Correcting
Out-of-Sequence Progress

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June 21, 2024

Abstract

Out-of-sequence progress sometimes occurs when actual status is applied to a planned CPM schedule. If the actual start date is earlier than the calculated early start date, then the actual date overrides logic. Depending on how the CPM calculation handles this occurrence, the remaining portion of the planned work may be delayed to re-enforce the planned logic. Studies show that approximately 40% of all started activities in typical construction projects are started out-of-sequence.

Most schedulers say that they 'fix' any out-of-sequence activity in schedule updates by modifying the activity or logic. This effort may be misinformed as many schedulers do not fully appreciate the number of out-of-sequence occurrences in their schedules. For example, P6 Professional software only reports on active, direct out-of-sequence activities. This is a small percentage of the actual out-of-sequence in a schedule. Besides, they may be fixing the wrong logic as the indirect out-of-sequence (which P6 Professional does not report) may be the correct activity to fix. This paper looks into the reasons, methods, and pitfalls involved in correcting out-of-sequence logic during updates. Definitive rules are proposed for various categories of out-of-sequence conditions presented in earlier papers.

Introduction

This paper will begin at the beginning by defining what is out-of-sequence logic and the problems it can create. Appendix A is included at the end of the paper to help define and illustrate terms that may not be familiar to some readers. Solutions to this issue depend on many factors and these are covered with illustrations. The question of when are corrections appropriate is presented in its many facets. Finally rules or guidelines for correcting out-of-sequence logic are offered.

What is Out-of-Sequence Progress?

Sometimes a critical path method (CPM) activity actually starts before it was logically scheduled. Activities that actually start before the CPM calculation allows are said to be starting logically out-of-sequence[1]. CPM calculation routines using a retained progress process cause the activity that began earlier than logic allowed to delay the scheduling of the remaining portion of the activity's work until the preceding work is complete. To prevent showing a non-work gap in such situations, many schedulers say that they 'fix' any out-of-sequence activity in schedule updates by modifying the activity or logic[2]. Interestingly enough, AACE does not mention fixing out-of-sequence conditions in their recommended practice on performing a schedule update[3].

2

This paper discusses adjusting CPM software to overcome out-of-sequence instances. Some such software automatically adjusts the network to prevent this situation from occurring. Others just produce a text report on this phenomenon to assist schedulers in locating and dealing with it. Some software only indicates this condition graphically. Other software does not report on this condition at all. Research indicates that most software properly reports direct out-of-sequence. [4] Although this paper was researched using Oracle/Primavera P6 Professional software and will use the terms defined there, this paper applies to all CPM software. Some CPM software does not support some of the methods presented.

Some software does not actually reflect the properties observed when out-of-sequence situations are observed. For example, Microsoft Project CPM software's calculation algorithm allows uncompleted work to be scheduled in what is displayed as before the status date. It also does not have a built-in report for out-of-sequence activities. This can be remedied by adding-in 3rd party scripts.[5]

Out-of-Sequence Solutions

Many schedulers say that they 'fix' any out-of-sequence activity in schedule updates by modifying the activity or logic[5].   How that is achieved has not been addressed in a systematic manner. The following suggestions are presented, depending upon the types of activities and logic used.

Out-of-Sequence Milestones

CPM milestones are different from activities because they have no duration. There cannot be a consideration of interrupting their execution in favor of working on related work. Milestones are points in time related by logic to the rest of the CPM network. They are defined by the logic that constrains then and the successor activities that follow them.

The logic constraining milestones should have already been vetted for their interpretation of conformity to the contract and other legal or procedural considerations. In most cases, any out-of-sequence events involving milestones are not a consideration of failed logic, but of incorrect status. The status of the milestone, not the logic should be first considered for modification[6].

Independent Out-of-Sequence

One of the simplest types of out-of-sequence conditions to fix is when the two activities are resource independent from each other. This can be true in the case of two different crews working on two different tasks that are logically related due to a shared workspace. In addition to resource independence, these activities should also be spatially independent enough to not interfere with each other's productivity do to crowding of workers or access.

By way of illustration, Figure 1 below shows a typical out-of-sequence scenario. The CPM Retained Logic algorithm suspends the continuing of work on Activity B until all work on Activity A is complete.
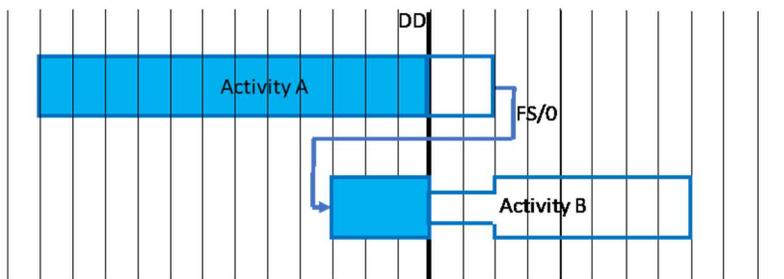

Figure 1 - Typical Out-of-Sequence CPM Condition

Figure 2 below shows a simple fix of replacing a finish-to-start relationship with a finish-to-finish one. Perhaps the finish-to-start relationship was too restrictive. Perhaps the next crew was able to begin Activity B but not able to complete it prior to Activity A's completion. A simple conversion of a finish-to-start relationship to a finish-to-finish relationship may be warranted. Figure 2 shows the result with the two different activities now scheduled to resume immediately. As a consequence of this change, Activity A has now changed its total float from 0 to 4.
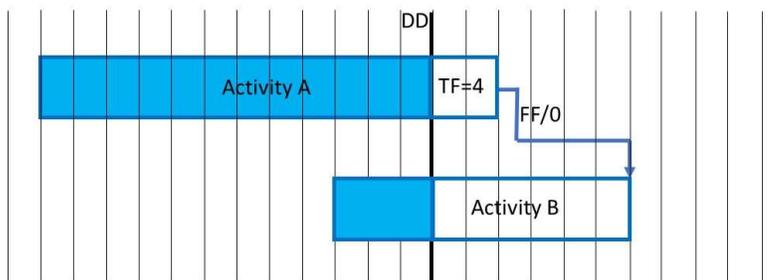

Figure 2 - Corrected Out-of-Sequence CPM Schedule

The premise presented here is that the crew performing Activity B can start on work already completed with Activity A but cannot finish until Activity A's work is completed.

If in the next update, Activity B completes before Activity A, then this solution would not be the optimum one.

Dependent Out-of-Sequence

Sometimes, individual tasks are related because they are sharing the same resource. Assume that one is trying to depict a common task such as installing ductwork on a normal building construction project. The contractor estimates that one crew can perform the entire job in 30 working days. A CPM schedule could depict this as a single activity as shown below in Figure 3. The data date for this schedule begins on day 0.
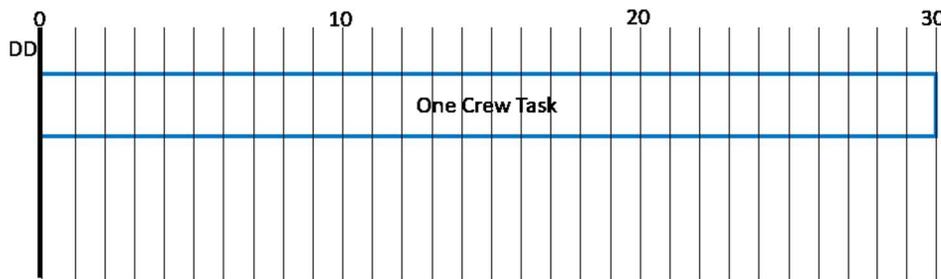

Figure 3 - Crew Plan for a Single Task

With many construction projects, it is quite common to break-up a long series of planned work into smaller activities to be able to more accurately monitor progress and estimate completion. The separate work may be differentiated by physical areas in the project as shown in Figure 4. There is nothing inherently important as to the scheduling of work in one area or another as long as the one crew is not scheduled to work at two different locations at the same time.
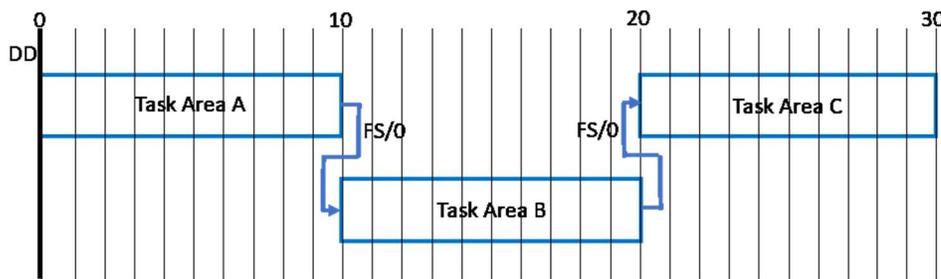

Figure 4 - Planned Typical Schedule

When a minor problem or issue holds up the work in one area, the work supervisor often just directs the crew to move on to a different area, expecting to come back to the original area when the issue is resolved. Unless the CPM logic is adjusted, then the next

schedule update will show out-of-sequence work like shown in Figure 5. Work had begun in Area A but was held up at the end of Day 4 and the workers switched over to Area B on day 5.
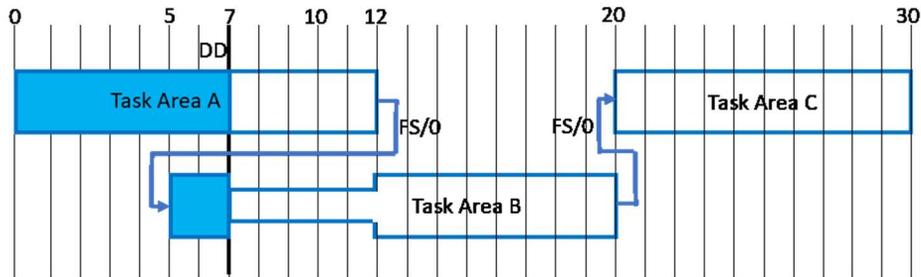

Figure 5 - Out-of-Sequence Schedule Showing Retained Logic

The most visible example of this condition is that the CPM algorithm will typically show the new work as immediately suspended in favor of resuming work on the earlier, incomplete area. This gap of non-work in Area B may not reflect the work supervisor's intention and thus a conflict between the CPM and the work schedule is created. This CPM condition can be called, a work-gap.

Another option available in P6 Professional is to ignore any logic that causes the out-of-sequence condition to exist. This change in computation will eliminate the planned work-gap.   One can automate this by switching the CPM calculation over to the progress override setting and recomputing the CPM. Changing the CPM setting will not document the changes made to the logic, as the ignored logic is still displayed as if it were active. Using this method frequently changes the out-of-sequence activity's total float.

Figure 6 shows the result of the scheduler changing the out-of-sequence calculation mode over to progress override. Since the finish-to-start relationship from Area A to Area B was broken, the algorithm ignores that single logic and allows the Area B work to commence immediately.
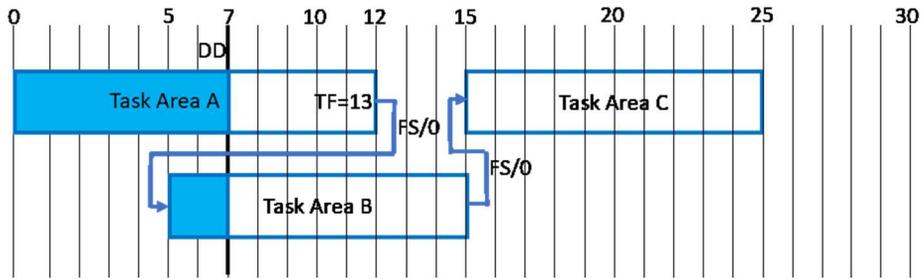
Figure 6 - Out-of-Sequence Schedule Showing Progress Override

The result of this change shows an improvement in the planned finish of the work by 5 days. In addition, the total float in Area A now changes from 0 to 13. Based upon resource considerations, this is not a reasonable result. The schedule may now indicate that the workers in Area B are intended to keep working in Area B but the schedule now no longer accurately predicts the proper completion of the total work.

Another well-recommended adjustment to the schedule continues to use the retained logic algorithm but replaces the finish-to-start relationship between Area A and Area B with a finish-to-finish relationship as shown in Figure 7. The total float of the Area A activity is reduced to 3, which is closer to the previously calculated 0 but the overall work completion date is still off by 5 days.
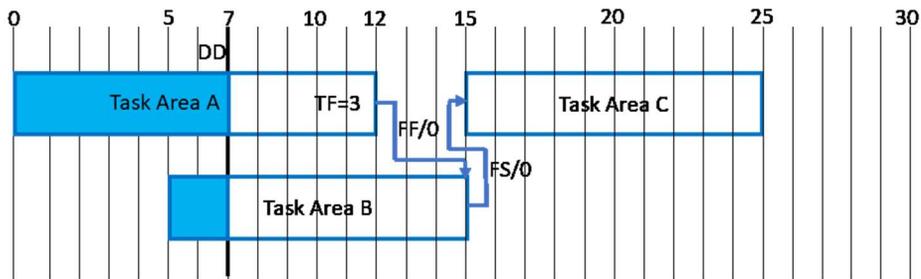

Figure 7 - Out-of-Sequence Schedule with a Simple Logic Change.

The suggested 'fix' of the out-of-sequence condition in this situation is to break the Area A work into two tasks: the completed work before the interruption and the remaining planned work as a separate activity. Figure 8 illustrates this.
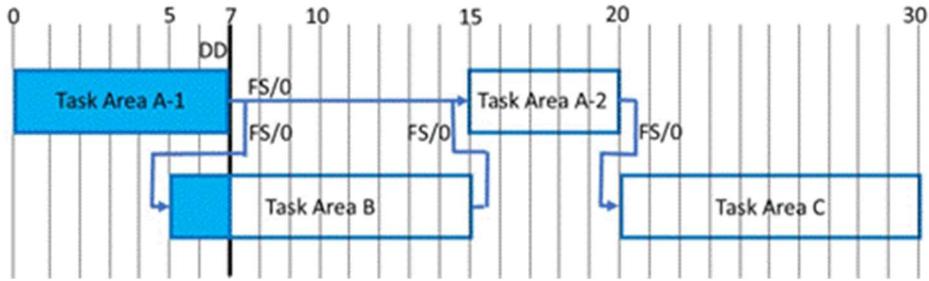
7

Figure 8 - Out-of-Sequence Schedule using Retained Logic and a Split Activity

Figure 7 above now shows the Area B work starting immediately and the overall work extending to the expected 30 days. There is still one discrepancy to take care of. The work in Area A stopped on day 5, not day 7. Although this depiction did not affect the scheduling of the correct timing of the activities, it infers that the same crew worked on two areas at the same time, which it did not. It also now predicts an expected actual duration of Area A work as 12 days instead of the planned 10.

What is needed for a complete fix of the out-of-sequence condition is to properly annotate the work interruption of Area A as it actually occurred, as shown in Figure 9, below.
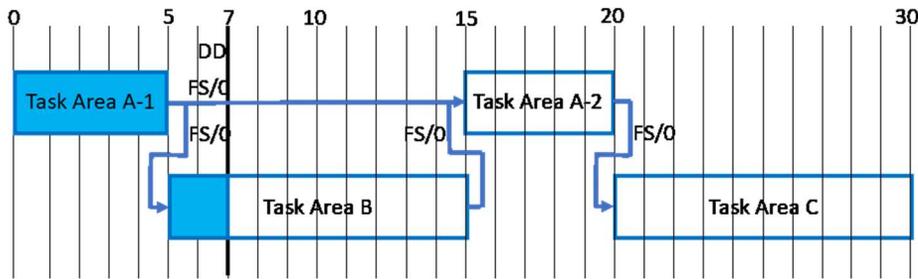
Figure 9 - Completed Adjustment of an Out-of-Sequence Schedule.

Suspending the Predecessor

Assuming the CPM software has this feature built-in, another possible fix for the out-of-sequence condition is suspending the predecessor activity. This would allow the successor activity to continue being scheduled without a work gap. Figure 10 below depicts such an arrangement. This would at least make the software display the correct number of actual work days. P6 Professional, only allows one set of suspenice/resume dates per activity, so this advice would not work on multiple work disruptions.
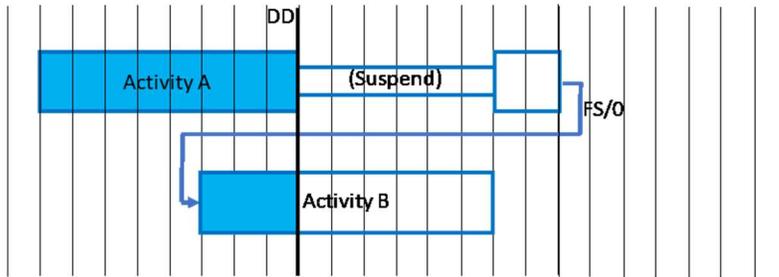
Figure 10 - Solving Out-of-Sequence Using Suspended Activity

Unfortunately, this is not how the suspend feature works using P6 Professional software. Figure 11 shows that it will delay the out-of-sequence activity even further if the predecessor activity is delayed via suspending the activity. At least in the P6 Professional environment, this is not a viable solution to correcting out-of-sequence progress.
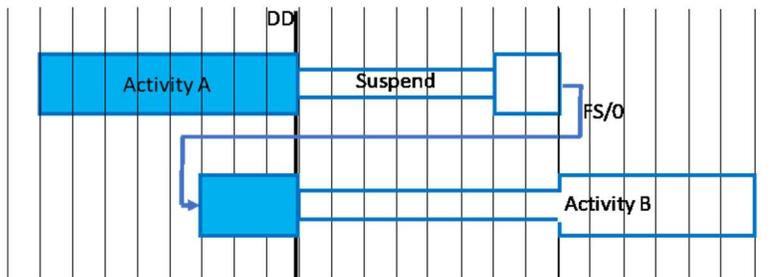
Figure 11 - P6 Professional Example of Suspended Activity

Direct Versus Indirect Out-of-Sequence

Sometimes the cause of an activity showing out-of-sequence work delay is not immediately apparent. This is because the immediate predecessor to this activity is already complete. Complete activities (ones having both an actual start and an actual finish annotated) can still be active and logically related to the earlier activity not completed in the logical order. The activity showing an out-of-sequence work delay is not the immediate successor to the uncompleted activity, but is still in the logic chain to the unfinished activity. This event is called an indirect out-of-sequence condition as shown in Figure 12 below.
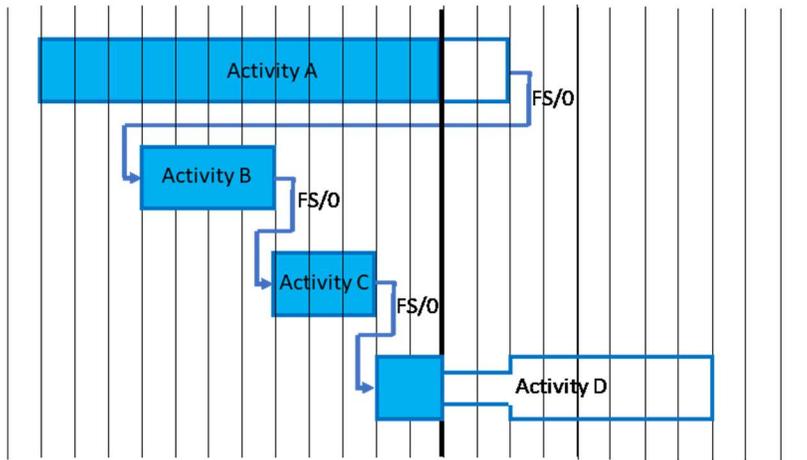
Figure 12 - Indirect Out-of-Sequence Condition

Identifying the cause of indirect out-of-sequence can be challenging. For example, P6 Professional software only reports on active, <u>direct</u> OOS activities. It does not identify active indirect cases as shown above.

In this situation, the first problem that the scheduler must solve is to identify the uncompleted activity that is somehow logically related to the out-of-sequence activity displaying the work-gap. Sometimes the quick solution is to note the length of the work delay in the out-of-sequence activity and then look for a preceding activity with that amount of remaining duration. The suspected activity can be tested by temporarily finishing the activity, re-running the CPM calculation, and confirming that the out-of-sequence work delay disappears. The scheduler should then return the tested activity back to its original status to maintain the integrity of the schedule update.

The solution to correcting the indirect out-of-series activities is similar to correcting a direct out-of-sequence condition as depicted in Figure 8 above. Activity A is split into two parts with the second part dependent on Activity A and Activity D finishing first. Because Activity B and Activity C not only started out-of-sequence but also finished before Activity A completed, the finish-to-start logic was clearly violated. To rectify this, we replace the finish-to-start logic with start-to-start. Figure 13 below diagrams this suggested change.
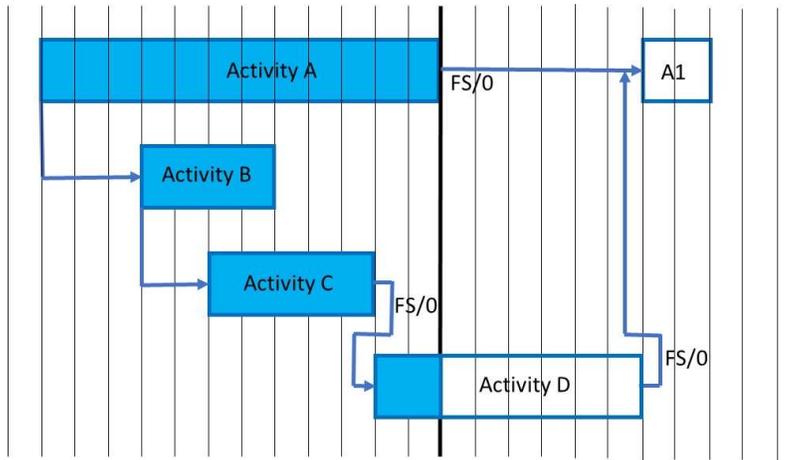
Figure 13 - Indirect Out-of-Sequence Solution

This indirect out-of-sequence condition can be further complicated in the case of a series of indirect out-of-sequence conditions as depicted in figure 14, below. In this case, one cannot just match the work gap in Activity E to the remaining work in Activity A. Solving the correct schedule adjustments in this scenario is also difficult. This sort of condition occurs often enough to be an issue plaguing schedulers.
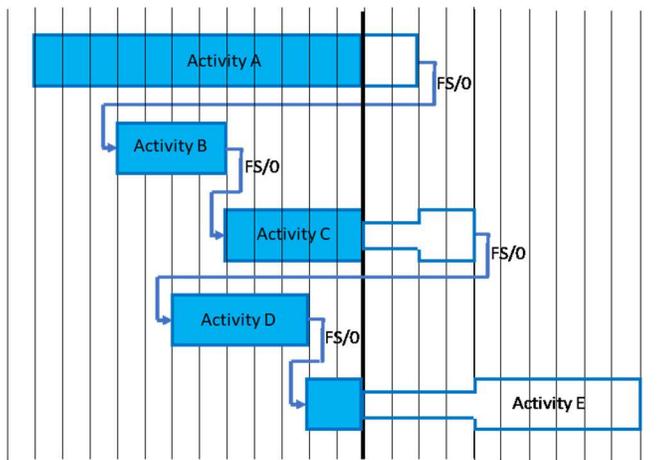
Figure 14 - Series Indirect Out-of-Sequence Conditions

The solution to the above example depends upon whether out-of-sequence Activity C is going to resume work first or out-of-sequence Activity E does.

Inactive Out-of-Sequence

Some out-of-sequence conditions do not create the work gap phenomena. One such condition is inactive out-of-sequence. The difference between active out-of-sequence displayed in earlier figures and inactive out-of-sequence activities is due to perspective

of the data date. Once the data date has passed the predecessor activity's actual finish, the follow-on out-of-sequence activities no longer cause the retained logic CPM algorithm to display work gaps in the scheduling of uncompleted activities. In this case, there is nothing that <u>has</u> to be corrected to fix a work-gap. Figure 15 below displays such an example.
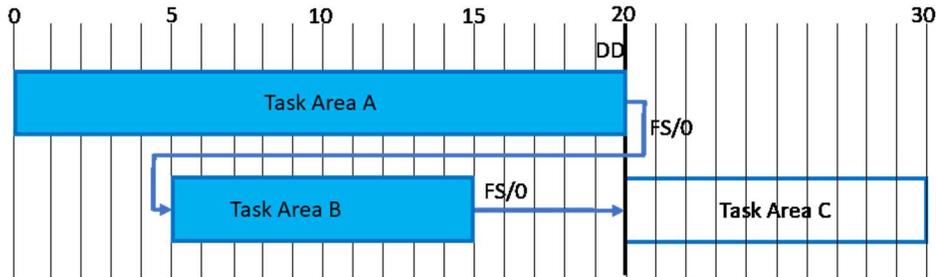
Figure 15 - Inactive Out-of-Sequence

Based upon the fix presented in Figure 8 above, Figure 16 below, may show the correct solution for fixing this particular inactive out-of-sequence condition. It seems that researching and performing this procedure on approximately 40% of all of the schedule's activities[2] in a typical construction project is inherently an impractical suggested correction.
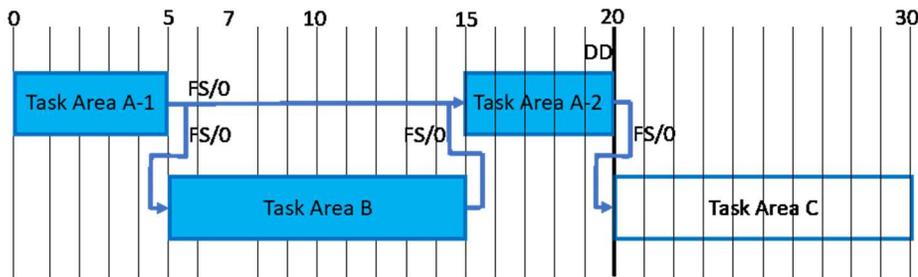
Figure 16 - Possible Inactive Out-of-Sequence Correction

In addition, schedulers may be fixing the wrong logic as the indirect out-of-sequence activity (which P6 Professional does not mention in its out-of-sequence report) may be the correct one to fix. The result to the as-built total float is not displayed for completed activities. Without an active response to any suggested fix, the actual ramifications of such adjustments are risky to make.

When is Correction Appropriate?

Most out-of-sequence activities maintain an active state for only a short duration (typically one update period or less). Because of this, most contractors resist making the logic corrections necessary to eliminate the out-of-sequence issues. They feel the offending condition will take care of itself in the next update. This reluctance means that the owner should qualify the problem better in order to overcome this inertia.

Out-of-sequence conditions exist throughout a project but only a few are in the active state at any given status update. As just stated, correcting inactive out-of-sequence status is very time consuming and error prone. It is reasonable to state that only active out-of-sequence activities should be considered for fixing or correction to the logic or activity during a schedule update.

As a side note, it should be noted that RP 29R-03, Forensic Schedule Analysis (MIP 3.9) [7] is based partly on correcting the logic of <u>all</u> as-built out-of-sequence activities (even the inactive ones) to model the as-built condition in an as-planned state. Such extensive modifications on large project CPM schedules reasonably requires an automated response using an algorithm to decide which logic to adjust.

Test for Importance

There is a quick check that a reviewer using P6 Professional software can make to see if the out-of-sequence condition is significant. AACE recommends that P6 Professional users use the Retained Logic CPM calculation mode[3] to best measure predicted project completion. The reviewer can first note the calculated project completion date using retained logic and then temporarily change the calculation mode to progress override and recompute the schedule. If the project completion date does not change, then one can assume that the out-of-sequence condition was not significant. This test should also be applied to required contractual milestones.

If the date does change, then perhaps a logic modification is appropriate.[8] After making this what-if test, the CPM calculation mode should revert to progress override and be recalculated.

Status Considerations

Another reason for creating out-of-sequence conditions is the scheduler failing to not status the predecessor activity as complete according to CPM logic. Work that is complete enough to allow the successor work to proceed to completion without hindrance should be statused as complete and the remaining work transferred to later

13

clean-up work such as the punchlist. As far as CPM theory is concerned, the successor work is not proceeding out-of-sequence[7].

Using the Wrong Tool

Before correcting for out-of-sequence conditions, the scheduler should first define what the CPM schedule is supposed to reflect. Is the primary goal of a CPM schedule to accurately predict project completion and to indicate activity total float or is the purpose of a schedule to be able to create a three-week lookahead work schedule depicting exactly what work will be accomplished and when?

Perhaps some people are using CPM software to create graphics when a different medium is more appropriate. Even before CPM software on microcomputers was available, schedulers used to hand-draw their 3-week look-ahead schedule. Using computer spreadsheet software to automate this process has refined this practice further. Without using CPM software, a typical three-week schedule created with a spreadsheet program is depicted in Figure 17 below.
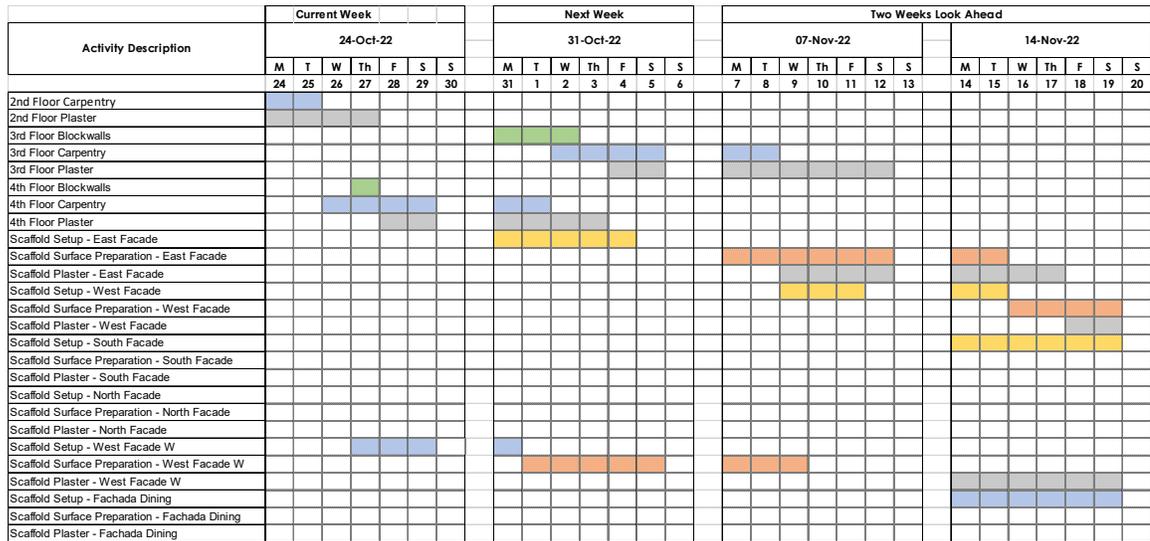
Activity Description	Current Week 24-Oct-22							Next Week 31-Oct-22							Two Weeks Look Ahead 07-Nov-22							14-Nov-22						
	M 24	T 25	W 26	Th 27	F 28	S 29	S 30	M 31	T 1	W 2	Th 3	F 4	S 5	S 6	M 7	T 8	W 9	Th 10	F 11	S 12	S 13	M 14	T 15	W 16	Th 17	F 18	S 19	S 20
2nd Floor Carpentry	█	█																										
2nd Floor Plaster			█	█	█																							
3rd Floor Blockwalls								█	█	█																		
3rd Floor Carpentry											█	█	█		█	█												
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4th Floor Blockwalls				█																								
4th Floor Carpentry				█	█	█	█			█																		
4th Floor Plaster			█	█	█																							
Scaffold Setup - East Facade								█	█	█	█	█																
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Scaffold Surface Preparation - West Facade																									█	█	█	█
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Scaffold Setup - South Facade																	█	█	█	█	█							
Scaffold Surface Preparation - South Facade																												
Scaffold Plaster - South Facade																												
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Scaffold Plaster - North Facade																												
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Scaffold Surface Preparation - West Facade W										█	█	█			█	█												
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Scaffold Surface Preparation - Fachada Dining																												
Scaffold Plaster - Fachada Dining																												

Figure 17 - Three-Week Lookahead Schedule Using a Spreadsheet

What If Creating a 3-Week Look-Ahead Schedule is Not an Issue?

If creating a three-week look-ahead graphic using CPM software is not required, then the question of fixing out-of-sequence becomes a matter of what process best predicts current activity float and program completion. When the schedule is calculated using retained logic, then out-of-sequence conditions will automatically reflect the suspension

of out-of-sequence work in favor of first completing the earlier work. While this may not be the work supervisor's intention for the immediate future, it preserves the original resource usage, activity float, and overall project timing.

What are the Dangers of Correcting Out-of-Sequence?

If out-of-sequence conditions are corrected to reflect the continuation of the work on the successor activity, then depending on how it is corrected will expose the schedule to the risk of calculating less accurate project float and project completion dates. Such corrections may infer a change in the inherent resource usage plan: for example, planning for two crews working simultaneously instead of just one working in series. Adjustment to the logic without an actual change in the workplan can affect the activity's total float. This questions whether float is just a concept that can be looked at in different ways or does it have a real, concrete meaning regardless of viewpoint.

Another forensic concern is that the schedule modification may codify contractor delays or errors, obfuscating delay responsibility. In particular, adjusting logic to finished activities displaying inactive out-of-sequence behavior will never display the underlying consequences of the adjustment to the as-planned condition. Once status is removed, what are the calculated changes to the total float? If the schedule's status is changed in completed activities, does the new logic create a new, different longest path?

The main purpose of a project CPM schedule is to predict the earliest project completion time and to communicate the schedule's status to the project stakeholders. If something is done to the schedule that worsens communication and hurts the predictive accuracy of the project schedule, then this is a bad change.

The scheduler's job does not normally include making a digital twin of project construction. To do this would require much more time and resources than currently employed. It would also require more access to the means and methods of the contractor than is normally allowed. The current use of a CPM schedule is for planning. It is not a daily diary.[9]

What are the Dangers of NOT Correcting Out-of-Sequence?

Not correcting an out-of-sequence issue can result in the loss of confidence in the schedule by some stakeholders. If a stakeholder is monitoring work progress of activities depicting a work-gap in the schedule due to out-of-sequence progress, the

invested person will feel that the schedule is not working properly. It will be challenging to explain the cause and effect of out-of-sequence progress when the stakeholder sees a discrepancy between the work in the field and that listed in the current schedule.

Sometimes the contract requires the fixing of out-of-sequence. It is possible that a contract would require the contractor to fix all out-of-sequence conditions. This would be unusual, as most project owners resist the contractor making logic changes after the project begins for fear of schedule manipulation of float and the accompanying responsibility for any delays that might occur. Knowing the near impossibility of fixing all out-of-sequence conditions, the contractor could request relief from this requirement. At the very least, the contractor should only be concerned with fixing active out-of-sequence conditions.

Rules for Correcting Out-of-Sequence

From the above discussions, it is possible to generalize a simple set of rules to help determine the fitness of a logic or activity change to correct out-of-sequence progress. A list of such suggested rules are as follows,

1. Retained logic CPM calculation mode (or the software equivalent) should be used to properly calculate activity float and project completion.
2. Maintaining the correct project completion date is more important than properly displaying the actual, current work.
3. Changes made to logic due to out-of-sequence progress should not assume resource increase unless specifically stated in the narrative.
4. Changes made to the schedule due to out-of-sequence progress should not modify the active activity's total float from that before the correction was made.
5. Descriptions of the corrections made due to out-of-sequence progress should be included in the schedule update's narrative.

Conclusion

This paper introduces the issue of what happens when CPM schedules are statused in violation of the existing sequential logic, or out-of-sequence status. The resulting situation when CPM calculation rules create a gap in planned work to accommodate finishing of predecessor work has prompted people to desire to fix this issue. It briefly outlines where fixing the conditions resulting from out-of-sequence falls in the professional consensus.

Several suggested solutions are presented here, depending upon factors such as independent or dependent shared resources, software suspending the predecessor activity, simple indirect out-of-sequence, a series of indirect out-of-sequence, and inactive out-of-sequence. Appendix A briefly describes some of the terminology used here.

The real question to fixing out-of-sequence conditions is when and where is it appropriate to do so. A test of importance to the overall schedule is presented. Perhaps the cause of the out-of-sequence condition is the result of incorrectly applying activity status in a manner that is not appropriate for CPM schedules. Perhaps the wrong tool is being used. A CPM schedule may not be the correct software to solve some scheduling requirements.

This paper considers the possible ramifications of correcting the out-of-sequence condition in a CPM schedule. It also considers the dangers of not correcting it.

CPM software producers should ensure that the suspension of any activity automatically removes any uncompleted portion of the suspended activity from interfering with the immediate start of any follow-on activity. This would automate the fixing out-of-sequence work suspensions.

Finally, some generalized guidelines are presented to discovering and correcting out-of-sequence instances in a CPM schedule. These guidelines would make a good beginning toward defining rules to govern the issue of how to fix out-of-sequence in a CPM schedule.

Out-of-sequence progress is quite common on most construction projects. It is not reasonable to expect the project scheduler to remove all instances of out-of-sequence progress from the CPM schedule. Modifying the logic to inactive out-of-sequence activities can be a herculean task and calls into question the resulting CPM calculations, should the schedule later be modified to reflect an as-planned condition. Project specifications that require all out-of-sequence conditions to be corrected are typically impossible to execute economically.

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[7] Recommended Practice 29R-03, FORENSIC SCHEDULE ANALYSIS, AACE International, Latest revision.

[8] Blog post: "What is the recommended Setting before doing F9 (General Scheduling Option)-Primavera?", Christopher (Chris) Carson CEP DRMP PSP FAACE, November 12, 2023, https://communities.aacei.org/discussion/what-is-the-recommended-setting-before-doing-f9-general-scheduling-option-primavera-1 ,

[9] "CPM in Construction Management, Sixth Edition", James O'Brien & Frederic Plotnick, 2006, Section 36.2, CPM Out-of-Sequence Methodology, Pg. 572-574.

The Author

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Appendix A – Out-of-Sequence Conditions

There are different, appropriate corrections to out-of-sequence status available, depending on the particular out-of-sequence condition. Previous papers have described such conditions and if the reader is to fully understand the proper correction, it is imperative to first understand the type of out-of-sequence conditions. These conditions have been addressed in earlier papers[1] and a very short recap is presented below.

Active versus Inactive Out-of-Sequence Logic

To illustrate the condition of out-of-sequence progress, Figure A1 below shows a simple two-activity CPM schedule with Activity A ready to start at the current data date as show as a darker line. Each vertical line represents a scheduling unit, such as a day. Activity B is scheduled to logically start as soon as Activity A finishes using a finish-to-start, zero lag logic.
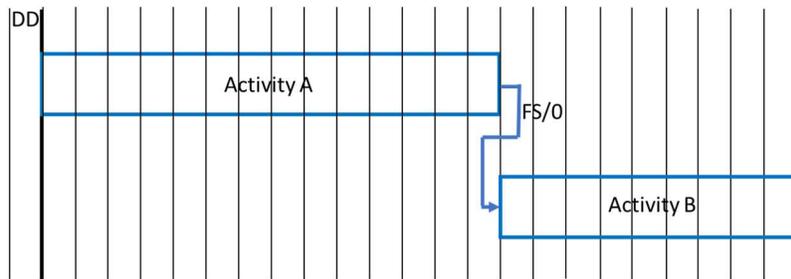
Figure A1 - Simple CPM schedule Before Status

If an activity with logical predecessors starting earlier that logic allows is still uncompleted, then the condition is said to be active and the work gap causing result of retained logic is active. Figure A2 below demonstrates this condition.
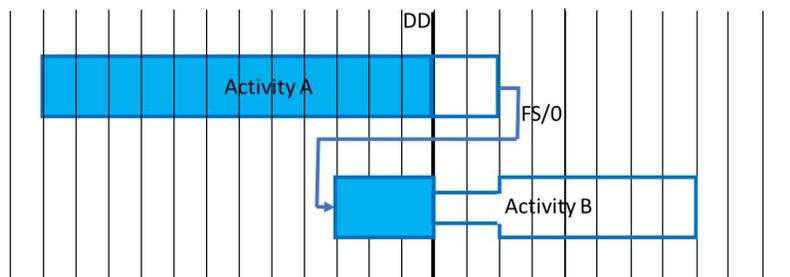
Figure A2 - CPM Schedule Showing Out-of-Sequence

The 'work gap' phenomena in CPM schedules is partly the result of the schedule's status date. The out-of-sequence condition may exist (i.e., an activity started earlier that the predecessor logic allowed) in the past but the late-finishing activity is currently statused as complete. Though the condition exists, it no longer affects the current scheduling of uncompleted activities. The condition is said to be inactive out-of-sequence. See Figure A3 below for an illustration of this.
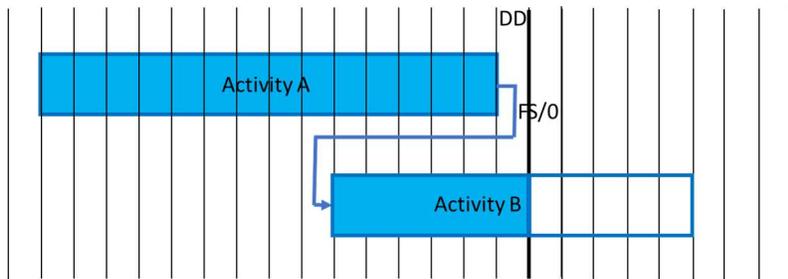

Figure A3 - CPM Schedule Showing Inactive Out-of-Sequence

Direct versus Indirect Out-of-Sequence Logic

The out-of-sequence condition causing a work-gap is fairly easy to identify visually in Gant Charts. It becomes much harder to note the origin of the issue (in this case, Activity A not having an actual finish) when the out-of-sequence condition travels through completed intermediary activities such as shown in Figure A4 below. Activity B is out-of-sequence to Activity A, even though is not out-of-sequence to its immediate predecessor Activity C.
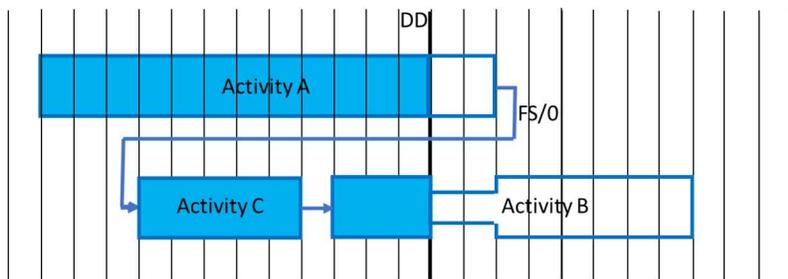

Figure A4 - CPM Schedule Showing Indirect Out-of-Sequence