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Resolving Schedule Delay Claims with Forensic Analysis

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Abstract

This paper demonstrates how the principals of forensic engineering can be applied to evaluation of schedules, daily diaries, status reports, meeting notes, and other project documentation to determine why delays occur on a project and which parties are responsible for delays. To understand the actual project history, the forensic engineer should conduct a thorough and fair evaluation of all available project documentation to understand the contractual requirements, project milestones, effects of changes, magnitude of delays to the Critical Path, and the basis of the delay claim dispute. The forensic engineer should have sufficient knowledge and experience with project planning, scheduling, and cost estimating to understand the technical basis of the project schedule. He or she must also evaluate and understand the schedule resource loading methodology, schedule logic structure, validity of the activity durations, actual sequence of events, and the material issues that affected the Critical Path. Use of the original planning software is usually necessary as well. The forensic engineer should conduct an impartial technical evaluation that addresses the important and material issues so responsibility for the delays can be determined and proven with a reasonable degree of certainty to resolve the dispute fairly.

Keywords

Critical Path Method, network schedule, Critical Path, critical activities, positive float, negative float, predecessors, successors, activity relationships, resource loading, activities, submittals, concurrent delays, procurement, logic, constraints, durations, earned value, status, progress, forensic engineering

Introduction

Planning and scheduling are two powerful project management tools if they are developed in a disciplined manner and maintained throughout the life of a project. However, if planning by the contractor is superficial — and schedules are not detailed and structured in a logical network format — the plans and schedules will have little or no value to the contractor for managing the work or to the owner and architect for understanding earned value and progress. Planning helps determine how to perform work, and scheduling applies a timetable to those plans. Plans must be realistic (and schedules have to be achievable), or they will be used to document failure to meet the schedules.

To demonstrate the forensic schedule evaluation process, this paper evaluates a $25-million project that was completed several months after the contract completion date. In this case, the contractor claimed the owner caused all of the delays; therefore, he was entitled to $2.6 million in direct and indirect costs as a result.

CPM Network Schedule Activities

A properly constructed Critical Path Method (CPM) network schedule, regardless of the software utilized, has several key components that include:

- Critical Path — the path through working activities that has the least amount of float.
- Activity relationships — which activities must be completed prior to starting new activities.
- Date constraints — when the scheduler makes mandatory start dates rather than making them a function of the prior activities status.
- Resource loading — applying the manpower levels to each activity that are required to complete the activity in the time scheduled based on experienced or estimated productivity.

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- Real time resource adjustments based on experience — when experience shows that the productivity level of the work being performed is either better or worse than planned, and the resources are either increased or decreased to compensate for the experience.

These are required to properly develop and maintain a CPM schedule as an effective management tool. The first components of a CPM schedule are the activities, which are graphical representations of the work items required to complete a project or part of the project in a certain amount of time.

Figure 1 shows what could be considered to be several typical construction activities at some point in time during a project's scheduled life. A predecessor is an activity that occurs before the successor activity, and the relationships between the activities define the CPM Network.

The schedule activities shown in this graphic are several typical construction activities that are identified in terms of activity description, activity duration, criticality, and relationships with other activities. The activities are represented as they were scheduled without progress measurement.

CPM Network Schedule Activity Relationships

Figure 2 shows the same activities from **Figure 1** with the addition of the types of relationships between the activities identified with green boxes. The most often-used and therefore most important schedule activity relationships consist of the following relationship types:

- Finish-To-Start (FS) — This is where one activity must finish prior to starting the succeeding activity.

- Start-To-Start (SS) — This is where one activity cannot start until the preceding activity starts.

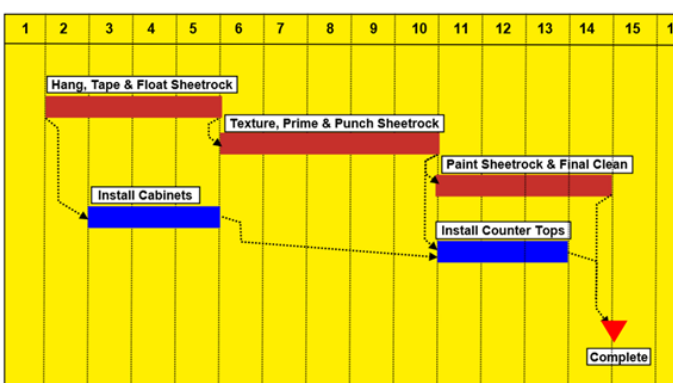

Figure 1
Schedule activities.

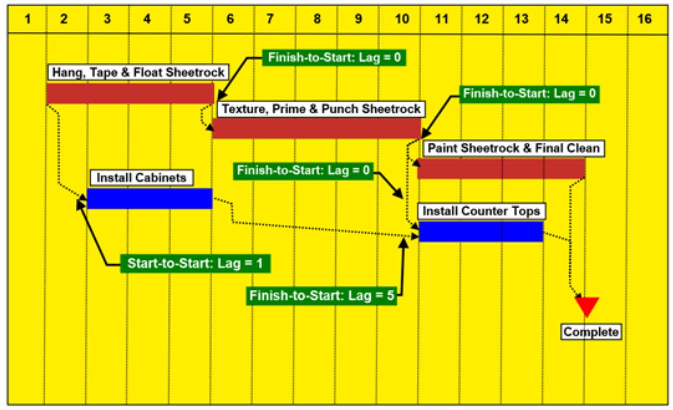

Figure 2
Activity relationships.

Each of these relationship types can be modified by a lag factor, which is the time difference between the predecessor and successor activities. For example, the first blue-colored activity in **Figure 2** cannot be started until one day after the preceding activity starts. The activity relationships also create the Critical Path (shown in **Figure 2** as the red-colored activities). They are on the Critical Path because there is no float between the critical activities while there is float between the blue-colored activities.

Date Constraints Override Logic

When an activity is constrained by a date, the logical relationships that would normally drive the activity start date as a function of preceding activity durations is overridden by the date constraint.

Figure 3 shows a situation where the "install counter tops" activity has been constrained by a date — that is, the scheduler has determined the activity should be started

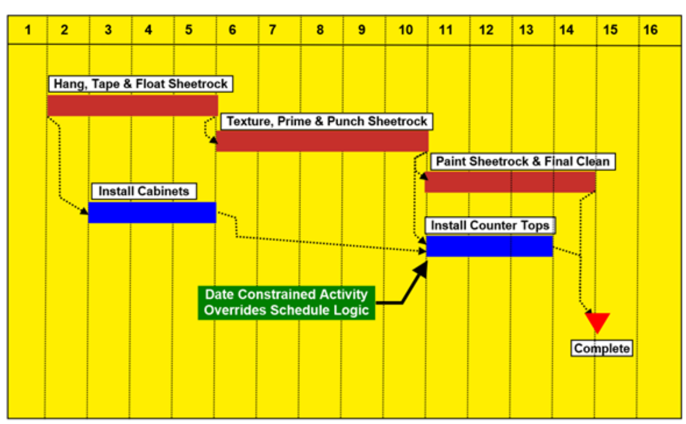

Figure 3
Date constrained activity.

on a certain date rather than be driven by logical activity relationships.

In this example, if the "texture, prime & punch sheetrock" activity were to take a few days longer, the "install countertops" activity will not move with the driving activity relationships because it is constrained by the date requirement. When the date-constrained activities do not move, the schedule provides misleading status information that includes incorrect float times and start dates that will not occur when shown on the schedule.

Schedule Activity Resource Loading

Resource loading is manpower. **Figure 4** shows examples of activity resource loading. For this case, the resources refer to the level of manpower that is to be used for each work activity for each day of the activity duration. The resource loading is expressed in terms of manpower per day for each activity. The basis for realistic activity durations is the resource loading. Without realistic resource loading and knowing earned value, the activity durations and progress are guesses.

Figure 5 shows an example of how resource loading defines and determines the activity duration and the quantity of items being installed. The resource loading is based on productivity factors, such as how many man-hours are required to install a square foot of steel stud and sheetrock walls. This graphic demonstrates how realistic installation unit rates allow the scheduler to determine realistic and achievable activity durations. Effective planning and scheduling require monitoring and maintenance of the schedule to include actual project performance in the schedule updates that provide an accurate picture of the progress.

Figure 6 shows how monitoring and maintaining realistic durations must include the actual experience to determine the differences between the planned and actual performance. The actual performance experienced will result in changes to activity durations — shorter if performance is better than planned and longer if performance is worse than planned. In this case, the actual installation rate was 90 square feet per man-hour, which is less than the planned rate of 106 square feet per man-hour, so the schedule duration must be extended to account for the worse-than-planned installation rate.

Forensic Schedule Evaluation Goals

The goals of forensic schedule evaluation include evaluation of the CPM network scheduling process elements that are required to develop a realistic and achievable schedule with a well-defined Critical Path that can be evaluated in terms of what delays occurred and which parties (if any) not in the control of the contractor caused delays to the Critical Path.

To determine what was required and actually occurred during the life of the project, the following issues should be evaluated and understood:

- Contract terms and conditions.
- The basis of the contractor's delay claim.

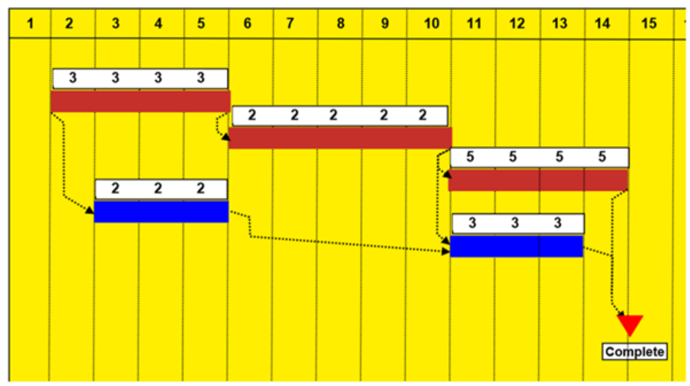

Figure 4
Activity resource loading examples.

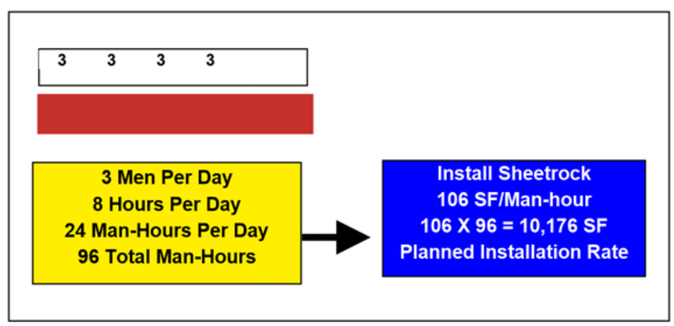

Figure 5
Resource loading establishes realistic activity durations.

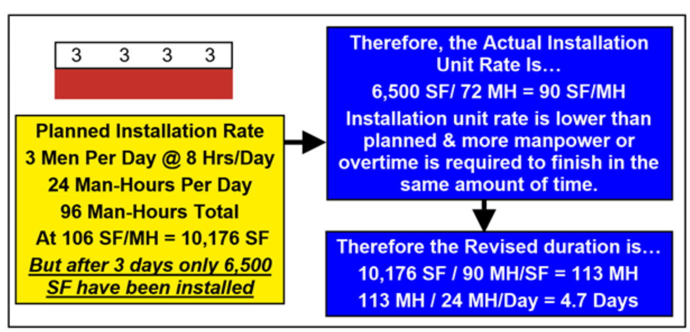

Figure 6
Monitoring and maintaining activity durations with actual experience.

- Determine if there was an approved project schedule.
- Determine if there was a procurement schedule.
- Understand the submittal scheduling process.
- Determine if the schedule met the contract requirements.
- Understand the activity relationships and schedule logic.
- Understand the activity resource loading methods.
- Determine which activities were on the Critical Path.
- Understand if there were concurrent delays.
- Compare the actual manpower to the planned manpower levels.
- Understand logic and resource differences between the different schedules.
- Determine if the activity durations are realistic.

Methodology

The forensic evaluation must be fair and thorough. The actions related to the dispute by all participants must be evaluated to determine and apportion responsibility for delays. The schedules provided by the contractor were evaluated to determine the following:

- If the schedules met the standard of care required for large projects, which is typically defined in the contract.
- If the schedules were functional management tools with proper logic that could be used to plan and schedule the work based on the available resources.
- If the schedules could be used to measure earned value (and therefore the actual status of the activities/project) and make adjustments as necessary.

A functional and valid CPM network schedule must include valid resource loading, valid activity durations, and proper logic. If not, it cannot be used as a management tool or as a basis to prove a delay was caused to the Critical Path by parties not in the control of the contractor.

Standard of Proof Required for Delay Claims

The standard of proof required for delay claims has been established by the Courts in Wilner v United States, 26 Cl. Ct. 260 (1992). The following elements provide a basis for the standard of proof required to prove a delay claim:

- *Realistic schedule*: The starting point for a compensable claim must be a realistic schedule that establishes the contractor's intent and documents actual experience.
- *An achievable schedule*: Courts hold that claims will be disregarded when schedules that have not been agreed to by the parties (or that the contractor never intended to follow or could not achieve) are used as a basis for the delay claim.
- *Submittal schedule*: The submittal process is important to work progress because this is how the contractor obtains approval for procured items from the architect during the life of the project. The contractor must schedule each submittal because submittal approvals are a prerequisite to the start of procurement and construction. If the submittal review process is not scheduled — or is scheduled unrealistically — subsequent construction activities that are a logical function of the submittals cannot be started until the submittals are reviewed and approved by the architect and/or owner. Inaccurate submittal scheduling results in inaccurate construction scheduling, and inaccurate schedules cannot be used as a basis for establishing a delay was caused to the Critical Path.
- *Realistic resource loading is required*: Schedules that contain unrealistic resource loading cannot form a delay claim basis because without resource loading, the activity and schedule durations cannot be realistically established. Courts have determined that CPM schedules must include valid resource loading as a required scheduling element.
- *Proper schedule maintenance is required*: When schedule updates are used to report the project status, the contractor must start with a realistic

plan and prove that it has taken appropriate action to: (1) revise durations to reflect actual experience; (2) revise logic to address out-of-sequence work to provide a network analysis system that reflects the actual status of the project and the current critical path; and (3) track actual start and finish dates.

- *Schedule changes must be communicated and documented*: The contractor must abstain from any manipulation of logic in updates to conceal contractor activities that could not be completed as scheduled. No material changes in important schedule elements, such as resource loading or logic ties, shall be made without informing the owner of the changes.

These parameters define the standard of proof for a delay claim that are required to prove a delay was caused to the Critical Path. A contractor's delay claim that is based on a schedule with invalid resource loading, improper/missing logic, and unrealistic activity durations should be denied because a faulty schedule cannot be used to prove the schedule was accomplishable — or that a delay to the Critical Path was caused by others.

Evaluation of CPM Network Schedule

Detailed evaluation of a CPM network schedule must be done with the native files and the scheduling program originally used to develop the schedule. **Figure 7** shows part of a graphical print-out that shows bars and lines, but no functional evaluation can be performed with this picture.

Without the native files and the scheduling software, the important informational reports, such as resource loading, activity logic relationships, float, predecessors, successors, and earned value (progress), cannot be accessed and evaluated.

Figure 8 shows one example of the type of information and detail that can be obtained from the native files using the appropriate software. It is a screen shot from the scheduling software program that was used to generate the native files. This particular report page shows the activity name, activity cost code, the resources assigned to this activity, the manpower units per hour, the resource availability window, and the budgeted quantity. This report showed that the resource loading was incomplete, undefined, and worthless for measuring earned value or progress.

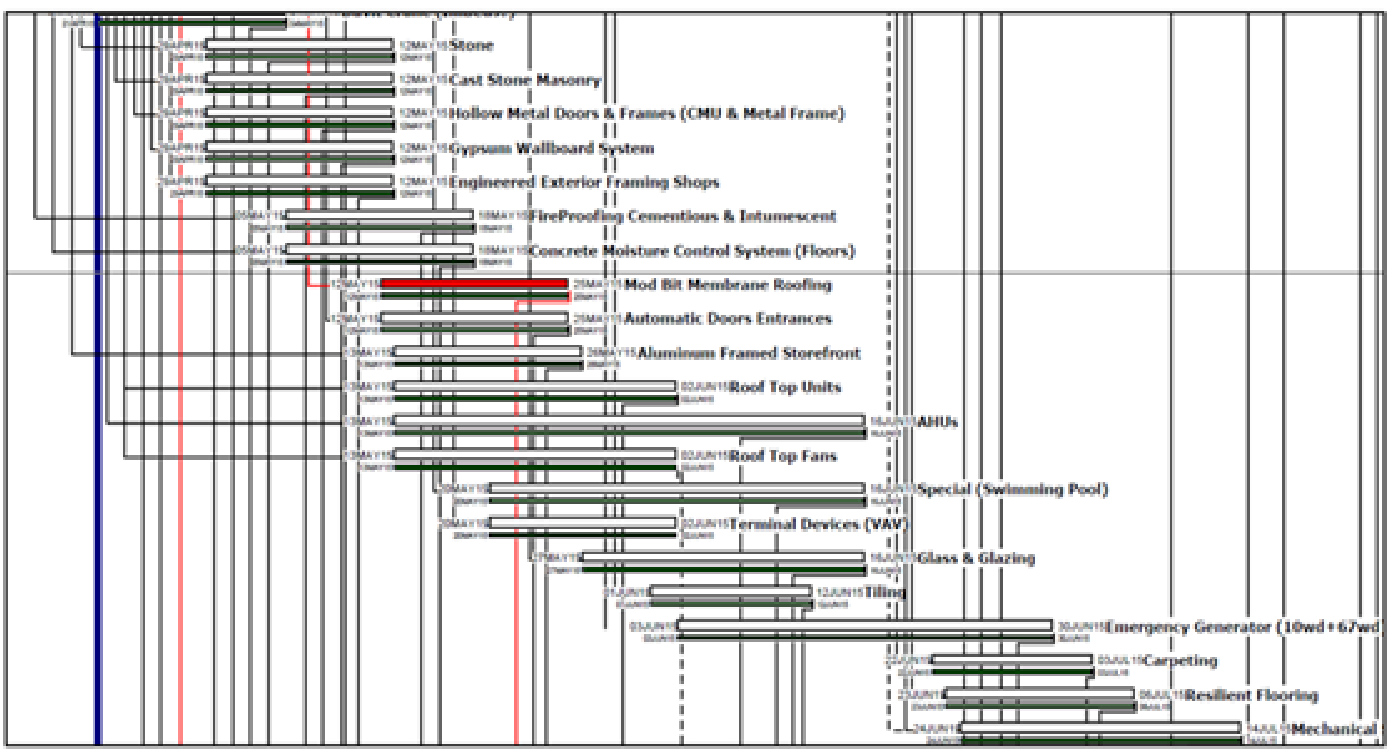

Figure 7
Graphical prints are not useful for accurate forensic evaluation.

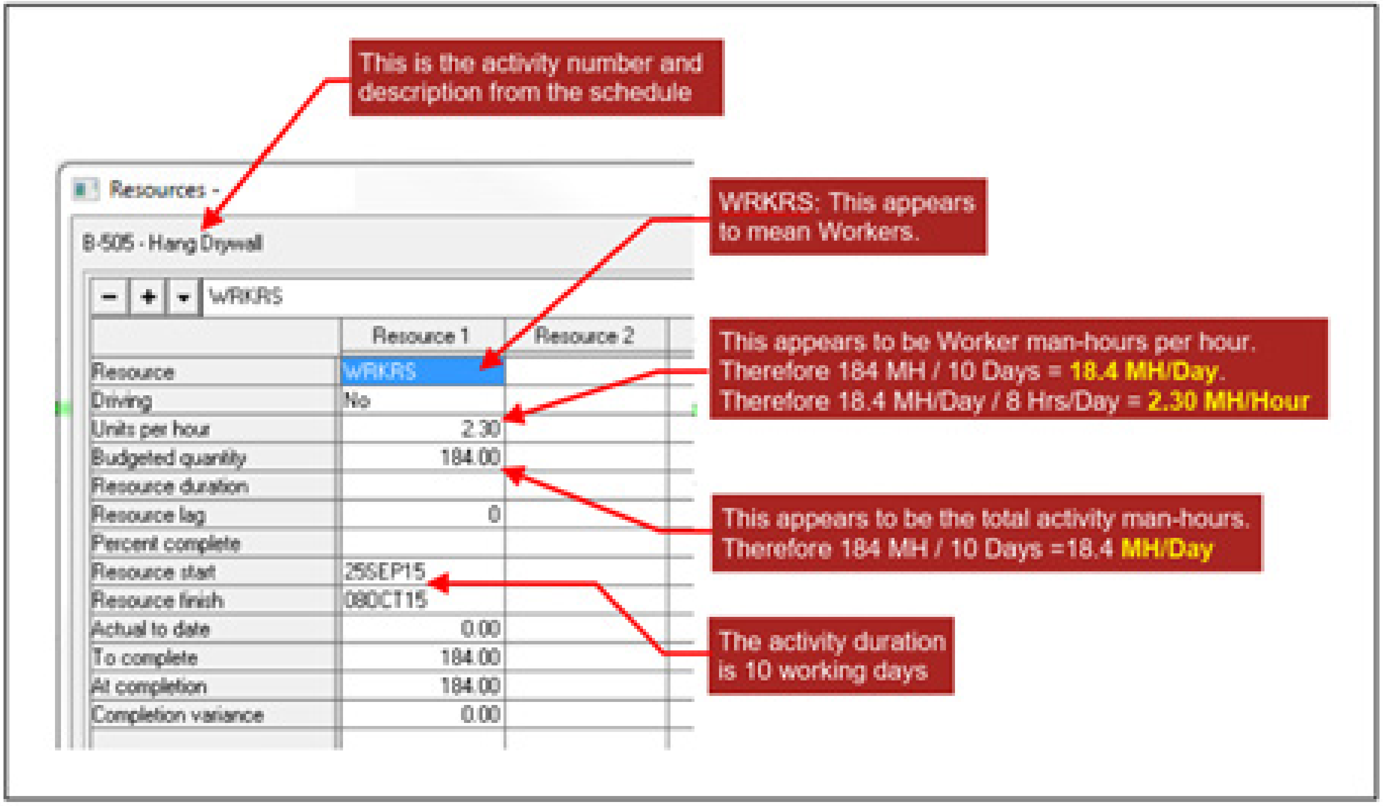

Figure 8
Native files provide information for detailed forensic evaluation.

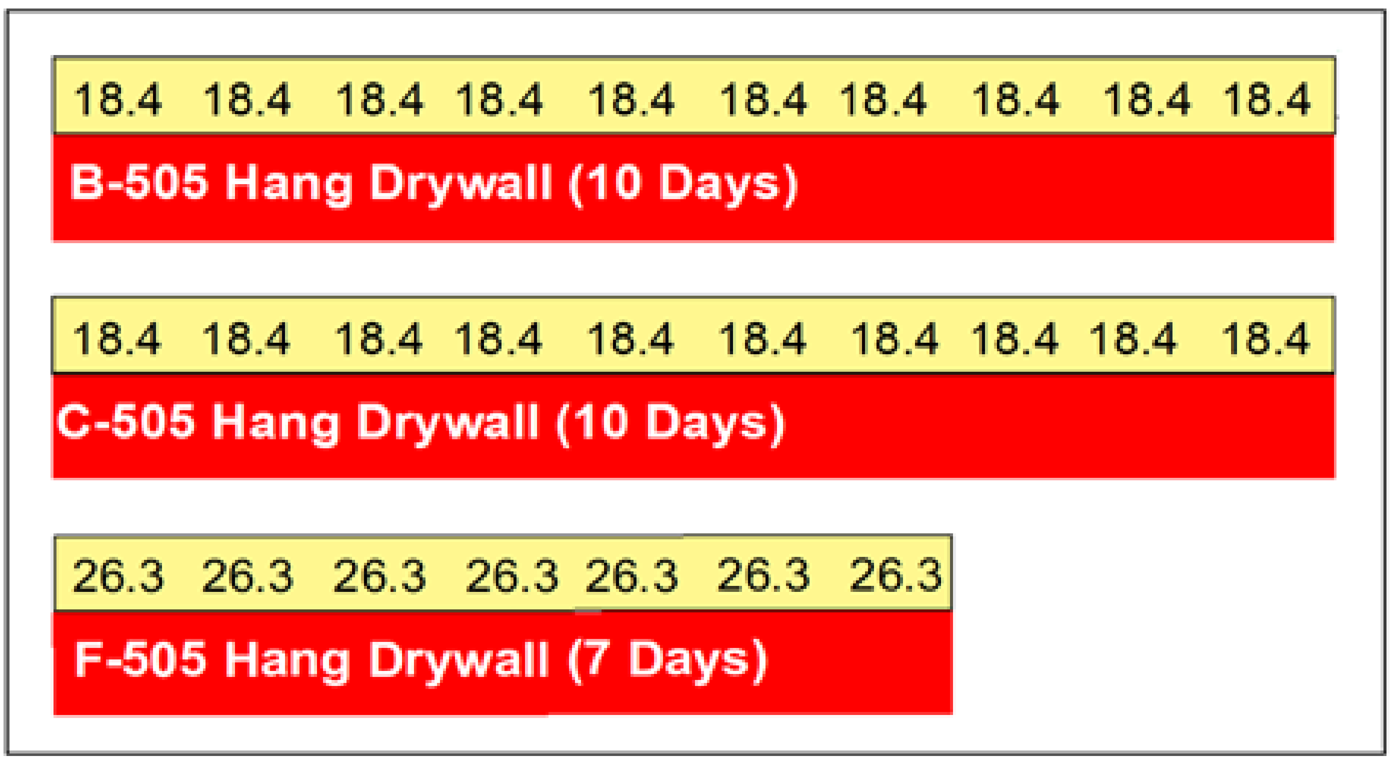

Figure 9
Evaluation of native files exposes faulty resource loading.

Figure 9 shows the manpower resource loading factors that were applied to three drywall installation activities. These are three examples of activities with faulty manpower loading.

The resource factors shown (18.4 and 26.3) do not make sense with respect to actual resources such as manpower, equipment, or other required resources. For example, it is impractical to work partial man-days or man-hours on an activity, which is what the values indicate — that is, resources should be assigned to activities in a manner that would actually be done on a job site rather than a mystery factor that provides no basis for measuring earned value.

Figure 10 shows the same three activities that were illustrated in **Figure 9** with the addition of the drywall quantities by area in the middle yellow boxes and the calculated unit installation rate in the blue boxes.

Figure 11 shows results of the quantities, resources, and unit rate evaluation compared to the *Walker's Building Estimator's Reference Book*, 26th Edition, drywall installation unit rate of 106 square feet per man-hour. It demonstrates how the contractor's resource loading has provided activity durations that are not realistic and cannot be attained. In Area B, for example, the scheduled unit rate of 616 square feet per man-hour is unrealistic and

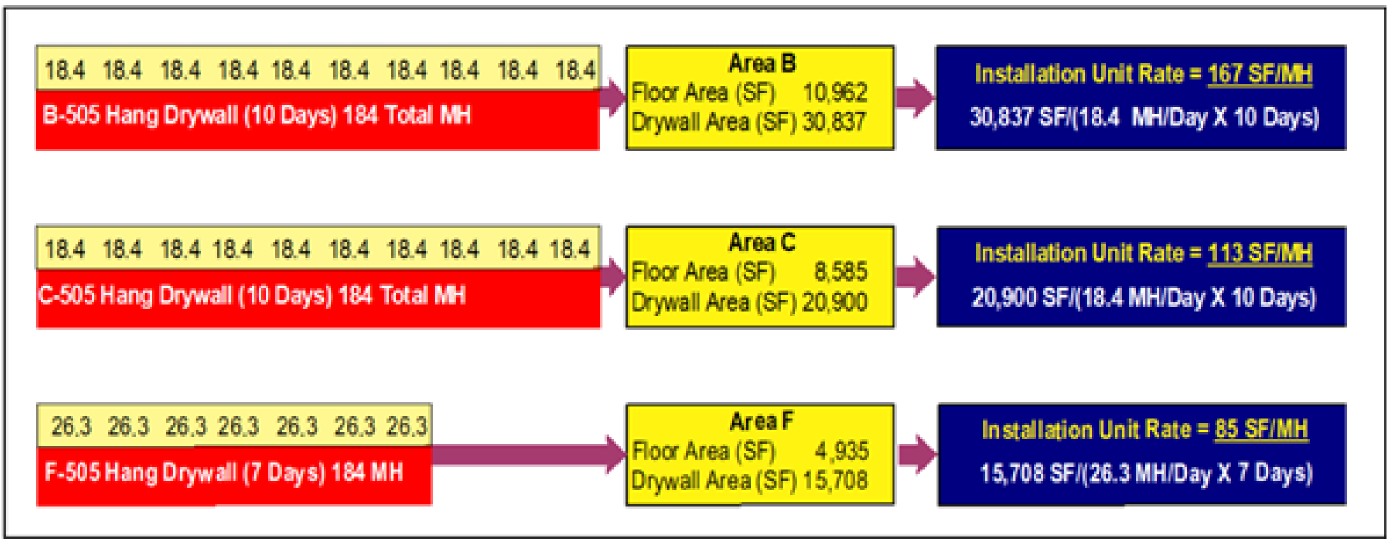

Figure 10
Evaluation of native file exposes widely divergent installation unit rates.

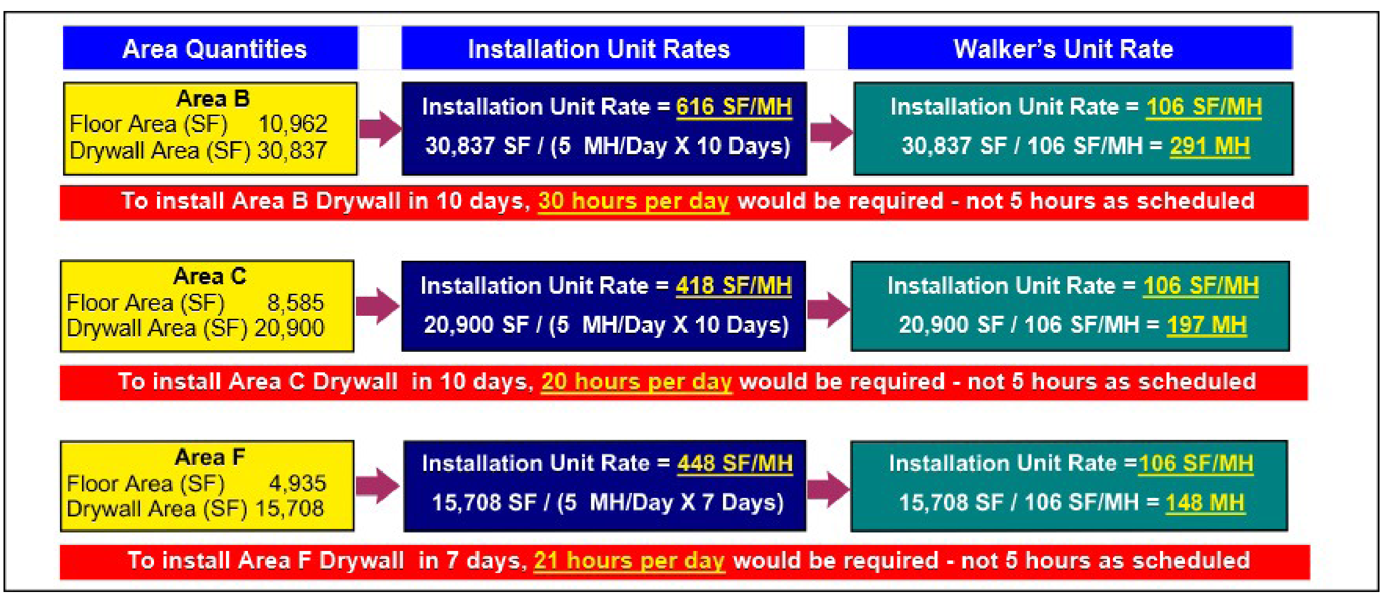

Figure 11
Poor scheduling practices result in unrealistic durations.

unattainable. With a more reasonable unit rate of 106 SF per man-hour, the resources required would be 30 hours per day rather than the 5 hours per day that was scheduled. The other two examples are similar in that they show the work cannot be accomplished as scheduled.

Forensic evaluation of the information that is only available in the native files showed the details of the resource loading methodology. The conclusion of this evaluation was that the resource loading method is not achievable.

Figure 12 shows a comparison of the resource loading for the same activities in two different schedule revisions issued approximately one month apart that is materially different. The different resource loading (15 and 5) — and the resulting installation unit rates (59 to 302) for the same activities in two different schedule revisions — provides unrealistic activity durations.

Figure 13 shows another report generated with the native files. The details of the report are highlighted, and the note boxes explain how the submittal scheduling practices are misleading (do not provide an accurate picture of the project's progress).

Figure 14 shows the planned manpower curve, which was derived from the original project schedule resource loading plan compared to the actual manpower during the project that was derived from forensic evaluation of the contractor's daily diaries.

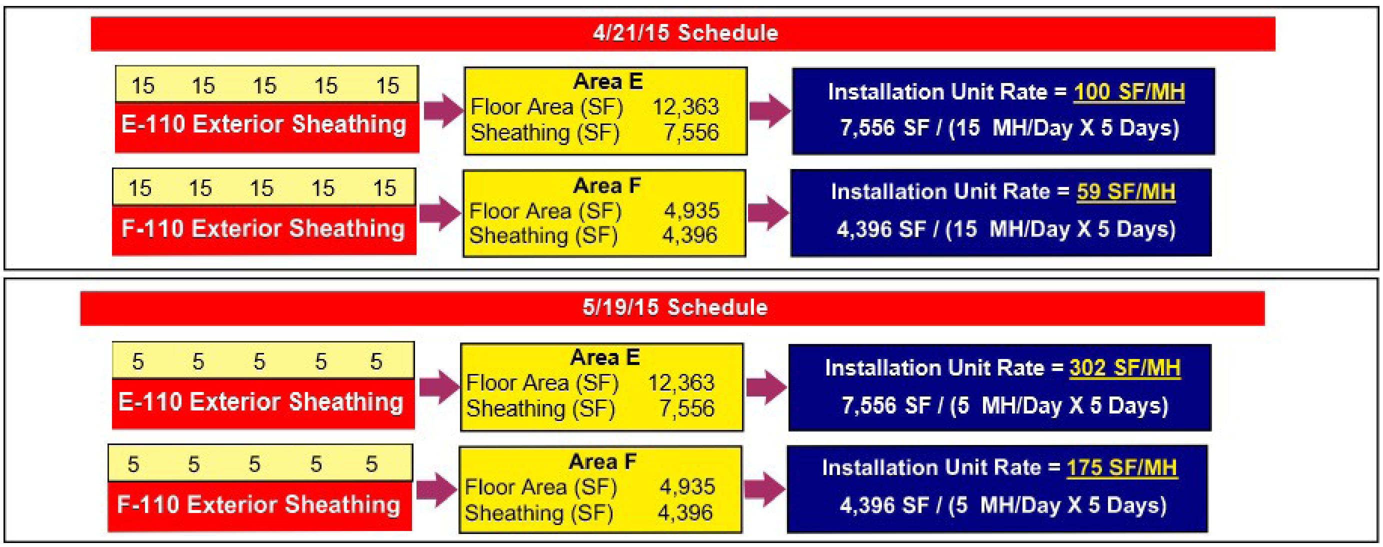

Figure 12
Different schedule revisions used different resources for the same activities.

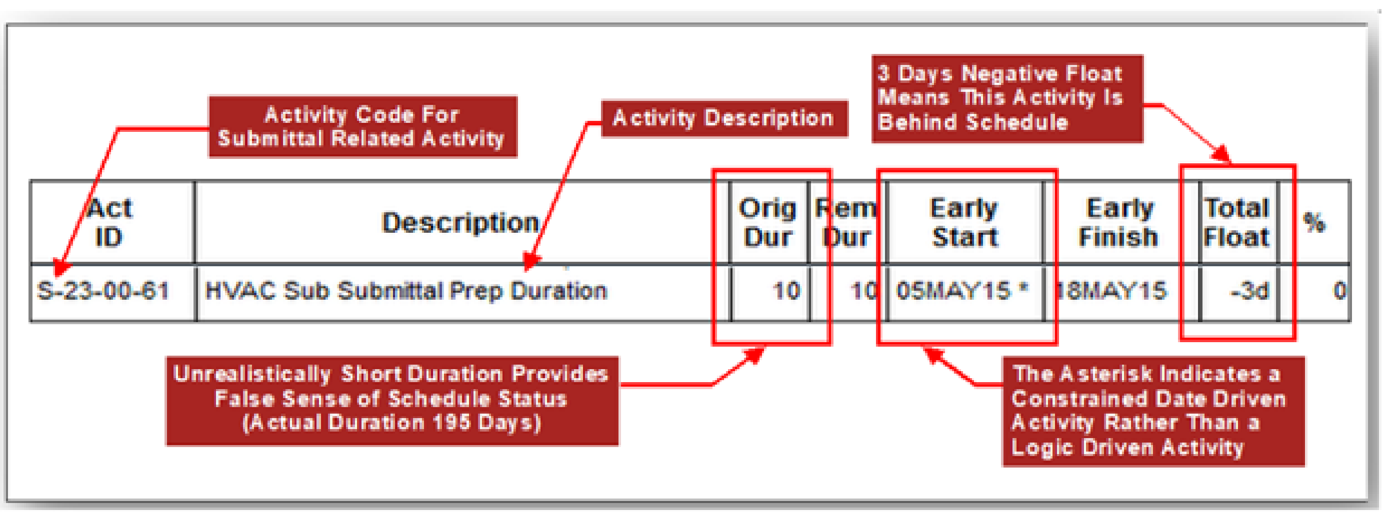

Figure 13
Native file evaluation exposes insufficient and incomplete submittal scheduling.

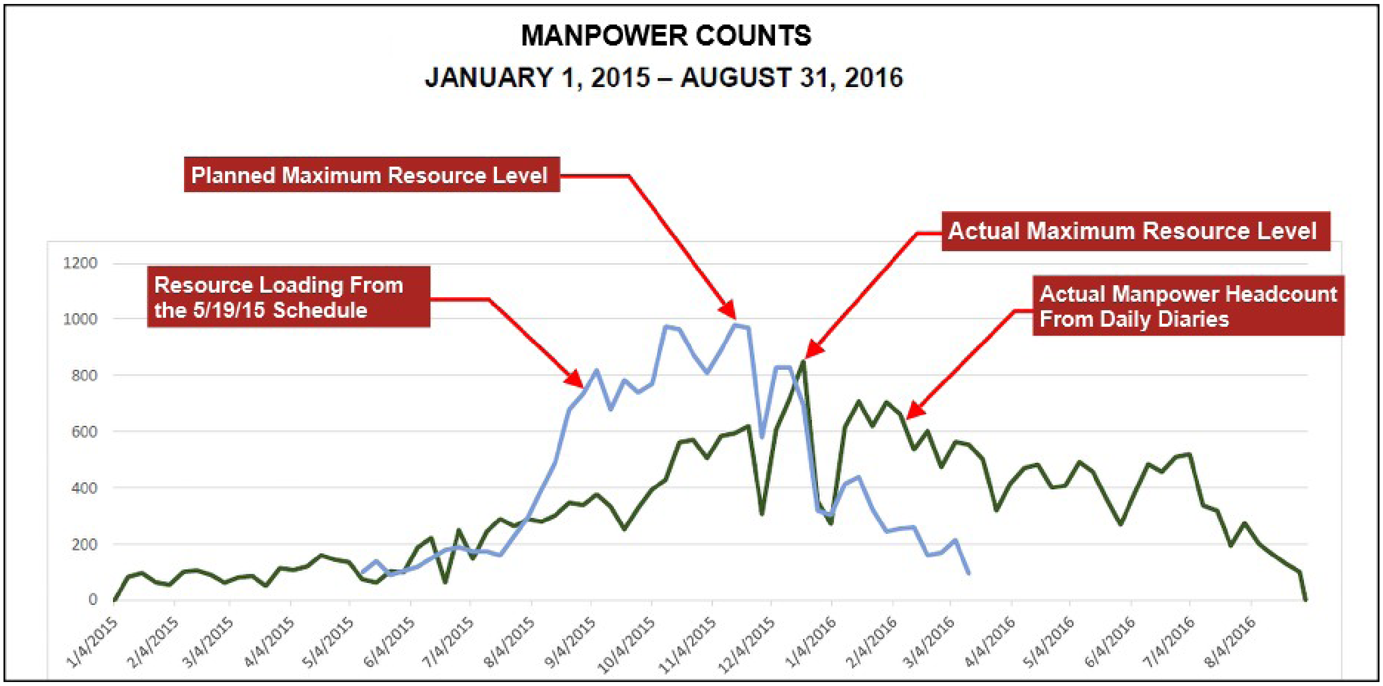

Figure 14
Actual manpower curve shows original schedule was not attainable.

Forensic evaluation of this information helped determine that the planned manpower levels were not very close to the actual manpower for most of the actual project life cycle. This actual experience information also shows that the schedule was extended several months past the originally scheduled completion date.

Indications of Inadequate Scheduling

The forensic evaluation should evaluate the schedule for inadequacies as well as contract-required elements. The following attributes of inadequate scheduling that were discovered during forensic evaluation of the contractor's schedules demonstrate that the schedules were not adequate for management of a large institutional project:

- Failure to schedule the majority of submittals that are prerequisites for construction.
- Failure to show critical procurement and succeeding installation activities.
- Logic that does not make sense in terms of construction sequencing.
- Failure to resource load the schedules in a manner consistent with CPM scheduling.
- Inaccurate schedule updates or inaccurate as-built information.
- Overly broad, inaccurate, or inconsistent activity descriptions.
- Suppression of information needed to evaluate the schedule.
- Assuming unlimited or unmeasured resources.
- Override logic with constraints results in excessive float or less negative float than actual.

Not only are the schedules not suitable for management of a large institutional project, but they are not sufficient for use as evidence that some other party caused a delay to the Critical Path.

Conclusions

Based on the forensic evaluation, the contractor's schedules provided for this matter cannot be reliably used to prove that a delay to the Critical Path was caused by another party that the contractor did not control for the following reasons:

- *Schedule was not approved*: The architect requested that the contractor provide a contract-compliant schedule numerous times, but R&M never produced a schedule that was approved by the architect or owner.

- *Resource loading was inconsistent, limited, and missing*: The contract clearly defines when the project schedule is to be submitted to the owner in Section 3.10.1, which states: “At the time of his issuance of the guaranteed maximum price, the contractor shall submit for the owner’s and architect’s review a contractor’s Critical Path Method (CPM) construction schedule (construction schedule) for the work.” The schedules developed by the contractor were not properly resource-loaded, and did not meet these basic contractual requirements to be a resource-loaded CPM schedule.

- *Contract requires alternate plans in case of delay*: The contract also states that: “The contractor propose an affirmative plan to correct the delay.” Forensic evaluation of the project documentation and correspondence revealed no work-around plans or other schedules were developed to address alternate work plans, increased manpower, or other similar efforts to meet the schedule.

Summary

The practice of Critical Path scheduling and the required elements of realistic Critical Path network schedules have been well-established during the past 50 years. The standard of care for proving delay claims and the contractual and legal requirements of CPM Network schedules have been established by the courts — and must be used as the performance standard in any schedule delay claim evaluation.

The forensic engineer should understand these practices, procedures, requirements, and standards to fairly and appropriately apply the practice of forensic engineering to evaluation of delay claims for a fair and reasonable resolution of the claim.