Expediting a Project, an Optimized Strategy Approach to Milestones Delay Management (MDM)

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Abstract

Disruption and Delay (D&D) is a common phenomenon happening all the time in almost all types and classes of projects. This paper reviews the literature on D&D and unusual calculation methods which can be used to quantify the effects of Disruption and Delay. Then it is focused on modeling and managing major delays (D&D) looking for an optimized strategy approach. The paper suggests that when delays happen, overemphasis on the critical path is not necessarily the best strategy as it could lead to distraction. It is possible that the domino or knock on effect of the delay of a non-critical milestone causes more financial damage than one on the CP. Hence for every progress report over the development of the project an optimized strategy should be worked out over how to deal with the D&D. This timely assessment of the situation provides the stakeholders with a basis which could be used in managing the delay and settling D&D claims. The author suggests that if a Delay and Disruption (D&D) claim is to be paid the cost should not be more than the value found using this approach called Milestone Delay Management Model.

Background and Literature Review

In a project environment, normally there are at least two parties, the owner, and the provider or contractor. When the contract is entered into, both parties believe that the contract will benefit them. The owner is planning to get work done in a certain fashion by a certain time, while the contractor is planning to deliver the work and get paid. Unfortunately, often, something unfavorable occurs on either side, and there is disruption and delay (D&D) of the project. If the solution cannot be reached amicably, the disagreement may lead to litigation. Ideally, it is better to avoid litigation, because of the "litigation costs, delays in obtaining final court decisions, lack of control over the outcome of the litigation process, [and] lack of control over the outcome" (Werderitsch, 2000). By following proper project management fundamentals we try to avoid claims and prevent the situation from reaching litigation, but in the event litigation or settlement is required, each side will need to determine a method to calculate their view of the impact of D&D on the project and calculate the compensation they plan to request from the other party. Also in the absence of any claims, as a minimum one needs to decide on a course of action to mitigate the impact of these delays. This decision need to be optimized by looking at what to do? Expedite the delayed sections of the project or not? Which parts of the project to focus on? How much does it cost? Could the delayed milestones be brought back on track?

The concept of delays and disruptions is a complex one. Disruptions are defined as "events that preclude the contractor completing the work as bid" (Eden, C, Williams, T., Ackermann, F., Howick, S ,2000). Delays involve the completion of the project being later than originally planned (disrupting the continuity). However it is not quite as simple as it might seem because delays act as disruptions in their own right and disruptions cause delays which in turn disrupt the project. In other words, "Major disruption and delay occur when there is disruption and delay avoidance because of management action taken to accelerate the project in order to avoid the impact of the disruption for delivering on time.", (Eden, C, Williams, T., Ackermann, F., Howick, S ,2000). A positive feedback loop is formed where both disruption and delay feedback on themselves causing further disruptions and delays. Due to the nature of feedback loops, a powerful vicious cycle will be created. So the dynamic nature of delays and the interaction of the impacts should not be ignored.

There are many different kinds of common root causes of Disruptions and Delays best described by (Battikha, Mireille, Alkass, Sabah, 1994, Cochran, Edward B. 1978, and Williams, T.M.,1999). A good understanding of the root causes could be very beneficial in formulating and using different types of calculations to determine the monetary impact of each delay or even adopting the right strategy to deal with it. It is worth mentioning that a simple count of root causes identified from the above sources shows that, "caused by owner" delays happens twice the ones caused by contractors. Also one can argue that contractors could benefit if they try to recover from the D&D that is caused by themselves or it is non compensable. Having said that the author believes that the assessment of the situation whenever a delay or disruption happens is a must with or without a claim.

It is evident that there can be many reasons for disruptions and delays in projects. However if good communication exists between the project owner and the provider, the problems will be flagged early so that both parties can try to find solutions. When communication is not flowing, one of the parties may be surprised, which leads to being unhappy with the state of the work, actions taken or not to tackle the problem to prevent the propagation of the damages which then may lead to litigation. Sometimes this lack of communication could be intentional. The contractor may not raise the flag hoping to claim a larger lump sump at the end. It is for this latter point that, anytime when a serious D&D happen a full assessment of the situation need to be done there and then without delay as the cost of recovery could be much more at later stages of the project.

Calculation Methods used to Analyze the Impact of D&D

In this section, we will briefly review the types of calculations for Disruption and Delay found in the literature. As previously discussed, it is difficult to determine if project slippage and overrun is caused strictly by Disruption or by Delay. In this section, we will look at the methods for both types, understanding that they actually have a feedback loop with each other.

Most of the calculation methods in literature are actually based on and are variations of the Critical Path Method. This method starts with the original Critical Path (baseline schedule), and determines the changes from that path, and thus the calculation of the difference between original plan and actual. Usually a per-diem charge is calculated for the provider plus an overhead amount.

The drawbacks of the CPM calculations are that they do not allow for inclusion of human elements into the model (Howick, S., 2003) and they do not adequately portray the feedback effect of delays causing disruption, and then causing delays. Also this approach is based on either not taking any action (accepting the delay) or one specific course of action based on which the updated project plan is/was generated. The approach does not search for the optimal strategy or best choice to deal with disruption or delay.
Some variations on the CPM calculations are: Bar Chart Schedule , Collapsed or Adjusted Schedule or “But-For” , Net Impact Technique (Ng, S. T., Deng, M. Z. M., Nadeem, A., 2004), Apportionment Delay and Window Analysis, or Snapshot/Isolated Delay Techniques. It could be seen that all these approaches are reactive models using after the fact analysis in contrast to a proactive approach where the potential costs are assessed and an appropriate action is taken or recommended.

The projection techniques on the other hand look at the history of the project at the current time, and attempt to project the costs for remainder of the project, or project the costs if the delay had not occurred. These techniques can be quite accurate, but rely on the historical data being representative of the projected future data. As-Projected Schedule (Battikha, Mireille, Alkass, Sabah., 1994), Measured Mile, Mathews curve (Heather, Paul R., 1989), Earned Value Method , Modified Total Costs and Time Impact Technique are the ones most widely used. None of the above approaches aim at dealing with the problem, instead they try to calculate the monetary value of the D&D assuming that nothing has been done to stop it (which is normally the case). This is mainly an after the fact approach as well.

One of the best tools yet available to do a realistic assessment of the impact of D&D is System Dynamics (SD) Modeling (Howick, S., 2003). This approach uses simulation modeling using System Dynamics to identify the discontinuities in the system causing D&D. SD can be used to prove causality, responsibility, and capture both hard quantitative effects as well as human soft factors effects. It can replicate reality to convince the audience that its predictions are adequate. It contains ability to add feedback to line up the event to the increased project costs. It could also be used as a predictive model to do what if analysis to choose an optimal course of action. However there are serious drawbacks associated with it, including but not limited to the skills and effort to build and operate the model, the perceived lack of transparency to others and the difficulty of portraying operational aspects of the project (Howick, S., 2003). The System Dynamics modeling is the most complicated to setup and has the highest costs to produce, but has been proven to have good results in real-life, very complicated and complex projects(Howick, S., 2003).

The simplistic methods do not take into account the real life interaction between concurrent D&D, and the feedback loops. The complicated methods are expensive to model and calculate, and suffer the problem of being somewhat difficult for the average person to follow. In summary there is no consensus in the literature of the best methods for delay management or how to calculate D&D. Some authors seize upon one method and claim that it is the solution. However, it seems that these different methods can be categorized into a spectrum from simplistic to complicated, and the appropriate method for the project in question and the size of the damages should be chosen. With the exception of system dynamics none of the existing approaches takes into account the possible mitigation strategies which could reduce the bill for D&D and recommend an optimized approach. The following model could be used as an add-in to complement any of these estimation tools. The data needed for the model could be collected using some of the estimation approaches explained above. The major difference is that here we attempt to calculate the potential cost of D&D by adopting a strategy to deal with it.

The point is that the ability to mitigate the delay and influence the cost impacts to the project diminishes as we move toward completion. So, timely identification of the delays, reporting them and then implementation of a workable strategy is a crucial factor for keeping the costs low.

Model Formulation for MDM(Milestone Delay Management)

After project sanction, the project team has a defined budget, schedule and deliverables (scope and quality) that can be baselined, measured and controlled. The costs associated with delaying a project or part of it after sanction to name a few include the cost of the project team, company overheads, personnel seconded from partners and government agencies, impacts on the various contracts and contractors involved in the project. The more complex the project, the greater the number of contractors and contracts involved and more complex the costs of delays and disruptions. A project delay may have a cascading impact on the interactions between various contractors for the delivery of materials, installation arrangements, testing and commissioning requirements, etc. As the mathematical formulation of the details including all the delayed activities of the project is almost impossible this model is focused on milestones where the milestone delay could be due to one or more chain of activities impacting the occurrence of the milestone(s). The objective is to manage delays and focus on bringing the project back on track by allocating some budget to mitigate the impact of the delays on milestones hoping that reduces the net impact of the delay and disruption. From the calculation performed the net cost of D&D could be figured out. This higher level, simplified version of the optimization model helps the PM to decide on points of focus or where to spend the limited money/budget available to minimize the loss or the costs associated with the delay(s). Focusing on milestones as the key points in the project reduces the micro management. The detailed decisions could be left for the sections or departments involved in implementing the activities(link) where impact of the delay could increase the costs. The model is named MDM or Milestones Delay Management for a want of better name.

Assumptions of the model:

- Limited contingency budget is available.
- Budget is the only resource used in the model.
- The milestones could be brought back on track by expediting one or more of the predecessor links (chain of activities) which could delay the milestone.
- The expedition cost or cost of crashing each link between the milestones is a fixed estimated value and not a per time unit or gradient value.
- If a delayed milestone is left unattended then there is a cost of delay associated with it.

The following notation is being used in formulating the model:

- e_{ij} - cost of expediting a link between milestones i and j
- y_{ij} - a flag which is set to "1" if the link (chain of activities between two milestone) is brought back on schedule and "0" otherwise
- C_j - cost of delay for milestone j
- Y_j - is a flag to indicate if the milestone is brought back on track by expediting the incoming link(s), 1 if delay prevented and 0 otherwise.
- n -number of milestones in the project
- M_j -milestone j
- S(j) -the set of milestones that succeed milestone j
- P(j) -the set of milestones that precede milestone j
- B -available budget for this round of updating the project plan

The back bone of this model is the network of the milestones for the project. As the data collected for managing the delay is based on managing the milestones within the project then the milestones network diagram is used to establish the model. The mathematical model used for formulating the situation and making the decisions is integer programming. The objective function shows the total cost of delay at any time which could be written as:

– *Min* $Z = \Sigma e_{ij} y_{ij} - \Sigma C_j Y_j$ *+Total original D&D Estimate*
– $j=1 \ldots N$ & $i=1 \ldots N-1$

The value of Z or the total cost of the delay is the sum of the costs associated with expediting the links to avoid delay costs and the costs of unattended delays or accepted penalty. If there is a penalty in the contract the cost of the penalty could be taken care of by having it incorporated as C_N which is the cost of the delay for the last milestone.

First constraint: This constraint insures that the expediting all the in progress links are needed to bring the milestone back on track:

– $Y_j = (\Sigma y_{ij} /n)$ *or*
– $\Sigma y_{ij} - n Y_j = 0$ *for in progress activities.*

Second constraint: When there are more than one immediate predecessors, then the required constraint to insure the milestone is brought back on track is that all the delayed links are set back on track. This could be formulated as:

– $Y_k = (\Sigma Y_j + \Sigma y_{jk})/n$

Third constraint: This constraint insures that the money spent on the links to minimize the delays does not exceed the given budget:

– $\Sigma e_{ij} * y_{ij} \leq B$

Fourth constraint: This constraint insures that when a milestone has been brought back on track the following link is not chosen for expedition and vise versa:

– $Y_j + y_{jk} <= 1$

So the overall model is:

– *Min* $Z = \Sigma e_{ij} y_{ij} - \Sigma C_j * Y_j$ *+Total original D&D Estimate*

s.t. :

$\Sigma y_{ij} - n Y_j = 0$ *for in progress activities.*

$Y_k = (\Sigma Y_j + \Sigma y_{jk})/n$

$\Sigma e_{ij} * y_{ij} \leq B$

$Y_j, + y_{jk} <= 1$

$Y_k , y_{ij} = 0,1$ *for all k and ij.*

In the following section the model has been applied to a theoretical milestone network to show the implementation process, formulation and use of Excel to find the solution to integer program formulated.

Application of the Model to a Theoretical Case Problem

To illustrate the use of the model a simple milestone network is used for demonstration purposes only, which is shown in Figure 1. The delay costs, expedition costs and other relevant data need to be estimated to tackle D&D situation. Artificially generated data is provided in Table 1.

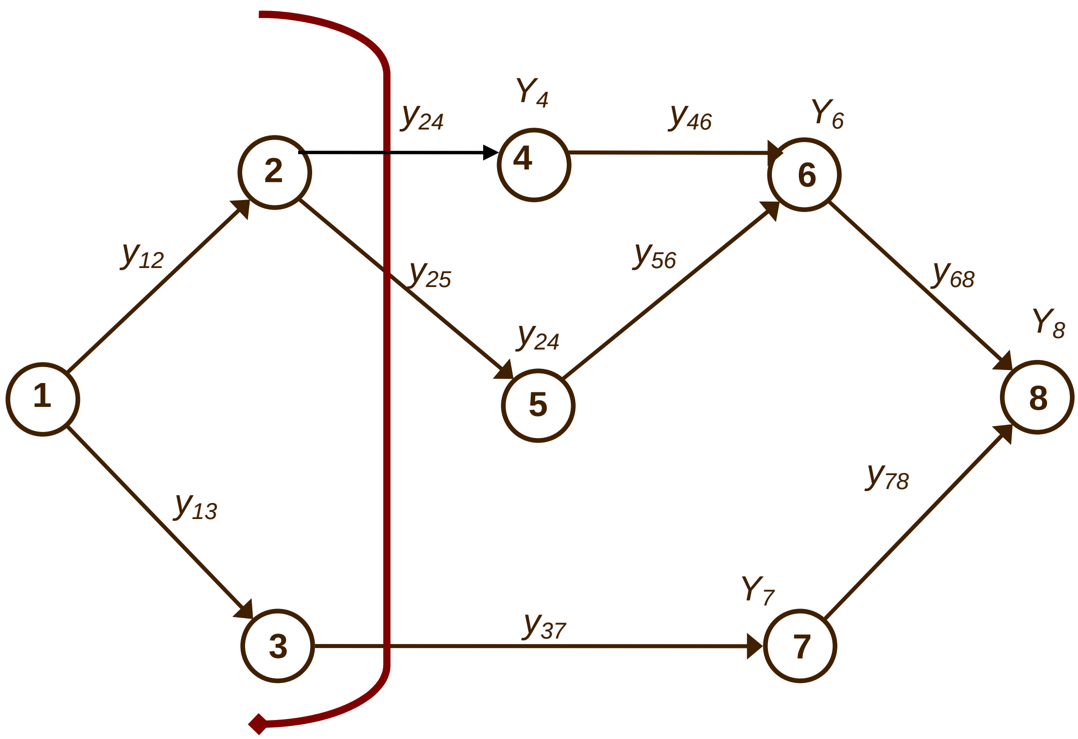

Figure 1 milestone network

Mj	Yj	*yij*	Cj	Link	eij
M1	0	-	2	-	-
M2	0	-	5	1-2	3
M3	0	-	4	1-3	5
M4	?	?	6	2-4	4
M5	?	?	5	2-5	7
M6	?	? ?	12	4-6 5-6	2 4
M7	?	?	2	3-7	9

M8	?	? ?	9	6-8 7-8	8 6

Table 1: D&D data

It is to be noted that in the absence of any action there is a total cost of 45 units associated with the D&D which could be the figure for the claim. The model for the case after simplification of the equations is shown below:
The objective is to:
Minimize Z=
$4y_{24}+7y_{25}+2y_{46}+4y_{56}+9y_{37}+8y_{68}+6y_{78}-(6Y_4+5Y_5+12Y_6+2Y_7+9Y_8)+45$
subject to:

- $y_{24}-Y_4=0$
- $y_{25}-Y_5=0$
- $y_{37}-Y_7=0$
- $Y_4+Y_5+y_{46}+y_{56}=2Y_6$
- $Y_6+Y_7+y_{68}+y_{78}=2Y_8$
- $4y_{24}+7y_{25}+2y_{46}+4y_{56}+9y_{37}+8y_{68}+6y_{78}<=B$
- $Y_4+y_{46}<=1$
- $Y_5+y_{56}<=1$
- $Y_6+y_{68}<=1$
- $Y_7+y_{78}<=1$

The above formulation was entered into Excel using solver add in and the problem was solved using IP. The solution of the model is shown in table 2:

y24	y25	y37	y46	y56	y68	y78	Y4	Y5	Y6	Y7	Y8				
0	1	0	1	0	0	1	0	1	1	0	1			23	
10	7	9	2	4	8	6	6	5	12	2	20				
1							-1					0	>=	0	ok
	1							-1				0	=	0	ok
		1								-1		0	=	0	ok
			1	1			1	1	-2			0	=	0	ok
					1	1			1	1	-2	0	=	0	ok
			1				1					1	<=	1	ok
				1				1				1	<=	1	ok
					1				1			1	<=	1	ok
						1				1		1	<=	1	ok
10	7	9	2	4	8	6						15	<=	20	ok

Table 2: solution generated by Excel solver

y24	y25	y37	y46	y56	y68	y78	Y4	Y5	Y6	Y7	Y8				
0	0	0	0	0	0	0	0	0	0	0	0			45	
10	7	9	2	4	8	6	6	5	12	2	20				
1							-1					0	>=	0	ok
	1							-1				0	=	0	ok
		1								-1		0	=	0	ok
			1	1			1	1	-2			0	=	0	ok
					1	1			1	1	-2	0	=	0	ok
			1				1					0	<=	1	ok
				1				1				0	<=	1	ok
					1				1			0	<=	1	ok
						1				1		0	<=	1	ok
10	7	9	2	4	8	6						0	<=	20	ok

The solution generated by the model suggests that the cost of the delay could be reduced from 45 to 23 by spending 15monetary units to expedite the occurence of milestones 5, and 6 and 8. This suggest the D&D specified in this case could be managed with far less budget than taking no action and making a claim at the end. The owner has every right to know about these options and should not be paying more for lack of communication or action from the contractor side. Also the contractor needs to be aware of possible options for dealing with the delay even if there was no claim to be made.

Further Research Conclusions and Recommendations

From the above simple case it could be seen that the model will provide an optimal strategy for minimizing the impact of delays which otherwise would be partially if not totally ignored. The model could be easily formulated as an Integer Program and applied even to relatively large complex projects as there are no more than 20-30 milestones. Also the model provides the opportunity for assessment of the impact of the delay before the fact which could change the faith of the project. While the model could be used for claim resolution as an after the fact calculation procedure based on the data collected on existing estimation models, it will also provide the least cost possible mitigation strategy in dealing with delays. The model is not focused on CP only, hence the impact of delays all across the project with the domino effect is taken into account.
As this was only an initial investigation, there are a number of areas where the model could be extended to make it more realistic. The first step is to find a real life project and try to see how the calculation and analysis compare with what was done in practice (A D&D case study). The second area could further research on the model and how to include partial mitigation where the costs are not fixed but follow some form of a predefined function.

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