand for "rig/set rebar cage"). Notwithstanding this proper instruction, often the field will incorrectly note the start of the prefabrication or even the raw delivery of the rebar as the start of this activity.

While it may be required to rectify the as-planned start or finish to follow the actual completion of a predecessor or to precede a successor, care must be taken while entering "new" data to both record the contemporaneously made entry and consider the possibility of minor overlapping of work (notwithstanding the stated logic). The ubiquity of jobsite photos as well as traditional job diaries, time sheets, and other hard evidence should be researched and appended to support that contemporaneously entered data should be rectified.

So why not simply use the contemporaneous updates for as-built dates? These certainly have the advantage of being entered contemporaneously. And perhaps part of the validation process should include at least spot-checking dates of the final as-built schedule against the update where such information should have been initially posted. A discrepancy should raise red flags and search for the reason why the date entered with the update was later changed. As noted above, even if both agree, it may be merely the result of an improper initial report of a start or completion to then be reconciled with the reported finish of a predecessor or start of a successor.

Review of contemporaneous updates may also reveal information on disruptions and other issues, which can lead to an improperly mixed "update plus revision" involving changes to logic or to original durations or for remaining durations for activities not yet started. Such occurrences should alert the forensic analyst to look for a causative event or factor behind such action.

Finally, where the actual start of an activity is reported before the actual finish of a predecessor, it may be correct reporting and evidence of either minor "jumping the gun" by field forces or of impromptu efforts to rectify minor disruptions. At some level, it may be desirable to report and explain all instances of work being performed out of sequence, as is suggested in the next chapter.

33.9 As-Built Logic Network

Emphasis in the previous section was placed on preparing an as-built schedule and not an as-built logic network. In this phase of the analysis, the actual dates of performance are important and are not the actual reason why one activity is performed before another. Thus, if work was performed out of sequence from

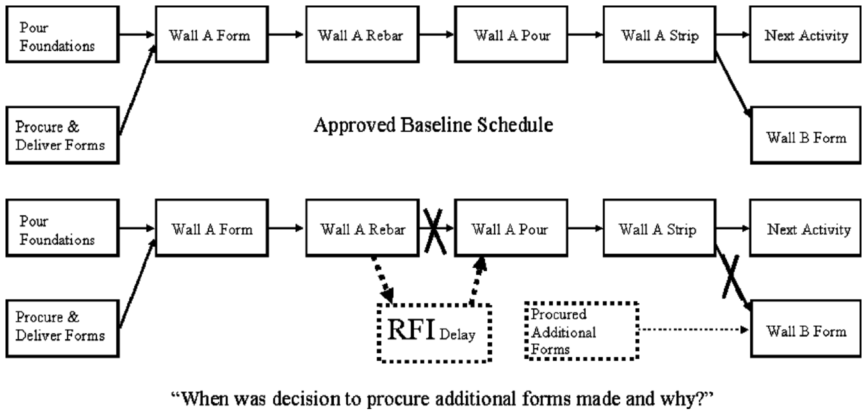


Figure 33.9.1 As-built logic network.

the as-planned logic, it is entirely possible that the as-built schedule will show an activity starting or even finishing before its predecessor.

An as-built logic network would record the actual logic—the "why" each activity was performed before the next. It may be possible to trace the actual logic for select portions of the project, but to do so for an entire project is usually difficult or impossible. Contemporaneous project records will rarely provide sufficient details for such an endeavor. As shown in Figure 33.9.1, an example of the details necessary to prepare a proper as-built logic network might include, the following:

- As-planned called-for forms used for wall A are to be used for wall B.
- An RFI is issued relating to a rebar conflict, delaying completion of wall A.
- Additional forms are rented and delivered to site.
- Wall B is constructed prior to completion of wall A.

Since the cause for deviation from plan is often not so straightforward and the reasons, therefore, rarely are recorded contemporaneously, the preparation of an as-built logic network for the entire project usually will involve a large degree of conjecture and subjectivity on the part of the preparer.

33.10 Causative Factors

Once the as-planned logic network and as-built schedule are completed, a uniform format for evaluating the causative factors in the delay is now available. (Even before the completion of the network and schedule, a separate group under the direction of the scheduling professional can begin the evaluation.)

The identity of most of the causative factors should be readily apparent, but the specific impact of different factors may not be obvious.

One of the first areas to be identified is force majeure. The most common examples are strikes and bad weather. Strikes should be documented in terms of their length, the remobilization time once they are over, and the trades and areas of work affected by them. Most contracts provide for time extensions because of strikes but not for compensation. In the case of a contractor making a claim, it would be important to be able to demonstrate that a strike had little or no impact on the critical path of a project, so that other compensable factors could be shown to be the cause of the damages being claimed. Conversely, an owner defending against claims would try to demonstrate that strikes did indeed cause the delays and other problems were, at worst, concurrent.

Other causative factors include the following:

1. RFIs, or requests for information: claimed by the contractor to the owner
2. CICs, or changes in condition: claimed by the contractor to the owner
3. CORs, or change order requests: presented by the contractor to the owner
4. PCOs, or proposed change orders: presented by the owner to the contractor
5. COs, or change orders: signed by the contractor and then the owner
6. PROs, or proceed orders: presented by the owner to the contractor
7. CCOs, or constructive change orders: claimed by the contractor to the owner
8. SWOs, or stop work orders: presented by the owner to the contractor
9. CQCs, or contractor quality control deficiencies noted: presented by the contractor to the owner or vice versa
10. ODNs, or owner deficiency notices: claimed by the owner to the contractor
11. REJs, or rejections of submitted shop drawings: claimed by the owner to the contractor
12. REWs, or reworks: reported by the contractor to distinguish from baseline productivity or vice versa

The acronyms may differ from jurisdiction to jurisdiction, and the list could go on to include other causative factors.

Causative factors are evaluated in terms of their specific impact on the progress of a project. This is done in two ways. First, a determination is made of the point in the network at which a particular causative factor impacted the fieldwork. In addition, when one is dealing with changing or modifying the scope of work to be performed, activities that were preparatory for implementing the change work are identified. Examples are change order proposals, ordering material, mobilization, and any other preimplementation factors. Other examples include demolition of defective work, reordering of material, and remobilization.

A separate evaluation is done for every causative factor in the project. In addition to identifying the basic impact of each on the plan, the analysis must identify the times of issue of the individual causative factor and reason for it. While a change order issued in the 11th month may be tied to the notice to proceed when all contract scope should be known and thus override contractor delays perhaps caused by understaffing, in an individual case, it may merely be tied to an activity preceding the one impacted when a visual inspection suggested the change to the owner. In such a case, the delay caused by the change would not override and would be considered partially concurrent with the previous delays but merely add new delay time to the delays already encountered.

It is important to try to include all causative factors that may have impacted the project. During this phase responsibility for the various causative factors is not assigned. Not only is it important to air what is initially thought to be your own "dirty laundry" (because the other side certainly will, if you do not), but also in many cases, there may be some question as to who is the responsible party. For example, a rejected shop drawing is typically charged to the contractor who is responsible for all her or his subcontractors and vendors. However, if the engineer's rejection is later deemed improper, the delays for resubmittal, review, and all consequential delays will be shifted to the owner. Similarly, poor productivity is usually charged to the contractor, unless it is the serial effect of shifting work from one season to the next due to causative factors chargeable to the owner.

Also keep in mind that most causative factors are not going to impact activities upon the critical path and will not actually cause delay to the project. However, it will be important to defuse the claims of "but he was doing that" when presenting the results of the delay analysis.

33.11 As-Impacted Logic Network

Once all the causative factors have been determined, they should be applied to another copy of the as-planned logic network. The rules of network development should again be rigorously adhered to, such as in the entering of actual dates and in not permitting open ends. Where it is known that a causative event did not occur until a specific date, it may be entered via a SNET constraint.

The courts are firm that causation must be specifically connected to the resulting delay. In *Titan Mountain States Construction Corp. v. U.S.* (ASBCA Nos. 22, 617, 22, 930, 23, 095, 23, 188, 85-1), the Board found, "A contractor was not entitled to time extensions for delay and impact allegedly resulting from modifications because his critical path analysis did not establish a causal relationship between the modifications and the alleged delays attributable to them."

In *Hoffman Construction Co. of Oregon v. U.S.* (40 Fed Cl. 184 [1998]), "proof that the government was the 'sole proximate cause' of the delay entails proof 'that no concurrent cause would have equally delayed the contract regardless of the government's action or inaction" [*Mega Constr. Co., Inc. v. U.S.*, 29 Fed. Cl. 396, 424 (1993)].

In *Fru-Con Construction Corp. v. U.S.* (44 Fed. Cl. [1999]), two burdens of the claimant contractor were described in the decision: (1) "Unless the Government retains control over the evidence, plaintiff bears the burden of establishing an excusable delay by a preponderance of the evidence" and (2) "It is not sufficient to establish that some work was prevented; the work prevented must be work that will delay the overall completion of the job."

In *PCL Construction Services v. U.S.* (47 Fed. Cl. 745 [2000]), the court held that the claim must meet three tests: "(1) the extent of the delay with a reasonable degree of accuracy; (2) that the delay proximately was caused solely by the government's actions; and (3) that the delay caused specific, quantifiable injury to the contractor."

33.12 As-Impacted Schedule

At this time, the as-impacted logic network should be saved to a secure file name, and then (and only then) the scheduling routine should be applied. The purpose of this step is to be able to demonstrate that a true evaluation was performed rather than merely going through the motions to back into a desired result. At this point, the scheduler has all the information needed in a format suited to perform an analysis of delay.

33.13 Time Impact Evaluations

When all the causative factors have been identified, a time impact evaluation (TIE) is prepared for each factor. The information is assembled as previously described, and it is prepared in a format so that the impact of each factor on the as-planned network can be determined and applied to it.

When the impacts of all the causative factors have been correctly determined and applied, the result should be an approximation of the as-built schedule. The as-impacted schedule is then compared with the as-built one, and any major disparities between them are examined to identify whether the TIEs were incorrectly applied or additional causative factors were not identified.

The theoretical effects of the impacting factors on the as-planned network must be explainable in terms of the as-built network, otherwise the proposed analysis is probably incorrect. Some professionals take a different position, however. One well-known scheduling consultant expounds the theory of 500 bolts: If an owner is to provide 500 bolts and has delivered only 499, in the consultant's opinion, the activity involved will be impacted until that last bolt has been delivered. But it appears more logical to examine the function of the last bolt. For instance, if the bolt is a spare or there is a readily acceptable substitute that permits construction to proceed, then it is not, theoretically, proper to claim that the as-planned network has been impacted by its absence. Another position, often taken by schedulers who conduct impact analyses on as-planned networks for contractor evaluations, is that all float belongs to the contractor. This has been a continuing argument in the profession. In fact, some recent owner's specifications, in order to counteract such claims, state, "All float belongs to the owner." Neither position is tenable, however.

Float is a shared commodity. Like a natural resource, it must be used with common sense. The owner should be permitted to use float for change orders, shop drawing reviews, and other owner-responsible areas. On the other hand, it is obvious that owners should not use float to the point that the entire project becomes totally critical. This would be an overreach on the part of owners. Conversely, contractors should be expected to use float only to balance their workforces and to work efficiently, to complete projects on time and at optimum budgets. Once all the TIE information has been imposed on the as-planned network, a standard CPM calculation is done. The calculation should correlate, as discussed previously, with the as-built network.

33.14 Zeroing to a Collapsed As-Impacted Logic Network

If there are many causative factors or if the determinations of responsibility for such are unclear, then zeroing out by category may not be practical and an alternate means will be required to determine the impact (if any) of each causative factor. To perform this portion of the analysis, it is necessary to prepare a separate spreadsheet or provide additional activity codes for each activity representing a causative factor. The additional columns or code fields include:

1. The order in which this causative factor is zeroed out
2. The project completion date prior to this causative factor being zeroed out
3. The number of days' difference between the project completion date before and after zeroing out
4. The number of days between the activity impacted and project completion

The process of zeroing out of causative factors one by one again begins with scheduling the as-impacted logic network Next, starting at the last activity, or project completion, the analyst works backward, tracing the driving relationships until reaching either a causative factor or the start of the network. This will constitute the critical path of the TIE. Often there will be more than one such path converging to one causative factor or more than one. Code the one or several causative factors as 001, note the finish date for project completion and start date for each causative factor, and calculate and record the number of days from the causative factor to project completion.

Then delete all successors to the one or several causative factors deemed the roots of the critical path(s). Next, reschedule the network and trace the critical paths back to the next root causative factor(s). Code as 002, record the new project completion date, calculate the number of days between the last recorded completion date and the new one, note the start date for causative factor(s), and calculate and record the number of days from the causative factor(s) to project completion. This process is repeated until one reaches the start of the network rather than a causative factor. This final result should again bring the network back to its as-planned status. Note that many of the causative factors still remain. This matches the reality that a majority of even the most "serious" causative factors encountered on a project are not the cause of delay. However, inclusion of such in the analysis proves such an assertion and may defuse quite a bit of argument related thereto. Where a project has intermediate milestone deadlines that are subject to actual or liquidated damages, the same approach may be used to determine time extension entitlement toward individual milestones. By starting from the milestone and working backward through the driving relationships leading thereto, the individual root causative factors can be ascertained until again one reaches the starting point of the logic network. This should ideally be done with a fresh copy of the as-impacted schedule for each milestone as an individual causative factor may have a separate impact on various milestones and project completion. At this point, two more columns may be added to the spreadsheet: one for the party alleged to be responsible for the causative factor and another to note whether that causative factor was the sole cause of the incremental impact to project completion or was concurrent with one or more other causative factors.

33.15 Zeroing Out to an As-Should-Have-Been CPM

If there are only a few causative factors impacting the as-planned logic network, it is suggested that the TIEs be selectively zeroed out by category.

For instance, the force majeure changes are zeroed out, and a run is made to determine the overall impact of their absence on the network. Similarly, contractor-related TIEs are zeroed out, and any further improvement their absence makes in the schedule is noted. Then, the owner-related TIEs involving changes and any hold orders, and so on, are zeroed out, and the final result should bring the network back to its as-planned status.

Because each category of change is zeroed out step by step, the effects of concurrency can be observed from the results of the three separate runs. This can provide an arbitrator or a court with the means to allocate delay damages and impacts caused by the various parties. One of the first applications of this approach was to a major airport project. The airport authority had contracted for the installation of a $15 million underground fueling system. The contractor for the work, who was the low bidder by several million dollars, prepared a construction CPM plan that was never accepted by the owner, and all the milestone dates were completely missed. The airport authority took under advisement whether to enter suit for delay damages that were due to losses in interest on money and in airport operating efficiency, as well as for other direct delay damages. When the contractor filed a $6 million delay suit against the authority, the authority promptly filed a counterclaim and litigation ensued. In the absence of a mutually acceptable as-planned CPM, the owner directed that an as-built CPM be prepared to evaluate the real causes of the delays. The daily, weekly, and monthly reports, as well as personal observations by the owner's field team and the CPM consultant, were used to develop the comprehensive plan. It contained milestone points reflecting actual dates of accomplishment for various activities. Between the milestone points, the estimates for the time that the work should have taken were inserted, and the CPM team then divided the delay proportionally by its causes. The causes were either by contractor, owner, combined, or neither.

The first computer run of the network showed the actual dates for all the events. The next computation established the amount of delay due to the contractor alone. The third established the amount of delay due to the owner alone. The fourth identified the amount of delay due to both. But the total actual delay was less than the combined total when the amounts caused by the owner alone and the contractor alone were added.

Using this very specific information, the managing engineer for the owner was able to facilitate an out-of-court settlement that took more than a year to negotiate. (Part of the owner's management team's willingness to negotiate was because they recognized the very real delays they caused by a slow shop drawing review. Many delays were due to the high workload of the owner's engineering department, but many were caused by the engineers trying to redesign the shop drawing submissions, a common mistake made in the course of reviews.)

33.16 Limitations of the TIE Methodology

Either via grouping by categories or by the more tedious method of zeroing out causative factors one by one, the TIE method may be used to determine entitlement for relief from liability for damages caused by delay. The fact that the project completion date of the as-impacted schedule may be later than the actual completion date is irrelevant so long as the impact to activities immediately successor to causative factors roughly matches the as-built. In fact, it is more likely that the project completion date of the as-impacted schedule will be later than the actual completion date since most contractors will make some attempt to mitigate the impact of various causative factors. However, these efforts by the contractor to mitigate cannot be used to reduce the contractor's entitlement. To some unquantified extent (at least at this point of the analysis), the difference between the calculated project completion date of the as-impacted schedule and actual project completion date of the as-built schedule represents the cost of the efforts of the parties to accelerate work and mitigate the delays incurred by the project.

On the other hand, the contractor should not be entitled to monetary compensation for damages that have been avoided by such mitigation. Thus, while the TIE methodology is conclusive in determining entitlement to avoid the payment of actual or liquidated damages for late completion of the project or stipulated milestones thereto, it may tend to overstate entitlement to compensatory damages. To determine the appropriate number of days for which a contractor may be entitled to compensatory damages for field and home office overheads associated with an extended project time frame, it is necessary to also factor in the impact of such mitigation. This is discussed in the section on the Windows analysis methodology that follows.

Finally, the fact that the TIE analysis may calculate a completion date beyond that of the actual completion date provides real information that may be of use in preparation of a claim. This difference in completion dates presumptively represents the level of mitigation by the parties, and it may be used as a gauge to ascertain the reasonableness of calculations of cost to accelerate. In many cases the cost claimed to accelerate may be less than the contract liquidated damages if the entitled-to delay had not been mitigated. And even where the cost claimed to accelerate exceeds this sum, such may be recoverable if provided in "good faith" or may be an indicator (and proffered as proof) of continued disruption of the efforts to mitigate.

33.17 TIE Example of John Doe Project

Take the 34-day CPM plan for the initial portion of the John Doe project as a schedule, and use it to measure delays or impacts. If, for instance, the well pump required a 6-week delivery time, the equivalent number of workdays would be 30. The impact area is measured by adding an activity starting at 0 and going to event 4. The activity would be titled "late delivery of well pump," and adding it would produce the result shown in Figure 33.17.1, the time-scaled version of the initial part of the John Doe project. Because the well work was on the critical path, the delay would force the late start of activity 4–5, install well pump, to await the delivery of the well pump. In this example, it is 30 minus 22, or a delay of 8 workdays.

Of course, it is necessary to view the entire contractual universe. For instance, if there were a 2-week delay in the notice to proceed for reasons other than the pump delivery, then the pump delivery delay would be better represented by disconnecting the initial, or *i* end, of the delay arrow from the 0 event and bringing it into the network as a new starting point with a specified date. Thus, if a 2-week force majeure delay were imposed on the start of the site work, the additional time needed for delivery of the well pump would become a concurrent delay. Figure 33.17.2 shows a TIE form describing the delay in the delivery of the well pump.

Review of the TIE points out a number of additional issues. The evaluation does not note the original duration for this "stock delivery" item was 10 days, but does note that the responsibility for the delay belongs to the architect/engineer for failure to deliver the specification for the pump. Thus, after leaving a minimum of 5 days for contractor procurement, this activity would initially have had 7 days of float. The TIE does not provide when the architect/engineer finally provided the specification (that presumably should have been provided no later than the notice to proceed), and thus this must be presumed to have been on day 15 to provide the following sequence:

15 days to provide spec + 5 days to shop among 3 local vendors
+ 10 days to prep and deliver to site = 30 days total

But what if the architect/engineer had taken 22 days to provide the specification but the contractor had mitigated by ordering the same day the spec was received with a vendor preselected to expedite the delivery in return for a slightly higher price? If the TIE had been prepared on day 22, the contractor would be entitled to a delay of 8 + 7 = 15 days. Should the contractor's entitlement be reduced due to his or her own initiative and additional expense? What if the architect/engineer had provided the specification within the 15 days of this example, but the contractor chose to extensively shop for the least expensive vendor, taking 7 days to order the pump (with preparation and delivery taking the normal 10 days)? The delay to the project would then be 10 days rather than the 8 cays calculated by the TIE. Keeping in mind that the contractor initially expected to need 5 days for shopping and had an additional

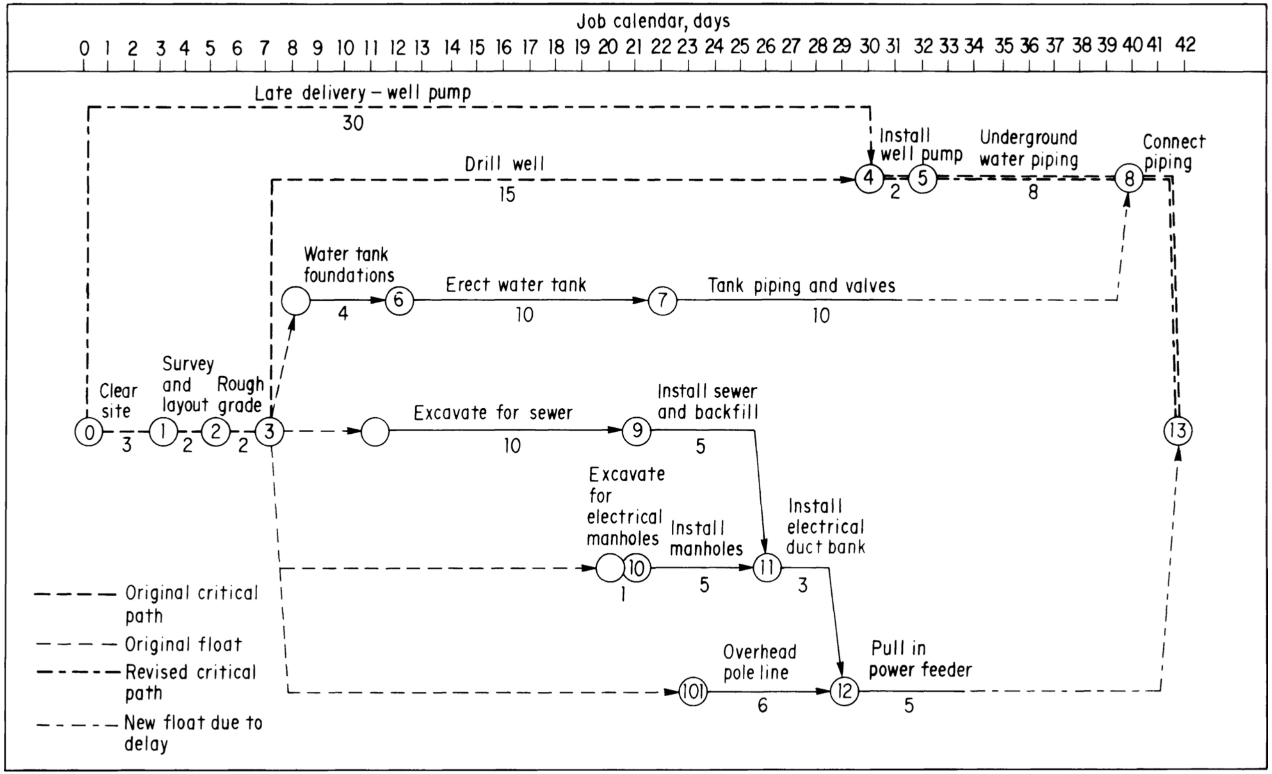


Figure 33.17.1 Time-scaled network showing late delivery of well pump delay.

TIME IMPACT EVALUATION

PROJECT: JOHN DOE TIE #: 1

PREPARED BY: J. J. O'BRIEN DATE: 9/15/95

DESCRIPTION: LATE WELL PUMP DELIVERY – DELIVERY WAS SIX WEEKS AFTER CONTRACTOR NOTICE TO PROCEED. CONTRACTOR WAS READY FOR PUMP AT DAY 22.

ACTIVITIES AFFECTED:

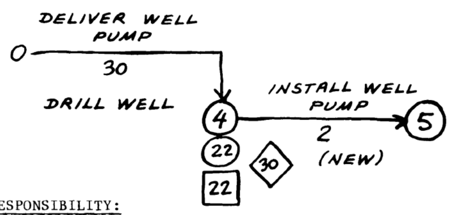
4-5 "INSTALL WELL PUMP"

TYPE OF IMPACT:

INCREASED DURATION: ________ AMOUNT: ________

DELAYED DATE/SUSPENSION OF WORK: DELIVERED @ DAY 30

FRAGNET:



EVALUATION/RESPONSIBILITY:

L.S. OF 4-5 WAS 22; ACTUAL START 30, THEREFORE 8 WORK DAYS DELAY ON CRITICAL PATH

RESPONSIBILITY: A-E (FAILED TO DELIVER SPECIFICATIONS)

Figure 33.17.2 Time impact evaluation (TIE) describing delay of well pump.

7 days' float, will this delay be charged totally to the owner (who is responsible for the architect/engineer) or split with the contractor?

Similarly, the TIE notes that the contractor was ready for the pump on day 22. If the 15-day activity of drilling the well was interrupted by rain on one day, was it really necessary for the contractor to make up the lost day by working a Saturday when she or he knew the pump would be delayed until day 30?

The TIE process does not look at these questions of who knew what when, but rather only at the day the impact is expected to or did occur.

A second delay, a 2-month delay to delivery of structural steel, further illustrates this issue, starting with the TIE form in Figure 33.17.3. The design change was also noted at the commencement of the project as a result of an

TIME IMPACT EVALUATION

PROJECT: JOHN DOE TIE #: 2

PREPARED BY: J. J. O'BRIEN DATE: 1/31/95

DESCRIPTION: STRUCTURAL STEEL DELIVERED IN 123 WORK DAYS RATHER THAN SCHEDULED 80

ACTIVITIES AFFECTED:

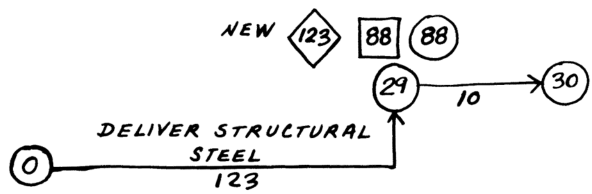
29-30 "ERECT STRUCTURAL STEEL"

TYPE OF IMPACT:

INCREASED DURATION: 43 AMOUNT:

DELAYED DATE/SUSPENSION OF WORK: DELIVERED @ DAY 123

FRAGNET:



EVALUATION/RESPONSIBILITY:

STEEL DELIVERY HAD 8 DAYS FLOAT.
THEREFORE DELAY IS (123 - 88) = 35

OWNER REQUIRED CHANGES. RESPONSIBILITY AS FOLLOWS: DESIGN CHANGES 15 DAYS
FABRICATION CHANGES 15 "
OWNER 30
FABRICATOR 5

Figure 33.17.3 TIE for 2-month delay in delivery of structural steel.

RFI generated by the contractor's efforts to prepare a CPM. The vendor, in pricing the change, agreed that it would deliver the steel no later than day 118, but ran into its own production problems and was not able to provide delivery until day 123.

When the two problems are imposed on the overall network, the critical path goes through procurement of the structural steel, as shown in Figure 33.17.4. The owner, knowing he or she would be held responsible for the delay to the steel, had no reason to rush out the specifications on the pump. The contractor had no reason to rush the procurement process, other than to mitigate the disruption to operations. The well pump was delivered late to the project; however, there is no impact on the overall project because the late steel delivery takes precedence.

As may be seen from this example, the TIE methodology alone may provide some difficulty in sorting out responsibility for multiple delays and in making adjustments for acceleration by the injured party to mitigate the impact of such delays. However, the use of the TIE is definitive in determining the total potential impact of any delaying causative event and calculating the time extension to which the injured party is entitled.

Thus, to determine the cumulative effect of all delays, all TIEs should be developed and impacted against the network simultaneously.

33.18 Windows Analysis

Just as the use of CPM allows project personnel to better understand a project by breaking down large scopes of work into small activities, the windows analysis allows a better understanding of large and overlapping delays. The purpose of this analysis is to measure the actual impact of various causative factors on the progress of the work, as opposed to measuring the theoretical impact to the as-planned logic network and plan of execution by which the contractor was entitled to not only a lack of impediment, but also an express obligation of assistance under the general precepts of contract law. The period of the windows runs from the start of the project to the first significant causative factor, then from that point to the next significant causative factor, and so on to project completion. It may be possible to run a window to each causative factor; however, the resultant analysis may become a day-by-day account of the project if each claimed RFI, CIC, SWO, or other causative event is included in the analysis. Thus, just as a scheduler needs to use some judgment in splitting, combining, and otherwise defining the scope of individual activities, so must some judgment be used in setting the time frame of individual windows. In applying this judgment, the scheduler may look to the likelihood that a specific causative event will have an impact upon the schedule. This task is greatly simplified if the TIE analysis has been subjected to a zeroing out analysis with the commencement of the various root causative factors being the start and end

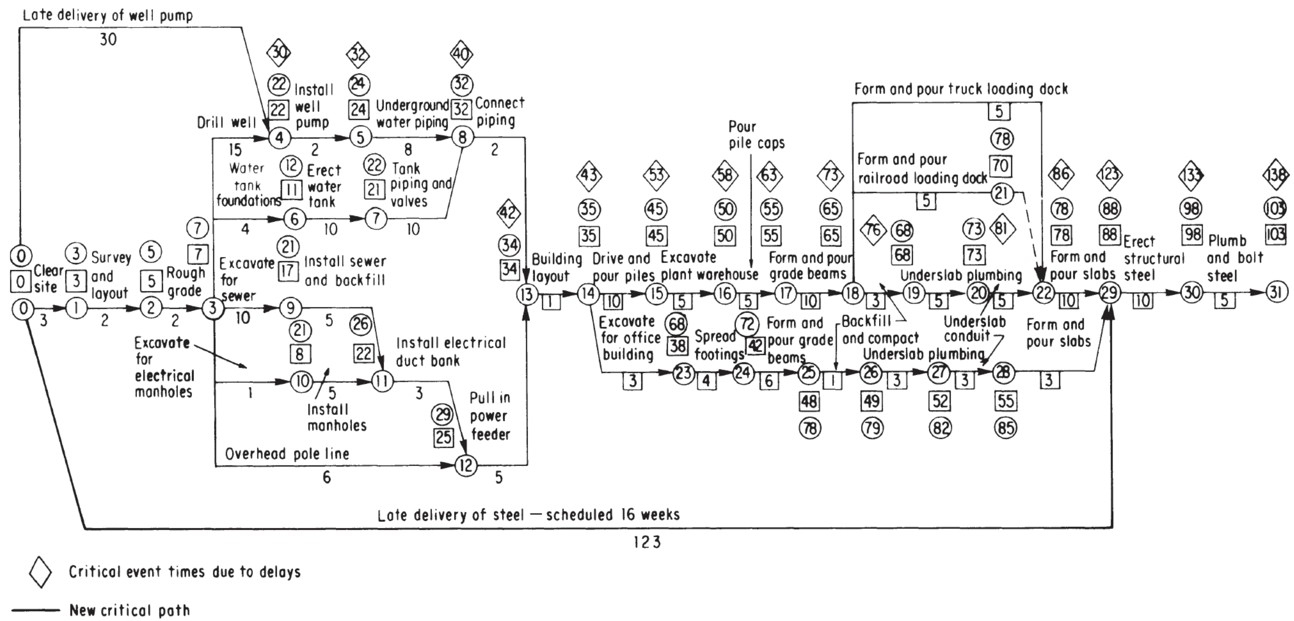


Figure 33.17.4 Time-scaled network showing steel delay.

of each window. Further latitude may be provided if a string of short-duration windows appears to be caused by factors chargeable to one party. A more detailed breakdown may be necessary if causative factors of differing or questioned responsibility overlap. In a complex delay claim situation, however, with dozens or hundreds of causative factors, it may be necessary to simply pick a standard time frame, such as 1 week or 1 month. Although careful tailoring of the window periods will be more accurate, a question of diminishing returns for the effort required must also be considered.

At this point yet another copy must be made of the as-planned logic network. If the scheduling software permits, it may be useful to import to a custom code field the actual dates recorded in the as-built schedule. To this copy should be added only those causative factors that start within the first window. However, the durations of the causative factors will have to be reviewed since in this forward-looking analysis, only the anticipated duration, rather than the actual duration, should be used.

The status of the activities of the window is then evaluated to the end of the window, using the actual start and finish dates from the as-built schedule. A special problem exists for activities started but not finished during this update in determining the remaining duration as of the new data date. If the window conveniently ends on or about the same date as one of the project updates, it may be possible to extract the remaining duration reported in that contemporaneously recorded document. However, often the two data dates will differ, or misreporting during the progress update may make such information less than accurate. (For example, a contractor forgets to report progress on some activities and reports their completion in a following update.)

The solution that best alleviates this issue is to set the remaining duration as the lesser of the actual finish minus the data date or original duration. Although this computed remaining duration may not be precisely what the field personnel may have anticipated on the data date, it will be a close approximation. Obviously, if either contemporaneous documentation or common sense dictates that reasonable field personnel would anticipate a larger duration (up to or even greater than the actual duration experienced), then that estimate of remaining duration should be used, although it should be footnoted appropriately. An important technical point in entering causative factors is the duration that will be assigned to them. For purposes of the TIE performed "after the fact," the entire and known duration of the causative event may be added. In many cases, rather than tediously calculate these durations, they may be entered by means of the expected finish constraint, allowing the computer to calculate the number of days from the known start to finish. If a causative factor, such as a stop work order pending resolution of a request for information, lingered from week to week for several months, this is the same as being told "replacement steel will be delivered in 12 weeks."

However, when a windows-based analysis is performed, the "what was known and when" issues come into play. In the first case, the duration should be 1 week since resolution is always expected by next week. In the second case, the duration should be the full 12 weeks. This may cause the causative factor of a 1-month window (to match an update cycle) to calculate an impact greater than the duration of the window.

At this point, the window file should be rescheduled with the new data date being the end of the window. The impact, if any, from the causative factors added and from the performance of work upon the baseline network logic will be calculated. This incremental delay to project completion should be recorded. Working backward via driving relationships from project completion will determine if one (or more) of the causative factors added is the root cause for this incremental delay, or if it is attributed solely to poor production during this time frame.

33.19 Zeroing Out within the Windows Analysis

If there are numerous causative factors in a specific window of an analysis and it is possible that differing parties may be responsible for overlapping delays, then either smaller windows may be utilized for this time frame or a zeroing out analysis, as described, may be used.

33.20 Windows Example of John Doe Project

To illustrate an example of the windows methodology, let us modify our previous example. Instead of the steel problem being determined around the time of the notice to proceed, it was not discovered until day 43 when the building layout was under way and the steel was already partially fabricated. Again, the fabricator agreed as part of the change order price adjustment to deliver the revised steel by day 118, but did not make actual delivery until day 123.

The two delays to the project are now distinct, as may be seen in Figure 33.20.1. The earlier delay of the well pump added the first 8 days to the project. This will be properly charged to the owner. Delivery of the pump marks the end of the first window. The second window begins when the steel issue is discovered on day 43. Since all work between delivery of the pump and discovery of the steel issue went according to schedule, no additional time is added to the project or charged to either party.

The third window begins with discovery of the steel issue and continues until the steel is delivered. The steel design issue adds only an additional 27 days and not the full 35 days calculated by the TIE, since the first 8 days are

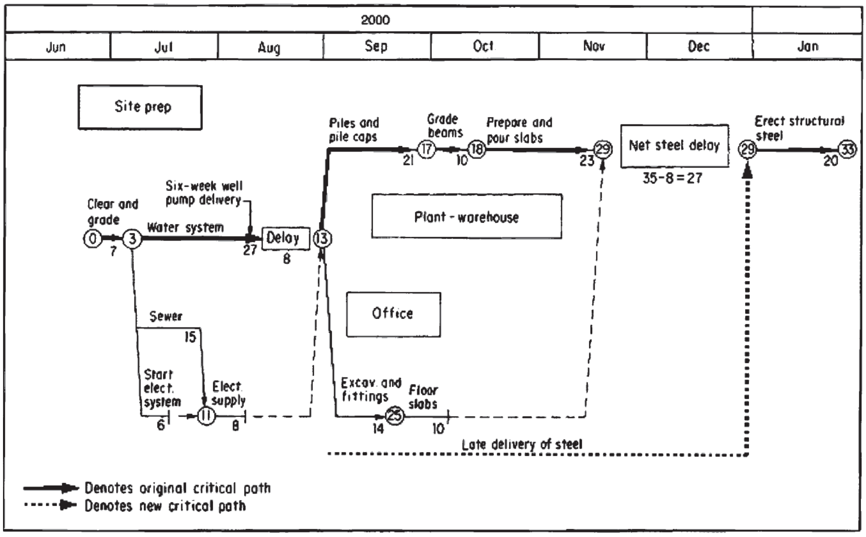


Figure 33.20.1 Overview of relative float created in sitework because of late deliveries.

now attributed solely to the well pump issue. Responsibility for this delay is further split to 22 days chargeable to the owner (and the architect/engineer) and 5 days to the contractor (and the fabricator).

33.21 Summary

The use of CPM in claims and legal cases has increased dramatically in the last three decades as parties to construction contracts have come to increasingly rely on litigation to settle disputes. The as-planned network, preferably approved by the owner, the contracting officer, or the construction manager, is key in the claim evaluation process. The best approach to such evaluation is the time impact evaluation, which applies all the delay factors to the as-planned schedule to determine how they impacted it. If there was no as-planned network or it was inadequate, an as-should-have-been network can be substituted based upon what may be ascertained as the contractor's original plan of execution. A detailed as-built network, compressed rather than impacted, can be used to evaluate a situation if a good as-planned network is not available; but this approach is highly subjective and subject to challenge. The as-built network can also be compared with the impacted, as-planned network, or the impacted, as-should-have-been network, to validate the evaluation of what impacts the delay factors had. Examples of the impact approach were given. The John Doe network updates are shown as the basis for a contractor's claim and an owner's defense.