Advanced CPM Milestone Review

by Ron Winter, PSP
Fellow of AACE International

Abstract

Several AACE recommended practices (RP) mention that the scheduler should specifically consider milestones in the creation and review of the typical construction schedule. These RPs do not detail what should be considered when reviewing milestones. It is not enough for the scheduler to look at them and hope that something 'pops-out'. Advanced schedulers should focus on a list of specific topics.

This paper discusses the hows and whys of the proper use of milestones in CPM schedules and how to make better schedules. From baseline schedules to schedule updates, this handy guide gives advanced schedulers more tools to ensure that they have better schedules and better run projects.

What is a CPM Milestone?

AACE International defines a milestone as a zero-duration activity or event that is used to signify a particular point in time for reference or measurement. [1] Milestones are often employed in critical path method (CPM) networks. In this case, milestones are interfaced with activities through logical connections called relationships. This elevates a milestone into project performance considerations.

There is some lack of clarity in what constitutes a CPM milestone. The textbook CPM in Construction Management [2] says, "Certain key events are called milestones; they represent important intermediate goals within the Network.   Milestones are points in time, and thus not activities with zero duration. Milestones are not inherently start milestones or finish milestones, just events. The concept of start or finish milestones was possibly invented to allow CPM to describe events in terms that the software could report."

Implementations of CPM milestones in professional software do not necessarily follow this definition. Microsoft Project® automatically labels any zero-duration activity as a milestone. There is no user-definable property to assess a zero-duration activity that is not a key event in the lifecycle of a project. As a result of this, every project milestone displays early and late start and finish dates just like any other activity.

Oracle Primavera P6® is different from Project in that P6 has the scheduler specifically designate whether or not a zero-duration activity is a milestone. In other words, P6 forces the scheduler to declare a milestone as a start milestone or a finish milestone. This is because it automatically blanks out the start or finish early and late date fields

depending upon which type is designated. This truly turns a CPM activity into an event as there is only one set of calculated dates shown.

CPM milestones can be used in two different ways. If it is used as a 'flag' to indicate the completion of some phase or event and does not have any logical successors, then it does not affect the network logic other than project completion. If milestones are included in logical networks as an actionable event with successor activities, then its status may affect the remaining work to be done. In the second case, proper statusing of milestones is essential to proper schedule management. [3]

Why Use CPM Milestones?

Most construction contracts specifically call out requirements for interim and final completion progress or deliverables that translate into specific dates. Establishing milestones as a contractual requirement helps the owner to control the project's progress without unduly controlling the contractor's means and methods. This contract language should be designed to allow for adjustment, should the owner and contractor agree to the terms. [1] The use of CPM milestones also brings more clarity of current project progress to all stakeholders, including but not limited to the contractor's management.

A milestone is a point in time where a significant event occurs. It is important to note that this event must be significant to the parties involved. Different types of project stakeholders will have different significant project events about which they are concerned.

Types of Milestones

Not all milestones are created equal. To better understand the use and misuse of milestones, they should be grouped and categorized. A logical organizational list of milestone types needs to be defined. Some signify operational issues, and some are required by contract. There does not appear to be a single, formal categorization for milestones published by an authoritative body. Many such lists have been proposed by individuals. One such published list [4] of types of milestones contains the following:

- Phases
- Communication of Special Events
- Decision Points
- Planning
- Design
- Resources
- Process
- Deliverables
- Integration

- Environments
- Training
- Objectives and goals

Some published papers cite that milestones can be used to determine when payments are due to vendors. [5] A different list of typical project milestones is focused on reviews and approvals, such as:

- Project Approval
- Requirements Review
- Design Approval
- Project Phases
- Final Approval

Another list of milestone types [6] includes:

- Project Start Date
- Project End Date
- Budget Reviews
- External Reviews
- Key Dates
- External Events
- Application Approvals
- Funding Receipts
- Major Equipment Deliveries
- Major installations
- Prototype Rollouts
- Major Contract Signing
- Key Personnel Hiring
- Phase Transitions
- Deliverable Completions
- Rates of Completion
- Performance Recognition

Recommended CPM Milestone Categories

Because CPM milestones interact with the timing of actionable tasks, a different type of categorization is needed. Milestones should be recognized for their contribution to the logical completion of the project's goals. A possible list could look like the following,

- Required
  - Legal
  - Contractual
  - Operational
- Not Required
  - Level 1 Schedule Milestones
    - For outside stakeholders
    - For internal use
  - Only needed to create a logical network
  - Other

Legal Milestones

Even if it is not mentioned in the contract, the owner and contractor still have to comply with local, state, and federal laws and requirements. The need for preparation for and passing of local inspections can delay or prevent further work from proceeding. Such inspections require coordination with the inspecting agencies but do not in themselves use contractor or owner resources and thus are appropriate to be characterized as milestones.

As an example, unsupervised, non-construction personnel often cannot be allowed in the new facility until the contractor receives the certificate of occupancy from the building inspector. Denying access to the facility prevents the realization of project substantial completion. This elevates this event to a significant project milestone.

For practical purposes, certificates of bonding and insurance are sometimes project-stopping milestones. If these types of events are not already achieved at the time of schedule creation, they should be included.

Contractual Milestones

Milestones should be grouped into categories based upon their contributions to the construction project. Some are contractually required. The contractor is typically not contractually allowed to enter the construction site and set up support facilities until the owner grants them permission with a notice to proceed (NTP). Other interim events are subject to bonuses or progress payments. Noting when the project is substantially complete such that the owner is able to use the new facility in the manner intended normally marks the end of any liquidated damage conditions.

For risk reduction purposes, contractors should avoid tying payment to milestone completion. [7] In times of price escalation and material scarcity, it is risky to the project to require the completion of a set milestone before the contractor can receive payment. This can put the contractor in a precarious financial position by throttling cash flow. Instead, it would be better that payment for work performed be tied to an assessment of progress.

Operational Milestones

Operational milestones can sometimes be used to explain the reason for the logic used. Typical operational milestones include the following:

Complete foundations. A lot of the early work on building construction is dependent upon first completing the foundation work. There may be many independent foundation tasks that all need to be completed and tied into a single finish milestone before follow-on work can be scheduled to begin.

Complete structures. The construction of structures can play havoc on the surrounding area. To allow access to the external parts of the structures and to prevent inadvertent damage to the surrounding area, it is sometimes smart to delay work such as landscaping and sidewalk construction until the structures are complete.

Close-ins or watertightness of structures. The use of this type of milestone explains to the reader why certain interior finished work follows other work. Material that is sensitive to exposure to the elements should be delayed until its integrity can be ensured. Failure to observe this order of construction can result in ruined work and possible costs and delays due to demolition and re-installation of such work.

Complete basic air handling system. Air handler ducts are large and fragile. It is wise to install them before the other trades begin and the valuable free space in utility corridors is crisscrossed with pipes and electrical conduits. In addition, good construction worker productivity is key to a successful project. Achieving good productivity depends upon providing an environment conducive to hard and sustained exertion. Many building projects in hot and humid climates prioritize rapid installation and commissioning of air conditioning to enable construction workers to do their best in a pleasant environment.

Start of temporary heat. In winter climates, many interior tasks require that the ambient temperature be above freezing or higher. Temporary heat requires enclosed rooms and certified indoor heaters.

Complete permanent heat. In cold climates, sometimes it is necessary maintain the building above freezing temperatures even after the contractors leave. This prevents frozen water pipes from bursting and maintains the warranties on certain materials.

Complete permanent power. Many equipment warranties forbid the operation of major electrical equipment until they can be powered by permanent, not temporary power. For example, permanent elevators usually cannot be used to facilitate construction if permanent power is not already supplied. Their warranty often forbids the use of non-permanent power.

Complete lighting systems. Interior rooms such as bathrooms may use intricate tiling or plaster work. This sort of craftsmanship is very difficult to do without permanent lighting. Permanent lighting may also be required for outside security even before substantial completion.

Other Milestones. Other milestones may just be inserted into the schedule for convenience or other non-contractual purposes. A professional scheduler needs to establish which milestones are 'needed by the project, or certain stakeholders, or mentioned in the contract, and then signal their logical completion.

It is important to not include superfluous milestones in the schedule. The project cannot be completed without statusing them, and some CPM software will not allow the scheduler to complete them without supplying the date of such. These dates become a reviewable certification that the scheduler must support. With perhaps hundreds of tasks active at any given time, the scheduler does not need to invent more work for them to consider.

Milestones in the CPM Schedule Review

A professional scheduler should add a targeted item to the formal schedule review: milestones. Instead of just looking at a schedule and hoping that something odd 'pops out', the schedule reviewer should investigate focus topics. Milestone integrity should be one such focus topic.

Milestone Baseline Schedule Review

For clarity and accuracy, the schedule should include all contractually required events as milestones. Instead of using milestones, leaving the finish of an activity to signal the meeting of contractual event results in a lack of precision to the event. Recommended Practice 53R-06, Schedule Update Review [8] states that the completion of an activity does not necessarily indicate that no more work is required, only that enough work has been completed to allow the continuous execution of the succeeding work. In other

words, an activity's finish signifies substantial completion of the task's work, not certification of the conditions of the contract's requirements. [9]

A baseline schedule review should look to see if start milestones necessarily precede contract work. Is the start of that milestone necessary in order to begin work on the succeeding activity or can the activity actually begin even if that milestone has not been achieved? The project's NTP and progress gates should usually be shown as start milestones.

Is the finish milestone dependent on the completion of the preceding work or could it reasonably be achieved even if the preceding work is not 100% complete? [10] All significant deliverables mentioned in a contract should be represented as a finish milestone. Designating a formal completion event can avoid later disagreements regarding when payment is due or late completion penalties are being considered. Interim required completion events and substantial completion of the project should usually be shown as finish milestones.

Incorrect logic to milestones. When milestones are designated as start or finish milestones, appropriate logic should be used. Start milestones should only have start-to-start or start-to-finish successor relationships, as start milestones do not have a finish date in many CPM software packages. Likewise, finish milestones should not have predecessors relating to its start. Many CPM software implementations do not enforce this restriction but starting with P6 version 20, this logical correctness is enforced. [11] Earlier versions of P6 allow for any type of milestone logic to exist.

Are milestones embedded in the schedule logic so that they affect the continuation of succeeding work or are they removed to act only as flags of work completed? Some schedulers believe that finish milestones should not have successors so that they do not directly affect project completion. On the other hand, if the contract specifically states that the next phase of the work shall not be pursued until certain conditions are met, then does a flag milestone indicate that succeeding work can begin before certification? Approval of a schedule that contradicts the contract may give support to a claim of waiver in some situations.

Are all milestones actually significant events? A milestone should not just be a gathering point for logic. They need to be statused, adding additional work for the scheduler later. Unneeded milestones can interfere with the proper forecasting of project completion. Such use of a milestone also violates the definition in Recommended Practice 10S-90 Cost Engineering Terminology [12]. The document

states, "A milestone should be capable of validation by meeting all of the items proscribed in a defining checklist as agreed with the stakeholders."

Milestones can also incorrectly be used as a convenient network gathering point to tie-up loose chains of logic. Instead of determining what work cannot proceed until a logic chain completes, inserting a non-contractual milestone at the end and either constraining the milestone or having it logically lead to an non-related piece of work is sometimes used.

Milestones with a large number of predecessors are susceptible to merge bias. [13] Merge bias predicts that milestones or activities logically depending upon the completion of many different activities will be delayed by the last one to finish, even if the others are well ahead of schedule. The beginning of the successor work is entirely dependent on the latest logic chain to complete even if all of the other predecessor activities were completed a long time earlier.

Operationally, inducing multiple logic chains to terminate at a single logic point will statistically delay the start of successor work. This is a sloppy and sometimes risky process due to creating a merge bias 'trap'. A well-constructed CPM schedule does not later need the schedule logic to be re-written just because certain late work is holding up the logical start of unrelated, available work. Perhaps more defined required logic can better describe the actual restrictions.

Sometimes this use of milestones is done with the goal of reducing large float values. Artificially reducing float values is sometimes encouraged by popular schedule analysis software. While it is useful to identify large float values as places in the schedule network possibly missing needed logical successors, it is not inherently correct to artificially cause such lowering. If certain activities truly do not hinder the work being performed, causing them to be completed before necessary is a wasteful effort and not in accordance with CPM theory.

This practice of artificially lowering the activity's float values may become a problem later in the project when such activities are delayed and interfere with subsequent program activities. Schedulers who do not create well thought-out schedules often end up having to modify them later when the schedule does not reflect reality. It is not always easy to modify schedule logic in an on-going project.

Besides logic, milestones can be directly constrained with software time constraints such as start-no-earlier or finish-no-later than a particular date. The reviewer should

confirm that contractual milestones with time constraints have the correct date as listed in the contract.

Reviewers should also confirm that the type of constraint used is the least constricting one available. Mandatory constraints that fix both the early and late dates should be avoided unless the contract specifically states that the milestone cannot occur early or late. It is unusual for that type of requirement to be specified. Some software mandatory constraints even override CPM logic and should not be used without clear reasons for its use.

Software implementations of intended constraints can also be misleading. For example, P6 uses the milestone's free float to implement its as-late-as-possible constraint whereas MS Project uses total float for its calculation.

Milestones depicting actual work or using resources should be eliminated. Actual work or resource expenditure do not occur as events, even if the work is small. Project scope should be relegated to activities, even if the activities are short or zero in duration.

Milestone Update Schedule Review

Considering the fact that milestones are significant events, the reviewer should inspect the schedule to make sure that no milestone has incorrect status. In particular, the scheduler should review incomplete milestones scheduled on the current status date to ensure that they were not overlooked for start or completion.

Critical milestones lead to Level 1 schedules [14] where executive stakeholders are often briefed on project performance. The Level 1 schedule does not show the underlying details, so it is crucial that the scheduler accurately certifies the milestone actual dates. Failure to do so may weaken the trust that the stakeholders have in the project.

New or modified milestones while the project is in-progress need particular attention. Modifying CPM milestone logic is more significant to contract adherence than modifying activity logic and should always be subject to scrutiny. Added and deleted milestones specifically should be accompanied with an explanation in the submitted narrative. [15] Particular scrutiny should be given to modified milestone logic. Do the changes adhere to contract requirements or are project deliverables being redefined? Modified logic to or from milestones should be justified.

Milestones may be the exception to the standard rule of 'fixing' the logic when an activity starts earlier that logic would allow. This is also called out-of-sequence progress. AACE defines this as reported progress with uncompleted logical predecessor work. [1] Perhaps the logic is correct and the status is in error.

Extra review attention should go toward completed milestones that had zero or negative total float in the previous schedule submittal. For milestones that were previously considered critical, the reviewer needs to identify any predecessor work that was incomplete at the time the milestone was certified complete. The reviewer needs to identify what successor work was started before the critical milestone was complete. Milestones thus identified should be individually researched to determine if the start or finish status date specified is proper.

When out-of-sequence is identified, the reviewer may want to ask themselves questions such as the following. Do statused schedules contain violated milestones where predecessor work finished after the stated milestone date? Do the schedules show milestone successor work beginning early? Does this milestone out-of-sequence condition indicate an incorrect status date or busted logic?

Before the analyst can decide the importance of an out-of-sequence milestone, they must first establish where each milestone belongs in the list of milestone types. Milestones categories should be operationally identifiable. Is the milestone required legally, contractually, or merely of importance to a particular stakeholder? This should have been determined when negotiating the baseline schedule acceptance. Categorization of the milestone types at the start of a project gives greater understanding of importance during the update or time impact analysis (TIA) reviews.

The intersection of contractual milestones and out-of-sequence progress is of particular importance. Milestones representing contractual events being statused as out-of-sequence may indicate that the contract was possibly violated. Seeing that the contract controls the project, a schedule reviewer usually is duty-bound to reject such status in these cases.

Milestones that are statused to occur in a logical out-of-sequence manner may represent contract violations or invalidate permission to proceed. There are three types of logical conditions that should be included in a milestone out-of-sequence review:
1. Logically Violated Start Milestones – The successor to a start milestone started early.
2. Logically Invalidated Finish Milestones – The finish milestone finished prior to predecessor work.
3. All other milestone violations:
    a. A start milestone that completes early to some successor.
    b. A finish milestone with a successor finishing early.

11

AACE RP 53R-06 Schedule Update Review generally mentions milestone analysis as a needed review item, but it does not specifically detail what should be included. In particular, it does not mention a milestone out-of-logical sequence review. In fact, none of the existing AACE recommended practices detail this particular risk.

When an activity is reported as starting out-of-sequence, the reason for this logic error should be investigated. Either the original logic was wrong, or field conditions permitted an informal change to the logic. It is possible that the preceding work reported as not complete is not part of the intended definition of the logic used, an error that should have been caught in the schedule baseline review. Finally, the predecessor activity may have been complete but the statusing was missed during the earlier reporting process. [2]

There may be logical reasons for correctly certifying a milestone actual date with out of sequence status, but those reasons need to be documented. For example, certifying a building weather-tight before all outside windows and doors are installed may be satisfied provided the remaining openings were protected with a waterproof covering. This, of course, is dependent upon if the inspector allows such temporary substitution before weather-sensitive construction such as installing drywall.

More to Be Done in Reviewing Out-Of-Sequence Progressing of Milestones

Direct verses indirect out-of-sequence. Milestones statused as having occurred out of logical sequence to some predecessor activity can be logically directly related to that activity or indirectly related through other activities. [16] To explain the difference, Figure 1 below shows the as-planned starting condition. The acronym, "DD" indicates the schedule's current data date with a darker date line and the term, "FS/0" is shorthand to indicate that the relationship is a finish-to-start with zero lag.
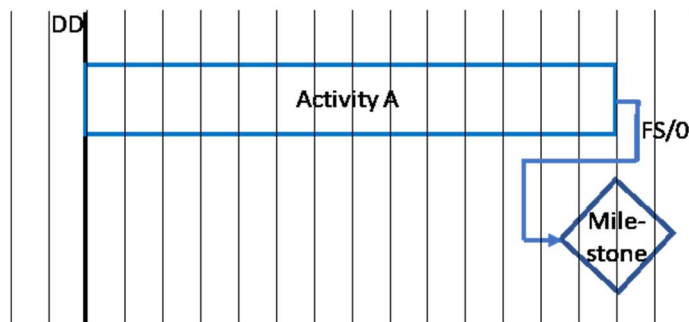

Figure 1 - The As-Planned Schedule Layout

12

The first type of out-of-sequence occurrence is called direct out-of-sequence and is illustrated in Figure 2 below. The data date has progressed and the milestone has been statused as complete before its predecessor activity is completely finished. The blue fill denotes progress toward completion. In other words, the milestone has started directly out-of-sequence to Activity A.
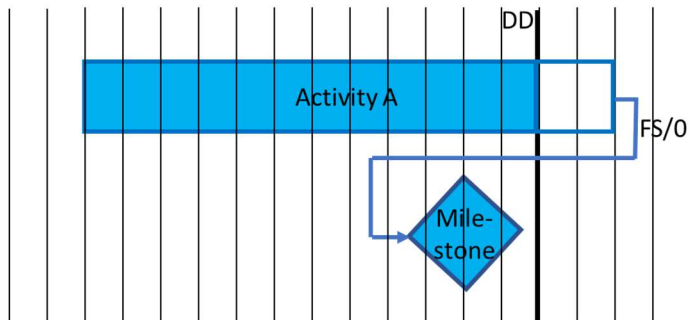

Figure 2 - Milestone Complete Directly Out-of-Sequence

The second out-of-sequence type is called indirect. The milestone has started in logical accordance to Activity B, which is its direct predecessor. This does not shield the milestone from starting indirectly out-of-sequence with Activity A. Indirect out-of-sequence can even occur when the immediate predecessor to the milestone occurred in 'proper' order but the two are still completed earlier than work preceding both.
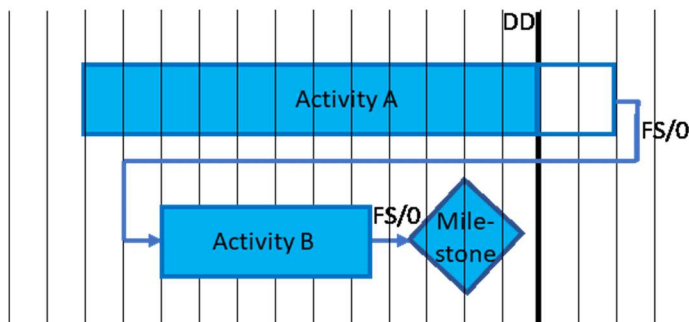

Figure 3 - Milestone Complete Indirectly Out-of-Sequence

The reason why it is important to understand the difference between direct and indirect out-of-sequence situations is due to difficulty of identifying the indirect. When looking at standard CPM graphics, the indirect out-of-sequence milestone may be difficult to spot. It may be listed dozens or more lines separate from the Activity A triggering the condition. As of this writing, while it reports on direct out-of-sequence activities, the Oracle/Primavera P6® software fails to identify indirect out-of-sequence activities and milestones such as shown in Figure 3. [16]

13

Invalid milestones as opposed to out-of-sequence ones. There is potentially an additional problem with improper milestone statusing. This occurs when activity statusing appears to invalidate the milestone's logic. To illustrate this, Figure 4 below shows an as-planned schedule with a start milestone determining the start of Activity A's work.
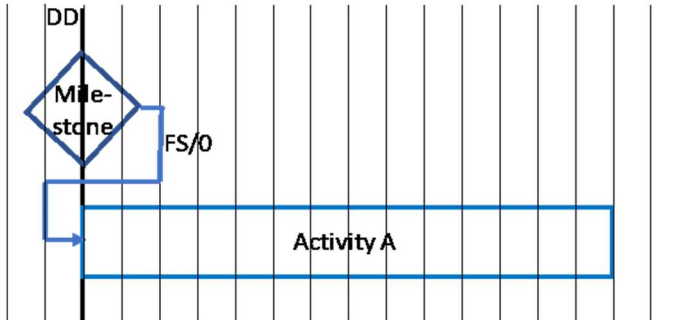

Figure 4 - Scenario Two As-Planned Schedule

Instead of the milestone starting earlier that logic allows as shown in the earlier example, an activity that is a logical successor to the milestone begins before the milestone is achieved. This activity should not have begun before the start milestone date but they did. In effect, the milestone was invalidated. Figure 5 below illustrates the scheduling situation where successor activity's early start invalidates the milestone logic.
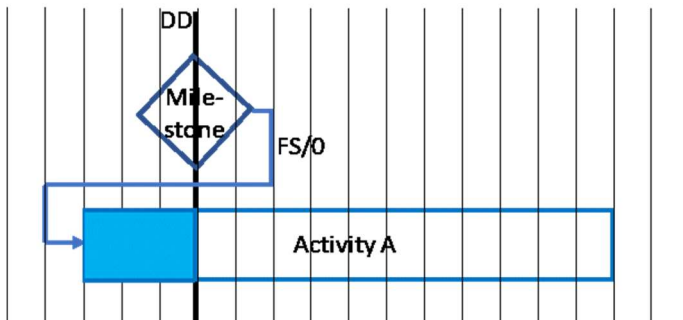

Figure 5 - Milestone Invalidated by Out-of-Sequence Status

How Common Are Milestone Out-of-Sequence Events?

Research into whether the issue of out-of-sequence milestone statusing is actually of concern in the construction industry was performed by this author. The general issue of any CPM activities being statused out-of-sequence was previously published. [17] A further investigation of instances of only milestone out-of-sequence and invalidated occurrences is presented here.

Fifty-one schedules were selected as representative of all different construction types from buildings to roadwork to industry production plants. [Appendix A]. Seven of the 51 schedules did not have any out-of-sequence or invalidated start milestones (14% of the total) and 11 of the 51 schedules did not have out-of-sequence or invalidated finish milestones (22%). [Appendix C] When start and finish out-of-sequence milestones are taken together, the survey above suggests that five out of 51 projects, or 10% of the projects did not have out-of-sequence milestones. The average schedule had 12 out-of-sequence milestones.

Severity of Out-of-Sequence Milestone Conditions

Simply counting the number of out-of-sequence milestones detected in a schedule does not entirely describe the issue. The severity of a particular milestone out-of-sequence occurrence can partly be determined by the number of predecessors to which a particular milestone was logically started early. A milestone may have started early to three immediate predecessor activities (direct out-of-sequence). A different but equal situation might occur if a milestone started earlier than logically allowed to one activity, but that activity was also earlier that the one predecessor activity before it and that activity also occurred earlier than logically allowed. In the second scenario, the milestone would have occurred earlier that the three activities logically before it (indirect out-of-sequence).

The number of activities that were logically violated by a single out-of-sequence milestone is called out-of-sequence events. In either of the listed scenarios, see Appendix, the milestone would be said to have three out-of-sequence events. Larger number of events of out-of-sequence milestones demonstrates a more severe instance of milestone statusing problems. The average schedule in the survey had 27 start milestone and 15 finish milestone out-of-sequence events.

These statistics clearly suggest that properly reviewing out-of-sequence milestone statusing is an industry-wide issue. It is unknown if the project scheduling team in the examples studied informed the contract team as to the reasons for each occurrence, but experience suggests that they did not. It is difficult to spot issues such as this unless one is specifically looking for it.

Milestones in Claims Resolution

Milestones may be used for analysis of claims. For instance, noting the milestone for watertight structure fell after the date of a severe storm will quickly help identify potential issues. [2] This same concern can be applied in the plan review stage to note if the expected rainy season will potentially harm structure interiors.

All TIAs should also include the time adjustment of any contractual intermediate milestones, as well as substantial completion.   It is essential for the analyst to accurately define which milestones are contractual so that the needed adjustments are completely covered in the analysis report.

Before determining the actual critical path of a completed project, the status date of each contractual milestone should be verified independently using job work logs, requests for information, and other supporting documents. Of all of the CPM activities in the as-built schedule, the status of milestone activities is the most obvious and simplest to recognize and define.

In Conclusion

CPM milestones should be limited to points in time where a significant event occurs. Use of milestones not depicting significant events in a project should be avoided. Milestones depicting actual work or consuming resources should instead be modeled as CPM activities.

Instead of simply looking at a schedule and hoping that something odd 'pops out', the schedule reviewer should investigate focus topics. Milestone integrity should be one such topic to be formally addressed.

Different issues should be covered with a baseline schedule review as opposed to the review of a schedule update. Ten different review topics were discussed that should be considered during baseline schedule reviews.

Proper statusing of milestones should be of significant importance during a schedule update review. Milestones frequently refer to legal or contractual obligations, which makes the accuracy review of particular importance. Ten different categories of reviewing milestones in schedule updates were presented and detailed.

Milestone integrity also includes consideration of the logic used. Milestones being statused in an out-of-logical sequence fashion are inherently self-questioning. Are contractual requirements being skipped or overlooked, or was the CPM schedule just developed incorrectly? A field study of a large number of diverse types of construction schedules strongly suggests that out-of-sequence milestones is a major, pervasive industry problem.

Many schedulers believe that out-of-sequence logic should be corrected. The reverse of this may be true of out-of-sequence milestone logic. The status of the milestone, not the logic should be considered for modification. Milestones frequently depict a physical condition. In cases such as this, redefining the condition is not the answer. Reevaluating the status of out-of-sequence milestones may be the more reasonable resolution.

The average scheduler is not sufficiently preparing and reviewing CPM milestones. They need to specifically consider milestone issues in their process. This paper is an attempt to spotlight and educate on solutions to this scheduling risk.

References

[1] Recommended Practice 10S-90, COST ENGINEERING TERMINOLOGY

[2] CPM In Construction Management, Sixth Edition

[3] Primavera P6 v20 logic to milestones discussion, Christopher Carson CEP DRMP PSP FAACE,, November 22, 2022, https://communities.aacei.org/discussion/primavera-p6-v20-logic-to-milestones-1

[4] 12 Examples of Project Milestones, Simplicable Guide by John Spacey, October 5, 2022 https://simplicable.com/new/project-milestones)

[5] Project Planning: What Are Typical Project Milestones?, Angela Bunner, March 04, 2020
https://www.clarizen.com/project-planning-what-are-typical-project-milestones/

[6] Everything You Need To Know About Milestones Planning, Sira Anamwong, October 10, 2021
https://www.cleverism.com/everything-you-need-to-know-about-milestones-planning/

[7] Control What You Can, Gina Lockwood, Merchants Bonding Company, ENR October 31, 2022.

[8] Recommended Practice 53R-06, SCHEDULE UPDATE REVIEW – AS APPLIED IN ENGINEERING, PROCUREMENT, AND CONSTRUCTION

[9] Recommended Practice 52R-06, Baseline Schedule Review – 10 As Applied in Engineering, Procurement, and Construction

[10] Recommended Practice 78R-13: Original Baseline Schedule Review - As Applied in Engineering, Procurement, and Construction, Ronald M. Winter, PSP, 2014 AACE International Transactions, PS.1595

[11] Michael Marcell EVP PSP, Primavera P6 v20 logic to milestones | Planning & Scheduling (aacei.org)

[12] Recommended Practice 10S-90 Cost Engineering Terminology, August 23, 2022

[13] Understanding Merge Bias in Schedule Risk Analysis, Jeffrey Valdahl; Christopher P. Caddell, PE CCE, 2010 AACE International Transactions, RISK.08, AACE International, Morgantown, WV, 2010

[14] Recommended Practice 37R-06, SCHEDULE LEVEL OF DETAILS

[15] Recommended Practice 53R-06: Schedule Update Review - As Applied In Engineering, Procurement and Construction, AACE International, August 14, 2008

[16] PS-3007, Analyzing Out-of-Sequence Progress, Ronald M. Winter, PSP FAACE, 2018 AACE International Transactions, PS-3007, AACE International, Morgantown, WV, 2018

[17] PS-3217, Mastering Out-of-Sequence Progress, AACE Annual Convention, June 2020.

The Author

Ron Winter, PSP FAACE is an independent CPM Scheduler and Owner of Ron Winter Consulting LLC, the makers of Schedule Analyzer for the Enterprise™ and Schedule Analyzer Enterprise Forensic™ Software. He can be reached via the web at Ron@RonWinterConsulting.com