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Delay Analysis Techniques Comparison

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Abstract

Many techniques have been used in the courts to demonstrate the criticalities of a delay event on the project schedule. At this time, there is no standard method to analyze a delay claim. This paper first introduced a fictional case study that has most types of delay and acceleration events that might be faced on a real project. The case study is applied to all current techniques of delay claims that have been identified from previous studies. The comparison uses the delay claim issues as criteria to evaluate all the delay claim techniques from the case study results. The case study result and discussion demonstrate that the Day-by-Day technique satisfies all the desired criteria while other techniques lack some.

Keywords

Construction, Scheduling, Claim, Delay, CPM

1. Introduction

Many techniques have been used in the courts to demonstrate the criticalities of a delay event on the project schedule. At this time, there is no standard method to analyze a delay claim. The recent court case of R.P. WALLACE, INC., Plaintiff, v. THE UNITED STATES, Defendant (R. P. WALLACE, 2004), proved the differences on the outcomes resulting from variation delay analyses:

> Both parties relied heavily on experts, who used critical path method analysis … to apportion the causes of the 305 days of project delays encountered here. Plaintiff's expert, Mr. Ostrowski, attributed 98 of those days to plaintiff and 207 to defendant, while defendant's expert, Mr. Weathers, attributed 250 days of delay to plaintiff and 55.

This paper discusses the differences in outcomes resulting from these techniques in responding to the common delay analysis issues that have been identified. This paper uses a case study that represents most of these issues to show how these techniques respond differently.

2. The Case Study Analysis

To explain the different outcomes from the current delay analysis techniques, a case study is used for comparison. The case study is designed to test most common scheduling issues. The case study has 16 activities; thus the project size is enough to show the complexity of large network. The activity, duration, and independent relationships are shown in Figure 1, which depicts the project schedule Network. To depict the actual project progress, the delay, acceleration, and change order events are adjusted in the As-Planned schedule, as shown in Figure 2. All As-Built delayed/accelerated event details are depicted in the bar chart from starting, ending, and duration as they occurred in each activity. Table 1 shows the final analysis results grouped by the delay responsibility types. Because of size limitation, the complete case study analysis schedules, results tables, and discussion refers to Al-Gahtani (2006).

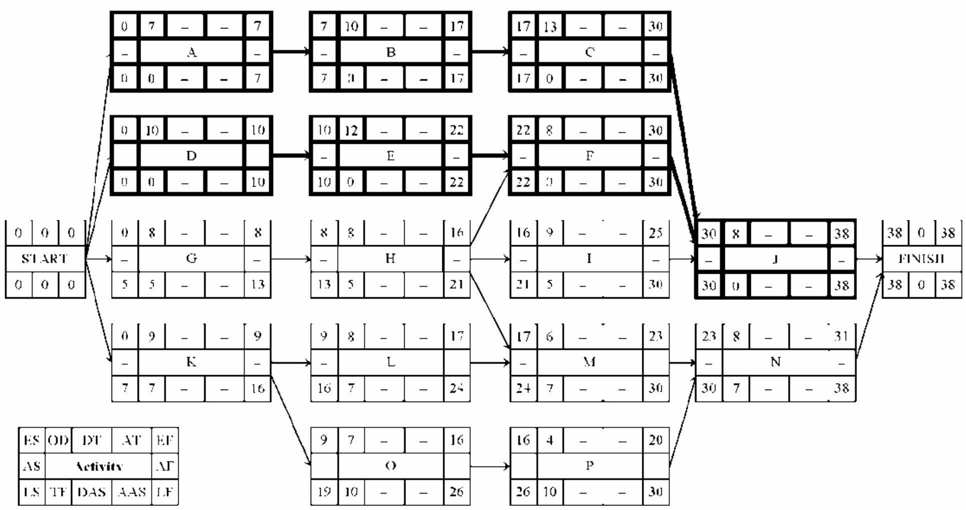

Figure 1: As-Planned CPM Schedule of the Case Study

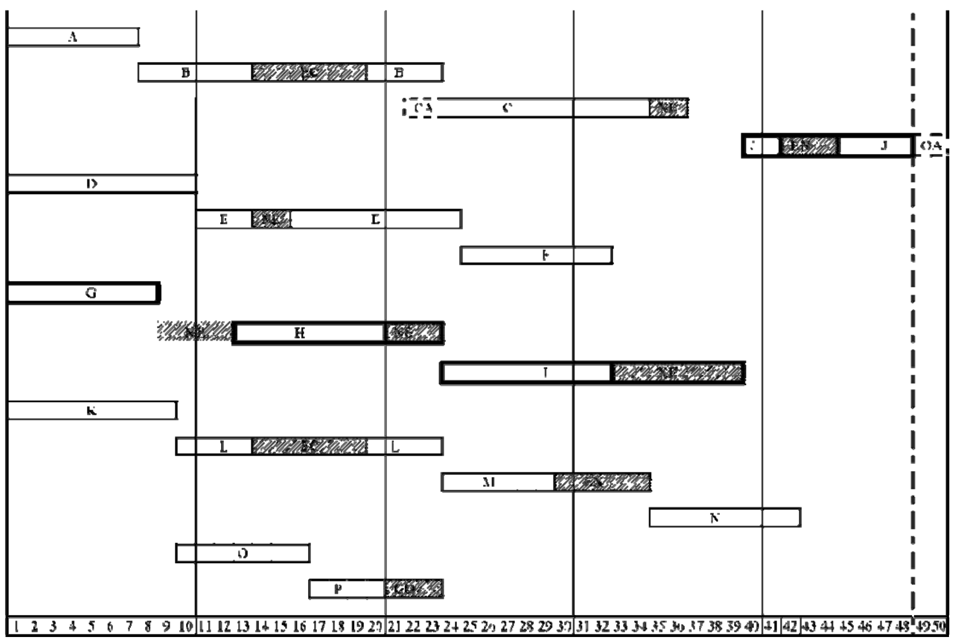

Figure 2: As-Built Bar Chart Schedule of the Case Study

Legends:
ES = Early start, LS = Late Start, AS = Actual start, DT = Delayed Time, DAS = Delayed Activity Start, EF = Early Finish, LF = Late Finish, AF = Actual Finish, AT = Accelerated Time, AAS = Accelerated Activity Start,
TF = Total Float, OA = Owner Acceleration, NE = Nonexcusable Delay, EN = Excusable Noncompensable Delay,
CA = Contractor Acceleration, EC = Excusable Compensable Delay, CO = Change Order.

Table 1: Results of Techniques Example

No.	Delay Analysis Technique	Project Delays (Days)					Total Float Delays	
		EC	NE	EN	Concurrent	Total Delay	EC	NE
1	Global Impact	12	18	8	–	38	–	–
2	As-Planned (Gross of Measure)	4	9	3	–	–	–	–
3	As-Planned (Unite of Measure)	4	8	3	–	–	–	–
4	As-Built	4	6	3	–	–	–	–
5	Impacted As-Planned	4	0	3	–	–	–	–
6	Time Impact	4	9	3	–	–	–	–
7	But For (Gross of Measure)	0	5	3	–	–	–	–
8	But For (Unite of Measure)	0	6	3	–	–	–	–
9	Isolated Delay Time (IDT)	6	9	–	–	–	–	–
10	Window/Snapshot	5	7	3	0	13	–	–
11	Window/But For	3	5	3	–	–	–	–
12	TF Management (Easy-Rule)	2	3	3	2	–	6	2
13	TF Management (Fair-Rule)	3	4	3	2	–	6	2

Legends:
NE = Nonexcusable Delay, EN = Excusable Noncompensable Delay, and EC = Excusable Compensable Delay.

2.1 Global Impact Technique

Global Impact Technique is the simplest technique to analyze construction delay claims (Alkass *et al.*, 1996). It considers that all delay events have an equal impact on delaying the project, which is not realistic. As a result, the Global Impact technique can be done without considering the project schedule. By applying the Global Impact Technique on the case study, the result is 38 delayed days, as shown in Table 1. The 38 delayed days result from summarizing all of the delay events of the project, regardless of their criticality or their delay types.

2.2 As-Planned Technique

The As-Planned technique uses the As-Planned schedule as a baseline to analyze delay claims (Callahan *et al.*, 1992). As-Planned schedule, in the publication, includes two known methods to implement the As-Planned technique; they are “Unit of Measure” and “Gross of Measure” (Bubshait and Cunningham, 1998). In the “Gross of Measure,” all of the delay events that one of the project parties is responsible for are imposed together on the As-Planned schedule. By doing so, the overall impact of the As-Planned schedule in the completion of the project is determined to know the responsibility of one party in delaying the project. The other method of implementing the As-Planned technique is the Unit of Measure. This method differs from the Gross of Measure in that the As-Planned schedule is impacted for each delay/acceleration event, rather than for events grouped together in one analysis step. In general, the As-Planned Technique fails to address several issues. It does not address properly the real time of delaying the events, because its analysis could be based on a critical path that might be different from the actual project schedule. This happens because the technique considers one type of delay events and ignores others. Furthermore, the technique fails to address the concurrent delay issues present in the case study. Giving the owner and the contractor credit for their acceleration is addressed by this technique; however, not considering the real time delay may give rise to a situation in which the contractor could not receive credit for its acceleration while the owner does, as was evident in the case study example. Finally, the method addresses only critical path delay (noncritical path delay is not accounted for in this method) but does not provide adequate guidelines for float consumption. Therefore, the contractor could consume the float to create a pacing delay situation.

2.3 As-Built Technique

The As-Built Technique uses the As-Built schedule as a baseline for analysis. Previous research has introduced two methods for implementing the As-Built technique of analysis (Bubshait and Cunningham, 1998; Callahan *et al*., 1992). One method is to compare the actual start and finish dates for each activity against the As-Planned dates (Callahan *et al*., 1992). Table 1 shows both the As-Planned and As-Built schedule dates. However, only a first comparison of the delayed activity on the schedule can give an indication about the real time impact of the delayed/accelerated events. Once the As-Planned schedule is impacted for the first delayed/accelerated event, all the early and late dates of successor activities consequently will be changed. As a result, comparing the As-Built dates with As-Planned dates for those successor activities cannot indicate whether or not the activity was on time. Accordingly, the true comparison should be made immediately before and after the impacted delayed/accelerated events on the schedule, as shown in the next improved technique.

The second method to implement the As-Built technique of analysis is to consider the Total Float (TF) impacted as a result of impacting the schedule (Bubshait and Cunningham, 1998). The TF of the As-Planned schedule is impacted by all the delayed/accelerated events for each impacted activity. Therefore, the new value of after the impact TF is calculated by using the following equation:

$$\mathbf{TF_{As\text{-}Built} = TF_{As\text{-}Planned} - Delayed/Accelerated\ Days} \qquad \text{(Equation 1)}$$

A negative As-Built TF value indicates that the impacted event affect delays the overall project completion by a number of days equal to that negative value. In case of having two impacts on the same activity, the TF will be impacted twice, one at a time, as shown in Activities C, H, and J. After determining all the As-Built TF for all affected activities, all the project delays/accelerations are added and grouped based on their responsible party, as shown in Table 1.

Because the two techniques provide similar results, the As-Built technique addresses the delay analysis issues in a manner similar to the As-Planned technique. The technique however, does not consider the real time events because it analyzes the delayed/accelerated events individually. Therefore, the real time critical path is ignored. For the same reason, the technique does not consider the concurrent delay issue. Moreover, the technique does not track the total float change or assign parties' responsibilities for consuming the total float. As a result, the method does not solve the pacing delay issue. However, the technique considers owner and contractor project acceleration.

2.4 Impacted As-Planned Technique

The Impacted As-Planned technique provides a delay analysis method that is more developed than the As-Planned and As-Built techniques (Trauner, 1990). It considers all the real time delay/acceleration events immediately before they occur. However, because the method considers only the delays/acceleration of the As-Planned critical path(s), the technique fails to address the shift of the critical path to noncritical path. Consequently, the technique does not address the real time status of delaying event properly. Besides, the concurrent delay is not considered by the technique because it ignores other critical path(s). Even in a situation in which two As-Planned critical paths are involved, the technique handles each path separately; thus, concurrent delay is overlooked, which is the situation in the case study example. The impact of delaying and accelerating the events of activities B, E, C, and J only have been considered by this technique because they are critical on the As-Planned schedule of the case study.

Some conclusion can be drawn from analyzing the case study by the Impacted As-planned technique. Although the technique tries to consider the real time delayed/accelerated events by including previous delayed/accelerated events before starting any analysis, it fails to consider the real time impact because of ignoring the shifting of the critical path and analyzing the parallel events separately. This separate analysis leads to overlooking the concurrent delay. In addition, because of the absence of a guideline for float consumption, the technique fails to address the pacing delay issue. However, the analysis considers the owner's and contractor's acceleration if they occur only on the As-Planned critical path.

2.5 Time Impact Technique

The Time Impact Technique is similar to the Impacted As-Planned Technique in considering the schedule impact prior to the analysis of any delayed/accelerated event. However, the Time Impact Technique is developed one notch more than the Impacted As-Planned schedule because it is taking into account all possible new developed critical path(s) prior to analyze each of the delayed/accelerated events. The technique updates the As-Planned schedule with As-Built data before starting any analysis of the delayed/accelerated events. The result is an Updated Analysis Schedule that reflects the real time impact and the actual critical path for the analyzed event. This Updated As-Planned schedule then is impacted with the delay event in question and its relevant activity. Following this, a comparison is made of the schedule before and after the impact to determine the effect of this event on the actual overall project completion (Alkass *et al*., 1996). The final result of each responsible party is grouped and added based on project parties' responsibilities, as discussed with previous techniques.

Although the Time Impact Technique considers the real time impact and acceleration issues, it fails to address the issue of concurrent delay and pacing delay. Two concurrent delay situations are observed in the case study and they are solved improperly (Al-Gahtani, 2006).

2.6 But-For Technique

The But-For Technique follows an analysis approach different from those of previous techniques. The previous techniques try to analyze the delay by imposing the delay/accelerated events on the analysis schedule as they occur in a forward matter, in trying to track the real critical path. However, the techniques fail to assess the concurrent delay accurately. The "But-For" technique uses a backward concept rather than a forward approach (Popescu-Kohler, 1998). In order to assess a delay/acceleration impact on delaying a project, this technique collapses the events in question from the As-Built schedule to show how the schedule has been impacted by these specific (but-for) events. Generally, the technique solves the concurrent delay issue. However, by not considering the change of critical path during the project, it solves the concurrent delay only if the critical path does not change during the project, as will be discussed later. Previous studies have introduced two methods to implement this technique: the "Gross of Measure" and the "Unit of Measure" (Trauner, 1990). The Gross of Measure method measures the delay by collapsing grossly (at one time) from the As-Built schedule all the delay/acceleration events related to a project party. The Unit of Measure, another method of implementing the But-For technique (Trauner, 1990), measures the delay by collapsing each of the delayed events individually. Then, it groups the results according to the project party responsible for delay. Table 1 shows the results of the analysis using this method, which produced three final outcomes.

In reviewing the But-For technique analysis results, many interpretations can be deduced. The But-For technique does not consider either the real time delay or the project acceleration issues in their analysis as proved by Al-Gahtani (2006). The inaccurate results of this analysis relate to the fact that the As-Built critical path is the sole path considered in the analysis. Finally, the technique does not solve the pacing delay issue due to the absence of float consumption regulations.

2.7 Window-Isolated Delay Type (IDT)

The Isolated Delay Type (IDT) is a technique that utilizes the Window concept to track the critical path changes (Alkass *et al*., 1996). Although it also attempts to solve the concurrent delay issue by isolating the delay type based on the determination of the responsible party, in different analysis schedules, it fails to assess the concurrent delay. The analysis starts by dividing the project schedule into segments of window periods. These periods are defined based on the number of delayed events that have occurred, and that in turn might change the critical path. In the case study, there are three such window periods: 0–16, 16–32, and 32–48.

The parties' delay responsibilities for each window are determined by comparing the two project completion dates analysis schedules. The owner analysis schedule for each window considers the EC delayed events only before and after impacting the window period. Before starting any window analysis, any EN delayed events that occurred before starting the window should be added to the owner analysis. Any changes to the project sequence that occurred during the analysis window also should be adjusted. The contractor analysis follows the same steps as the owner analysis, except that it considers only the NE delayed events and overlooks the EN and EC delayed events.

2.8 Windows-Snapshot Technique

The Snapshot Technique, another method that uses the window concept as a manner of analysis, does not specify one method to analyze the window delay schedule (Alkass *et al.*, 1996). To follow a specific method in the case study, any delayed events in the snapshot window critical path would be the cause of the project delay on that window. Therefore, the case study has been divided into three window periods similar to those that have been used in the IDT analysis (0–16, 16–32, and 32–48 days). Table 1 shows the final analysis results of the Snapshot technique. The delay in the project for each window is determined by comparing the project completion dates for each snapshot window, before and after the delayed events on each window segment. The three types of delay for each snapshot window are deduced by observing the delayed events on the critical path of each window schedule. Any delayed events that fall on the critical path within the snapshot window therefore are considered critical delays. Finally, the concurrent delay is observed visually in each snapshot window when two incidents occur on the critical path(s).Three analysis results are obtained from applying the Snapshot technique to the case study.

The accuracy of the Snapshot technique in solving the real time issue is questionable. Although the technique tries to use the window concept to solve the real delay issue, sometimes it fails to quantify it accurately due to the vagueness that characterizes the technique's definition of window intervals, as illustrated by Al-Gahtani (2006). In addition, the accuracy of determining the concurrent delay is affected equally by the vague definition of window periods (Al-Gahtani, 2006). Due to the difficulties of tracking the critical paths, this technique is less accurate for solving the concurrent delay issue. Finally, the last two delay analysis issues, acceleration and pacing delays, are not solved by this technique (Al-Gahtani, 2006). In sum, this method does not provide a systematic approach to analysis and can lead to misleading analysis results, especially by increasing the schedule network complexity.

2.9 Window-But-For Technique

The concept of Window-But-For technique integrates two delay analysis concepts, Window and But-For (Baram, 2000; Schumacher, 1995; Schumacher, 1997). It used the window concept to track the critical path during the project in order to determine the real time delay status. Simultaneously, it used the But-For or the collapsed concept to determine the delay impact for each window analysis. By doing so, the integrated technique solves the disadvantage of the previous two techniques. Applying Window-But-For technique in the case study, three window analysis periods, 0–16, 16–32, and 32–48, have been applied. The analysis results can be deduced by comparing the project completion dates of the two analysis schedules, before and after the collapsed delay events that need to be analyzed. The analysis is repeated and summarized for each project party: the owner, the contractor, and the third party.

The final results of the Window-But-For technique show that it solved the most common delay analyzing issues: real time delay and concurrent delay. However, the technique fails to address the acceleration and pacing delay issues (Al-Gahtani, 2006). From the discussion of previous techniques, the Window-But-For method is considered the most accurate because it solves the two most common issues in delay claim analysis: real time and concurrent delay. However, the technique can reach a more accurate result by solving the acceleration responsibilities and incorporate it in the analysis. Such analysis can be achieved by imposing the activities' acceleration events into the analysis schedule instead of collapsing it. This solution can be applied to the case study, and then accurate results would be reached that are compatible with the Day-by-day technique results.

2.10 Day-by-Day/TF Management Technique

Day-by-Day technique is a detailed method that aims to track the real time delay, concurrent delay, acceleration, and float consumption issues as they happened day-by-day (Al-Gahtani and Mohan, 2007). It is more accurate than window techniques because it follows a daily analysis approach for analyzing the real time delay, concurrent delay, acceleration, and float consumption, and can be utilized to eliminate any disentitled float consumption, such as pacing delay. Besides, the technique can analyze the concurrent delay by using two concurrent rules: Easy-Rule and Fair-Rule (Kraiem and Diekmann, 1987). The difference between the two rules is that the Fair-Rule allows apportioning of the concurrent delay, while the Easy-Rule does not. The concurrent delay by using Easy-Rule is determined as an excusable delay for the contractor and a noncompensable delay for the owner. The Easy-Rule has been followed by the previous techniques and most U.S. courts, despite providing less accurate results. The rule implies that in the concurrent delay situation, the value of compensable damages can be offset by the value of liquidated damages, which is an inaccurate comparison.

Simultaneously, analyzing the project delay that included the concurrent delay analysis, the float consumption also has been analyzed by using the Day-by-Day analysis approach. As a result of delaying the project by concurrent delay, the total floats of the parallel noncritical path also are affected. The analysis of total float uses only Fair-Rule when analyzing the float consumption. Accordingly, the float consumption analysis results of Table 1 are identical for both rules.

3. Summary of the Comparison

Thirteen outcomes were obtained by applying 10 different techniques on a case study example, as shown in Table 1. As seen in the Table, the only delay analysis technique that allows tracking of the disentitled float consumption is the Day-by-Day/TF Management technique. By comparing the results on Table 1, it can be argued that the day-by-day method comes first, followed by the window/but technique in terms of their analysis accuracy. These two techniques are the only techniques that properly address the most common issues of delay analysis, those of real time and concurrent delays. Table 2 shows a comparison among all delay claim techniques. It should be noticed that the window/snapshot technique addresses the delay claim issues, however, with questionable accuracy, as mentioned before.

4. Conclusion

Ten techniques have been evaluated by using a case study. None of the current techniques responds accurately to all of the four common delay issues: real time delay, concurrent delay, acceleration, and pacing delay. The "Window/But-for" technique is found to be fairly accurate; however, it needs to be adjusted to account for accelerations. The Day-by-day technique or Total Float Management technique is the only method that can solve the issue of pacing delay sufficiently because of its ability to track the float consumption for each of the project parties. In addition, the technique is the only one that has the ability to apply the two rules of concurrent delay. Moreover, the technique follows a systematic day-by-day approach that provides accurate results, as well as the ability to be computerized, which in turn increases the analysis accuracy.

Table 2: Comparison of Current Techniques on Delay Types Used

Delay Analysis Techniques	Real time Delay	Concurrent Delay	Acceleration Credit	Pacing Delay
Global impact	×	×	×	✓
As-Planned	×	×	✓	×
As-Built	×	×	✓	×
Impacted As-Planned	✓	×	✓	×
Time impact	✓	×	✓	×
But-for	×	✓	×	×
Window-IDT	×	×	×	×
Window-Snapshot	✓*	✓*	×	×
Window-But For	✓	✓	×	×
TF Management	✓	✓	✓	✓

* Less accurate

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