Reviewing a Baseline Schedule

by Ron Winter, PSP

July 21, 2014

OVERVIEW

The accepted, initial schedule is often referred to as the baseline schedule. The use of this term refers to the fact that the projected activity dates will be used as a baseline for comparing the actual, achieved dates and measuring progress. This same rationale also applies to budgeted costs, if used.

Most modern contracts require the contractor to submit a baseline schedule. The baseline schedule is a model of the contractor's project execution plan. The schedule should be a reflection of the contractor's intent to reach project completion while integrating the various contractual requirements. Because of this, it is typically created and updated by the contractor. The owner indicates their willingness to rely on the schedule as a means of communication and negotiation by accepting the schedule submittal. The accepted baseline schedule usually serve as a common basis to organize and frame all future discussion on project progress.

In competitively bid projects, a contractor often has limited time to put together a detailed schedule for an entire project. This detailed schedule may be dependent upon submission of subcontractor schedules and other inputs that may not exist at the very start of the project. To fill-in for the lack of an initial baseline schedule, often the contract requires the contractor submit an additional, preliminary schedule that focuses on detailing the first 90, 120 or 180 days of the work. Just like the baseline schedule, the preliminary schedule should be approved by the owner to be acceptable. This approved as acceptable interim schedule is used until an accepted baseline schedule can be achieved.

Reaching agreement on a baseline schedule is often difficult, frequently requiring team efforts, negotiation, and perseverance. During the initial stages of preparing the baseline schedule, meetings between the contractor and the owner to discuss expectations and requirements of the schedule can go a long way in assuring the timely completion, review and acceptance of a useful and effective document.

The successful completion of this process is the hallmark of a good scheduler using the correct process. A lack of timely agreement on the acceptance of a baseline schedule can result in confusion, disagreements, loss of productivity, extra work, and un-resolvable issues that will likely lead to claims or disputes afterward. Failure to reach timely agreement on the acceptance of the baseline schedule is a clear sign that the project itself is in danger of failure. Therefore, it is in the best interests of all parties to achieve an accepted baseline schedule in a timely manner.

APPLICABILITY

Baseline schedule reviews should preferably take place prior to the start of execution of the work or as quickly after that so as to remain pertinent to the start of the work. Even if performed later, the reviewer should disregard all knowledge of events that transpired after the start of work. The guidance presented here is not applicable to revised baseline plans or a schedule update review.

A baseline schedule review focuses on the following issues that are not normally the focus of a schedule update review

- Focus on quality,
- Sequence and work flow,
- Constructability,
- Timing and phasing,
- Adherence to legal and contractual requirements,
- Unambiguous and clear descriptions of the work,
- Resource usage and balance,
- Level of detail,
- Design and coding of activities and project organization.

OVERARCHING PRINCIPLES

The optimal processing and review of a baseline schedule requires completeness, delineation of responsibility, and enforceability. Contractually, if the owner requires the contractor to submit a baseline schedule then the owner of the project has a responsibility to review and comment on that submittal in a timely manner. Review comments (if any) from the owner should be made in writing and returned to the contractor.

Completeness

The schedule should include all contractual deliverables and significant pieces of work to be performed by the contractor and its subcontractors. Any significant expenditure of resources under direct or indirect control of the contractor should be described. Significant pieces of work performed by the owner, their agents, and other significant stakeholders should also be included in the schedule.

Delineation of Responsibility

Each activity in the schedule shall have a primary agent or a single entity in control of the work and responsible for its completion. Work by different contractors or under other parties' control should not be combined together into a single activity.

Enforceability

If the schedule specification allows or prohibits a particular CPM practice, then that practice is allowed or prohibited (as the case may be) regardless of other considerations. The contractor may request that any specific schedule practice be waived and if such waiver is granted by the owner, may disregard that particular practice. Other than for issues of commonly observed good scheduling practice, the reviewer should not add any further prohibitions to the project than those that already exist in the contract, specifications, and plans.

Not all scheduling specifications are worth the 'cost' of enforcing them. The owner may choose to ignore selected contractual requirements for the sake of project success. Because of this, specific schedule specifications are often waived by the owner. Sometimes the variance from specifications has little impact on the quality of the schedule and the specification is not applicable or relevant to the current project. Other times, the variance may have a large negative impact on the contractor and the owner will waive the variance in the interest of timeliness and in the spirit of cooperation that must exist for a project to be truly successful. The only alternative to permitting a particular variance is to reject the entire baseline schedule submittal because of that variation.

Specification provisions that are not enforced at the time of reviewing the submittal possibly may not be retroactively enforceable at a later date against the same approved submittal. It is possible that repeated failure to enforce a scheduling specification clause may be considered a waiver of that clause for the duration of the contract. For clarity and security, it is important for the owner to formally acknowledge any deviations granted and state the limits of such deviations to the schedule specification with clear, written guidance. This should be done in a timely manner so as to preserve the enforceability of the remaining provisions of the specifications. The contractor may also find it advisable to list any variances taken from the contractual scheduling requirements in the narrative that accompanies the baseline schedule submittal.

PLANNING FOR THE BASELINE SCHEDULE

Planning for the execution of the work is essential to project success. There should be a planning session held prior to creating the final baseline schedule. This requires the involvement of all project leads, including project management, project engineering, project controls, procurement, execution or construction, and start-up (if applicable.) All major stakeholders should be involved in the planning in some form or another, even if not physically present at the planning session itself.[8]

There are many reasons why contractors should take the time to create a CPM schedule beyond just tracking the project.[2] Contractors generate a CPM schedule to assist in planning of the project because they need to

- Define expectations,
- Identify required activities,
- Anticipate resource requirements,
- Assist in coordination between affected parties,
- Help establish communication,
- Forecast project duration and cost (where applicable),
- Comply with contract specifications,
- Coordinate their bid plan with its schedule to execute the work.

Contractors and owners then use the CPM schedule as a tool to monitor and control the work during execution or construction when they need to

- Provide a means of measuring progress and making payment to the contractor,
- Assess actual versus planned performance,
- Identify and solve problems,
- Aid in the decision making process,
- Coordinate future events with equipment and resource needs,
- Alert the team of upcoming issues,
- Model “What If” scenarios,
- Report to other project stakeholders,
- Establish cash-flow projections for future payments and funding purposes.

Finally, contractors and owners depend on the CPM schedule for documentation and analysis so they can

- Document progress,
- Record and track changes,
- Analyze delays and impacts,
- Determine causation,
- Establish accountability,
- Generate as-built schedules,
- Communicate their position on delay issues,
- Record historical production data for future work.

The baseline schedule should reflect a feasible and reasonable plan to meet all contractual requirements. If it is not feasible and reasonable, the baseline schedule is rather useless as a tool to either manage the ongoing work or to evaluate time extension requests.[7]

Prior to creating a baseline schedule, the planner should investigate and consider risks and opportunities facing the project timeline. Although the schedule may have provisions for known risks, the knowledge and awareness of the risks and opportunities by the reviewer will assist and complement this work. This information should be documented.

The baseline schedule must show a plan for accommodating weather events that can be reasonably predicted or as required in the contract. The contractor may find that they

are later unable to seek time extensions for extreme weather if their baseline schedule fails to reasonably accommodate for the effects of likely adverse weather.

BASELINE SCHEDULE SUBMITTAL

At a minimum, the baseline schedule submittal consists of a schedule narrative and a copy of the schedule's electronic backup file that can be read by corresponding software. Additional schedule submittal components may include printed or electronic copies of CPM reports and graphics, submittal/procurement schedules, early/late progress and budget curves (called S-Curves,) and related resource graphics.

For cost and liability issues, some schedulers believe that the owner should consider minimizing the required contract scheduling submittals. Reducing unnecessary submittal requirements helps to reduce overall preparation costs which may lead to lower project cost. Liability may be assumed with additional submittal requirements due to the fact that the owner is responsible for reviewing the contents of all submittals. Reviewers can produce any additional reports that are needed for the review from the electronic schedule backup file. On the other hand, the submittal of some printed reports may be necessary to verify that the received electronic schedule produces the same calculated dates as the original schedule.

Additional benefits may be accrued by reducing the amount of required submittals. It may be more useful to have the contactor's scheduler observing and coordinating the work instead of requiring the scheduler to spend days to creating the scheduling submittal. Printed graphics may require the absence of the scheduler from the job site to return to the home office. The schedule review meeting may be held sooner after the status has been gathered.

If extensive submittals are required, then the owner may wish to consider specifying a minimum review period in the contract to provide for sufficient time for this process. It is in both party's best interest to minimize review time periods in order to obtain a baseline schedule acceptance as soon as possible.

Open discussions between the contractor and the owner early in the baseline schedule creation process may aid in establishing the true needs of the owner. These baseline schedule coordination meetings are highly effective in streamlining the entire baseline schedule process and saving time and money. Typically the baseline schedule submittal consists of the following components

- A written narrative describing the general workplan for the project,
  The schedule narrative adds and supports understanding of the basis and assumptions in the schedule. The narrative should include an overview of the contractor's workplan. Because a narrative supports and adds to the understanding of the submitted schedule, a written narrative should be submitted along with the baseline schedule.

- A complete electronic copy of the baseline schedule,
  This file should be in the format that is produced by the CPM scheduling software that allows a similar program to interpret its contents and build a duplicate of the original schedule complete with all internal data. This format is not a static picture of the schedule like a .PDF file.
- Printed reports as required by scheduling specification,
  Care should be taken with printed reports as they may not reflect the calculated dates in the electronic schedule. It is usually best for the reviewer to print her or his own reports, if needed. On the other hand, having a printed report submitted may be useful to prove that the electronic copy is displaying the exact same dates and data as found in the original schedule.
- Graphics, as required by scheduling specification.
  Graphics may be in the form of an electronic file (as in a .PDF file) or as a printed document, as described in the specifications. An electronic version allows the entire submittal to be transported via the internet, but requires the owner instead of the contractor to perform any desired printing.

When significant portions of the project involve subcontracted work, the contractor should provide documentation to show that each subcontractor has reviewed the submitted baseline schedule and agrees that their portion of the work is achievable and within their expectations as depicted in the submitted schedule.

BASELINE SCHEDULE REVIEW PROCESS

The reviewer is usually either the owner's representative or a member of the owner's staff. As a staff specialist, the reviewer should be working in the best interests of the owner as well as for the successful completion of the project. The reviewer needs to be fair and objective in the overall review process. He or she should understand the type of project to be performed as well as be trained in good scheduling practices. The reviewer should read and have a good understanding of all the contract documents related to the schedule (contract, general conditions, supplemental conditions, specifications, plans, and other documents) before starting the baseline review process.

Review Process Overview

A baseline schedule review is performed by observing the entire schedule and determining if the schedule reflects a realistic, complete, and workable plan in accordance with the contract requirements to achieve successful project completion. The schedule should adhere to industry standard CPM principles that will allow it to be used to track progress and forecast updated project completion. The baseline schedule should be evaluated using the following criteria

- Requirements included in the contract and contract specifications,
- Volumes, sizes, locations, nomenclature, and instructions found in the contract plans,
- The contractor's stated approach or plan,

- Resource availability,
- Professional scheduling practices and guidelines generally accepted for use by professional scheduling practitioners. The specific guideline publication to be used may be listed in the contract documents.

Acceptance versus Approval

The accuracy and viability of the submitted baseline schedule is the responsibility of the contractor. The schedule should be the contractor's assessment of the project workplan. The owner does not take responsibility for the contractor's actions by either accepting or approving the baseline schedule submittal. The owner merely indicates whether or not they accept the submitted baseline schedule as meeting the contract requirements, scheduling specification requirements, and standard scheduling practices. In the context of baseline schedule submittals, the term 'approval' means the same thing as 'acceptance' and does not constitute any shift in the responsibility of scheduled work from the contractor to the owner unless otherwise specified by contract.

Factors for Disapproval

If the baseline schedule cannot be approved, then it has limited value to the project team as a tool to manage the contract, track the project's progress, and identify and measure project delay. There are several factors that can cause a baseline schedule to not be approved. These factors include instances when the plan depicted in the baseline schedule does not meet the requirements of the contract, the plan depicted in the baseline schedule is determined to be unachievable, the baseline schedule does not represent the contractor's plan for completion, or when there are fatal technical errors.[5] One must weigh the negative consequences of disapproving a schedule against the problems with accepting a flawed schedule before deciding on a course of action.

Baseline Schedule Review Items

Important items that should be considered in the baseline schedule[2] are

- Critical procurement and long lead time activities,
- Activity durations that account for utility or permit restrictions,
- Concurrent activities of similar work that exceed daily planned crew resources,
- Predecessor activities unrelated to successor activities,
- Project milestones,
- Area access restrictions,
- Coordination with other projects,
- Identifiable critical path,
- Compliance with contract requirements.

Pre-Analysis Checks

Before analyzing the specifics of the submitted baseline schedule, one should review general issues. Instead of taking the entire normal review time looking at detailed information only to discover a disqualifying major issue later, the general issues should be reviewed first. This process may shorten the time that it takes to reject the submittal, speeding the re-submittal process. General issues that should be reviewed first include the following

- Proper identification of the schedule,
  Check to see that the schedule contains the proper company name, project title, project manager, primary resource, version, etc. Proper and complete titles are important for later identification. This information should be sufficient to identify the project and participants when viewed at a later date and out of context. Schedules should have unique identifiers so that any report or graphic will correctly identify the exact project involved. The report title section and project version should say, “baseline” as well as version number and date if revisions have been made.
- Calculate the schedule,
  The CPM schedule dates must be calculated and early and late calculated dates should be present for every activity. This condition will not be true if logic loops were never resolved and would be strong grounds for schedule submittal rejection. It is very important for the contractor to calculate the schedule before transmitting it to the owner for review. If the reviewer calculates the schedule to discover that the early or late dates have changed, this poses a problem for the reviewer as to which dates to review.
- Imposed finish date,
  Many scheduling software systems let the scheduler impose a must finish date on the entire project. Schedulers should not use this feature. It is better to constrain the final activity directly, if a constraint is desired. The ‘final activity’ should represent substantial completion, mechanical completion, or whatever term is used in the contract documents as the point at which execution or construction is essentially complete. Other activities that logically fall after substantial completion should not be constrained by this date and schedules cannot accommodate this condition if a project must finish date is imposed.
- Correct data date,
  The project status date, or data date should equal project start, which should equal the project notice to proceed (NTP). If this is not the case, look for an explanation in the accompanying narrative. There should not be any activities statused as having actually started, except perhaps the notice to proceed date. Whatever status is in the accepted baseline schedule may be considered the ‘baseline’ and therefore not part of any delay.
- Minimum duration measurement,
  The CPM calculation duration unit (i.e. days or hours), indicating the smallest indivisible time unit should be appropriate for the project length, if the software allows for this setting. Unless a schedule is depicting a short-duration turn-

around or fire rebuild project (for example where status is taken each hour), it is better to schedule most projects in days. This is not related to how the software displays the time units, only in what units of time it uses internally as the smallest, indivisible time unit. Many CPM software packages do not allow the user to set the smallest unit of measurement and only have one setting.

- Correct cost label,
  Projects that track costs should ensure that the correct cost label (i.e. US Dollars, Dirhams, or Ringgits) is set as the default. If cost is tracked in the schedule, it is strongly suggested that all costs be expressed in the same cost type.
- Start day setting,
  The start day for the week is used for reporting on a weekly timescale and as a default setting to determine when weekends occur for calendars. It should agree with the first workday in the week most commonly used on the project.
- Calendar check,
  Care should be taken to thoroughly review all calendars before reviewing calculated dates. An error in the calendar setup will cause errors in dates that are very difficult to later troubleshoot. A reviewer should
    - Look for odd weekend definitions where non-work will occur,
    - Look for missing or un-informative calendar names,
    - Look for 7-days per week, 24-hours per day calendar (7/24 Calendar) to properly schedule such things as the curing of concrete,
      This is the only type of calendar that should not have holidays assigned.
    - Look to see that all calendars have holidays assigned (except for 7/24 Calendars),
    - Look for consistency in the number of hours per working day in a calendar,
      Mixing days with 8 hours per day with others showing 9 hours per day will result in activities with fractional day durations.
    - Review all calendars for consistency in assigned holidays,
      All calendars should have the same holidays except where explicitly different by the nature of what is being scheduled. Global calendars typically do not have holidays assigned, as adding workdays back into a copy of the global calendar when personalizing it for a particular project is confusing and prone to error.
    - Look to see that holiday exceptions are implemented correctly and not as additional holidays,
      A calendar exception is a normally non-workday that is scheduled as a working day. These exceptions typically are detailed using hours even when holidays are only detailed to the whole day.
    - Look to see that all calendars cover the entire project,
      Calendars are not additive and must continue for a significant period after expected project completion to accommodate any potential delays.
    - Compare calendar holidays with the dates specified in the contract as holidays,
      Check that the holidays falling on weekends are properly set to delay to

the next working day or advance to the previous working day, as appropriate.
    - Check the contract specifications and drawings for other non-working periods and verify that these non-work periods are included as necessary,
    - Check for specialty calendars for activities affected by weather, access restrictions, shift work or other non-standard circumstances, if appropriate, Legal restrictions such as environmental closure periods may be properly modeled by assigning the restriction period as a non-work holiday.
    - Look for improper use of repeating holidays for holidays that fall on the first Monday of a certain month, for instance,
      Some CPM software programs do not support the feature of repeating holidays.
    - Confirm that activities are assigned to the appropriate calendars,
    - Look for defined calendars that are not referenced by any activity in the schedule,
    - Schedulers should use project calendars instead of global calendars, if this feature is available,
      Global calendars can be modified by outside parties without notice to the project scheduler. If project calendars have an option to electronically maintain the reference to their global counterpart (such as with Oracle/Primavera P6), schedulers should turn off that link for the same reason.
    - Check working hours of the calendars, if available,
      In some software packages, even though the project is scheduled in days, the calculations are in minutes and hours and work hours mismatch can cause calculation errors and fractional working days.
    - Confirm that resource calendars (if used) match or complement the activity's working calendars.
- Internal operating rules,
  If the software supports documenting the name and date of the person setting the internal operating rules, then confirm that they are properly set. Confirm all settings, even cost-oriented settings even if cost is not being monitored, as some such settings also affect standard CPM operations.
- Out-of-sequence CPM calculation rules,
  The scheduling method should be set to accommodate out-of-sequence progress using retained logic, for those software systems that support this. Retained logic will best ensure that correct total project length is maintained in the situation where out-of-sequence progress occurs. Progress override is usually used when logic is only used to sequence activities and not to show interdependencies.
- Scheduling method,
  For those CPM systems that support this, the software should recognize interruptible activities. Without interruptible calculations, doubly-constrained activities typically are scheduled to start later than necessary. Use this setting for projects where work is aggressively pursued, starting whenever it is possible without regard to maintaining a steady and continuous work flow. Another scheduling method called, continuous activities is best used in situations where

work will not begin until the contractor believes that they will not run out of work before the task is complete. Not every scheduling system supports two or more different scheduling methods.

- Total float calculation,
  There are at least two methods for calculating total float; subtracting the calculated early start from the late start dates or subtracting the calculated early finish from late finish dates. This will generally result in the same value except for interruptible activities and summary activities. Interruptible activities usually work better using finish dates and summary activities work usually better using the start dates setting. Some software also allows for the lower of the two settings to be used. The use of this third setting is recommended, if available.
- Critical path identification,
  For those CPM software packages that support this, confirm which setting is being used to identify the critical path. Possible settings may be by lowest total float, total float less than 1 (or some other set number,) longest path, or resource longest path.
- All other calculation settings.
  Check to see if the scheduling specification calls out any specific schedule calculation settings and confirm that they are properly set. It is always a good practice for the owner and contractor to document and agree upon the various schedule calculation settings to be used, preferably before the baseline schedule is submitted.

PROJECT ANALYSIS

Early Project Completion

The exact contract project completion date should be met in baseline schedules or a clear intent and capability of delivering the project early should be demonstrated. A baseline schedule with an early project completion date typically represents a request for early project completion that should be negotiated. Once on-time completion has been demonstrated in the accepted baseline schedule, early project completion is generally dealt with as a shared project resource and is not subjected to the scrutiny that is typical for baseline schedules.

Baseline schedules that depict an earlier finish than required by contract are called ‘early completion schedules.’ This could mean that the contractor is declaring their intent to complete this project early in order to save the cost of the extended overhead required if they stayed longer. If the early completion baseline schedule is accepted, the owner might be liable for additional project costs associated with owner-cause delays, even if the project finishes on or before the original required completion date.

Other Project Issues

Other project-related review issues include

- Total number of activities,
  Many contracts specify the maximum or minimum number of activities allowed in the schedule. This requirement helps guide the desired level of detail and serves to warn the contractor on the level of scheduling effort desired. If the number of activities is specified, then the type of activities considered in that total should also be specified. For example, some reviewers only count fixed and resource-driven duration activities in the total while others count every activity including milestones and summary. If not specified, then this should be made clear in the early scheduling meeting.
- Percentage of activities that is critical or near-critical,
  Many specifications limit the percentage of activities that can be critical or near-critical in the baseline schedule. It is not usually reasonable to extend this limitation to schedule updates later in the project. A typical upper limit is a maximum of 30% critical and 50% critical or near-critical, although there is no industry standard. Near-critical float activities are those activities that may become critical over the next update period. Near-critical float limit may be defined as any float equal or less than one half of the standard working days in the update period but this is not a set 'rule' unless specified in the contract.
- Activity distribution histogram,
  Schedulers should confirm that the level of detail in the schedule is roughly equally distributed from the start to the finish of the project. Showing a significantly larger number of activities in the first half of a schedule than in the second might indicate an under-developed finish plan. An example of this is 'rolling-wave' schedules where the later portions of the schedule are developed only as needed. This type of under-developed plan is dangerous as the true critical path in the early stages of the project is then in question.
- Identify all contractual milestones.
  All events listed in the contract should be identified as milestones in the baseline schedule. All other milestones in the baseline schedule other than those contractually required should be discussed and their inclusion negotiated between contractor and owner as these non-contractual milestones may help frame the nature of later negotiations.

DETAILED ANALYSES

Activity Analysis

The following activity characteristics should be reviewed:

- Mechanically incorrect dates,
  Inherently incorrect dates should not be allowed in the schedule under any circumstances. The list of such dates includes missing early start dates and missing early finish dates (except for milestone activities.) Finish dates should

not be earlier than start dates (otherwise a situation of negative float will exist.) Actual dates should not be listed before the project start date or after the data date.

- Actual dates in baseline schedule,
  Because baseline schedules are a depiction of the contractor's plan when bid, they should not contain actual dates. The only possible exception to this rule is of notice to proceed if the event has already passed. Otherwise, schedulers risk having poorly performing activities accepted as part of the baseline and not as part of the history of the project. A non-contractual actual date for notice to proceed may compromise contractual requirements. Even baseline schedules that are approved months after the start of the project should not have actual dates. Those actual dates should be submitted as part of the first schedule update submittal.
- Initial logic should be used,
  The CPM logic presented should represent the initial workplan and not reflect any changes resulting from events that occurred after the notice to proceed. Any changes based on events after the notice to proceed will corrupt any later delay analysis and is not in the best interests of the contractor.
- Planned dates,
  If the scheduling software provides a separate data entry point for planned dates that does not interfere or override the early and late calculated dates then it is an acceptable practice to enter planned date information. This is allowed provided that the dates fall within the range of calculated early and late dates. The "three-week look-ahead schedule" (or equivalent) is a more appropriate place for the contractor to indicate planned start dates
- Proper activity types,
  Most CPM scheduling software allows for different activity types that give the activity special characteristics, such as fixed durations or durations that automatically change depending upon resource assignment or other activity's durations. Just because an activity has resources assigned is not sufficient reason to have the activity duration be resource dependent. Resource dependent settings should only be used on projects where varying the resource loads will be used to directly control activity durations or if the contract requires it.
- Proper activity percent complete type,
  Some CPM scheduling software allows for different types of settings for the calculation of activity percent complete (duration, physical, unit, etc.) This setting may possibly affect earned value calculations and should be set appropriately and consistently.
- Negative float,
  Baseline schedules should not have activities showing negative float. Negative float indicates that the schedule does not meet contractual requirements and that the plan is not possible to complete on time as currently described. This condition usually disqualifies the baseline schedule submittal. This limitation does not extend to later, statused schedules. It is generally 'allowable' (although regrettable) for update schedules to show negative float.

- Activity ID coding,
  Most contracts do not specify how activity IDs should be identified but there should be a consistent system for coding activity IDs. It makes them easier to find in listings and may optionally be coded so as to indicate location or responsibility. This optional coding is called, “smart activity IDs.” Activity IDs should be alpha-numeric and not plainly numeric as this allows all codes to be left-justified in reports. Schedulers should look for numeric IDs that are not right-justified as this is an indication of embedded blanks. Activity IDs should not contain spaces as this makes them difficult to type accurately when referencing.
- Activity duration checks,
  Look for longest activity durations and check to see if they are within the limits specified in the contract, if listed. Task durations should not be any longer than the reporting period so that they do not actively span into three reporting periods. In-progress, long duration activities are also difficult to accurately estimate their remaining durations. Consider creating a histogram of the number of activities and their durations as a way to ‘see’ the distribution of planned work. Typically, this duration requirement does not include summary activities and activities depicting deliveries of long-lead items. If the software supports default durations automatically entered when creating an activity, the reviewer should review all activities using that value for obvious mismatches indicating an oversight. Task activities normally should have durations greater than zero. The use of milestones is recommended instead of employing zero-duration ‘tasks.’
- Suspicious task durations.
  Many schedules have activities with durations in even multiples of working days in the week. This is a common way to estimate long durations. In situations such as this, long activity durations in non-even durations stand out as odd. These durations may have been correctly computed using rate and volume of work or they might have been artificially decreased to ‘remove’ them from the critical path or to create multiple critical paths. Artificially steering the critical path is not an acceptable scheduling practice. Activities with suspicious durations should be further investigated, especially if they are critical or near-critical.

<u>Activity Description Checks</u>

The title or description of an activity defines the work to be performed. All activities should have meaningful descriptions and those descriptions, along with activity notebooks and other documentation accompanying the baseline schedule can be used to determine the ‘correctness’ of the activity’s inclusion into the schedule. Items to be considered include

- Activities missing descriptions,
  All activities should have unique, descriptive titles. This title serves as a form of scope of work definition and thus further defines the contract. Typically, descriptions follow a verb-noun-location format.
- Notice to proceed,
  Look for a notice to proceed activity or an unusual number of notice to proceed activities. All projects that are subject to the concept of, “time is of the essence"

require a formal declaration of the start of the project. Multiple such events not required by contract invite confusion and should be studied closely.

- Field mobilization,
  Look for mobilization or an unusual number of mobilization activities. Mobilization is often required by specification, or specifically called out as a pay item and can be an important legal point in delay disputes. It is the owner's best interests to emphasize early mobilization as this event will support all follow-on work.
- Substantial completion/mechanical completion,
  On most projects, liquidated damages stop accruing when the project reaches substantial completion or mechanical completion. This condition is also called transfer of care, custody, and control (TCCC). This is normally not the same thing as all work complete.
  If there is no substantial completion/mechanical completion indicated in the schedule, it will still exist. Regardless of whether substantial completion/ mechanical completion is called out by specification, it is widely recognized legally as the termination point for the assessment of liquidated damages and thus should be included in the schedule. Substantial completion/mechanical completion activities should be coded as milestones and not as task activities with a duration, otherwise confusion between start and finish of the event can result.
  It is best to schedule a project so that the early computed completion date exactly matches the contractually required completion date. Then, if either party delays the project past that time, the delaying party pays the appropriate compensation for the delay to the other party. If the owner accepts a baseline schedule that shows an substantial completion/mechanical completion early date finishing later than allowed by contract, it may mean that the owner forfeits the right to assess liquidated damages until after the early finish date depicted in the accepted baseline schedule.
- Beneficial occupancy,
  Look for 'beneficial occupancy' or 'occupy' activities. This is similar to the effects on project completion as substantial completion/mechanical completion and should not be found in the same schedule without opening the possibility for confusion and interference. Any occupancy of the contracted structure may be considered a case of beneficial occupancy. Beneficial occupancy legally marks the end of liquidated damages, even if the project is not complete. Beneficial occupancy may override substantial completion or mechanical completion in determining the end of the period of liquidated damages.
- Activities with work percentages in their title,
  Activities that are defined as a percentage of larger work are poorly defined and difficult to monitor. Instead of percentages of a larger whole, schedulers should use physical lengths of progress such as, "INSTALL CULVERT, 0 - 100 METERS" or "POUR FOUNDATION, 1-3 GRIDLINE".
- Submittal activities,
  It is in the owner's and contractor's best interests to include all submittals in the schedule or at the very least, the significant ones. It serves as a checklist, helping the contractor to remember this important task. More importantly, the

submittal-review-deliver process frequently impacts the critical path of projects with major items to install.
Submittal activities with a high likelihood of needing re-submittals should have those re-submittals pre-defined in the baseline schedule as separate activities. This will better indicate the correct expected float for that path. Submittal activities with high float values should not be artificially constrained to start later in an effort to 'clean-up' the CPM, as this risks late submittals once the project is underway. It is better to just filter or group the submittals in reports and graphics than to constrain such activities to separate them from current work in schedules.

- Review and approval activities,
  All major activities involving the owner's or owner-agent's (such as an a design professional or construction manager) interaction and possible hindrance in contractor progress should be identified as activities and coded so as to be easily selectable for reporting purposes. These review activities should be separate from the contractor's prepare submittal and internal review activities. Sufficient time should be allowed for the owner to review, evaluate, and respond to submittals. The reviewer should ensure that the review activity durations are in compliance with the contractually required durations.
- Major materials purchase and delivery,
  The baseline schedule should contain activities depicting all major material fabrication and deliveries. Each such activity should logically precede the appropriate activity in the schedule where the material is needed. Materials under contract to be provided by the owner should be coded to make them easy to assemble in a report. Owner-supplied material delivery dates should be reviewed to make sure that they are achievable.
- Inspection activities,
  Major inspection activities, especially those involving critical or near-critical path work should be provided. It is not necessary to include minor or on-going inspection services in the schedule. Schedulers should check to see that these activities are scheduled based on workday (not weekend) schedules, unless allowed by contract.
- Utility activities,
  Utility activities typically include work that is performed by public utility companies (such as electrical hook-up to the power grid) and not the contractor. Utility companies are typically considered 'third-parties.' They are not under the control of either the owner or contractor. Delays caused by the utility company may be counted against either the owner or contractor or neither, depending upon circumstances. Check to see if specified notice periods and durations are included in the schedule. Utility dates and events mentioned in the specifications such as, "start of service" should be represented as milestones in the schedule.
- Temporary activities,
  Sometimes, contractors propose temporary measures that are not part of the final deliverables. Contractors sometimes plan to create temporary barriers, access points, or structures that could conflict with owner operations, warranties, or safety rules in effect. If these temporary measures are not part of the specified

plan, then schedulers should confirm that all of these proposed actions are acceptable.

- Startup, testing, and commissioning activities,
  In facilities-type projects, the schedule should include activities depicting startup and testing of the facility at the end of the project. Owners typically have superior expertise in the determination of the correctness of the sequencing and time necessary for this portion of this work. The schedule should also show the time required for the preparation and review of procedures, permits, and other relevant information. Required vendor representation for major equipment installation should be noted in logs or activity codes.
- Duplicate activity descriptions,
  Activities with descriptions exactly matching those of other activities are confusing to track and may lead to statusing errors. Even though the activity may be coded for different areas using activity codes or activity ID codes, this is not always clear on print-outs and input forms. Duplicate activity titles should be modified so as to have a unique location identifier added, such as adding, “AREA A - ” to the front of the activity description instead of just the work description.
- Zero-duration activities.
  Look for milestones coded as activities. Zero-duration activities differ from milestones in that they have early as well as late computed dates, which allows for confusion as to which date type to use.

Activity Code Analysis

Activity codes are optional data fields used to associate various activities into different functional groups. They are very useful for organizing schedules, especially when the schedules contain thousands or even tens of thousands of individual activities. The reviewer should consider the following

- Activity ID codes,
  Check to see if activity ID codes are used. Activity ID codes are different from the activity codes feature. Activity ID fields are reserved parts of the activity ID that can be used to group related activities. Typically, an alpha/numeric ID is used and the first 1 or 2 spaces are used to define areas, phases, responsibility, Construction Specifications Institute (CSI) number, etc. This type of coding of the activity ID is also referred to as, “smart IDs.” Smart IDs allow a reviewer to know the location and/or responsibility of the activity even if the listing or report is not organized by the desired information. Some CPM software programs do not actively support this type of coding, although schedulers can still enforce this manually.
- Activity codes,
  Activity codes be extensively enumerated in the baseline schedule to help manage the schedule database containing a large number of activities. Schedulers can group, sort, and/or select activities by area, responsibility, phase, or any other user-defined heading. Baseline schedules should have activity code fields for location and responsibility, as a minimum. The responsibility code

should have entries for owner-related issues as well as outside agents such as vendor representation for the installation of major equipment.

- Activity code definitions,
  Once the activity code fields are established, they must be populated with instances. These instances should be defined or labeled in a short description that is easily understood. The descriptions should be unique so as to avoid confusion. Code field definitions are often automatically used in graphics legends.
- Blank activity code definitions,
  Look in activity code dictionary for blank or gibberish descriptions. This can occur when the auto-insert feature is on and the User enters the wrong code for an activity. Identify the activities so coded and request the scheduler to put in the correct code. Make sure that the owner, inspector, design professional, and construction manager are represented in the responsibility activity code field to prevent overlooking required activities later.
- Duplicate activity code definitions,
  Look in the activity code dictionary for duplicate or near-duplicate descriptions. This will most likely cause operational errors later and allow activities to be overlooked and under-reported. One of these duplicates should be deleted and the affected activities updated to use the remaining code definition.
- Blank activity code fields,
  It is easy to miss entering a code field when building a schedule. Look for blank activity code fields for activities to confirm that all activities were properly coded. If no activities use a particular code, the code definition most likely should be deleted. If the activity code is not pertinent to some activities, then define a “N/A” (not applicable/available) definition so that schedules do not have a gap in graphics or reports. It is important that all activities have a code so that they won't be overlooked in reports, filters, and views. If a code field is blank, then Schedulers should look for a similar activity and use the code found there. If no code applies, consider 'GENERAL' or 'OVERVIEW.'
- Non-applicable activity codes.
  At the start of the PC ‘revolution’, computer memory storage space was at a premium and it was good advice to delete all unused activity codes to free up space. Much more powerful computers and very large storage capacities make this issue near-insignificant unless there are a massive number of unassigned codes. Extra, unused codes do make picking the correct ones more time-consuming and error-prone and thus consideration should be made of deleting unused activity codes.

Wbs Code Analysis

A work breakdown structure (WBS) is a framework for organizing and ordering the activities that makes up a project. It uses a systematic approach to reflect a top-down hierarchy structure, with each lower level providing more detail and smaller elements of the overall work.

Sometimes contracts require that the schedule be organized and activities to be categorized by WBS. Some CPM Scheduling software requires at least a minimum WBS that places the entire schedule as a WBS element. A more detailed WBS, breaking down the project into its components can have a real benefit to improving the work plan but is not actually required unless the contract specifies that one be used. The reviewer should consider

- Useable work breakdown structure,
  Check for a useable WBS definition. The use of WBS assignments is a good planning technique to ensure that all work is accounted for and should also be included in the narrative. It has the built-in ability to summarize groups of activities without adding hammocks and additional logical relationships, as required by summary activities. Some computer CPM programs do not fully support the use of WBS in grouping and sorting for reports or graphics in favor of using activity codes.
- Missing WBS definitions,
  Confirm that all WBS levels are fully defined and not blank. Missing WBS definitions will lead to confusion and possibly a failure to correctly account for work or costs properly.
- Incorrectly coded WBS summary activities,
  WBS summary activities automatically begin when the first activity with that WBS code begins and ends when the last activity with that WBS code ends. Activities coded as WBS summary activities typically should not have defined relationships to other activities as they will not behave like CPM activities, even if relationships and durations are included. Not all CPM software programs support the WBS summary activity type.
- Undefined WBS Summary Activities,
  A WBS Summary Activity is a special-use activity type that automatically summarizes the time span of all other activities with that exact same WBS code. All WBS-type activities should be identified with a WBS code. WBS-type activities with no corresponding activities with that WBS code will act like a hammock without activities. Because of this, look for zero-duration WBS summary activities.
- Duplicate WBS names.
  Similar to duplicate activity descriptions, check the WBS for duplicate WBS names. Duplicate names can cause confusion and lead to incorrect WBS assignments.

<u>Relationship Analysis</u>

Baseline schedules should normally only have a single activity without a predecessor relationship (representing project start) and a single activity without a successor (representing project completion.) All other activities should have both a predecessor activity and a successor activity. This rule can be modified on a case-by-case basis if a legitimate reason is presented. One such exception might be in the case of including non-critical, end-of-project activities such as landscape maintenance. Relationship analysis includes the following checks

- Summary activities,
  Check for proper coding of summary activities such as hammocks and level of effort. With the exception of WBS-type summary, each summary activity should have at least one start-to-start (SS) predecessor and at least one finish-to-finish (FF) successor, or as appropriate for that particular CPM software. Other, non-supported relationships may corrupt the purpose for the summary activity and should be reviewed. Look for summary activities with ignored relationships. Any relationships and lags that are not used (such as with WBS Summary Activities) and ignored by the scheduling software should be reviewed. Sometimes such 'unused' relationships are used for graphics purposes to produce summary schedules depicting the hammock activity in the network instead of the detailed activities that it is summarizing.
- Meaningful logic,
  Consider the necessity and method of including start-up and/or completion activities, including
  - Activities that logically occur after substantial completion,
    Activities such as landscape maintenance and punchlist normally should logically occur after substantial completion and not before (or at least not logically before) unless required by contract. Normally, any activity after substantial completion is legally free of damages for late completion. In cases of activities logically after substantial completion, look to see if contract requirements specify an additional time restriction for all work complete (and perhaps the release of retention funds.)
  - Late activities not logically tied to substantial completion,
    Tasks indicating late finish dates occurring after substantial completion typically should still be related to this activity. Most tasks should have successors unless there is no logical or contractual reason for doing so. It is generally assumed that each unconstrained activity will complete before substantial completion. These tasks can show incorrect float if there is an allowable activity after substantial completion (like landscape maintenance) that extends the completion of the schedule and thus the late dates for these unconstrained activities.
  - Activities that logically occur prior to mobilization,
    Some projects get off to a bad start when the contractor fails to mobilize on the construction site in a timely manner. There should be few logical reasons for the contractor to delay mobilization in the schedule other than issuance of the notice to proceed (NTP.) On the other hand, mobilization should logically follow some authorization to be on the site, such as an issuance of a notice to proceed unless the contract documents have provided for a two-step NTP process.
  - Activities that logically occur before notice to proceed,
    Normally, the contractor is not authorized to perform any paid tasks prior to the notice to proceed. Some contracts provide an additional administrative notice to proceed to encourage early planning, scheduling, and submittal work. Schedulers should review any activity logically prior to the NTP to avoid

authorizing early work or even unintended early NTP unless provided for in the contract.

- Early activities not logically tied to notice to proceed.
  Check to see that the schedule does not authorize the contractor to perform tasks before the notice to proceed. This can accidently happen when an activity is missing any predecessor relationships.

- Submittal activities without successor review activities,
  Every submittal activity should normally be logically followed by a review activity. This ensures that sufficient time is allotted between the submittal and the need for the submitted items. The review activity should have a fabrication/delivery or actual installation successor.
- Multiple, simultaneous near-critical path activities,
  Under normal circumstances, CPM networks should not have multiple critical paths occurring at the same time without thorough justification. You should make a more detailed review of these simultaneous activities. It is possible to adjust durations, logic, and lead times so as to artificially create multiple paths. This increases the number of critical activities, which in turn increases the potential that any owner-caused delay will look like a delay to the project. On the other hand, many EPC projects with coordinating system and transition milestones often naturally generate multiple critical paths so this is not a hard and fast rule.
- Activities with interruptible logic relationships,
  Look for activities with both start-to-start (SS) and finish-to-finish (FF) predecessors to same activity and a single SS relationship to a successor activity. If the scheduling algorithm used does not allow for interruptible activity scheduling, the activity will be scheduled to start late due to the FF predecessor. Follow-on tasks may be scheduled to begin later than they will probably occur due to the software-imposed later computed early start. This problem is avoided if the CPM software has an interruptible scheduling setting.
- Start-to-finish relationships,
  Most scheduling programs recognize at least four 'legitimate' relationships. Finish-to-start (FS) is the most common, followed by start-to-start (SS) and finish-to-finish (FF.) A start-to-finish (SF) relationship would indicate that the succeeding activity could not finish until the preceding activity started. It is highly unusual to use start-to-finish (SF) relationships in a schedule and their use should be scrutinized.
- Multiple relationships between two activities,
  Activities can logically have up to four different relationships between each other at the same time. Some CPM Software programs only support one logical relationship between any two activities. Only the start-to-start and a finish-to-finish relationships are commonly used as a pair. Any other combination is unusual and should be investigated.
- Missing finish relationship,
  All activities should have a relationship that defines the requirements for the finishing of that activity. This means that activities should have a finish-to-start (FS) or finish-to-finish (FF) relationship with another successor activity. If not,

then there will be no CPM requirement for activity completion once it starts (other than project completion.)

- Preferential or invalid relationship.
  Check for activities that have predecessors or successors that are not logical. For example, a grading submittal review that is driving the start of electrical switchgear submittal is not logical. Another example is if an activity in Area A is driving an unrelated activity in Area B. Such activity relationships should require an accompanying justification or clarification. Preferential relationships are not 'wrong' as long as the reason for the inclusion is properly documented.

Lag and Lead Checks

Fixed, minimum time durations for relationships are commonly called lags or leads. The difference between these two terms is confused in the industry, with some claiming that both words mean the same thing while others claim that they are opposites to each other in time. Throughout this discussion we use the term, 'lag' to refer to both lags and leads.

While lags have legitimate uses, any such time interval over a threshold value should be individually investigated. They are legitimately used to prevent having to 'break-up' discrete activities into smaller ones in order to properly time other work performed in parallel. However, they can also be used to 'hide' float or otherwise artificially expand a project schedule without being visible in graphics or in most reports.

Negative lags can hide an unworkable project schedule by shortening it without changing activity durations. Like any tool, negative lags can be the perfect solution to describe a real dependency or the wrong thing to use. There is nothing inherently wrong in using a negative lag, as long as the real-world situation is correctly being modeled.

The following rules should be followed unless a valid reason exists on a case-by-case basis to not follow them

- SS and FF relationships should only have zero or positive lags,
- FS relationships should not have positive lags (values greater than zero,)
  This restriction is due to the fact that the calendar used for the relationship is typically not individually adjustable and often is inappropriate. In addition, there is typically no way to status or review the status an on-going positive lag. An activity should be used instead of a lag for this purpose.
- Large lags would be better coded as separate activities.
  Lags cannot be statused to indicate whether they were behind or ahead. For lags of long duration (such as the delivery of a major piece of equipment,) it would be better to create an activity that would show-up on reports and would need to be statused every update. Generally, lag values in excess of 15 work days should be defined as schedule activities for better visibility, justification and statusing.
- Lags that do not overlap the activity,
  Lags that do not overlap either the predecessor or successor activity are

unusual. Lags are legitimately used to describe linked activities that are staggered and at least partially overlap in time.

- Lags longer than the activity's duration,
  Lags typically are used to allow related activities to overlap in time. When the lag is larger than the activity duration, this overlap condition no longer exists and the reason for using the SS or FF relationship disappears.
- Any lag other than zero.
  Besides just 'odd' lags, most schedulers are interested in reviewing any relationship that uses a lag other than zero. Each such instance should be reviewed for a reason why they exist.

Constraint Analysis

Constraints are forced-date overrides to computed CPM dates that may be assigned to the entire project or to an individual activity in a CPM schedule. This discussion of constraints only considers the use of directly overriding of dates and does not involve logical, resource, or other types of constraining issues.

Constraints may change or modify the CPM calculations or they may have no effect. As constraints hide the pure-logical relationships between activities, their use is discouraged in the baseline schedule unless specifically required by contract. A bar chart schedule may be thought of as a fully-constrained CPM schedule. Some schedulers incorrectly use constraints to make activities fall in time periods as if they were preparing a bar chart schedule. Constraints should be used to reflect contractual requirements and not used just to make the early start date of an activity equal to the planned start.

The reviewer should list and review all constraints. A succinct listing of all constrained activities with the constraint and dates serves as an important reference point for addressing constraints. From this list, the reviewer should look for consistency and for odd dates. A listing and explanation for the use of all non-contractual constraints should be included in the baseline schedule narrative.

Baseline schedules should be relatively free of imposed or "mechanical" constraints. Schedule updates are more flexible in the allowance and use of (mechanical) schedule constraints than in the baseline schedule. Baseline schedules should only contain constraints that are specifically called out in the contract, plans, and specifications. Adding non-contractual constraints reduces activity float that may later become 'critical' due to the actions of the Owner when no real project delay has occurred.

Allowing a non-contractual constraint to be added to the schedule may signal the owner's willingness to allow this same constraint to be considered even in the event of a future delay. If the reviewer feels that the non-contractual constraint may be left in the schedule, then it is advisable to include a comment in the review report that such additions must be removed prior to performing any delay analysis. If the contractor

wishes to show a scheduling intent, then they should state this in the narrative and not through the use of constraints.

Not all types of constraints are found in every CPM scheduling software package. Some software packages label their constraints with different nomenclature but act in a similar behavior. The use of any constraints should be scrutinized for its implication to the schedule calculations. The following types of constraints should be considered for extra scrutiny over other types of constraints, if present:

- Zero free float constraints (also known as late as possible constraints,)
  Activities with an assigned zero free float constraint are being delayed as late as possible without delaying any succeeding activities. This type of constraint is typically used to delay the delivery of needed material until the 'last minute.' Contractors like to delay material delivery to
  - Reduce storage costs,
  - Reduce the chance for damage while being stored,
  - Because a down payment is usually required when ordering. Contractors usually benefit from delaying expenditures for as long as possible.

  Using a zero free float constraint for delivery activities can pose a project risk as any delay in delivery will then delay successor work activities. Special concern should be made for owner-supplied material as the owner would then be at risk of delaying the project. The reviewer should verify the reasonableness of all such situations.
- Zero total float constraints,
  Activities with zero float constraints are artificially being coded as critical without regard to network logic. Though similar, this is definitely different from a zero free float constraint where delaying the activity will not necessarily delay project completion. Activities with zero total float constraints will delay the project if delayed. This constraint not only affects the coded activity but all preceding activities on the same float path.
- Expected finish constraints,
  Expected finish constraints compute remaining durations necessary to complete the activity on a specified date and automatically increase the activity's duration to achieve that date. This function is automatically performed, regardless of what duration is required (as long as the duration is a positive number.) The use of expected finish constraints may indicate an attempt to artificially inflate the duration of an activity to use all of the available time. Expected finishes should not be left in a baseline schedule without justification.
- Mandatory constraints,
  Mandatory start and finish constraints completely override network logic and do not allow for proper float calculations. The activity configured in this manner will be scheduled to start on the date given even if all predecessors are not complete. If a constraint must be used, then start no earlier than, start no later than, or even a start on constraint should be used in its place.
- Start on constraints.
  Start on constraints control the start of an activity in both the forward and

backward direction. Unlike mandatory constraints, they will still obey CPM logical rules and not start activities prior to all predecessors being satisfied. On the other hand, such constraints do not allow for the activity to adjust for changing conditions. They should not be used in conditions when an activity can contractually be started at an earlier date. To delay the start of an activity, use a start no earlier than constraint. To have an activity finish by a certain date, then a finish no later than constraint can be used. Both allow the activity to meet restrictions and still accommodate circumstances.

A particular concern with CPM schedules that use hours as well as days in the date calculations is with the handling of any finish date constraints. Some CPM software products default to the first minute of the day (i.e. "00:00") when a date is entered. This default 'midnight' setting is not a strong concern for activities having a constraint that applies to the start of the activity, as the working day calendar will just 'round up' and begin that constraint on the first available working hour of that date. The concern is that constraints with a 'midnight' hour setting affecting the finish of an activity will be 'rounded-down' and effectively constraint that activity's finish to the end of the working day prior to the date set. The result is that finish constraints with a 'midnight' hourly setting will be constrained one day short of the intended restriction and all float calculations prior to that activity will also indicate a value of one day too little.

Cost Analysis

CPM schedules can optionally allow one to add expenses or cost resources to individual activities. Quite often, these 'cost-loaded' schedules are used to assess payment due or earned value. Schedule cost analysis is not "accounting" but every reviewer should look for logical errors or oddities in the cost records, if present. A more stringent level of control is used when the schedule is used as a payment mechanism including the review of quantities and cost loaded line items versus contract values. Cost analysis includes the following checks

- Unused cost account codes,
  These account codes were defined but unused. Perhaps this condition is due to an oversight but nevertheless, it can cause confusion.
- Check for negative values,
  In order to understand the basics of schedule costs, schedulers need to evaluate three categories: budgeted costs, earned value, and actual costs. None of these should be negative.
- Earned value,
  Earned value should be zero in a baseline schedule.
- Activities with automatically adjustable durations and costs,
  Adjustable duration activities such as level-of-effort, hammocks, or ones that are coded with an expected finish may have costs assigned to them. The constraints cause the activity's duration to change when conditions in the network change. The change in duration is applied to the unit cost, causing the costs for these activities to automatically change as well. The costs may be in balance with the baseline schedule but incorrectly vary later once status is applied.

- Consistency with bid items or schedule of values.
  Check to see if the cost-loading is consistent with the bid items in the schedule of values. For example, check to see if the overall budgeted cost of the project matches the contract bid amount minus the non-task specific amounts such as that allocated for profit and overhead. Further, ensure that quantities loaded into schedule activities are consistent with those identified in the contract, if applicable.

Notebook or Log Review

Some CPM software provides the ability to keep notebooks or logs associate with each activity. Reviewers should be cautious about activity logs or notebooks. They can be considered a form of written notification from the contractor to the owner about intent or understanding. It is prudent to review and comment on any logs or notebooks which state facts not in agreement by both parties in order to reserve their rights later.

The log or notebook section of the schedule is an excellent place for the contractor to further define the parameters of each task. Here schedulers can describe planned resource usage, assumptions as to weather conditions, planned substitutions, and deviations from specifications. As this information is not 'visible' in normal views and reports, it is very typical for a reviewer to forget to look at each log or notebook entry during a review. Producing and reviewing a report listing all notebook entries is an excellent review practice.

OTHER BASELINE SCHEDULE CHECKS

There are other items reviewers should check that are not as quantifiable as the list above. Before a baseline schedule review is complete, one should refer to the following documents and issues

- CPM calculation report (sometimes called, "schedule log",)
- Standard activity listing,
- Standard logic listing,
- Time-scaled network diagram graphic,
- Constructability issues,
- Access issues,
- Resource availability,
- Resource congestion,
- Seasonal considerations.

RESOURCE LEVELED SCHEDULES

Resource Loading

Some contract specifications do not require that a schedule be resource loaded. A lack of specification does not prevent the contractor from resource loading their schedules anyway. Resource loaded schedules indicate to the owner the level of the contractor's intent to staff and pursue the work. Such loading is very useful for conducting productivity analysis to demonstrate and calculate the effects of interference and delay.

Schedules that are resource loaded put a burden on both the contractor and the owner. The owner may have to maintain independent records to check to see if the planned loading is being accomplished. If resource loading is included in the baseline schedule, the reviewer should analyze it and it should be reasonable. Resource loading is not the same thing as resource leveling.

All schedules should account for expected resource constraints. This may simply entail having enough activity duration or float to accommodate resource difficulties. Logic may be used to ensure that activities competing for the same resources are offset from each other. Many CPM scheduling software programs also have routines to analytically consider resource constraints when assigning computed dates. This latter process is called automatic resource leveling.

Resource Leveling

Automatic resource leveling is accomplished after the CPM calculation is made and is used as a forecasting tool by the contractor to better plan requirements. A resource leveled schedule results in activity scheduling changes that are either manually adjusted, automatically adjusted through software routines, or a combination of both.

The term, "automatic resource leveling" refers to the delaying or constraining the scheduled start of activities for resource considerations without the use of logic. Modifying the scheduled start of activities using logic is not considered in this context. The schedule must be resource loaded before it can be resource leveled in this manner. Most project scheduling specifications do not discuss the application of automatic resource leveling after completing critical path method calculations.

Ordinarily, the first action that a reviewer performs after loading the schedule is to recalculate the schedule using the project 'as of' status date (which is usually already set in the schedule software parameters.) This is done to ensure that no latent information contradicting the CPM calculations exists before reviewing.

The exception to this rule is when the reviewer is analyzing automatic resource-leveled schedules. In this case, the CPM calculations should not be made on the original schedule. Unwittingly re-calculating the CPM and then reviewing a schedule that was

submitted as an automatic resource leveled schedule might result in the acceptance of a schedule that might otherwise have been rejected. Many reviewers create a copy of the automatic resource leveled schedule, perform the CPM calculation on the copy and then compare the two schedules.

CPM scheduling software generally does not indicate if automatic resource leveling has been used, which makes that determination a problem for the reviewer. If it has been used, then the contractor should state so in the narrative.

There is no easy, definitive method of checking to see if the submitted schedule has been automatic resource leveled. Reviewing the leveling set-up portion of the software and noting the lack of assigned resources to be leveled and/or prioritization selections is a reasonable sign that no leveling has been performed. The only true test for both manual and automatic resource leveling is performed by making a copy of the schedule, performing a CPM calculation against this copy, and then making a date-by-date comparison against the original update schedule. This activity-by-activity comparison is time-consuming process, error prone, and seldom performed.

An automatic resource leveled schedule is not a “CPM schedule” in the strictest sense. An automatic resource leveled schedule is a CPM schedule that has been further adjusted to override and invalidate the CPM early and late date calculations. If the specification requires a CPM schedule submittal, then an automatic resource leveled schedule does not meet that requirement unless the owner allows this modification to the specification. If the owner wishes to accept automatic resource leveled schedules, then it is the responsibility of the contractor to explain exactly what changes were made in addition to the ones made during the actual CPM calculation process.

Engineering calculations should not contain more ‘precision’ than the level of accuracy of the input data. Anything reported in a more detailed manner than was known from the inputs may be mathematically correct but misleading. This same principle also holds true for automatic resource leveling of CPM schedules. Resource availability is not typically dynamically known nor modeled to exactly match the current environment. Resource limits are seldom backed by adequate study and description (and in fact are often exceeded on construction sites.) Finally, the algorithms used to determine activity scheduling using resource constraints scientifically cannot be proven to be the most optimal. For these reasons, most resource leveled schedules cannot be said to be the best, precise plan for project execution.

If the owner does not wish to accept the automatic resource leveled schedule as meeting the requirement for submitting a CPM schedule, there is a possible alternative (other than rejecting the submittal outright.) The reviewer can recalculate the CPM using the exact CPM calculation settings in effect for that schedule and reviewing this re-calculated schedule as the submittal. If this is done, the reviewer should clearly state that they reviewed and accepted only the CPM schedule in their written review. The contractor should object to this procedure in writing if they do not wish to accept this

adjusted schedule as their submittal with the understanding that the objection nullifies the reviewer's acceptance.

ABOUT THE AUTHOR

Ronald M. Winter, PSP has over 20 years of experience in construction scheduling, delay claims preparation, programming, information management, training, and project management in construction and manufacturing industries. He has developed and implemented CPM scheduling and Management Information Systems for an impressive variety of projects.

Since 2002, Mr. Winter has presented numerous papers at professional conventions such as AACE International, PMI College of Scheduling, Primavera User Conventions, and the Construction CPM Conferences. He was one of the members of the Planning and Scheduling Professional (PSP) Certification Implementation Task Force. Ron has served in the past as the Chair of the AACE Planning & Scheduling Subcommittee and AACE North American Marketing Committee. He is also recognized as a Fellow of AACE International.

Since 1997, Ron Winter has developed and distributed the popular software packages, Schedule Analyzer™, Schedule Analyzer Forensic™ and PROJECT WATCH™. Please visit the website at http://scheduleanalyzer.com/ . You can contact Ron Winter, PSP via the web at ron@ronwinterconsulting.com.

REFERENCES

1. Ron Winter PSP, " Checks and Balances: BASELINE SCHEDULE CHECKS," Prepared for the 2002 Primavera Users Conference, October 22, 2002 by Ron Winter Consulting LLC.
2. PS 1373, Baseline CPM Schedules – Communicating the Plan, AACE International 2013 Transactions by David M. Keffer, PE PSP and Praduman Maraj, PE

3. AACE Recommended Practice 38R-06, Documenting the Schedule Basis, AACE International, Morgantown, WV.
4. AACE Recommended Practice 53R-06, Schedule Update Review – As Applied in Engineering, Procurement, and Construction, AACE International, Morgantown, WV.
5. CDR.1436, Generating Claims through Contract Provisions and Management Practices, AACE International 2013 by Mark F. Nagata, PSP and Frank DiCianni
6. Construction Scheduling Games – Revisited, Navigant Consulting, Inc. 2011 by James G Zack, CCM, CFCC, FAACE, FRICS, PMP, Stephen Pitaniello; PE, CFCC; Amanda Jo Amadon, PMP.
7. PS-841, The Law of Schedules, AACE International 2012 by Patrick Kelly, PE, PSP and John Livengood, CFCC, PSP
8. PS-08, Planning a Complex Project – An Under Appreciated Effort, AACE International 2010 by Christopher W. Carson, PSP, and Glen R. Palmer, CFCC PSP