FLOAT – IS IT REAL?

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Introduction

The concept of schedule 'float' did not exist until 1957. The existence of a 'critical path' and non-critical activities (with their associated 'float') grew out of the science of 'scheduling' as defined by the Critical Path Method (CPM). In 1956/57 Kelly and Walker started developing the 'Activity-on-Arrow' methodology[1]. Before then, Gantt charts, milestone charts and industrial processes such as 'flow line planning' were used to control projects, and whilst these techniques could show how far ahead (or behind) schedule work was, there was no concept of interdependencies or float contained in the techniques.

From the 1960s onwards, the use of 'critical path' techniques began to dominate project controls. Initially Activity-on-Arrow and PERT were the dominant techniques, then Precedence networking was introduced. The variability inherent in the PERT system proved progressively less popular with organisations, despite the greater accuracy of the mathematics. The apparent precision of the single duration estimate required for the 'critical path' techniques (both Activity-on-Arrow and Precedence) dominated. The battle for dominance between the Activity-on-Arrow and Precedence techniques has also been decided with Precedence now being the undisputed methodology of choice. Therefore, whilst this paper will focus on 'float' which is an intrinsic part of all three methodologies mentioned in this paragraph; the examples will be based solely on the Precedence Diagramming method.

This paper will analyse the factors creating the 'critical path' and 'float' within a schedule and then look at the issues surrounding float. Potential solutions to be canvassed include the UK 'Delay and Disruption Protocol', client led integrated teams and the use of alternative planning methods such as location-based scheduling, trend analysis and earned schedule.

Is Float Real?

Float certainly exists as a calculated result in CPM schedules. 'Free Float' and 'Total Float' are defined in the PMBOK Guide 3rd Edition[a] Glossary as:

- Free Float is defined as *'The amount of time that a schedule activity can be delayed without delaying the early start of any immediately following schedule activities'* (PMBOK p362). Free float is calculated by deducting the early finish time of the activity from the earliest of the early start times of its successors.

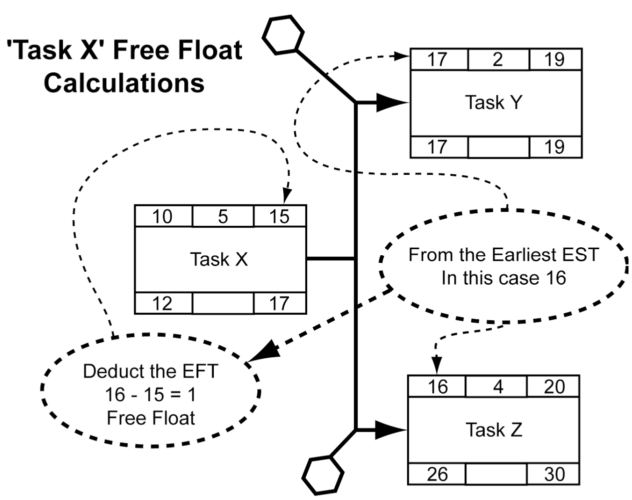


Fig. 1 - Free Float Calculations

[a] These definitions remain fundamentally unchanged through to the current time.

- Total Float is defined as *'The total amount of time that a schedule activity may be delayed from its early start date without delaying the project finish date, or violating a schedule constraint'* (PMBOK p378). Total float is calculated by deducting an activity's early finish date from its late finish date.
- In the past various other types of float have been defined including 'Start Slack', 'End Slack', 'Free Float Early', 'Free Float Late' and 'Independent Float'[2]. Current usage tends towards 'Slack' and 'Float' being interchangeable terms and only 'Free Float' and 'Total Float' being calculated[b].

Most contracts treat the schedule and its float values as 'real'. Every legal dispute over a failed contract seems to feature claims and counter claims totalling $thousands (if not $millions) based on various interpretations of:

- The existence of float and the critical path;
- Entitlement to 'Excusable delays' (or EOT's[c]) based on the schedule;
- Delay and disruption costs caused by impacts on the scheduled works and
- Damages for late completion.

The mathematical precision of critical path scheduling has definitely caught the attention of lawyers and contract draftsmen leading to the evolving concept of the 'contract program' and conferring a degree of legal certainty onto the schedule that cannot be supported by objective analysis. Whilst CPA is an extremely useful way of gaining insight to the essence of a project and helping define an agreed way of working to achieve the project outputs; CPA is not an accurate or foolproof determinant of 'the future'. As this paper will demonstrate, every schedule is a creation of assumptions and presumptions crafted (with greater or lesser skills) by a scheduler and influenced by the algorithms built into the software used for analysis.

Before Kelley and Walker invented CPM in 1957[1] there was: no critical path, no float (free, total or other) and no logic-based scheduling. But people still managed to have contractual fights over progress, disruption and damages; and most legal precedents dealing with delays, damages and disruption had long been established. CPM has added greater insight and the potential for more effective controls but declaring an activity 'critical' based on CPM calculations does not change its importance, nor does declaring an activity non-critical make any less important in the overall scheme of a project.

The Origins of Float

The Critical Path Method requires:

- Activities (or Tasks) to be defined
- Their 'logical' relationships (or dependencies) to be defined
- Their duration to be defined (based on the estimated work content of the activity and the anticipated resource availabilities/requirements)
- And then the network is analysed based on a set of arithmetic rules to calculate the 'critical path'.

This process is highly subjective and requires a massive simplification of the work in a project to allow CPM analysis. The myriad of work steps needed to do a job are condensed

[b] For more on the calculation of float valuses and the different types of float see ***Schedule Float***: http://www.mosaicprojects.com.au/PDF/Schedule_Float.pdf

[c] EOT – Extension of Time (usually to the contracted completion date)

into a single activity. Consider the thousands of individual processes needed to 'Form Reinforce and Pour' a concrete slab:

- Carpenters lifting and fixing hundreds of pieces of timber and formwork,
- Steel fixers positioning and tying thousands of pieces of reinforcement,
- Plumbers, electricians etc, fixing their 'cast in' items,
- Concreters preparing, placing, finishing, and then curing the actual concrete.
- And a host of supporting works such a surveying, quality control, etc.

This simplification occurs in all industries, the hundreds of decisions needed to develop a single piece of software code, the scores of individual processes needed to conduct a 'test' etc.; are always condensed into a single activity description.

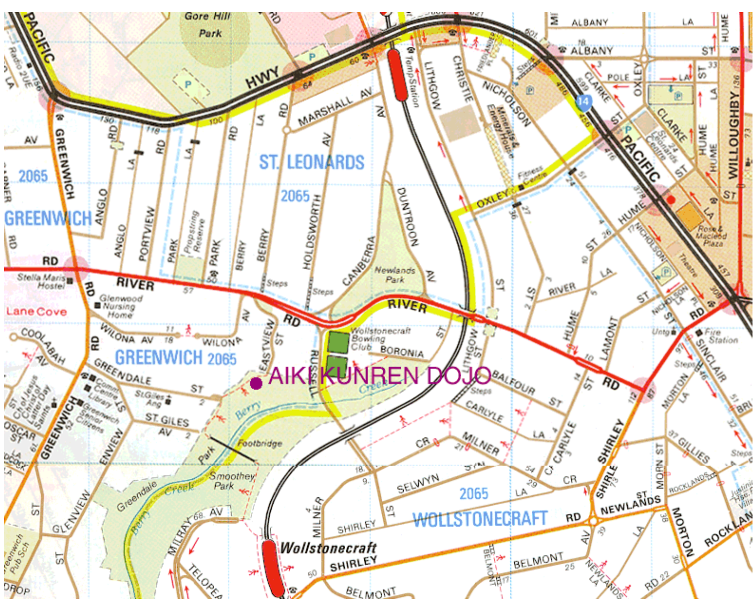
Similarly, the complex interrelationships possible between two activities are reduced to a single statement, with a single 'Lead' or 'Lag' value, that is either zero or a +ve or -ve integer:

- Finish to Start assumes the preceding activity will be completely finished before the succeeding activity can start.
- Start to Start and Finish to Finish recognise overlap (and may be used together) but still treat each of the two connected activities as homogeneous entities.

The reality is that there are an infinite number of variables that may occur between the work in one activity and the work on another as people move between the two, but any attempt to map all of the options would lead to an unimaginably complex schedule that is totally impractical to use as a management aid.

The result of building a CPM network is the creation of a simple mathematical model of the project capable of analysis using relatively simple techniques. And if the scheduling is done well, it becomes a useful 'road map' to assist the project team to manage the project through to a successful completion. However, the relationship between 'usefulness' and reality is not close:

- The most 'useful' map to use driving through a strange city is a Street Directory[d]



[d] Street Directory from Sydway, photograph from Google Earth. Which is more help finding the Aiki Kunren Dojo?

- The most accurate map is probably based on high-definition aerial photographs

In the same way the Street Directory has been focused and simplified to make it useful to drivers, the CPM schedule has been focused and simplified to make it useful to project managers. A good CPM schedule is unquestionably useful, but how 'real' is any schedule? At best the schedule is a representation of one reality heavily influenced by the decisions of the scheduler who created it.

Sources of Schedule Variability

The activities used to create the schedule are variable; different planners can and will choose different patterns of activities to describe the same work. The durations allocated to each activity are variable, based on presumed resource availabilities and productivity. Similarly, the interconnecting logic used to define the dependencies between activities is highly variable and subject to the views and preferences of the scheduler. The same schedule dates can be achieved on two overlapping activities by using a Start-to-Start link, a Finish-to-Finish link or a Finish-to-Start link with a negative lag. However, the consequences of the chosen link type can have very different outcomes if the planned sequence of work is 'disturbed' during the execution of the works.

Other planning presumptions and calculations are equally doubtful. 'Overloaded' resources are impossible; a resource can only work for 60 minutes in an hour, even if the scheduling tool is showing 90 minutes work is required! Similarly, 'under-utilised' resources are rarely seen; most committed team members will find something useful to do even if this means blurring and re-shaping the neatly defined activities included in the schedule.

The schedule may look 'logical' and may represent the best intentions of the project team at the time it is developed, but it is not the actual future (this cannot be foreseen). The schedule is only a presumed future that may happen, and equally, may not. If the project team make effective use of the schedule and attempt to work to achieve it, the existence of a schedule will certainly help shape the project's 'future', set expectations and guide the project leadership in directing the work of the project. But these influences do not control the future.

All sorts of unplanned internal and external disturbances will impact the work on the project[3]. Consequently, the actual project future will be influenced in part by the actions of the project team and in part by unforseen disturbances from within the project (eg a team member becomes ill) and unforseen disturbances from external sources (eg a power blackout). The value of the schedule lays not in its ability to influence these factors (that is impossible), rather in its ability to measure the impact of the disturbances as they occur so that corrective actions can be planned and implemented (or the schedule changed to reflect reality!).

However, recognising that 'scheduling' is an imprecise art (supported by mathematics) forces the project's stakeholder community to face up to a range of governance problems. Effective planning, based on this recognition, requires a willingness to continually monitor and adapt the schedule to make sure it represents the 'best' way forward based on the team's current knowledge of the project; supported by a cooperative approach to problem solving[e]. This is diametrically opposed to the 'legal' view of effective project governance, which tends to require certainty and focuses on risk mitigation, which is quite understandable given the potential size of delay, disruption and prolongation claims on a major project.

Currently, the 'legal' view is pre-eminent and has created the concept of 'the contract program', that can only be changed by agreement (if at all), and the assumption that only delays impacting the 'critical path' can give rise to extensions of time, delay costs, etc. Whilst offering the appearance of security, one has to question the presumption that the 'legal' view of the schedule actually offers the best chance of achieving a successful project outcome. The alternative of recognising the inherent uncertainty of any attempt to predict the future and cooperating to manage reality as it unfolds may deliver significantly improved project outcomes. But implementing this approach requires cooperative contractual arrangements (eg, partnering or alliance contracts) rather than adversarial approaches[4].

The Variability of Float

The calculation process to determine float is arithmetically precise, but the data used in the calculation is a collection of estimates, guesses, simplifications and assumptions. Once created, float is ephemeral; the effluxion of time will of itself destroy float (there is no float on completed activities). Similarly, float cannot be bought, sold stored or transferred, it only exists as a result of an arithmetic calculation, on some future activities in a schedule and any changes that occur during the execution of the project can have dramatic effects on the overall schedule and all of its embedded float values.

Variable Durations Change Float

CPM assumes one fixed duration for an activity; PERT and Monte Carlo analyses recognise the inherent uncertainty in any estimated duration. As durations change from the original plan (both projected and actual), it is quite likely the critical path will move. Tools such as Pertmaster[5] can demonstrate this variability using displays like the 'Tornado Chart' and 'Criticality Distribution Profile' that show how often an activity appears on the critical path and how influential it is on the overall project durations.

[e] For more on this see Schedule Density: http://www.mosaicprojects.com.au/WhitePapers/WP1016_Schedule_Density.pdf

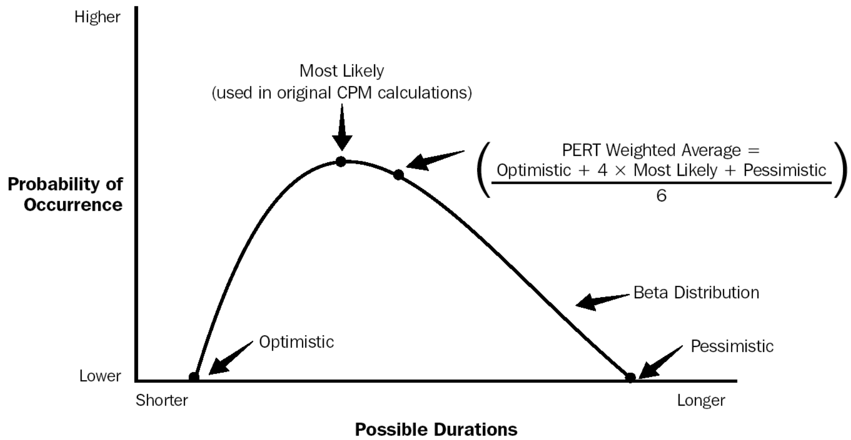


Fig. 2 – Typical BETA distribution for an activity duration.

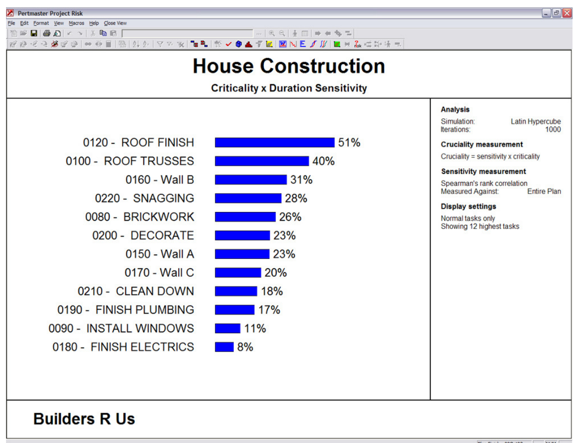


Fig. 3 – Pertmaster 'Tornado Chart'.

Despite the CPM requirement for a single duration estimate, durations are variable; changing the estimate of a planned (future) duration or differences between the actual duration and planned duration on completed activities will change the available float and may change the critical path.

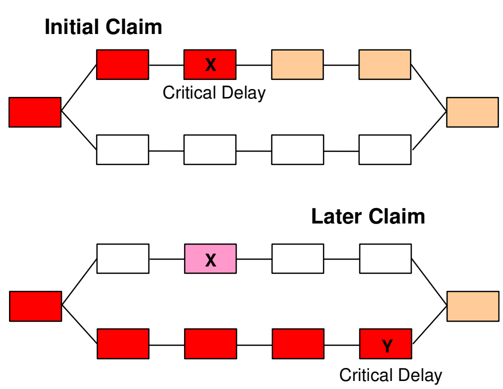


Fig. 4 – The critical path can change.

In the example above, at the 'Initial Claim' the critical path was running through the top chain of activities and 'delay x' was encountered. As no one can predict the future, it would be reasonable for everyone involved in the project to assume this is a critical delay and administer the contract accordingly.

Later, changes in the duration of the activities cause the critical path to move (either reduction in the time needed to complete some activities in the top chain or increases in duration in the lower chain, or both). When 'delay y' occurs as a 'Later Claim', this is also a critical delay based on the schedule at the time of the delay. However, given the definition of the 'Critical Path' is: *Generally, it is the longest path through the project. …that determines the duration of the project.*[6] The difficult question to answer is what happens to 'delay x', it appeared to be critical based on the best information available at the time the delay occurred. But changes over time (and after the time of the initial delay) have shown 'delay x' to actually be non critical.

With the benefit of hindsight, rather than focusing on solving 'delay x' the project may have been better served by focusing on the lower chain of activities which eventually controlled the completion of the project. Unfortunately, CPM systems do not come equipped with 'hindsight' and foretelling the future is an imprecise art that attempts to project into the future what is known of what has happened in the past. The fundamental problem was neatly summed up by Gottfried von Leibniz in 1703: "Nature has established patterns originating in the return of events, <u>but only for the most part</u>."[7] Prior experience can only be a guide to what <u>should</u> happen; it is not a guarantee of what will happen! It is important for all members of the project team, and project stakeholder community to recognise the inherent uncertainty of any estimated duration.

Varying Logic Changes Float

The structure of the network can also change float. Figure 4 shows a small network in which all of 'Activity 1' is critical and the Finish-to-Start link between Activity 1 and Activity 2 has a negative lag of 5 days.

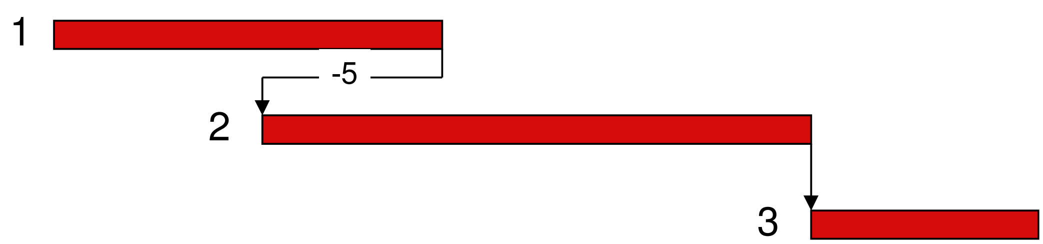


Fig. 4 – Activity 1 as a single entity.

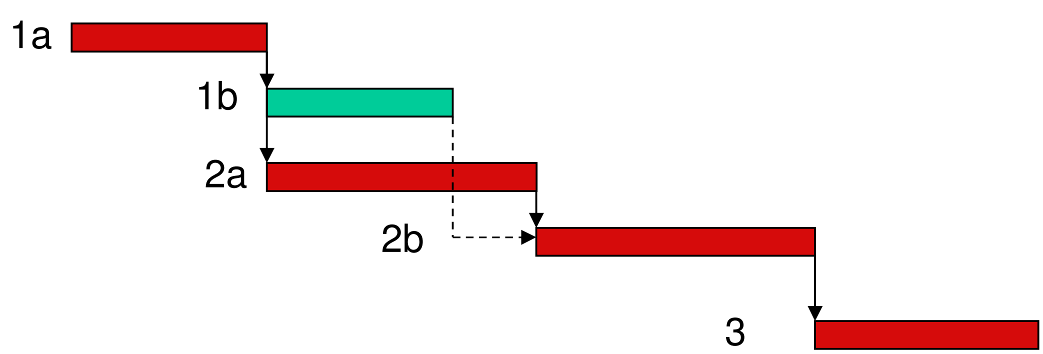


Fig. 5 – Activities 1 and 2 split.

Assuming that 'Activity 2' only required 50% of 'Activity 1' to be completed before it can start and the second half of 'Activity 2' requires the balance of 'Activity 1' to be completed before is starts, the same overall schedule could be achieved by splitting the activities into two halves and using Finish-to-Start links rather than the negative lag. See Figure 5.

By increasing the amount of detail in the schedule, half of the old 'Activity 1' gains float! If there was a delay in the second part of Activity 1 would an EOT be due on either schedule?

Other Variables that Change Float

Some of the other variables and assumptions that impact on the accuracy of the float values calculated during a CPM analysis include:

- The project team intend to and actually are working to the schedule (mitigated by regular status updates[8])
- The types of link used accurately reflect the dependencies between activities (the real world is complex)
- The scheduled resources are available and will perform as assumed (production rates)
- The structure of the project data is reasonable. Structural elements impacting float include:
    - Multiple calendars (Activity calendars, Link calendars, Resource calendars)
    - Imposed dates and constraints
    - Unnecessary logic
    - Resource levelling and smoothing algorithms used by the software

The Variability of Float – Section Summary

In summary:

- Float is a creation of the CPM scheduling process and defines the critical path.
- The schedule (and its embedded float) may represent the real situation; it may not.

But for the balance of this paper, we will assume it is reasonably accurate!

Using Float

Float disappears as time moves forward - at the end of the project, there is no float! But using any float is not risk free:

- Using <u>Free Float</u> will not delay the start of any other activity. But, delaying any activity changes the date and/or time resources are required to accomplish its work. The changes in the timing of resource requirements may shift a well-balanced resource demand into a resource overload causing delays in other parts of the schedule, with the potential for major delays to the end date.

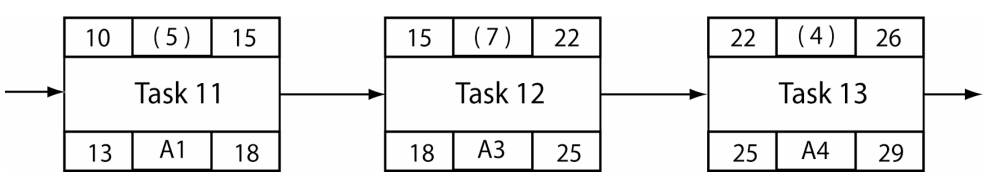


Fig. 6 – Total Float example.

- Using Total Float will always delay following activities and 'consume' float along the entire 'chain'. In the example above, delaying 'Task 11' by 3 days reduces the available float on Tasks 12 and 13 by 3 as well.

Consequential Delays

The following scenario is not unusual.

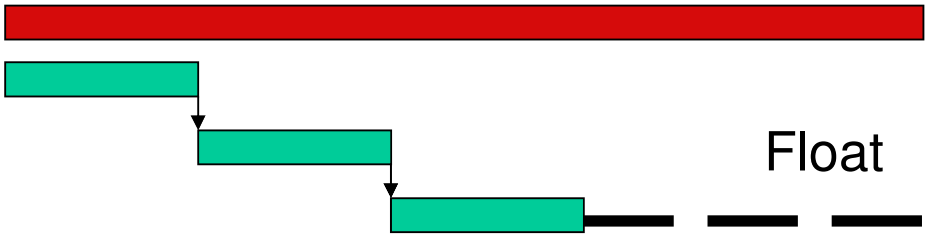


Fig. 7 – Baseline Schedule.

Figure 7 shows the planned schedule for a small project with a critical path and a series of non critical activities in another path. The situation mid way through the project is shown by Figure 8. During the progress of the works, all parties have focused on maintaining the schedule by concentrating effort on the critical activity. But there is a non critical delay caused by the client to the start of the second non critical activity. Under most contracts, this delay would be noted but would not generate any entitlement to an 'Extension Of Time' (EOT) because there has been no change to the project end date caused by this delay.

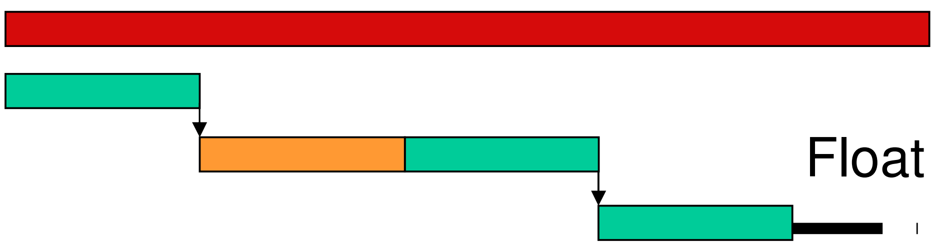


Fig. 8 – Client Delay, non critical.

Figure 9 shows the final situation, the project has finished late. The delay to the third 'non critical' activity was caused by the contractor and has made the contractor liable for damages for late completion. But the actual delay caused by the contractor was significantly less than the original float available to the contractor in the baseline program. The only reason there is a delay in completing the project is the total delay to the 'non critical' sequence of activities caused in part by the client and in part by the contractor.

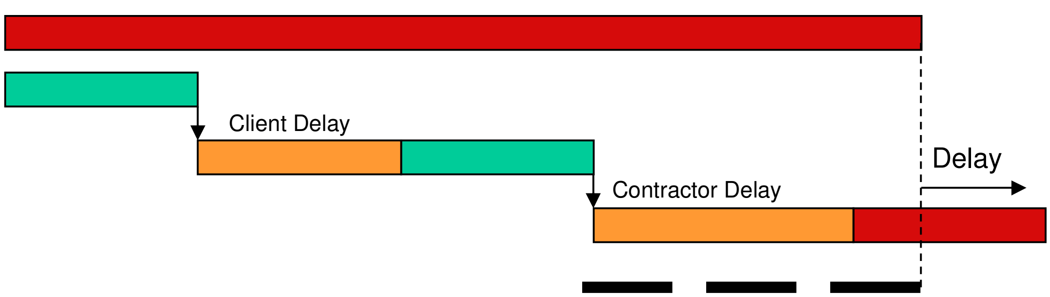


Fig. 9 – Critical Contractor Delay.

Under most contracts, if the first delay was caused by the client and the second by the contractor, the contractor would be liable for damages for the total extent of the delay shown in Figure 9, but if the situation was reversed, with the initial delay being caused by the contractor and the second delay by the client then the contractor would be entitled to an EOT and reimbursement of delay costs. A highly undesirable lottery!

Some authors are suggesting that float be apportioned in advance between the client and the contractor[9]. This solution has some merit (particularly at the theoretical level), but managing the schedule to know what float is available and how it should be allocated given the uncertainties and variability inherent in the CPM process would require a major expenditure of resources. However, this could offer a better solution than float being consumed on a 'first in, best dressed' basis (ie float being treated as a 'resource' available to the project).

Concurrent Delays

The discussion thus far has only considered a single delay event. If there are parallel (or concurrent) delays impacting different parts of the schedule at the same time; understanding the consequences and apportioning liability becomes far more complex. For more on this topic, refer to the paper; 'Concurrent Delays in Contracts[10]'.

Resource Levelling

One of the primary uses of float in scheduling is to smooth or level resource demands. All resource levelling options cause float to change. Generally, float is consumed to allow some work to be delayed to remove peaks in the resource demand curve, occasionally, additional float is created in some parts of a schedule by the resource levelling process shifting the overall completion date to a more realistic and achievable time. Effective resource levelling is a highly skilled process that requires far more than simply selecting an option in your scheduling software. Some aspects of the process required for effective resource levelling are discussed in the paper 'Five Steps to Project Success'[11].

One characteristic of a resource levelled schedule can be discontinuous critical paths as the control on schedule dates flows through resource movements controlled by the algorithms in the scheduling software rather than 'logical' connections in the schedule. Another key consideration is that any change in the scheduled dates for work can cause the levelling to fail and the overall schedule to be delayed. Arguably, there is no float in a resource levelled schedule, only the current scheduled dates for the activities that achieve a balanced resource demand.

The Consequences of Consuming Float

'Float' unquestionably provides a contingency within the schedule that can be used to offset problems and delays, but any reduction in float increases the risk of the project overrunning! As demonstrated in the example shown in Figure 9, above, an 'inconsequential' delay to a non-critical activity (that only consumed some of the available float) was a direct cause of the project finishing late.

As more paths through a schedule approach 'criticality' there is an increased likelihood that a delay on any one of the near critical paths will cause the project to finish late. If there is more than one critical path, then **any** delay on **any** of the critical paths will cause the project to be late and the chance of completing on time will be significantly reduced.

Using Float - Summary

- Float is a creation of the scheduling process and both its quantum and 'location' are heavily influenced by the perceptions and decisions of the people creating the schedule.
- Using float always increases the risk of project failure.
- But if float is not used it disappears – it is impossible to 'bank' float for use in the future.

Managing Float

The clear message of this paper is that if float is to be considered in the management of a project, its use needs to be very carefully controlled by all parties.

When managing internal projects, where there are no formal contracts, float should be treated as a valuable resource to be actively managed by the project team. It is not 'free' to squander early in the project but is available to balance resource demands and overcome problems. The approach should be similar to the management of 'buffers' in the Critical Chain methodology (arguably float and 'buffers' are the same thing, or at least very similar).

In contractual situations the management of float is controlled by the contract. The contract drafters and the lawyers should give active consideration to the best way to manage float for the desired outcome. Most law suggests float is a 'project' resource available to both parties to make use of but this is not always the best option. The UK 'Delay and Disruption Protocol[12]' offers a pragmatic approach to the management of float based around the proactive management of the whole schedule. Whilst the protocol was developed by the UK Construction Law Society, it is useful on <u>**ALL**</u> projects - not just construction projects!

Delay & Disruption Protocol

The starting point in the protocol is that the contractor is responsible for the creation of the schedule and consequently, the creation of float. When the contractor's schedule is approved by the client both parties accept the float 'as is'.

As work progresses, the use of float is first in – best dressed! Either party can cause delays that consume float, but under the protocol, both parties are obliged to work towards achieving a successful outcome. Rigorous reporting obligations are built in to the protocol to identify problems early and allow appropriate corrective actions. The reporting process also tracks the current state of float based on actual progress to date, thereby eliminating arguments over what the 'real' situation is at any point in time.

A key element in the protocol is the separation of the contractor's entitlement to cost reimbursement for disruption from its entitlement to EOTs.

- Disruption occurs when the client delays work necessitating reorganisation – delays to non-critical work may give rise to disruption costs without an EOT entitlement.
- An EOT entitlement arrises when the client delays work that causes a delay in the completion of the project (but this may not cause disruption if the contractor is not actually inconvenienced).

The protocol is a sophisticated document designed to minimise disputes by requiring effective and disciplined scheduling and the rigorous monitoring and reporting of actual performance. To be most effective, the protocol needs to be incorporated into the contract terms and conditions; in the interim it can provide useful guidance.

When incorporated into contracts, the protocol will almost certainly prove most beneficial in collaborative contract arrangements such as client led integrated teams or alliances. The protocol is built on the requirement for open and effective reporting; after relationships break down around a project it is unlikely to help much. Similarly, if the contract is set up to encourage adversarial dealings, the contractor is unlikely to develop a schedule showing the optimum levels of float, to benefit all parties, rather the schedule is likely to be 'fixed' to show the minimum possible levels of float.

Alternative Strategies

Despite its wide spread use, CPM is not the only option for planning and controlling project works, and it is not always the best choice. The use of alternative planning methods such as location-based scheduling, 'line of balance', trend analysis and earned schedule can provide equally as effective in the right situation and each overcome some of the identified shortcomings in CPM (whilst introducing complexities and problems of their own). There is insufficient space in this paper to analyse the relative merits of these systems useful links to information on these topics can be found at:
https://mosaicprojects.com.au/PMKI-SCH-025.php.

Conclusions

The existence of a 'critical path' and float is a creation of the CPM technique. Whilst CPM schedules can and should provide a useful 'road map' for the project team and key stakeholders to use to manage their project to a successful conclusion, the technique is neither fool proof nor perfect. Skill and knowhow are required to craft a useful schedule that is likely to be realistic and achievable, taking into account the resources likely to be available.

Once a realistic and achievable schedule has been developed, regular statusing and updating is required to keep the project and schedule aligned, as work proceeds and the 'reality' of the future unfolds. During this process, the consumption of any float inevitably increases the risk of project failure. Consequently, the management of float needs careful consideration by the project team and the project stakeholders at all times.

Whilst scheduling is an imprecise art, developing and maintaining a 'realistic and achievable' schedule delivers major benefits (provided it is properly used by the project team and key stakeholders). The schedule provides:

- An agreed way forward for the coordination and direction all of the future works on the project.
- A baseline 'time budget' that allows variations from the plan to be identified, quantified and acted upon.
- A framework for problem solving.
- A framework for communication and negotiation within the project stakeholder community (in respect of time, resource requirements, etc).

No schedule can accurately predict or control the future (this is simply impossible), but having a schedule in active use will influence the course of the project. The existence of a 'good' schedule, that is perceived to be useful by the project team, sets expectations and influences actions and decisions of individuals working on activities and the project team as a whole. The real value of scheduling lays in these areas, not in the calculation of arbitrary float values and 'critical paths' to fuel claims and allow unnecessary delay to occur simply because an activity is deemed to have 'float'. To misquote David Ogilvy: "Schedules are for the obedience of fools and the guidance of wise men", especially where float is concerned.

Finally, where formal contracts and contract law become involved, consider applying the UK 'Delay and Disruption Protocol'. The protocol is the best attempt yet to balance the contradictory realities of contract law and scheduling; even if it treats float as being 'real'.

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