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Time Impact Analysis in Windows– Concurrency Analysis

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Abstract–Time Impact Analysis in Windows (TIA) is recognized as one of the most credible techniques for analyzing construction delays according to AACE MIP3.7 Recommended practice 29R-03. This type of analysis was used to produce a concurrency analysis to prove contractor entitlement to prolongation costs. The critical path was investigated in a similar way to the Time Slice method. After investigation, fragnets were built using supporting documentation. The selection of the updated schedule to be impacted was made based upon the start date of the delay fragnet. The selected updates created the window periods, therefore this method breaks the project into discrete time increments (Windows) and examines the effects of the delays attributable to each project participant as those delays occur.

The TIA in Windows contains elements of retrospective analysis as the project schedule is reviewed in a series of 'snapshots' or 'time slices.' The analysis also contains a prospective analysis as the delays identified are swapped for an element of 'prospective' modelling. The analysis therefore combines a retrospective and prospective view and can be easily used to provide clear demonstration and calculation of concurrency and mitigation. Concurrency analysis using the TIA in Windows method has successfully led to the granting of prolongation costs to contractors.

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Introduction

Claims for Extensions of Time can be presented using many different delay analysis methods as described in AACE International Recommended Practice No. 29R-03 or the Society of Construction Law Delay and Disruption Protocol 2017. Both of those documents are of great help to professionals in terms of the quantification of extension of time entitlement and associated prolongation costs. One topic that makes all professionals unsure however, is concurrency quantification.

Time Impact Analysis (TIA) is a method of calculating the delay to a project based on the delay to project completion. It is normally associated with being a best practice method for assessing a single delay on the critical path of the project schedule current at the time that the delay event occurred, and as such analysis is carried out on a prospective basis. Some professionals will argue that unrealistic results can be created by using TIA on a prospective basis. Splitting the project into windows eliminates this problem and the impact will not exceed the window period.

To help to shed more light on this subject the existing delay analysis method MIP3.7 Time Impact Analysis in Windows was used for the calculation of concurrency.

The sections below describe the steps to produce the results:

- Requirements to start the analysis,
- Preparation work,
- Modelling and Inserting the delay fragnets into the schedule,
- Summarizing the results,
- Conclusion.

Requirements to Start the Analysis

As with every type of analysis, to commence it is necessary to collect the information which is required such as the schedules, all revisions of the baseline schedule, progress updates, any recovery, acceleration, mitigation schedules, etc. Delay events need to be developed and researched from Minutes of Progress Meetings, Monthly Reports, Progress presentations, variation orders or from discussions with the site team.

Preparation Work

Schedules Identification

The preparation stage for the implementation of the analysis is more important than the technique itself. The basics steps to analyzing the schedule should be as follows:

- Identify the Baseline schedule and contemporaneous progress updates.

During this step the analysist needs to review all approved baseline and update schedules. The decision whether to use contemporaneous updates or reconstructed updates needs to be made. Follow the Source Validation Protocol (SVP) 2.1 and SVP 2.2.[1]

- Verify the validity of the schedules.

Export the schedule to excel, for example, and compare the actual dates and progress data to see if it appears to be reasonable and realistic.

The actual dates need to be verified according to the Schedule Updates Protocol SVP 2.3.[2] The actual dates are important, if they are not correct they can impact the critical path and subsequently the critical delay event can change. Any errors or ambiguities in the schedule progress updates should be corrected.

- Select the Window periods.

The selection of the window period depends upon how detailed the analysis is required to be. Preferably one month intervals or in line with the progress updates, however, it must be borne in mind how long the analysis will take – there may not be enough time to carry out 24 windows and equally there may not be so many delay events that such intervals are needed.
Selection of the number of windows depends greatly on the type of project and the number of delay events which need to be introduced into the analysis.

Identify the start of window and end of window schedules – match to the window period. See the example below:

Windows				
Window ID	from (start A)	to (end B)	Window duration	Cumulative Duration
1	01-Feb-13	31-Mar-13	59	59
2	01-Apr-13	31-May-13	61	120
3	01-Jun-13	31-Jul-13	61	181
4	01-Aug-13	30-Sep-13	61	242
5	01-Oct-13	30-Nov-13	61	303
6	01-Dec-13	28-Feb-14	90	393
7	01-Mar-14	30-Jun-14	122	515
9	01-Sep-14	31-Oct-14	61	638
10	01-Nov-14	31-Dec-14	61	699
11	01-Jan-15	28-Feb-15	59	758
12	01-Mar-15	30-Apr-15	61	819
13	01-May-15	30-Jun-15	61	880
14	01-Jul-15	31-Aug-15	62	942
15	01-Sep-15	31-Oct-15	61	1003

Table 1–Windows Duration

[1] AACE International Recommended Practice No. 29R-03
[2] AACE International Recommended Practice No. 29R-03

Very often the start (A) and end (B) of the window match with the monthly progress updated schedules.

Critical and Near Critical Activities

Identify the driving and sub-critical driving activities in each window, for the end of window schedule. The driving activities need to be analyzed within the program for each milestone/section of the project that attracts liquidated damages. See example below:

			Finish Milestones
Window	**Critical Activities**		**System**
	Section 3		
BL	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W1	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W2	DS04CM11401	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W3	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W4	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W5	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W6	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W6	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W6	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W7	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W7	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W7	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower
W7	DS03CC681000	Reinstatement work in all respect (surrounding areas)	03-SBR Tanks
W8	DS03CC681000	Reinstatement work in all respect (surrounding areas)	03-SBR Tanks
W8	DS03CC681000	Reinstatement work in all respect (surrounding areas)	03-SBR Tanks
W9	DS03CC681000	Reinstatement work in all respect (surrounding areas)	03-SBR Tanks
		Actual Completion	
	Section 4		
BL	DS03CP021000	Pipeline - 04 ,4A ,4B (All works - installation & Hydrotesting)	03- SBR Tanks
W1	DS03CP021000	Pipeline - 04 ,4A ,4B (All works - installation & Hydrotesting)	03- SBR Tanks
W2	DS15CM011100	Fixing of Fine Bubble Diffuser	15- SAS Balancing Tank & Pumping Station
W3	DS15CM011100	Fixing of Fine Bubble Diffuser	15- SAS Balancing Tank & Pumping Station

Table 2–Driving Activities

Next the selection and analysis of the delay events become important. Based on the driving activities it is known which activity needs to be impacted in the schedule to drive the completion date on the critical and near critical paths. The delay events introduced to the driving activity table above are shown in the following table:

			Finish Milestones	
Window	Critical Activities		System	Delay Event
	Section 3			
BL	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W1	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W2	DS04CM11401	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	DELAY EVENT DE02
W3	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W4	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W5	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W6	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W6	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W6	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W7	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W7	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	DELAY EVENT DE06
W7	DS04CM11400	Balance Mechanical Works for Completion SBR Blower	04- SBR Blower	
W7	DS03CC681000	Reinstatement work in all respect (surrounding areas)	03-SBR Tanks	
W8	DS03CC681000	Reinstatement work in all respect (surrounding areas)	03-SBR Tanks	
W8	DS03CC681000	Reinstatement work in all respect (surrounding areas)	03-SBR Tanks	
W9	DS03CC681000	Reinstatement work in all respect (surrounding areas)	03-SBR Tanks	
		Actual Completion		
	Section 4			
BL	DS03CP021000	Pipeline - 04 ,4A ,4B (All works - installation & Hydrotesting)	03- SBR Tanks	
W1	DS03CP021000	Pipeline - 04 ,4A ,4B (All works - installation & Hydrotesting)	03- SBR Tanks	DELAY EVENT DE04
W2	DS15CM011100	Fixing of Fine Bubble Diffuser	15- SAS Balancing Tank & Pumping Station	
W3	DS15CM011100	Fixing of Fine Bubble Diffuser	15- SAS Balancing Tank & Pumping Station	DELAY EVENT DE06

Table 3–Driving Activities with the Delay Events Assigned

Delay Events

During projects many delay events can occur which impact the critical paths or near critical paths of the project. Of these there can be delay events which occur in parallel or are modelled to represent additional works. The table below included all delay events, which were introduced into this example:

No.	Delay event	Start date	Finish date	Impacted Activities	Relationships
DE05	DELAY EVENT DE05	6-Feb-13	2-Aug-14	CPCES23340, CPCES23280, CPPFTAAI4, CPPFTAAI3, CPPFTBAI4, CPPFTBAI3	FS
DE01A	DELAY EVENT DE1A	1-Feb-13	13-Nov-13	CPCES24110, CPCES24070, CPCES24090, CPCES24100, CPCES24120, CPCES23220, CPCES23230, CPCES23240, CPCES24020, CPCES23260, CPCSPA1D13, CPCES32550	FS
DE01B	DELAY EVENT DE1B	14-Nov-13	31-Oct-15	CPCES33060, CPCES23260, CPCES23220, CPCES23230, CPCES23240, CPCES33060, CPCIEUEO10, CPCIEUEO63, CPCIEUEO66, CPCIEUEO34	FS
DE07	DELAY EVENT DE07	1-Aug-14	31-Oct-15	CPCES23520, CPCES23580, CPCES23530,CPCES23510, CPCES23540, CPCES23550, CPCES23560, CPCES23570,	FS
DE02	DELAY EVENT DE02	1-Feb-13	31-Aug-14	CPCES31940, CPPTOQLN33, CPPTOQHN24, CPPTOQEN23, CPPTOQVN18, CPCES33060	FS
DE06	DELAY EVENT DE06	12-Apr-13	14-Apr-14	CPCEGA1D2, CPCEGA2D2, CPCEGA3D2, CPCEGB1D2, CPCEGB2D2, CPCEGB3D2, CPCEGC1D2, CPCEGC2D2	FS
DE09	DELAY EVENT DE09	1-Sep-14	11-Jul-15	CPCEGC1D5	FS
DE10	DELAY EVENT DE10	1-Mar-15	31-Oct-15	CPCES31670, CPPFBKWL7, CPUFBKWL7, CPCFBKWL7, CPCFBMAI21, CPCFBNWL9, CPCFBOWL7, CPPFBPCM3, CPCFBMAI19	FS
DE03	DELAY EVENT DE03	1-Feb-13	31-Aug-14	CPCES23340, CPCES23280, CPCES23290, CPCES23270	FS
DE04	DELAY EVENT DE04	1-Feb-13	15-Nov-13	CPCGEN21, CPCES28872	FS

Table 4–Delay Events

The table includes each delay event introduced into this TIA in Windows analysis, including the start date and finish date of the delay event. Each start date and finish date should be supported by the relevant correspondence or actual dates. Before starting to introduce the delay events into the analysis, the activities which were impacted by these delay events should be selected along with the corresponding relationship. After this step the modeling process can start.

Modelling and Inserting the Delay Fragnets into the Schedule

There are 15 windows and 10 delay events in this example which need to be modeled in the schedule. DE03 represents a contractor delay event in this example. The example is based on a historic project and therefore the names of the delay events and the impacted activities in the schedule were removed and replaced with numbers only.

Window 1

The model will start from window 1 were it is necessary to insert 5 delay events as these all started during the window 1 period.

W 1		WINDOWS DAYS		W1 59
	DELAY EVENTS	**DELAY START DATE**	**DELAY FINISH DATE**	**Feb-13**
DE05	DELAY EVENT DE05	6-Feb-13	2-Aug-14	
DE01A	DELAY EVENT DE1A	1-Feb-13	13-Nov-13	
DE02	DELAY EVENT DE02	1-Feb-13	31-Aug-14	
DE03	DELAY EVENT DE03	1-Feb-13	31-Aug-14	
DE04	DELAY EVENT DE04	1-Feb-13	15-Nov-13	

Table 5–Window 1 Schedule Analysis

Each of the delay events was introduced separately into the schedule, for example delay event DE05 impacted the activities noted in Table 4 with a Finish Start relationship. The duration of window 1 in this case was 59 days so the duration of the delay event will not exceed 59 days. The impact based on this delay event was then marked in the simple excel sheet table shown below:

Milestones		Windows				
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013		
		Date	*D*	*Date*	*D*	*M*
Section 3	29-Apr-13	29-Apr-13	-	26-Jun-13	58	
Section 4	31-May-13	31-May-13	-	29-Jul-13	59	
Section 5	31-Aug-13	31-Aug-13	-	28-Oct-13	58	
40 MLD	6-May-14	1-Jul-14	56	10-Jun-14	35	(21)
Final Completion	6-May-14	2-Jul-14	57	25-Jun-14	50	(7)
	A	B	C=B-A		D	

Driving Delay

Longest Path

Mitigation

Dates from P6 W1A

Dates from P6 W1B

Remarks:

If C = D » Correct Impacted activity

If C ≠ D » Activity is not on the Longest Path.
Look for another!

Table 6–DE05 Impact in Window 1

The table above is the result of the DE05 impact. It can be seen that DE05 did not impact the Section 3, 4 and 5 milestones, but impacted the milestone 40MLD and Final Completion. Window 1A measures the impact and window 1B shows the updated schedule at the end of window 1.

To be able to get the correct impacted activities, the values in window 1A need to be the same or a higher value than in window 1B. In this example, for DE05 the impact on the milestone was 56 days at window 1A, but at the end of window 1B the impact was only 35 days, which means there was mitigation of 21 days.

The Final Completion milestone was impacted 57 days by DE05, at the end of the window the impact was 50 days, which means there was 7 days mitigation to the schedule.

Window 1 has the other delay events DE01A, 2, 3 and 4. The next step was to measure the impact of each of these in a similar way as for DE05. The results were as shown below:

Milestones		Windows			
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013	
		Date	*D*	*Date*	*D*
Section 3	29-Apr-13	29-Apr-13	-	26-Jun-13	58
Section 4	31-May-13	31-May-13	-	29-Jul-13	59
Section 5	31-Aug-13	28-Oct-13	58	28-Oct-13	58
40 MLD	6-May-14	31-May-14	25	10-Jun-14	35
Final Completion	6-May-14	25-Jun-14	50	25-Jun-14	50

Table 7–DE1A Impact in Window 1

The table above shows that DE1A impacted the Section 5 milestone by 58 days and the delay to this milestone was also 58 days at the end of window 1B.

Milestones		Windows			
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013	
		Date	*D*	*Date*	*D*
Section 3	29-Apr-13	26-Jun-13	58	26-Jun-13	58
Section 4	31-May-13	25-Jun-13	25	29-Jul-13	59
Section 5	31-Aug-13	28-Oct-13	58	28-Oct-13	58
40 MLD	6-May-14	31-May-14	25	10-Jun-14	35
Final Completion	6-May-14	31-May-14	25	25-Jun-14	50

Table 8–DE02 Impact in Window 1

DE02 impacted the Section 3 and Section 5 milestones by 58 days which is the same as the delay shown by the updated schedule at the end of the window 1B.

Milestones		Windows			
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013	
		Date	*D*	*Date*	*D*
Section 3	29-Apr-13	25-Jun-13	57	26-Jun-13	58
Section 4	31-May-13	27-Jul-13	57	29-Jul-13	59
Section 5	31-Aug-13	28-Oct-13	58	28-Oct-13	58
40 MLD	6-May-14	30-May-14	24	10-Jun-14	35
Final Completion	6-May-14	30-May-14	24	25-Jun-14	50

Table 9–DE03 Impact in Window 1

DE03 impacted the Section 5 milestone by 58 days which is the same as the delay shown by the updated schedule at the end of the window 1B.

Milestones		Windows			
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013	
		Date	*D*	*Date*	*D*
Section 3	29-Apr-13	18-Jun-13	50	26-Jun-13	58
Section 4	31-May-13	29-Jul-13	59	29-Jul-13	59
Section 5	31-Aug-13	21-Oct-13	51	28-Oct-13	58
40 MLD	6-May-14	24-May-14	18	10-Jun-14	35
Final Completion	6-May-14	24-May-14	18	25-Jun-14	50

Table 10–DE04 Impact in Window 1

DE04 impacted the Section 4 milestone by 59 days which is the same as the delay shown by the updated schedule at the end of the window 1B.

Based on the above tables it is clear that the Section 3 milestone was impacted as a result of DE02 by 58 days, Section 4 milestone was impacted as a result of DE04 by 59 days, Section 5 as a result of DE1A by 59 days, 40MLD milestone as a result of DE05 by 56 days which was mitigated by 21 days and the final completion milestone as a result of DE05 by 57 days with mitigation of 7 days.

DE03 in this example was a Contractor delay event which impacted the Final Completion Date by 24 days.

Window 2

After window 1, the model continues with window 2 during which 6 delay events needed to be inserted, including the 5 delay events from the previous window 1 and one new delay event that occurred during window 2.

W 1-2		WINDOWS DAYS		W1 59	W2 61
	DELAY EVENTS	**DELAY START DATE**	**DELAY FINISH DATE**	**Feb-13**	**Apr-13**
DE05	DELAY EVENT DE05	6-Feb-13	2-Aug-14		
DE01A	DELAY EVENT DE1A	1-Feb-13	13-Nov-13		
DE02	DELAY EVENT DE02	1-Feb-13	31-Aug-14		
DE06	DELAY EVENT DE06	12-Apr-13	14-Apr-14		
DE03	DELAY EVENT DE03	1-Feb-13	31-Aug-14		
DE04	DELAY EVENT DE04	1-Feb-13	15-Nov-13		

Table 11–Window 2 Schedule Analysis

To create window 2A, window 1B was copied with all the delay events included in window 1 and the file renamed 2A. In the second window the delay events from the previous window were kept and the duration of the delay events extended if ongoing. In this example DE05, 01A, 02, 03 and 04 continued in window 2.

Each delay event was introduced separately into the schedule. Delay event DE05 impacted the activities mentioned in Table 4 with a Finish Start relationship again in a similar way to that of window 1. The duration of window 2 is 61 days so the duration of the delay event will not exceed 61 days.

The impact based on the delay events was then marked in the simple excel sheet tables as before, as shown below:

Milestones		Windows									
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013			W2A Impact		W2B Update 01-06-2013		
		Date	*D*	*Date*	*D*	*M*	*Date*	*D*	*Date*	*D*	*M*
Section 3	29-Apr-13	29-Apr-13	-	26-Jun-13	58		26-Jun-13	-	29-Aug-13	64	
Section 4	31-May-13	31-May-13	-	29-Jul-13	59		29-Jul-13	-	27-Sep-13	60	
Section 5	31-Aug-13	31-Aug-13	-	28-Oct-13	58		28-Oct-13	-	31-Dec-13	64	
40 MLD	6-May-14	1-Jul-14	56	10-Jun-14	35	(21)	10-Aug-14	61	9-Aug-14	60	(1)
Final Completion	6-May-14	2-Jul-14	57	25-Jun-14	50	(7)	10-Aug-14	46	25-Aug-14	61	

Table 12–DE05 Impact in Window 2

Milestones		Windows							
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013		W2A Impact		W2B Update 01-06-2013	
		Date	*D*	*Date*	*D*	*Date*	*D*	*Date*	*D*
Section 3	29-Apr-13	29-Apr-13	-	26-Jun-13	58	26-Jun-13	-	29-Aug-13	64
Section 4	31-May-13	31-May-13	-	29-Jul-13	59	29-Jul-13	-	27-Sep-13	60
Section 5	31-Aug-13	28-Oct-13	58	28-Oct-13	58	27-Dec-13	60	31-Dec-13	64
40 MLD	6-May-14	31-May-14	25	10-Jun-14	35	30-Jul-14	50	9-Aug-14	60
Final Completion	6-May-14	25-Jun-14	50	25-Jun-14	50	25-Aug-14	61	25-Aug-14	61

Table 13–DE01A Impact in Window 2

Milestones		Windows							
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013		W2A Impact		W2B Update 01-06-2013	
		Date	*D*	*Date*	*D*	*Date*	*D*	*Date*	*D*
Section 3	29-Apr-13	26-Jun-13	58	26-Jun-13	58	29-Aug-13	64	29-Aug-13	64
Section 4	31-May-13	25-Jun-13	25	29-Jul-13	59	17-Sep-13	50	27-Sep-13	60
Section 5	31-Aug-13	28-Oct-13	58	28-Oct-13	58	31-Dec-13	64	31-Dec-13	64
40 MLD	6-May-14	31-May-14	25	10-Jun-14	35	3-Aug-14	54	9-Aug-14	60
Final Completion	6-May-14	31-May-14	25	25-Jun-14	50	3-Aug-14	39	25-Aug-14	61

Table 14–DE02 Impact in Window 2

Milestones		Windows			
Milestones	W1B Dates	W2A Impact		W2B Update 01-06-2013	
		Date	*D*	*Date*	*D*
Section 3	26-Jun-13	29-Aug-13	64	29-Aug-13	64
Section 4	29-Jul-13	27-Sep-13	60	27-Sep-13	60
Section 5	28-Oct-13	31-Dec-13	64	31-Dec-13	64
40 MLD	10-Jun-14	3-Aug-14	54	9-Aug-14	60
Final Completion	25-Jun-14	3-Aug-14	39	25-Aug-14	61

Table 15–DE06 Impact in Window 2

Milestones		Windows							
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013		W2A Impact		W2B Update 01-06-2013	
		Date	*D*	*Date*	*D*	*Date*	*D*	*Date*	*D*
Section 3	29-Apr-13	25-Jun-13	57	26-Jun-13	58	20-Aug-13	55	29-Aug-13	64
Section 4	31-May-13	27-Jul-13	57	29-Jul-13	59	19-Sep-13	52	27-Sep-13	60
Section 5	31-Aug-13	28-Oct-13	58	28-Oct-13	58	22-Dec-13	55	31-Dec-13	64
40 MLD	6-May-14	30-May-14	24	10-Jun-14	35	25-Jul-14	45	9-Aug-14	60
Final Completion	6-May-14	30-May-14	24	25-Jun-14	50	25-Jul-14	30	25-Aug-14	61

Table 16–DE03 Impact in Window 2

Milestones		Windows							
Milestones	Rev2 Dates 01-02-2013	W1A Impact		W1B Update 01-04-2013		W2A Impact		W2B Update 01-06-2013	
		Date	*D*	*Date*	*D*	*Date*	*D*	*Date*	*D*
Section 3	29-Apr-13	18-Jun-13	50	26-Jun-13	58	18-Aug-13	53	29-Aug-13	64
Section 4	31-May-13	29-Jul-13	59	29-Jul-13	59	27-Sep-13	60	27-Sep-13	60
Section 5	31-Aug-13	21-Oct-13	51	28-Oct-13	58	21-Dec-13	54	31-Dec-13	64
40 MLD	6-May-14	24-May-14	18	10-Jun-14	35	24-Jul-14	44	9-Aug-14	60
Final Completion	6-May-14	24-May-14	18	25-Jun-14	50	24-Jul-14	29	25-Aug-14	61

Table 17–DE04 Impact in Window 2

Based on the above tables for window 2 it is clear that the Section 3 milestone was impacted as a result of DE02 by 64 days, Section 4 milestone was impacted as a result of DE04 by 60 days, Section 5 as a result of DE02 by 64 days, 40MLD milestone as a result of DE05 by 61 days mitigated by 1 day and the Final Completion Milestone as a result of DE01A by 61 days.

DE03 in this example was a Contractor delay event which impacted the Final Completion date by 30 days.

Window 3

After window 2 the model continues with window 3 where 6 delay events from the previous window were inserted as they were ongoing.

W 1-3		WINDOWS		W1	W2	W3
		DAYS		59	61	61
	DELAY EVENTS	DELAY START DATE	DELAY FINISH DATE	Feb-13	Apr-13	Jun-13
DE05	DELAY EVENT DE05	6-Feb-13	2-Aug-14			
DE01A	DELAY EVENT DE1A	1-Feb-13	13-Nov-13			
DE02	DELAY EVENT DE02	1-Feb-13	31-Aug-14			
DE06	DELAY EVENT DE06	12-Apr-13	14-Apr-14			
DE03	DELAY EVENT DE03	1-Feb-13	31-Aug-14			
DE04	DELAY EVENT DE04	1-Feb-13	15-Nov-13			

Table 18–Window 3 Schedule Analysis

To create window 3A, window 2B was copied along with all delay events included in window 2 and the file renamed 3A. In the third window the delay events from the previous window were kept and the duration of the delay events extended if ongoing. In this example DE05, 01A, 02, 06, 03 and 04 continued in window 3.

Each of these delay events was introduced separately into the schedule. Delay event DE05 impacted the activities mentioned in Table 4 with the Finish Start relationship as in windows 1 and 2. The duration of window 3 is 61 days so the duration of the delay event will not exceed 61 days. The impact based on these delay events was then marked into the simple excel sheet tables as in window 1 and window 2.

Window 4

After window 3 the model continues with window 4 where 6 delay events as the 6 delay events needed to be inserted from the previous window 3 as they were ongoing.

W 1-4		WINDOWS		W1	W2	W3	W4
		DAYS		59	61	61	61
	DELAY EVENTS	DELAY START DATE	DELAY FINISH DATE	Feb-13	Apr-13	Jun-13	Aug-13
DE05	DELAY EVENT DE05	6-Feb-13	2-Aug-14				
DE01A	DELAY EVENT DE1A	1-Feb-13	13-Nov-13				
DE02	DELAY EVENT DE02	1-Feb-13	31-Aug-14				
DE06	DELAY EVENT DE06	12-Apr-13	14-Apr-14				
DE03	DELAY EVENT DE03	1-Feb-13	31-Aug-14				
DE04	DELAY EVENT DE04	1-Feb-13	15-Nov-13				

Table 19–Window 4 Schedule Analysis

To create window 4A, window 3B was copied with all delay events included in window 3 and the file renamed 4A. In the fourth window the delay events from the previous window were kept and the duration of the delay events extended if ongoing. In this example DE05, 01A, 02, 06, 03 and 04 continued into window 4.

Each of the delay events was introduced separately into the schedule. Delay event DE05 impacted the activities mentioned in Table 4 with a Finish Start relationship in a similar way to that in windows 1, 2 and 3. The duration of the window 4 is 61 days so the duration of the delay event will not exceed 61 days. The impact based on these delay events was then marked into the simple excel sheet tables as in the window 1, window 1 and window 3 examples.

Window 5-15

The analysis continues through the remaining windows until window 15, which was the end of the analyzed period in this example as shown in the table below:

W 1-15		WINDOWS		W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
		DAYS		59	61	61	61	61	90	122	62	61	61	59	61	61	62	61
	DELAY EVENTS	DELAY START DATE	DELAY FINISH DATE	Feb-13	Apr-13	Jun-13	Aug-13	Oct-13	Dec-13	Mar-14	Jul-14	Sep-14	Nov-14	Jan-15	Mar-15	May-15	Jul-15	Sep-15
DE05	DELAY EVENT DE05	6-Feb-13	2-Aug-14															
DE01A	DELAY EVENT DE1A	1-Feb-13	13-Nov-13															
DE01B	DELAY EVENT DE1B	14-Nov-13	31-Oct-15															
DE07	DELAY EVENT DE07	1-Aug-14	31-Oct-15															
DE02	DELAY EVENT DE02	1-Feb-13	31-Aug-14															
DE06	DELAY EVENT DE06	12-Apr-13	14-Apr-14															
DE09	DELAY EVENT DE09	1-Sep-14	11-Jul-15															
DE10	DELAY EVENT DE10	1-Mar-15	31-Oct-15															
DE03	DELAY EVENT DE03	1-Feb-13	31-Aug-14															
DE04	DELAY EVENT DE04	1-Feb-13	15-Nov-13															

Table 20–Window 1-15 Schedule Analysis

Once all the impacts per each delay event and window have been marked in the detailed excel sheets the summary of the results can commence.

Summarizing the Results

Each of the Milestones has been analyzed and the conclusions reached are as follows:

Section 3

The contractor was forecast to complete the Section 3 works by 29 April 2013. As a consequence of DE02 and DE06, that were employer delay events, the contractor is entitled to an Extension of Time of 542 days to Section 3 with a revised Completion Date of 23 October 2014. The actual completion of Section 3 was 19 October 2014.

EOT Summary Table for Section 3		Windows								
Delay event	Responsibility	W1	W2	W3	W4	W5	W6	W7	W8	Total Entitlement
DE02 Delay event	Employer	58	64	62	57	61			63	365
DE02 Delay event	Contractor Mitigation								-1	-1
DE06 Delay event	Employer						90	122	26	238
DE06 Delay event	Contractor Mitigation						-1	-59		-60
									Total:	542
									Original MS Completion Date:	29-Apr-13
									Revised MS Completion Date:	23-Oct-14
									Actual Completion Date:	19-Oct-14

Table 21–EOT Summary Table for Section 3

Section 4

The contractor was forecast to complete the Section 4 works by 31 May 2013. As a consequence of DE04, DE06, DE02 and DE09, that were employer delay events, the contractor is entitled to an Extension of Time of 635 days to Section 4 with a revised Completion Date of 25 February 2015. The actual completion of Section 4 was 25 February 2015.

EOT Summary Table for Section 4		Windows											
Delay event	Responsibility	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	Total Entitlement
DE04 Delay event	Employer	59	60										119
DE06 Delay event	Employer			61	61	61	90	90					363
DE06 Delay event	Contractor Mitigation						-1	-59					-60
DE02 Delay event	Employer								63				63
DE02 Delay event	Contractor Mitigation								-12				-12
DE08 Delay event	Employer									61	61	59	181
DE08 Delay event	Contractor Mitigation											-19	-19
												Total:	635
												Original MS Completion Date:	31-May-13
												Revised MS Completion Date:	25-Feb-15
												Actual Completion Date:	25-Feb-15

Table 22–EOT Summary Table for Section 4

Section 5

The contractor was forecast to complete the Section 5 works by 31 August 2013. As a consequence of DE01A, DE02, DE06 and DE01B, that were employer delay events, the contractor is entitled to an Extension of Time of 845 days to Section 5 with a revised Completion Date of 24 December 2015.

EOT Summary Table for Section 5		Windows															
Delay event	Responsibility	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	Total Entitlement
DE01A Delay event	Employer	58															58
DE02 Delay event	Employer		64	62	57	61		122									366
DE02 Delay event	Contractor Mitigation							-1									-1
DE06 Delay event	Employer						90										90
DE06 Delay event	Contractor Mitigation						-1										-1
DE01B Delay event	Employer								63	63	58	61	62	97	64	61	529
DE01B Delay event	Contractor Mitigation								-20			-19	-44	-47		-66	-196
																Total:	845
																Original MS Completion Date:	31-Aug-13
																Revised MS Completion Date:	24-Dec-15

Table 23–EOT Summary Table for Section 5

40MLD

The contractor was forecast to complete the 40MLD works by 06 May 2014. As a consequence of DE05, DE09 and DE10, that were employer delay events, the contractor is entitled to an Extension of Time of 597 days to 40 MLD with a revised Completion Date of 24 December 2015.

EOT Summary Table for 40 MLD		Windows															
Delay event	Responsibility	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	Total Entitlement
DE05 Delay event	Employer	56	61	61	58	50	53	123	61								523
DE05 Delay event	Contractor Mitigation	-21	-1		-6		-125		-3								-156
DE09 Delay event	Employer									33	61	59			63		216
DE09 Delay event	Contractor Mitigation										-29				-5		-34
DE10 Delay event	Employer												62	61		61	184
DE10 Delay event	Contractor Mitigation												-39	-43		-54	-136
																Total:	597
																Original MS Completion Date:	6-May-14
																Revised MS Completion Date:	24-Dec-15

Table 24–EOT Summary table for 40 MLD

Final Completion

The contractor was forecast to complete the works by 06 May 2014. As a consequence of DE05, DE01A, DE01B and DE07, that were employer delay events, the contractor is entitled to an Extension of Time of 597 days to Final Completion with a revised Completion Date of 24 December 2015.

EOT Summary Table for Final Completion		Windows															
Delay event	Responsibility	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	Total Entitlement
DE05 Delay event	Employer	57						123	30								210
DE05 Delay event	Contractor Mitigation	-7							-2								-9
DE01A Delay event	Employer		61	62	60	46											229
DE01A Delay event	Contractor Mitigation																0
DE01B Delay event	Employer					15	90					59	61	61	64	61	411
DE01B Delay event	Contractor Mitigation						-187						-21	-47		-85	-340
DE07 Delay event	Employer								31	35	61						127
DE07 Delay event	Contractor Mitigation										-31						-31
DE03 Delay event	Contractor	24	30	30	29		29										142
DE03 Delay event	Contractor Mitigation						-126										-126
																Total:	597
		Total Impact	977													Original MS Completion Date:	6-May-14
Longest Path		Total Mitigation	-380													Revised MS Completion Date:	24-Dec-15

Table 25–EOT Summary table for 40 MLD

The Completion date was impacted by the employer delay events DE05 in window 1, DE01A from window 2 to window 5, then the critical path moved to DE01B in windows 5 and 6. In windows 7 and 8 the critical event was DE05, which moved in window 8 to DE07 and stayed there until window 10. The delay event DE01B was driving the critical path from window 11 to window 15. If those employer delay events had not existed, then the contractor delay event DE03 would have driven the project Completion date.

During the first six windows the contractor delay event DE03 was ongoing and impacted the Completion date by 142 days. This delay event was mitigated in window 6 based on changes in the sequence of activities in the program which created 126 days of mitigation. So the difference between the impacted delay and the mitigated delay is 16 days, which shows that if no employer delay event had existed, then the project would have been impacted by the contractor delay event to give a delay of 16 days.

Therefore in terms of prolongation costs the Contractor is entitled to 597 days prolongation costs as per the extension of time entitlement less 16 days of net contractor concurrent delay as a result of DE03.

The delay events were split into groups of critical, near critical and concurrent delay events based on their impact on the overall Completion date as presented in the time lost table below:

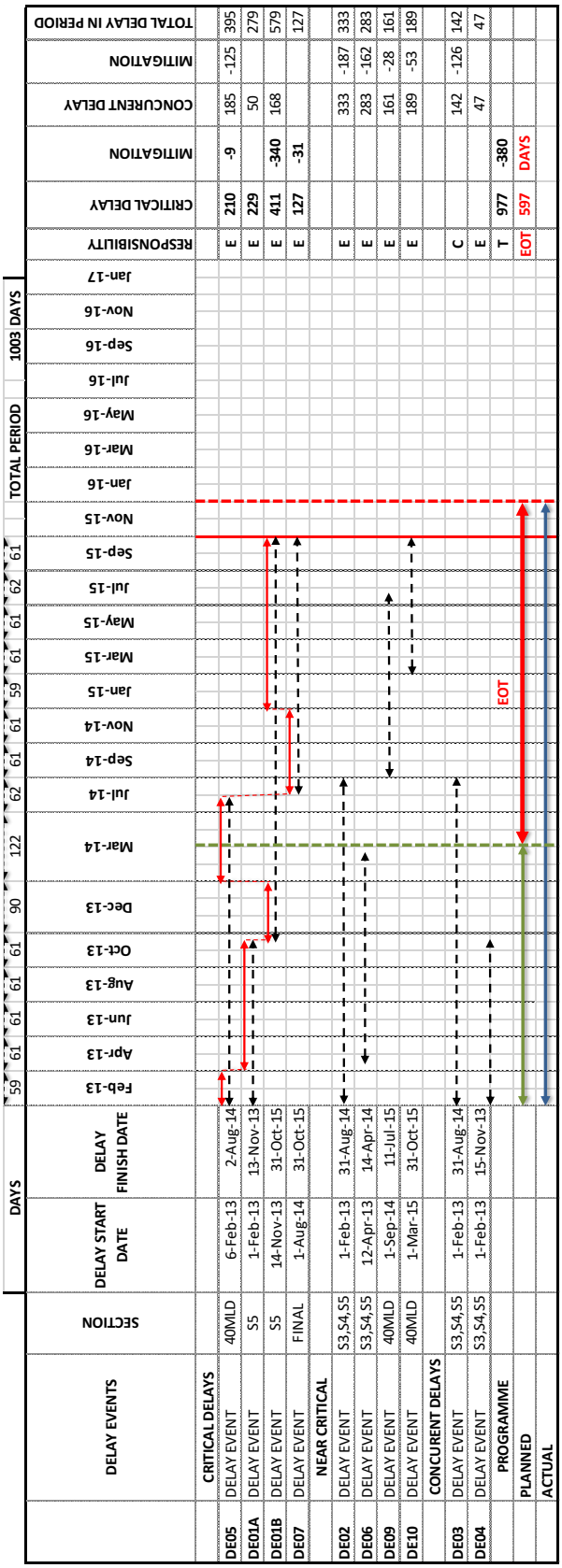

Table 26–Summary of Time Lost

Conclusion

As shown in the example above the Time Impact Analysis in Windows methodology can be a useful tool to prove a contractor's entitlement to prolongation costs. What is important is to be able to concentrate on the events which impacted the critical and near critical paths of the project. The selection of the critical path should come from logic and not strictly from a programming tool as sometimes this can be misleading. A common sense approach should be applied.

Some delay analysts impact numerous delay events of which most are not impacting the critical activities of the project. The main concentration should be on the main drivers. A lot of times analysts select every delay activity during projects and maintain that this is proof of concurrency. Experience has shown that as many as 3000 events have been quoted as being delay events, but when a single fragnet is created for each of these, as in DE03 above, and impacted on the schedule there will be no effect on the Completion date. Therefore these cannot be said to be concurrent delay events and hence will not discount prolongation costs.

There was only one contractor's delay event in this example analysis, but there can be more depending on the findings during the analysis of the project. There are many techniques for selecting the correct activities such as float mapping, which can be used to help to select the activities needing analysis. After this the connection between the effected activities (effect) and cause of the problem (cause) is required to be established as mentioned in this example. Without this there can be a lot of causes without any effect on the Completion date.

Therefore using Time Impact Analysis in Windows can provide clear demonstration and calculation of concurrency and mitigation for specific delay events. Concurrency analysis using TIA in Windows methodology has successfully resulted in the granting of prolongation costs to contractors when applied and offered the contractor and employer a clear model in terms of calculation and understanding of the main problems experienced on the project. After a lot of schedule analysis and excel tables only the single page of the Time Lost table was presented to management who have no understanding of the delay analysis.

So make it simple and clear to others!

References

1. AACE International, "Forensic Schedule Analysis," Recommended Practice 29R-03, AACE International, (25 April, 2011 Revision).
2. Society of Construction Law Delay and Disruption Protocol, 2nd Edition: February 2017.

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