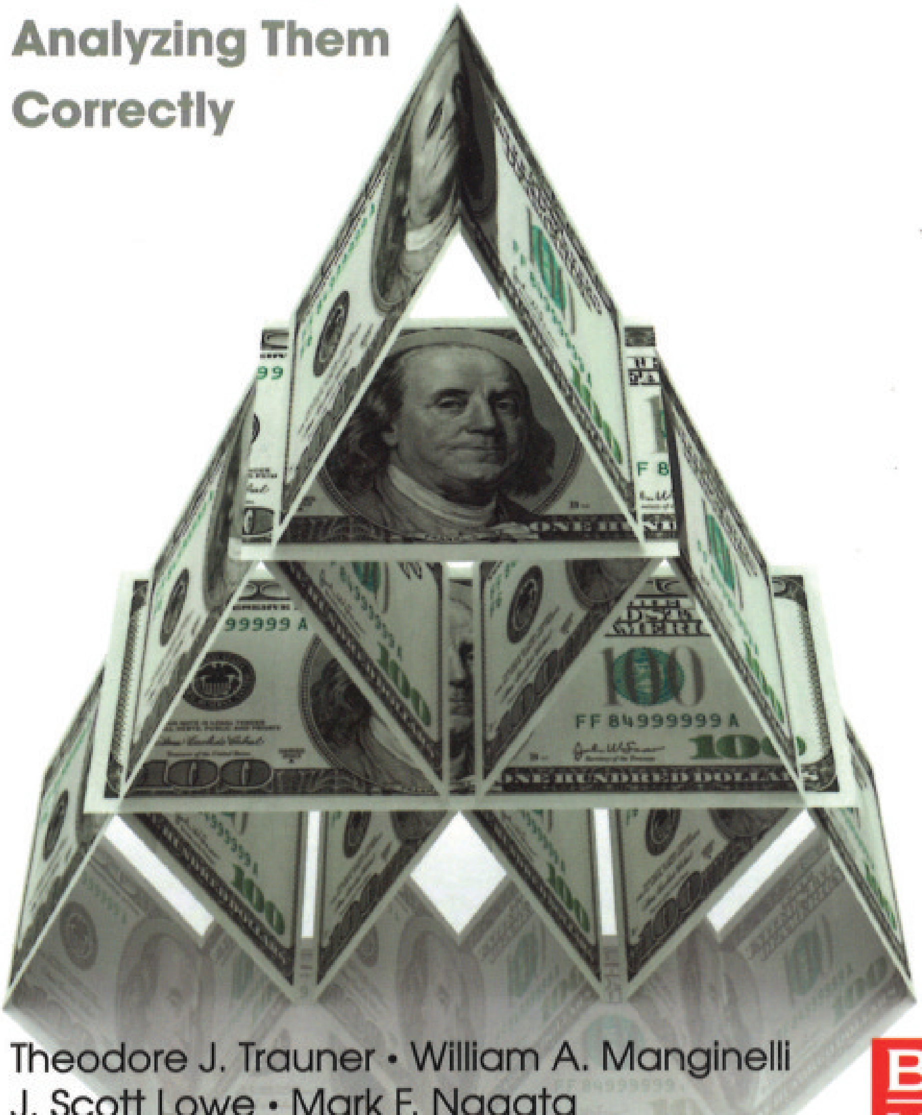
CONSTRUCTION DELAYS

Understanding Them Clearly, Analyzing Them Correctly

SECOND EDITION



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Foreword

This book was first written and published in 1990. Over the past 19 years, we have received significant positive feedback on the contents of the book. As part of that feedback process, readers have asked questions and made suggestions concerning the content. For that reason, we decided to prepare this second edition. We trust that many of those questions will be answered in the new edition and that we will provide more examples of the proper approach to analyzing delays. Also, scheduling software has become far more powerful. As a consequence, some of the scheduling "rules" are no longer sacrosanct. The power of the software has allowed schedules to expand far beyond the basic "forward and backward pass" days when Critical Path Method (CPM) scheduling was created. For this second reason, we decided to update the information to reflect the subtle and significant changes that one may see when reviewing or analyzing a schedule. We will note the areas where the software may have an effect on how one assesses a schedule and determines the critical path. We have also incorporated more examples and more complex examples. Our first edition kept the information as simple as possible because we wanted our audience to be as broad as possible and still allow everyone to gain a clear understanding of delay analysis. But as the software has grown in power, so, too, has the understanding of our readers. CPM scheduling is far more commonplace in the industry and much better understood.

When a construction Project is delayed beyond the Contract completion date or beyond the Contractor's scheduled completion date, significant additional costs can be experienced by the Contractor, the Owner, or both. Because Contract schedules are so important and delays can be so costly, more and more projects end up in arbitration, litigation, or some form of dispute concerning time-related questions. A judge, jurors, or arbitrators are then faced with the task of sorting out who is to blame from a complex collection of facts and dates. Oftentimes, experts are required both to perform an analysis of the delays that occurred and to provide testimony to explain the analysis. One of the most difficult tasks of the expert is to educate the parties involved so that an understanding can be reached concerning the delays that occurred and who is responsible for them.

This book provides the background information necessary to understand delays. This understanding is not geared solely to the context of disputes but rather provides a framework to help prevent disputes from occurring and to resolve questions of time as they arise during the Project.

Chapter 1, "Project Scheduling," provides an overview and definitions of basic scheduling concepts and terms that will be referred to throughout the book. It is not intended as a CPM scheduling primer. Rather, it addresses important basic concepts required for using Project schedules. Key elements include float, reviewing and approving schedules, the critical path, and early completion schedules.

Chapter 2, "Types of Construction Delays," explains the basic categories of excusable and nonexcusable delays and the subcategories of compensable and noncompensable delays. It addresses the concept of concurrency and also noncritical delays. This primer in delays prepares the reader for the specific issues covered in succeeding chapters.

Chapter 3, "Measuring Delays—the Basics," explains how to approach the analysis, including the starting points of as-planned schedules and as-built diagrams and how one must compare the two in order to quantify the delays that have occurred. The question of liability is addressed separately, since this determination is made most expeditiously after the specific delays have been identified. Chapter 4, 5 and 6 travel through the actual process of analyzing delays with bar charts, CPMs, and no schedule.

Recognizing that there are numerous approaches used in analyzing delays, Chapter 7 comments on some of the more common approaches used and the strengths and weaknesses associated with them.

Damages to the Owner and Contractor are addressed in Chapters 8 through 13. Since inefficiency and acceleration costs are often time-related issues associated with delay, they have been addressed separately in the hopes that some of the myth and magic that surrounds them may be cleared away. Similarly, the topic of costs associated with noncritical delays has been given special attention, since many projects experience these with little or no recognition of the problem.

Chapter 14, "Determining Responsibility for Delay," explains the process used to assess the party who caused the delay. The responsibility for delays is addressed separately from the delay analysis because we believe that this is the proper approach to use: first determine the activities that are delayed and the magnitude of the delay and then address responsibility or liability.

Chapter 15, "Risk Management," could also be called "Prevention of Time-Related Problems," since it focuses on the delay-related risks of the various parties in a construction Project. By maintaining this focus, each of the parties has a tendency to better control time and resolve delay problems as they occur.

This book has been written with the hope that a better understanding of delays, time extensions, and delay costs will help to prevent problems rather than foster and fuel the already litigious atmosphere that exists in construction.

Bear in mind that the methodology described herein can be applied to any type of Project that (1) has a time constraint and (2) is amenable to scheduling and the monitoring and control of time. This category could include supply contracts, manufacturing projects, and research and development projects, as well as traditional construction projects. The approach will be the same for all situations, given a logical and reasoned application within the context of the existing facts.

Chapter | three

Measuring Delays—The Basics

THE IMPORTANCE OF PERSPECTIVE

"Reality is a question of perspective; the further you get from the past, the more concrete and plausible it seems."

—Salman Rushdie, *Midnight's Children*

The length of a critical delay is often a question of perspective. Every analyst has a way of illustrating this point, but the classic example is the "ribbon-cutting" story. Consider a Project where in addition to all its other responsibilities, the Contractor must also provide the scissors for the mayor's ribbon cutting at the conclusion of the Project. The Architect rejected the Contractor's original scissor submittal (the Contract specified something larger and grander). The Project Manager shoved the rejected submittal to the bottom of her "to-do" pile, where it languished and was eventually lost. The Project ultimately finished late due to an error in the design of the structural steel. The error necessitated refabrication of steel, delaying the critical structural steel erection work.

At the ribbon-cutting ceremony, it quickly became apparent that the scissors had not been purchased. The Project Manager, at the last minute, ran to the local office supply store and bought the biggest, brightest pair of scissors she could find. She returned to the Project site just as the mayor was about to cut the ribbon. The proceedings were held up only a few seconds as she ran up to the entrance of the new water treatment plant.

After the ribbon-cutting ceremony, the Project Manager met with the Architect to close out the Project. The Contractor sought a time extension due to the steel design error. The Architect rejected the Contractor's request, stating that even without the steel design error, the formal opening of the Project would have been delayed by the lack of scissors to cut the ribbon.

The ribbon-cutting story points out the importance of perspective. Viewed solely from the end of the Project, the lack of a pair of scissors, and the flawed procurement process that caused them to turn up missing, appears to be critical to opening the Project. Given these facts, most of us quickly see the error in the Architect's logic, but what if the scissors are changed to aluminum tank covers? In response to the steel design error, assume that the Project Manager called the fabricator of the aluminum tank covers to let him know that the Project would be a little late, the delivery of the tank covers should be postponed. If the tanks weren't ready when the covers were delivered, they would have to sit before they could be installed and might be damaged. As the Project Manager recommended, the tank covers were delivered later than originally scheduled, but they finally arrived and were installed as the delayed tanks were completed.

In this revised story, the Contractor and the Architect again meet after the ribbon cutting to close out the Project. Again, the Contractor asks for a time extension, and, again, the Architect refuses the request. This time, however, the Architect denies the time extension because the "aluminum tank covers were late." We know all the facts, so we, again, see the error in the Architect's logic. But what if the facts weren't known? What if there was no written record of the Project Manager's conversation with the tank cover fabricator? Absent verifiable facts, is the Architect correct? Is the view from the end of the Project a relevant and valid perspective?

Perhaps it's only the view from the end of the Project that is problematic. What about the view from the beginning? Consider the same Project. As required by the Contract, the Contractor prepared a CPM schedule. The first schedule prepared on a Project is called the initial, baseline, or "as-planned" schedule. It typically depicts only the Contractor's plan, and it doesn't include "as-built" or actual performance information. The critical path of the Project as depicted in the Contractor's as-planned schedule proceeded through the erection of structural steel. During the close-out meeting, the Architect requires the Contractor to prepare an analysis that demonstrates that the steel design error introduced in the first paragraph of this chapter delayed the Project. The Contractor concludes that the best way to evaluate or "measure" the delay associated with the steel design error would be to simply "insert" this delay into its as-planned schedule. This is typically accomplished by developing a minischedule that models the work associated with the problem. This minischedule is called a fragnet (a fragmentary network). According to the Contractor, inserting a fragnet representing the steel design error into the as-planned schedule will show both that the error caused a critical delay and, when the schedule is recalculated and compared to the unaltered as-planned schedule, the magnitude of the delay. If we didn't know anything else, this approach might be acceptable.

But we do know something else. We know that a dispute developed between the Contractor and its steel erector. In fact, the steel erector abandoned the Project. The Contractor was not able to get another erector on site until after the prefabricated steel was delivered to the site. But the Contractor's analysis doesn't consider this problem. The only fragnet inserted into the schedule is the fragnet for the steel error, and this results in a Project delay. Is the Contractor entitled to a time extension for the steel design bust regardless of what else might be going on at the Project site when the delay occurred? Is the view from the beginning of the Project a relevant and valid perspective?

In addition to viewing critical Project delays from the end of the Project or the beginning, another perspective would be to evaluate delays as they occur—in other words, evaluate delays to the Project at the time the delay is experienced. This would avoid the ribbon-cutting error and would force the analyst to consider everything else happening on the Project when the delay occurs. But what if the analyst isn't brought in until long after the Project has been completed? Is the view from the time when the delay actually occurred still relevant and valid, even though the analyst knows what ultimately happens?

The answer to the questions raised so far in this chapter are at the heart of many of the disagreements among analysts regarding the best way to analyze delays on a construction Project. Does the analyst evaluate the delay from the perspective of the beginning of the Project, adding delays to the as-planned schedule, or from the end of the Project, evaluating only those delays that appear to ultimately hold up the Project's completion (the ribbon-cutting example)? Or should the analyst try to put herself in the shoes of the Project Manager at the time the delay occurs? It would be disingenuous to suggest that analysts are united in their answers to these questions. There is, however, an emerging consensus supported not only by many analysts but by case law, as well. First, a little background.

Perspectives—Forward Looking and Backward Looking

Though rarer now, there was a time when delays were sometimes analyzed by "impacting" the as-planned schedule. The as-planned schedule is usually defined as the earliest complete and Owner-approved Project schedule. It represents the Contractor's plan for completion of the Project before any work is actually done. If delays are analyzed using an "impacted as-planned" approach, the delay (or impact) is inserted into the as-planned schedule, and the schedule is then recalculated. The difference between the originally scheduled completion date and the completion date that results from impacting the as-planned schedule is the Project delay attributable to the impact. This type of analysis takes the position that delays should be measured from the perspective of the beginning of the Project, considering only the Project team's original plan and the delay being analyzed. The problems with this analytical approach will be discussed in more detail in another chapter, but here's what a judge had to say about this approach in *Haney v. United States* [30 CCF ¶ 70, 1891], 676 F. 2d 584 (Ct. Cl. 1982).

> We have found that [the contractor's] analysis systematically excluded all delays and disruptions except those allegedly caused by the Government.... We conclude that [his] analysis was inherently biased, and could lead to but one predictable outcome.... To be credible, a contractor's CPM analysis ought to take into account, and give appropriate credit for all of the delays which were alleged to have occurred.

Essentially, the judge's criticism was that the outcome of an impacted as-planned analysis, because it ignores everything other than the as-planned schedule and the delay the analyst is evaluating, was predetermined. It would overstate the delay, if any, associated with the inserted delay. Years of experience analyzing impacted as-planned analyses have confirmed this judgment. They very nearly always overstate the Project delay, predicting Project delays well beyond the actual Project completion date. On this basis, an analysis of delays based solely on the perspective from the beginning of the Project and employing an impacted as-planned analytical technique is flawed and to be avoided.

The logical opposite of an impacted as-planned analysis is the "collapsed as-built." Again, the problems with this analytical approach are discussed in another chapter, but a discussion concerning perspective is appropriate here. Stripped to its essentials, a collapsed as-built analysis is performed by first identifying the "as-built schedule" for the Project. This is essentially a schedule showing how a Project is actually constructed. It is not a schedule that ever existed on the Project, though it is theoretically composed of actual Project events. The analyst creates the "as-built schedule" after the Project is completed. The next step is to identify the delay to be analyzed. Note that this approach is a little like the tail wagging the dog. The delay must first be identified before it can be analyzed. The analysis is performed by removing the delay from the as-built schedule and then rerunning the schedule to see what happens. If the collapsed schedule shows an earlier Project completion date, then the conclusion would be that the delay that was removed was responsible for a Project delay equivalent to the improvement in the Project completion date associated with the collapsed schedule. This analysis presumes that delays are best analyzed from the perspective of the end of the Project.

Setting aside the questions concerning the mechanics of a collapsed as-built analysis, consider what it means. Essentially, the collapsed as-built approach is based on the assumption that all that matters is what *happened,* not what was planned. To understand the problems with this assumption, consider the following example. A Contractor is tasked with excavating a 100-foot rock face and then lining the face with concrete. Excavation began, and the Contractor immediately encountered a problem. It turns out that a fault zone ran through the area of construction. This fault zone was oriented in such a way that as the Contractor removed rock, the rock face that was left tended to slip into the excavated area. This was not only dangerous, but it prevented the Contractor from excavating the planned 100-foot rock face. The Owner and the Contractor met to discuss the problem, and they decided to pin the rock face with rock anchors as the face was excavated in 10-foot lifts. Also, the Owner decided that the concrete lining had to be constructed before the next 10 feet of the rock face could be excavated.

At the conclusion of the Project, the Contractor asked for a time extension to cover the additional time it had expended excavating and lining the rock face in

10-foot lifts as opposed to all at once, as planned. The Owner responded with a collapsed as-built analysis showing that the only delay was the time required to install the rock anchors, which had not been contemplated in the original design. The rock excavation and concrete liner were not "delays," since this work had always been required.

The fallacy of the Owner's analysis was that in addition to the rock-anchor delay, the Contractor was also delayed because the Contractor built the Project in 10-foot lifts rather than all at once, as planned. Because the Owner's delay analysis considered only what happened (the as-built schedule), it could not quantify delays associated with deviations from the Contractor's plan. And this is the essential failure of any analysis based solely on what happened or solely on the perspective from the end of the Project.

If the perspectives from the beginning of the Project and the end of the Project are flawed as the logical basis for analyzing delay, the only perspective remaining is to analyze the Project at the point where the delay actually occurred. An analysis based on this perspective has a name: contemporaneous analysis. Before discussing how such an analysis might be performed, consider this judge's decision.

> Mr. Maurer, appellant's expert, testified about the critical delays to the Project.... The analysis about the critical delays was based on appellant's original schedule, the schedule updates, the daily reports, Project correspondence, and the contract documents. Mr. Maurer described his analysis as a step-by-step process, beginning with the original schedule and proceeding chronologically through the Project, updating the sequence at intervals to see what happens as the Project progressed [(tr. 262) ASBCA No. 34, 645, 90–3 BCA ¶ 12, 173 (1990)].

A second judge's decision is also relevant to this discussion.

> In the absence of compelling evidence of actual errors in the CPMs, we will let the parties "live or die" by the CPM applicable to the relevant time frames [Santa Fe, Inc. VABCA No. 2168, 87–3 BCA ¶ 20677].

Taken together, these decisions have an important message: When analyzing delays, it is important to evaluate Project events relying on the documents in use on the Project at the time the delay occurred. Of particular importance are the original schedule (as-planned schedule) and schedule updates. These contemporaneous schedules form the foundation of a credible analysis of Project delay. To put it in the judge's terms, absent actual errors, the parties will "live or die" by the Project plan and the events as depicted in the schedules that were in place at the time the delay occurred.

In summary, the only valid perspective for the analyst is to adopt a view of the Project contemporaneous to the delay itself—not from the beginning of the Project or the end of the Project. Now, let's see how such an analysis would be performed.

USE THE CONTEMPORANEOUS SCHEDULE TO MEASURE DELAY

In Chapter 1, we defined the contemporaneous schedule, and now we are going to explain why the contemporaneous Project schedule should be used to identify and measure delay. As stated in Chapter 1, a contemporaneous schedule is the Project schedule, which typically consists of the baseline schedule and schedule updates that were used to manage and construct the Project.

It is necessary to use the contemporaneous Project schedules in an analysis of Project delays because they are essentially snapshots of the Project's status at specific moments in time. As snapshots in time, the schedule updates identify what work has been done and the order in which it was completed. Perhaps most important, the contemporaneous Project schedules also capture changes made to the construction plan in reaction to ever-evolving Project conditions.

The contemporaneous Project schedules are the preferred tool to measure Project delay because they were used by the Project participants to manage and construct the Project and provide the most accurate picture of the plan to complete the Project at a moment in time based on the known Project conditions. These attributes provide the analyst with a real-time perspective of the Project and enable the analyst to identify, measure, and assign Project delay using the same information available to the Project participants at that moment in time. By using the contemporaneous schedules and updates, and by tracking delays as they occur throughout the Project, there is no need to attempt to inject information that is known at a later date. Information is incorporated into the analysis in a contemporaneous fashion throughout the analysis. In other words, if the analyst knows that something significant occurs in month ten of the Project, when month ten is being analyzed with the schedule updates from that period, it is then that the information is incorporated.

DO NOT CREATE SCHEDULES AFTER THE FACT TO MEASURE DELAYS

In the absence of contemporaneous schedules, an analyst may feel it would be acceptable to create a schedule after the fact that he believes portrayed the Contractor's intended construction plan. Although the analyst may rely on the Project documentation and his own knowledge of the type of construction being performed, creating a schedule for the sole purpose of measuring and identifying Project delay after the Project is complete negates the objectivity of the analysis. Even though the analyst may do his best to remain objective, the fact remains that he would have complete knowledge of all the facts that pertain to the construction of the Project and all the problems that were encountered during the course of construction. This after-the-fact perspective would influence the after-the-fact schedule and ignore, or at least significantly diminish, the contemporaneous knowledge and thinking of the Project participants before and during the Project.

The analyst may argue that creating an after-the-fact schedule will allow the analysis to be more precise, containing all the facts of the Project. However, it should be noted that schedules created after the fact should not be relied on because there is more than one way to build a Project, and the analyst may choose a different approach than the original planner. And even slight differences in a schedule could affect the results of an analysis. Using a schedule created after the fact to measure and identify Project delay, however, has two weaknesses: The schedule does not depict the original construction plan, and the schedule may include predetermined conclusions concerning delays. There are many ways a construction plan can be represented in a schedule. Preparing one after the fact merely shows the plan the analyst believes was intended. This does not make it correct.

When possible, it is always best to use the contemporaneous Project schedules to measure Project delay. While the analyst may make very minor modifications to the contemporaneous schedule to account for obvious errors, such changes must be made judiciously. This subject is addressed in more detail in Chapter 5.

WHAT TO DO WHEN THERE IS NO SCHEDULE

There are instances when contemporaneous Project schedules cannot be used to measure Project delay. In those cases, the Project schedules either were not developed and maintained or the analyst might determine that the contemporaneous schedules did not accurately depict the plan to construct the Project and would not be a reliable tool to measure Project delay.

When a contemporaneous schedule is not available to measure critical Project delays, the analyst should use an as-built analysis (discussed later in the book) to identify the critical delay, which is based on an as-built diagram. An as-built diagram is prepared using the Project's contemporaneous documents. Those documents may include, but are not limited to, timesheets, inspector daily reports, meeting minutes, Project photos, and so on. When complete, an as-built diagram should depict the order and durations of the Project work activities. The analyst would then proceed as described in the as-built analysis section of this book.

WHAT IS THE AS-PLANNED SCHEDULE?

As its name implies, the as-planned schedule is the schedule created either before construction begins or very early in the first stage of the Project and should represent the Contractor's plan to construct the Project based on the information it had at the time of bid. Most projects have some form of an as-planned schedule. The as-planned schedule is most often the Contractor's original schedule submitted in accordance with the Contract documents.

Forms of As-Planned Schedules

As mentioned in Chapter 1, Project schedules can take many forms. Depending on the construction Project's size and level of complexity, it may be a written narrative of the Contractor's plan, a simple bar chart, or a detailed CPM schedule. Don't dismiss a schedule merely because you believe it lacks detail or because it is a bar chart schedule instead of a detailed CPM schedule. The most important characteristic to remember is that you are trying to identify the earliest and most accurate representation of the Contractor's construction plan.

Identifying the As-Planned Schedule

The analyst must carefully choose the schedule that best represents the Project's as-planned schedule. For example, the Owner may have included a schedule with the bid documents as a guide for the Contractors bidding the work. However, it may be erroneous to use the Owner's version as the as-planned schedule for the Project because the Contractor may plan to construct the Project in a different sequence or manner. Typically, the Contractor's initial schedule submission serves as the Project as-planned schedule. It is common for the Owner's representative to send the initial schedule back to the Contractor for changes or corrections. If the Contractor submits the schedule a second and third time until it is finally accepted by the Owner, chances are that the third schedule submission best represents the as-planned schedule for the Project. In some cases, the Contract may require Owner approval or acceptance of the initial schedule submission as a method of establishing the Project's as-planned schedule.

Reviewing the As-Planned Schedule

After identifying the schedule that most reasonably represents the Contractor's original planned sequence of work, the analyst should review that schedule for sequencing and feasibility. A note of caution: Often the analyst, or the person assessing the Project for delays, reviews the Contractor's schedule and decides that it did not correctly portray (1) the sequencing of the Project or (2) the durations for the activities. The analyst might then change the schedule to reflect his judgment about the errors. The analyst should avoid this practice at all costs. If there are minor errors or inconsistencies in the Contractor's as-planned schedule, they will be accounted for during the analysis of the delays. The decision as to whether or not the Contractor's schedule was practicable is a highly subjective one. Therefore, it is far better to give the Contractor the benefit of the doubt than to disallow, ignore, or even change the schedule.

WHAT IS AS-BUILT INFORMATION?

As-built information is the actual start and finish dates of the Project work activities. One of the best places to find as-built information is in the Project schedule updates, because the periodic updates typically record the dates that specific activities start and finish. Even if the updates contain the Project's as-built information, it is always wise to verify information in the updates, using as many independent sources as possible. For example, the analyst might review the Project daily reports to verify that specific activities started and finished on the dates indicated in the updates.

If the updates do not provide the information required or do not exist, then the analyst has no alternative but to prepare his own as-built diagram, using the contemporaneous Project documents. These documents should be reviewed for possible sources of as-built information:

- Project daily reports
- Project diaries
- Meeting minutes
- Pay requests/estimates
- Inspection reports by the Designer, Owner, lending institution, and so on
- Correspondence
- Memos to the file
- Dated Project photos

Note that in the creation of an as-built diagram, the analyst should document every day that work is recorded for each activity. It is not enough to merely record the start date and then the finish date. While the start and finish dates are extremely important, the determination of whether work was continuous or interrupted may also be significant.

In some instances we have used the term as-built "schedule" with the word *schedule* in quotation marks. This is intentional. An as-built is not truly a schedule but rather a chronicle or history of when specific work is performed.

THE IMPORTANCE OF THE CRITICAL PATH

As stated earlier, the critical path of the Project is the longest path of work activities through the network. Due to the fact that the critical path is solely responsible for determining the date that the Project can finish, it is logical that only delays to the critical path will delay the Project.

In many instances, as the Project progresses and Project conditions change, the critical path can shift to other work paths. This shifting of the critical path will occur when other work paths are either delayed or changed to a point that they now are on the longest path, become critical, and because they are now critical, determine when the Project will finish. If the contemporaneous Project schedules are properly maintained and updated, they will capture the shifting of the critical path as the Project conditions change. Therefore, reliance on the contemporaneous Project schedules to identify the critical path at specific moments in time throughout the Project's duration will enable an analyst performing an analysis of delays after the fact to accurately identify the work activities that were actually critical and correctly assign Project delay to the responsible party.

The analyst should never assume that the critical path is static and remains unchanged throughout the Project. Experience teaches us that the reverse is more often true. Changes in the critical path are normal and should be expected.

UNDERLYING PRINCIPLES FOR ANALYZING A SCHEDULE FOR DELAYS

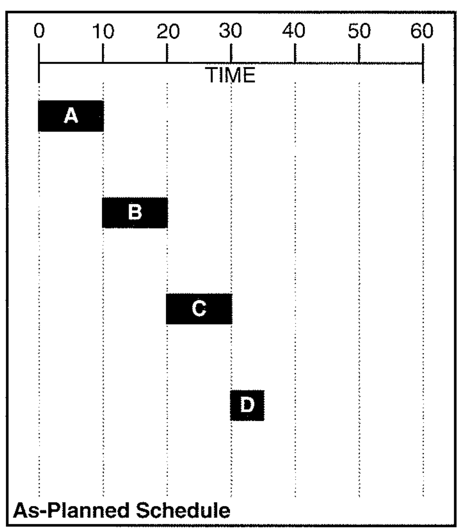
In most of the methods for analyzing delays that are discussed in this book, the analyst should be following certain general principles during the analysis. Obviously, the specific steps in the analysis will vary, depending on the nature of the available information. In general, the following approach is used during the evaluation of delays.

The first step is a determination of the Contractor's as-planned schedule. For purposes of this discussion, we will use a simple bar chart to demonstrate. Figure 3.1 is the Contractor's as-planned schedule for a Project. To determine what occurred on the Project, the analyst will create an as-built diagram or chart. For this example, Figure 3.2 represents the as-built chart for the actual progress of the work as it occurred on the job.

At this stage of an analysis, there often is the inclination to compare the as-planned schedule with the as-built chart and attempt to reach conclusions concerning what was delayed. The comparison of the as-planned schedule and the as-built chart is shown in Figure 3.3. When we look at Figure 3.3, we might conclude that activity D was delayed by 25 days, from day 35 to day 60. If we know that the Subcontractor performing the work on Activity D showed up the day it started, we might conclude that the delay of 25 days was caused by the late arrival of the Subcontractor—and this conclusion may be totally incorrect.

When we are analyzing delays, we need to start at the beginning of the Project and move through the Project chronologically. As we do this, we should be able to identify each delay as it occurs and update the schedule accordingly. Let's do that with the information we have, using Figure 3.4. When we look at Figure 3.4, we start with the first activity, Activity A, and we compare the

FIGURE 3.1



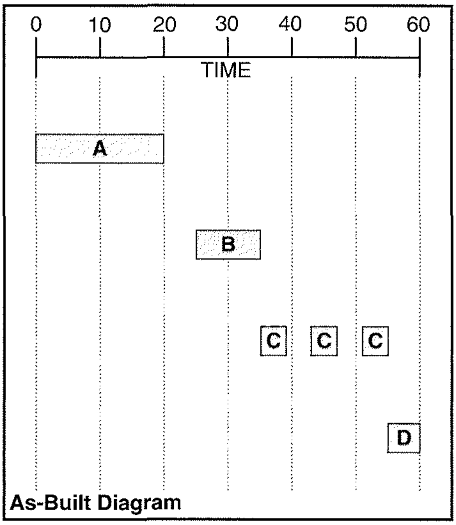


FIGURE 3.2

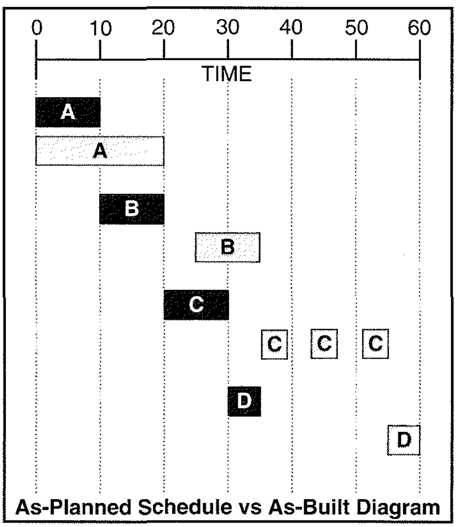


FIGURE 3.3

as-planned schedule for activity A with the as-built information. We can readily see that Activity A started on time but took twice as long to perform as was planned. As opposed to 10 days, Activity A took 20 days. From that we should conclude that Activity A was delayed for 10 days as a result of an extended duration.

Now that we have identified the delay to the first activity, we need to update our schedule for the effect of the delay to Activity A to the remaining planned activities. In Figure 3.5 we show the original planned Activity A and the as-built for Activity A. We then move or update the planned start of Activity B later because the start of Activity B depended on the finish of Activity A. We have

FIGURE 3.4

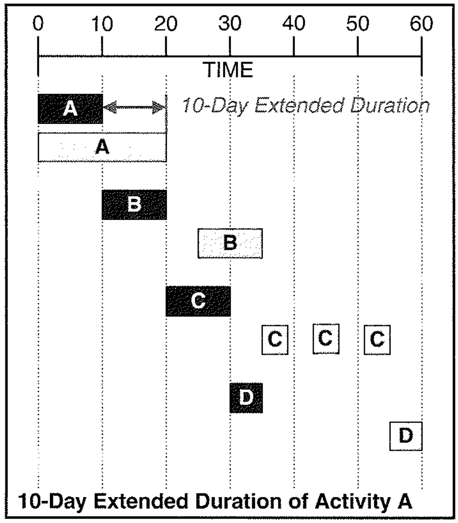
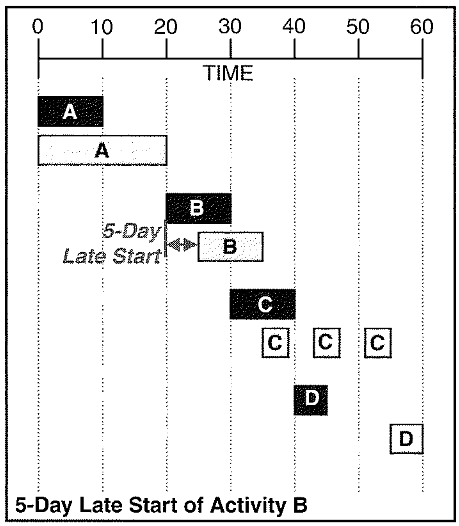


FIGURE 3.5



updated or "bumped" the start of Activity B because of the delay to Activity A. Now that we have updated the planned schedule for the actual performance of Activity A, we can look at Activity B to see whether it affected the completion of the Project. As we see in Figure 3.5, Activity B started 5 days later than it should have, based on the late finish of Activity A. Therefore, we have identified our second delay: Activity B was delayed 5 days because of a late start.

The process repeats itself for each subsequent activity. In Figure 3.6, we update the schedule. Based on the two preceding delays to Activities A and B, now we can look at Activity C to determine if it experienced any delay. As we can see in Figure 3.6, Activity C was delayed 10 days. Since we plotted our

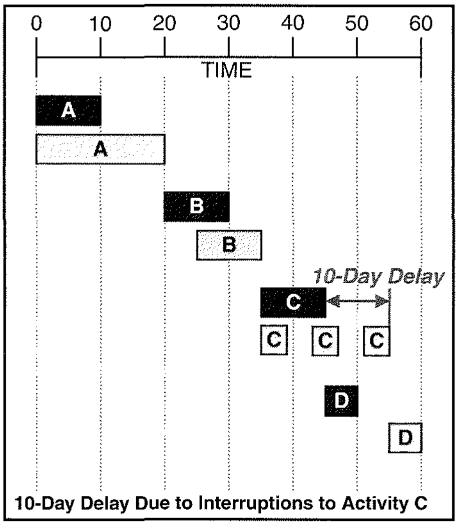


FIGURE 3.6

as-built chart as precisely as we could, we also know that the 10-day delay was the result of two periods where no work was performed on the activity. The last step is identical to the preceding steps. We update the schedule once more and look at Activity D.

Figure 3.7 shows that Activity D caused no delay to the Project. This conclusion is very different from the one we might have initially reached if we had solely looked at a comparison of the as-planned schedule and the as-built chart. Figures 3.8 and 3.9 summarize the results of our analysis.

In one form or another, this stepwise approach starting at the beginning of the Project should be used in almost all analyses of delays. We also note that precise charting of the as-built information is very helpful when the analyst

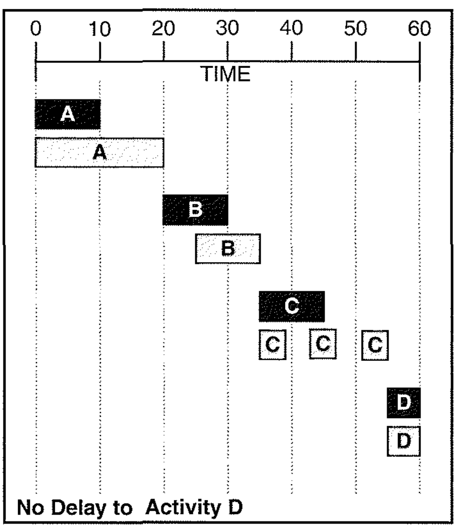


FIGURE 3.7

FIGURE 3.8

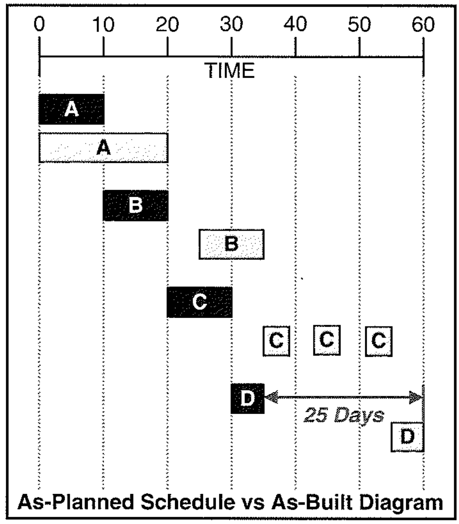
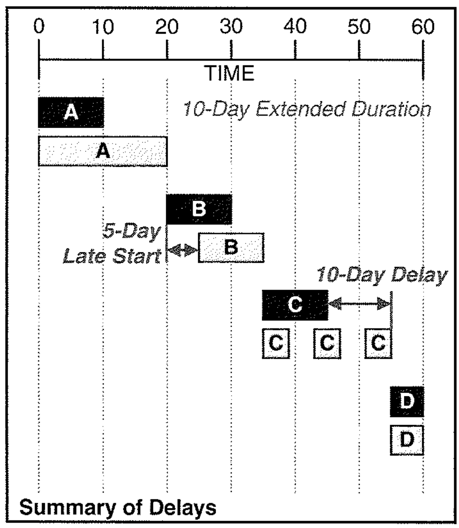


FIGURE 3.9



moves to a determination of the cause of the delay or the liability for the delay. For instance, by knowing that Activity C was interrupted, as opposed to just taking longer, you can review the available documentation for reasons why the work would have stopped for those two periods.

THE UNIQUE POSITION OF SUBCONTRACTORS

Because the duration of a Project can only be extended by delays to activities on the Project's critical path, a Contractor's performance period can only be extended when the Project experiences a critical delay. However, this is not necessarily the case for the performance period of a Subcontractor.

While certain Subcontractors may have work to perform during the entire Project period, it is more typical for a trade Subcontractor to have its work become available sometime after the Project work has begun and be required to complete its subcontract work before all the Project work can be or has been completed. As a result, the trade Subcontractor's work may or may not ever show up on the Project's critical path. Still, delays that extend the Subcontractor's work will require the Subcontractor to be on the job longer, thus extending the Subcontractor's performance period.

For example, a masonry Subcontractor may not be able to begin its subcontract brick veneer work until the exterior sheathing has been installed on a building that is expected to take 18 months to construct. The as-planned schedule may show that after the exterior sheathing had been completed on one elevation, the masonry work can begin and will take three months to complete, followed by other exterior and interior finish work. Because the masonry work is planned to follow the expected pace of the exterior sheathing installation, the masonry may never show up on the critical path.

Presuming that the exterior sheathing work experiences delays, the exterior sheathing work is more likely to show up on the critical path than is the masonry work. Yet, the masonry work will be delayed because it will not be able to proceed at the pace planned. As a result, the masonry work takes five months to complete instead of the planned three-month period. The mason claims that its performance period was extended by two months through no fault of its own. It requests additional compensation for extended overhead costs and other delay damages.

In this example, an analysis of delays along the critical path of the Project may not support the mason's request. However, from the facts presented, it is evident that the mason's performance period was extended, and, depending on the provisions of its subcontract, the mason may be able to recover the delay costs caused by others.

If a critical path analysis of the Project does not support the mason's claim, what type of analysis should be performed to determine if the mason's claim has merit? In the preceding simple example, the answer appears straightforward. For most Subcontractors, however, their work is integrated with many aspects of the Project work. Often, the relationships among the various work activities of the Prime Contractor and the various Subcontractors are more complex than the preceding simple example. To complicate matters, when the Subcontractor's work is not on the critical path of the Project, unless constrained in some other way, it will have float. Therefore, any analysis of Subcontractor delays will also involve an examination of the Subcontractor's obligations with respect to activity float.

When investigating potential delays to a Subcontractor's performance, we begin by evaluating the performance requirements of the subcontract. The objective of this evaluation is to determine the period of performance for which the Subcontractor is obligated under the terms of the subcontract. Often, a Subcontractor is required to perform its work according to the Project schedule. Typically, the Prime Contractor reserves its right to modify the schedule as necessary to complete the work in a timely fashion. The subcontract will then require the Subcontractor to perform according to these modifications as well. Because these modifications are not known at the time of the subcontract agreement, there is a certain expectation that the parties have regarding the Subcontractor's performance period. This expectation will usually be a product of the particular negotiation that led to the signing of the subcontract.

While the Subcontractor typically takes on some risk regarding the Prime Contractor's right to modify the schedule, this risk is typically not without limits. The Contract CPM schedule will identify early and late dates for all of the Subcontractor's work activities. When obligated to perform according to the Contract schedule, it is reasonable to conclude that the Subcontractor is obligated to be on site from the projected early start date of its first activity to the late finish of its last work activity. This conclusion recognizes that the work activities do not need to be performed on the early dates for the Project to complete on time. Thus, performance of the work within the early and late date ranges are foreseeable because such performance is, in fact, "according to" the schedule. This remains true, even if such performance affects the continuity of the trade Subcontractor's work activities.

The Prime Contractor, however, may argue that the subcontract allows for modifications to the sequence and duration of the work. Here again, there may be a question as to the degree such modifications are foreseeable. It may be reasonable for the Prime Contractor to argue that because it is responsible to the Owner to complete the Project on time, it must continually assess progress against its plan to complete the work. When the actual progress differs from that planned, it must modify the sequence and duration of future work to ensure an on-time completion. As a result, modifications to the schedule that change the sequence and duration of the Subcontractor's work activities within the original Project performance period may be foreseeable. Much of this argument, however, will depend on the nature and extent of these changes. Unlimited modifications to the sequence and duration of the work are generally not anticipated by the parties.

Through careful evaluation of the subcontract and the understandings and circumstances leading to the subcontract agreement, the Subcontractor's planned performance period can be determined. Unlike the Prime Contractor's contract performance period, which is generally expressed in the Contract, the parties may be unable to agree on the subcontract period of performance. In such cases, the parties will prepare their respective arguments based on the subcontract performance period they believe to be correct.

Once the subcontract period of performance has been established, a comparison to the Subcontractor's actual performance period provides a measure of the total delay experienced by the Subcontractor. But this is only the beginning of the story. Next, it is necessary to determine the causal link between the actions of the parties and the delays incurred in order to determine if the Subcontractor's delays were caused by others.

In order to determine the cause of any delays to the subcontract period of performance, it is necessary to determine the critical path of the Subcontractor's work. The critical path of the Subcontractor's work is the longest path of activities leading from the first work activity to be performed by the Subcontractor to the last. This path may consist of some or all of the Subcontractor's work activities, as well as work activities performed by others. Because these activities are integrated within the entire schedule network, the analyst cannot simply isolate the Subcontractor's work activities and evaluate the paths among these in a vacuum. Many of the Subcontractor's work activities will be driven by activities being performed by others, and all of these relationships must be considered in the analysis.

As a result of these complexities, it may not be possible to determine the longest path between the Subcontractor's start and end points through electronic analysis of the schedules. As an alternative, it may be necessary to determine the Subcontractor's critical path through a detailed evaluation of the Subcontractor's daily work progress. This evaluation is similar to the As-Built Delay Analysis discussed in Chapter 6.

This process begins with the preparation of a detailed as-built diagram that tracks all of the Subcontractor's actual performance. This performance is then compared to all of the available planned performance information. To begin with, the analyst determines if the Subcontractor was able to meet planned durations for its work and, if not, why not. Did the Subcontractor provide sufficient resources to accomplish the work? Was the Subcontractor given access to the work as anticipated or was it required to perform its work under conditions that differed from those it expected to encounter? Was the Subcontractor in control of the pace of the work, or was something else controlling the pace?

We also look at the sequence of the Subcontractor's work to see if it differed from that planned and, if so, why. As the work progresses, we also consider all of the subcontract work remaining and the precedent requirements of that work. For example, if the Subcontractor was delayed in one area of the Project, was there other available work for it to perform?

By evaluating the Subcontractor's as-built work performance moving forward through the Project and considering the work that remains, we can determine the critical path of the Subcontractor's work and those factors that extended the work along this path.

When a Project is managed by a well-thought-out and periodically updated CPM schedule, the analyst has many tools at his disposal to help determine the delays to the Prime Contractor's performance period. To begin with, the Contract will usually state the Contract performance period, and the longest path through the Project can easily be determined by the scheduling program. However, in the case of delays to the Subcontractor's performance period, these tools are less effective. As a result, we must apply a more in-depth knowledge of both the subcontracting process and of the Project management process in order to determine the most appropriate way to resolve disputes related to Subcontractor delays.