Assessing Delays in Agile & Distributed Projects [1]

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Introduction

For the last 50 or more years, the internationally recognized approaches to assessing delay and disruption have been based on the forensic assessment of a CPM schedule. The premise being there is a well-developed critical path schedule that defines the way the work of the project will be, or has been, accomplished. However, there was no concept of a critical path before the 1957[2], and in the 21st century, there are many projects where the critical path method (CPM) is simply not used, or does not represent the way the work is accomplished.

The legal concepts of delay, disruption, extensions of time, and liquidated damages (the *legal framework*), were defined many decades before CPM was developed. In more recent times the advent of agile, lean, and other team-driven approaches to managing projects have been shown to be incompatible with the fundamental concepts of CPM. Earlier papers in this series have also shown distributed projects such as erecting wind farms, or repairing potholes after a flood, are another type of project that has no particular requirement for the work to be undertaken in any pre-defined order, which again makes CPM suboptimal[3].

The key management objective in both agile and distributed projects is optimizing resource utilization and consequently the effect of any intervening event has to be considered in terms of the delay and disruption caused by the loss of resource efficiency, rather than its effect on a predetermined, arbitrary, sequence of activities.

The focus of this paper is to offer a practical solution to the challenge of assessing delay and disruption in agile and distributed projects where the traditional concept of *a critical path that must be followed* simply does not exist.

The foundations of the *legal framework*

The need to assess delays and disruptions affecting the delivery of a project is directly linked to the existence of a contract requiring the predefined scope of a project to be completed to the required standards, within a defined period. If there are no contractual obligations (typical with internal projects) normal project control functions that meet the

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[2] For more on the development of CPM see ***A Brief History of Scheduling*** (page 8), download from: https://mosaicprojects.com.au/PMKI-ZSY-020.php#Overview

[3] See ***Scheduling Challenges in Agile & Distributed Projects***: https://mosaicprojects.com.au/PDF_Papers/P208_Scheduling_Challenges_in_Agile_+_Distributed_Projects.pdf

requirements of the organization's management are appropriate[4]. This requirement changes as soon as there is an external client and a contract.

When a contract is in place, the obligations defined in the contract documents are legally enforceable. The premise contained in the common law[5] is that the contract defines the agreement between the two parties, and both are bound to comply with all of the contract terms and conditions. This means that if one party fails to perform its obligations under the contract, the other party is entitled to be compensated for the resulting breach of the contract terms.

In law, the damages caused by a breach of contract are usually reduced to a financial payment that will, as nearly as practical, leave the disadvantaged party in the same position it would have been had the breach of contract not occurred[6].

The common law framework also includes a presupposition that the only way a contract can be altered is by mutual agreement. This works perfectly well for simple transactions, and in situations where the parties to the contract are willing to work together. In more complex situations, the contract document needs to be drafted to deal with a range of foreseeable issues such as the need to make changes to the scope of the contract, and how other unavoidable delays will be dealt with.

Consequently, most well drafted contracts will incorporate clauses defining the processes for:

- Determining the extent of any change required by the client, including incorporating the change into the contract, and modifying the contract to adequately compensate the contractor for the time and costs involved in implementing the change.
- Allocating the risk of foreseeable delay events between the parties and compensating the contractor for the occurrence of events that are the client's risk.

These processes should be fair to both parties but may not be. However, Common Law expects both parties to honor the contract they have chosen to sign.

Mercantile transactions tend to be relatively straightforward and shaped the Common Law for centuries. The law of contract was primarily focused on trade prior to the 1800s, and this branch of contract law continues to be important through to modern times. This started to change towards the end of the 18th century with the need for judicial oversight of contractual disputes on the increasing number of engineering and construction projects required to build the infrastructure needed for the industrial revolution.

[4] See ***Predicting Completion in Agile & Distributed Projects***:
https://mosaicprojects.com.au/PDF_Papers/P214_Predicting_Completion_In_Agile_+_Distributed_Projects.pdf

[5] **Common Law** is the legal framework used in the UK, most of the USA, and most Commonwealth countries. Other legal frameworks include Civil Law used in Europe and many other countries, and Islamic Law.

[6] The way the amount of damages to be paid for a breach of contract are assessed was defined in *Hadley & Anor v Baxendale & Ors [1854] EWHC J70*. It sets the leading rule to determine the extent of consequential damages: *a breaching party is liable for all losses that the contracting parties should have foreseen*.
Download from: https://mosaicprojects.com.au/PMKI-ITC-020.php#Cases

Unlike mercantile transactions, engineering projects are far more complicated, typically take longer to complete, and the contract needs to incorporate processes to assess the effect of a change and calculate the time and money needed to offset its effects. Consequently, a new branch of contract law focused on building and engineering contracts emerged and was refined through the 19th century. Construction and engineering law continues to evolve into the 21st century, and in many jurisdictions today, has its own specialist courts, judges, legal practitioners, and allied experts. This trend is now starting to extend into the realm of IT contracts[7].

As the sophistication of this branch of the law developed, drafting one-off contracts to manage engineering and construction projects became increasingly complex and expensive. This led to the development of standard forms of contract designed for use in a specific industry. Standard forms of contract tend to reduce cost, improve quality, and help develop a culture of conformance. But they also set expectations and defined norms of behavior.

Some of the earliest standard forms of building contract were created in the UK in the second half of the 1830s. Both the Builders Society (now the CIOB) and the Royal Institute of British Architects (RIBA) were formed in 1834 and were concerned with contractual matters. Together, these organizations developed a set of standard forms of contract for building projects.

One of the issues the early contracts covered was accommodating the need for the client to make changes to the building design after the contract was signed. However, for clauses enabling this type of change to be legally acceptable, there also had to be a provision for the contractor to be properly compensated for the consequences of the change. Normally this involves a financial payment together with an extension to the time allowed to complete the project[8]. Typically, both the cost and time are determined by agreement, or in the absence of an agreement by the decision of a named third party (typically the Architect), or if this is not accepted an impartial third party (often an Arbitrator).

The inclusion of extension of time (EOT) provisions in a contract interacts with another contract component, liquidated damages (LDs). Most contracts include a clause setting a pre-defined estimate of the amount of damages the client would be entitled to receive per day if the project finishes late (pre-estimated and liquidated damages[9]). LDs make

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[7] For example, the UK *Technology and Construction Court* (TCC). The TCC is a specialist court with specialist judges who deal with all types of construction, engineering, and technology disputes.

[8] This approach mitigates the concept of the *prevention principle*. If any part of a delayed project completion was caused by an action, or omission, of the client or its agents, the completion time is set 'at large', all the contractor has to do is complete within a reasonable time. The requirement for a contract to make express provision for extensions of time to cover this type of delay was established by:
- Holme v Guppy (1838) 3 M & W 387
- Wells v. Army & Navy Co-operative Society Ltd. KING'S BENCH DIVISION [1902] 86 LT 764.

Read a summary of ***Wells v. Army & Navy Co-operative Society Ltd [1902] 86 LT 764***: https://mosaicprojects.com.au/PDF-Casewatch/1047_Wells-v-Army_and_Navy.pdf

[9] The UK Court of Appeal defined the concept of liquidated damages in the judgement by Lord Dunedin in Dunlop Pneumatic Tyre Co Ltd v New Garage Motor Co Ltd [1915] AC 79. Read a summary of ***Dunlop Pneumatic Tyre***

recovering the cost of a late completion much simpler than proving actual damages, but the client can only recover damages for late completion if there is an enforceable contract completion date. As soon as the completion date is *at large*[10], there is no practical way for the client to recover damages for a late completion by the contractor. Granting an EOT to compensate for any changes to the contract preserves the completion date, and therefore the right to LDs if the contract finishes later than the approved extended date for completion.

The wording of the clauses allowing the granting of an extension of time vary, a typical example from the 1930s[11] is *"it shall be lawful for the engineer …... to grant from time to time …... Such extension of time for completion …… as to him may appear reasonable"*. Implementing this type of contractual obligation required the architect or engineer to assess the effect of any change and then award an extension of time for the completion of the project. From the 1830s on, Court records show this function was performed regularly and while there were many disputes, when an assessment of the delay was made properly, most of the time the amount of time granted by the architect does not seem to have been contested, and even when it was, the court had the power to correct the architect's determination.

In summary, the ability of the parties and the Courts to assess delay and disruption was developed in the 100-year period before critical path scheduling was invented, and many of the cases referenced above are still the foundation of contract law in the 21st century. It therefore seems logical that extensions of time can be legally determined today without relying on a CPM schedule in situations where the critical path technique is inappropriate. The challenge is developing a way of assessing the consequences of a delay event without a CPM schedule.

The Critical Path Method (CPM)

CPM theory and calculations have been in relatively widespread use for more than 65 years. CPM was developed in 1957 and by the early 1960s CPM and PERT had merged into a general approach to network scheduling[12]. The fact CPM has survived virtually unchanged through to the present is because CPM schedules are useful in a lot of situations.

Critical path theory assumes there is one best sequence of discrete activities, that have to be completed in a pre-defined order, to deliver a project successfully. This assumption creates a perception of certainty that the schedule accurately defines how the work will

Co Ltd v New Garage Motor Co Ltd [1915] AC 79:
https://mosaicprojects.com.au/PDF-Casewatch/1034_Dunlop-v-New_Garage.pdf

[10] Changing the amount of work in a contract without an EOT provision means the original contract date is no longer valid, and there is no contractually valid way of assessing a revised date – the date is *at large*. If the contract has an EOT clause, the parties may argue of the amount of delay, but ultimately this dispute can be resolved by a court, and the contract corrected preserving LDs if the completion is still late.

[11] Quoted in: Miller v London County Council [1934] 50 T.L.R. 479.

[12] For more on the origins of CPM and PERT see ***A Brief History of Scheduling***:
https://mosaicprojects.com.au/PDF_Papers/P042_History_of_Scheduling.pdf

be accomplished, allowing the critical path and float to be calculated[13]. Based on these calculations, the effect of progress and delays can be assessed and apportioned between the parties to the contract. Over the last 50 or so years, the theory of CPM scheduling has underpinned:

- Contract drafting
- Legal precedents, and
- The forensic assessment of project delays.

These developments have led to two, largely complementary frameworks for assessing delay and disruption, the AACEi ***Recommended Practice 29R-03 Forensic Schedule Analysis*** and the Society of Construction Law ***Delay and Disruption Protocol*** (2nd edition)[14].

- ***RP 29R-03 Forensic Schedule Analysis*** states it is a unifying reference of basic technical principles and guidelines for the application of critical path method (CPM) scheduling in forensic schedule analysis. It discusses several methods of schedule delay analysis but is not intended to establish a standard of practice, nor is it intended to be a prescriptive document applied without exception.
- The ***Delay and Disruption Protocol*** provides useful guidance on some of the common delay and disruption issues that arise on construction projects, with a view to minimizing disputes.

The foundation of both frameworks is a well-constructed and maintained, contemporaneous, CPM schedule. Preferably developed before the work commences, although 'as-built' schedules created after the project finishes are used in some of the analytical processes[15].

There are recognized problems with these approaches to schedule delay analysis, most notably different experts can produce very different answers to the same question by either using different analysis techniques or by using the same approach but making different assumptions. The various courts and tribunals hearing contractual disputes are well practiced in resolving these differences. The approach is not perfect, but is the best we have for projects where the basic CPM assumption of *one-best-way* of accomplishing the project's work holds true.

Fundamental problems with this established approach start to arise when the intrinsic nature of the project allows different sequences of working to be adopted (and changed) without detriment to the overall progress of work. This means a CPM schedule cannot define the one best way of undertaking the work, because there are many equally viable

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[13] For more on developing a CPM schedule and the calculations see ***CPM Schedule Management***: https://mosaicprojects.com.au/PMKI-SCH-010.php

[14] Papers discussing ***RP 29R-03*** and the ***Delay and Disruption Protocol*** can be downloaded from: https://mosaicprojects.com.au/PMKI-ITC-020.php#ADD

[15] An excellent paper detailing the steps needed to construct an as-built schedule, where the project has no effective CPM schedule is ***Delay Analysis on Non-CPM Scheduled Projects*** by Navigant. Download the paper: https://mosaicprojects.com.au/PDF-Gen/Delay_Analysis_on_Non-CPM_Scheduled_Projects.pdf

alternatives. In some situations, there may be a CPM schedule showing the intended sequence of working at the start (but this can be easily changed), in others there is no predetermined sequencing of the work. Approaches such as lean and agile are based on encouraging flexible decision making on what to do next as the work progresses. A different paradigm for assessing delay and disruption is needed for this type of project.

Project types that are not suited to CPM

In an earlier paper, ***Scheduling Challenges in Agile & Distributed Projects***[16] we developed four classifications for projects based on the applicability of the CPM approach. Under this classification system:

- **Class 1 & 2** projects are suited to the CPM paradigm, there is generally one best way to accomplish the work:
  - **Class 1** projects are physically constrained, there is only one viable work sequence (for example high rise buildings)
  - **Class 2** projects are practically constrained, once management has agreed the best work sequence, all of the work needs to follow the imposed flow in sequence (for example a road can be built from either end, but, once management decide on the start point everything needs to flow in the same direction).
- **Class 3** projects (the focus of this paper) include a wide range of soft and distributed projects where there is range of options for completing the work, and any planned sequence can be changed relatively easily to deal with emerging situations. In Class 3 projects, there is always some degree of overarching constraint affecting the overall sequence of working, with varying degrees of flexibility in the way the detailed work is performed, but the *one-best-way* of doing the work does not exist. This type of project is typically managed using agile, lean, or adaptive approaches.
- **Class 4** projects are 'Class 3' projects where management has imposed a CPM schedule, on the assumption there is only one best way to do the work. This may be cultural (it is the way we've always managed projects), or frequently, the use of CPM is a contractual requirement.

The problem with Class 4 projects are:

- The CPM assumptions fall to bits under stress:
  - The schedule logic is ignored
  - People keep working on the other available work
  - Controls are ad hoc – usually based on common sense and conversation (no documentation), and consequently
  - There are no tools for assessing genuine delay or disruption
- The artificial CPM outputs:
  - Do not provide useful management information, and

[16] Download ***Scheduling Challenges in Agile & Distributed Projects***: https://mosaicprojects.com.au/PDF_Papers/P208_Scheduling_Challenges_in_Agile_+_Distributed_Projects.pdf

- Are increasingly being rejected by the courts (see *Problems with delay assessment using CPM* below).

Managing Class 3 (agile and distributed) projects

As outlined above, CPM works well in Class 1 & 2 projects, but is suboptimal in Class 3 & 4 projects. The options for managing Class 3 projects include the various forms of agile, lean, and other similar approaches. The common factor is the people doing the work decide on the next set of activities to undertake at regular, relatively short, intervals. The decisions are made based on the current situation, any overall project requirements or road map, and any identified constraints or specific sequencing issues. The planning process is iterative and is repeated until the project work is complete.

There are many different methodologies and tools designed for use in this type of project, most focus on optimizing resource efficiency in the short term. Some of the more common tools in use are considered in ***Calculating Completion***[17].

Calculating Completion identifies two tools that will work effectively for assessing the current status and predicting the completion of Class 3 projects (as well as Class 1 & 2):

1. **Earned Schedule** (ES). ES requires earned value management (EVM) to be implemented before it can be used. It has a very reliable calculation of the current status and the likely project completion date[18].
2. **Work Performance Management** (WPM). WPM is also a predictive tool, similar in its approach to ES. It also has a reliable calculation of the current status and the likely project completion date but can operate stand-alone[19] (EVM is not required).

However, neither of these tools can be used for the day-to-day control of the work (they are predictive tools). Detailed forward planning needs other techniques such as bar charts, CPM schedules, or other agile techniques.

Consequently, while ES and WPM can predict the likely project completion date accurately, and their predictions are generally more accurate than CPM in Class 1 & 2 projects, they cannot be used for assessing the delay caused by a specific intervening event[20]. Both tools look at the overall performance to date and use this information to calculate the project status and predict its completion. Delay analysis needs the segregation of both the cause and effect for each individual delay event to assign responsibility between the parties to a contract.

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[17] Download ***Calculating Completion***:
https://mosaicprojects.com.au/PDF_Papers/P217_Calculating_Completion.pdf

[18] For more on ***Earned Schedule (ES)*** see: https://mosaicprojects.com.au/PMKI-SCH-040.php#Process2

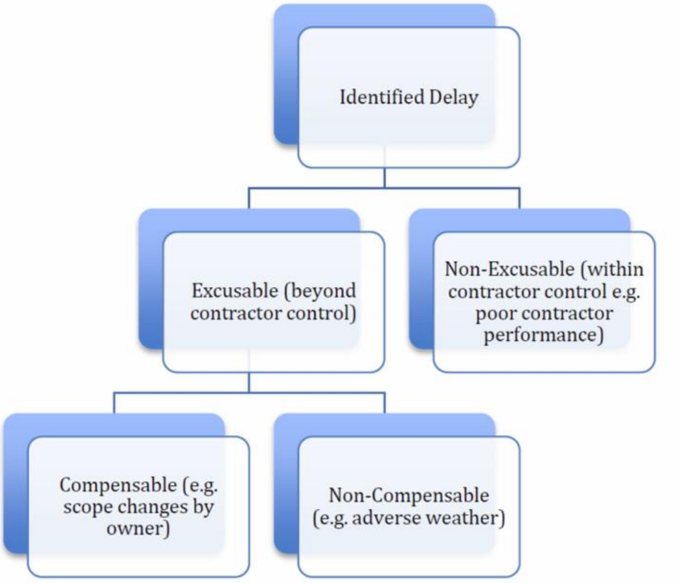
[19] For more on ***Work Performance Management (WPM)*** see:
https://mosaicprojects.com.au/PMKI-SCH-041.php#Overview

[20] An ***intervening event*** is unforeseen occurrence which interferes with or disrupts the planned progress of the work.

Basic Delay Assessment

The basic principles of assessing delay and disruption involve:

1. Identifying each individual event (intervening event) that has caused a delay to an aspect of the work.
2. Separating those that are the responsibility of the contractor from those caused by, or the responsibility of, the client.
3. For the client delays, work out their effect on the work (disruption) and see if they also affect the project's completion (i.e., cause a contractual delay).
4. For the client delays affecting completion, identify the duration of the delay and separate those that only generate an EOT from those that also create a right to compensation.



These basic steps do not change, but in the real world there are many complications and difficulties including various delays occurring in parallel, work occurring out of the planned sequence, and the flow-on effect of one delay event to another. Most contracts require these issues to be resolved as the work progresses, in disputed contracts the final decisions are usually made by an Arbitrator or court long after the project was completed[21].

Problems with delay assessment using CPM

Courts are increasingly rejecting CPM evidence for Class 4 'distributed' projects, two examples are
Costain Ltd v Charles Haswell & Partners Ltd [2009] EWHC B25*
(TCC - 24 September 2009), and
White Constructions Pty Ltd v PBS Holdings Pty Ltd [2019] NSWSC 1166,*
(6th September 2019).

Costain Ltd v Charles Haswell & Partners Ltd[22]

This dispute involved the construction of a water treatment works involving multiple structures. A CPM schedule was used as a basis of a time claim and delay was proved to two foundations using a 'windows analysis' which is a recognized way of assessing EOTs and is included in both the SCL *Delay and Disruption Protocol* and the AACEi

[21] ***Forensic delay analysis*** is a complex process, for more on this see: https://mosaicprojects.com.au/PMKI-ITC-020.php#Process1

[22] For a more detailed analysis of ***Costain Ltd v Charles Haswell & Partners Ltd [2009] EWHC* B25 (TCC - 24 September 2009)*** see: https://mosaicprojects.wordpress.com/2023/03/25/costain-vs-haswell-revisited/

Recommended Practice No. 29R-03 Forensic Schedule Analysis. The two experts engaged by the parties only disagreed on the extent of delay.

However, the basis of the forensic CPM analysis used by the experts was rejected by the Judge:

> [Clause 185] ….*no evidence has been called to establish that the delaying events in question in fact caused delay to any activities on site apart from the RGF and IW buildings.*

> [Clause 233] *…. experts have agreed that the delays to the RGF and IW [foundations] were critical delays since those buildings were on the critical path of the project at the relevant time. Ordinarily therefore one would expect, other things being equal, that the project completion date would be pushed out at the end of the job by the same or a similar period to the period of delay to those buildings. However, as experience shows on construction sites, many supervening events can take place which will falsify such an assumed result. For example, the Contractor may rearrange his programme so that other activities are accelerated or carried out in a different sequence thereby reducing the initial delays*.

This judgement suggests that on distributed projects where the work sequence can be changed with relative ease, the use of a predetermined CPM schedule that shows only one way of accomplishing the work will not support an overall delay claim – more information is needed.

White Constructions Pty Ltd v PBS Holdings Pty Ltd[23]

This dispute related to the construction of a 100-lot subdivision on the NSW South Coast including the construction of roads and underground services. There were delays in approving the sewage system, and a large part of the dispute centered on the consequences of this holdup.

Delay experts were engaged by both of the parties, to construct an as-built CPM schedule but they disagreed on methods and the evidence of the experts was mutually contradictory. To resolve this impasse, the Court appointed its own expert Mr McIntyre and based many of its findings on his report.

The judgement includes:

> [Clause 195] *Mr McIntyre's opinion, upon which I propose to act, is that neither method [used by the parties' experts] is appropriate to be adopted in this case.*
>
> [Clause 196] *Mr McIntyre's opinion, upon which I propose to act, is that close consideration and examination of the actual evidence of what was happening on the ground will reveal if the delay in approving the sewerage design actually played a role in delaying the project and, if so, how and by how much. In effect, he advised that the Court should apply the common law common sense approach to causation…*

Whilst there was evidence that approval of sewer designs was delayed for a period during construction, there were no details concerning how the delayed work affected the progress of other aspects of construction The contractor's resources were kept busy working for the full period – therefore no proof of an actual delay.

Commentary

The first thing to note in both cases is the event causing a delay to a significant element of the works was proved – work was delayed. What was not shown was if the delay to one element of the work on a distributed project flowed through to cause a delay in the overall completion. The judges refused to accept traditional CPM analysis on the basis that the CPM activity sequence was not shown to accurately reflect the reality of what occurred. These findings do not mean there was no overall delay to the project, rather

[23] For a more detailed analysis of ***White Constructions Pty Ltd v PBS Holdings Pty Ltd [2019] NSWSC* 1166, (6th September 2019)*** see: https://mosaicprojects.wordpress.com/2024/02/19/white-constructions-v-pbs-holdings-revisited/

the approach used by the claimant's experts to demonstrate the delay based on CPM was not valid in a situation where there were many different, equally effective, ways of completing the work.

This problem affects:

- All distributed projects where workflows can be redirected relatively easily.
- All agile projects (not just IT) where workflows are chosen by the project team as work proceeds.
- And all projects using lean construction and last planner techniques for similar reasons.

In these types of projects, the traditional concept of a critical path does not exist. There may be a high-level road map outlining the desired route to completion and/or specific constraints on parts of the work but overall, there is a lot of flexibility in the way the work may be accomplished. In many cases, particularly projects using various agile methodologies, there is a deliberate management intent not to follow a predetermined sequence of activities defined in a CPM schedule.

But, without a CPM schedule, there are no generally recognized techniques for assessing delay and disruption. The SCL *Delay and Disruption Protocol* makes a point of separating the cost of disruption from the right to an extension of time (EOT), but its approach is still dependent on a valid CPM schedule. Without the schedule, there is no recommended approach to determining the cost of the imposed inefficiency or determining the consequential delay (if any). A new paradigm is needed.

The challenge is developing effective protocols for assessing delay and disruption in the absence of CPM. The good news is, both the SCL *Delay and Disruption Protocol* and the AACEi *Recommended Practice 29R-03 Forensic Schedule Analysis* both recognize other approaches to assessing delay may be valid, and the courts also appear to be recognizing this.

Assessing delay and disruption in the absence of CPM

As discussed above, the traditional concept of a critical path does not exist in agile and distributed (Class 3) projects, there may be a high-level road map outlining the desired route to completion and/or specific constraints on parts of the work but there remains a significant degree of flexibility in the way most of the work is accomplished:

- In many projects being managed using agile or lean construction concepts, there is a deliberate management intent not to follow a predetermined sequence of activities.
- In others, while there may be a CPM schedule, when circumstances force a change in plan, there is very little disruption to the work.

The courts have identified the failings in CPM when applied to distributed projects (Class 4), and the industry has identified the failings in CPM when applied to agile projects (Class 3). But without a CPM schedule there are major challenges in:

1. Measuring how is the work progressing, to identify issues and opportunities.

2. Predicting project completion in a consistent and defensible way.
3. Assessing the consequences of delay and disruption to calculate EOTs and delay costs.

An effective solution to these problems is also likely to work on Class 1 & 2 projects, allowing the CPM schedule to be used proactively rather than contractually.

Assessing status and completion

The techniques discussed in *Managing Class 3 (agile and distributed) projects* above achieve the first two points. Both ES and WPM[24] will calculate the current status of the project, and can be applied to sections of the work to assess progress by individual teams, trades, or areas of work. Then based on the progress to date and current performance they also calculate the likely completion date. However, these techniques are unlikely to provide much assistance in assessing delay and disruption, they are based on a holistic assessment of progress, and cannot be used to segregate the effect of one specific event from the other deviations from the baseline.

Both the SCL *Delay and Disruption Protocol* and the AACEi *Recommended Practice 29R-03 Forensic Schedule Analysis* state other common-sense approaches to assessing delay are valid but fail to document any such approach. However, the basis of any delay and disruption[25] assessment remains the same. To prove a delay, you need to show:

1. There is a project plan. The plan can be very simple, but at a minimum the amount of work to be accomplished, the overall project timeframe, and the planned workforce must be known.
2. A prospective, or actual, intervening event must be identified.
3. The intervening event has to be shown to impact the planned work.
4. The consequences need to be measured.
5. And the owner of the risk (consequences) needs to be determined.

While the basics do not change, this paper recommends shifting the assessment of delays and disruption away from its effect on an arbitrary sequence of activities in a CPM schedule, to understanding the effect of the intervening event on the productivity of the resources working on the project. The best way to make this assessment will depend on the nature of the intervening event. Four adaptations of this basic concept are outlined below.

1. Full project delays

Delays affecting all the work of a project are the easiest to assess. Events such as project wide industrial action, major weather events, and other similar occurrences that stop the

[24] For more on ***Work Performance Management (WPM)*** see: https://mosaicprojects.com.au/PMKI-SCH-041.php#Overview

[25] **Delay** means the time for completion of the project will be extended. If a delay is approved, an Extension of Time (EOT) for the completion is awarded
Disruption means the work of the project is made less efficient thereby increasing costs. Disruption of non-critical work has a cost consequence but does not generate an EOT.

work simply need the duration of the delay to be determined. This requires a record of the time the event started, and the time it finished. Sometimes this is clearcut, on others, agreement may be needed particularly around the end of the delay period if the return to work is staged over a period. Good record keeping helps.

2. Homogeneous team delays

Many Class 3 projects are worked on by an integrated team of people, where to a large extent one person can cover the work of another. This is common in many soft projects[26] (particularly IT) but can occur in other situations. Basically, a team of people are assigned to deliver the project, and they work as a homogenous, cross-functional team. In this situation a delay occurs when an intervening event reduces the productivity of the team. The event may cause a 100% loss of productivity, or a partial loss. Where a partial loss of productivity occurs, this needs to be adjusted to an equivalent period of total loss.

For example, a major storm causes an evacuation of a city where an IT project is running. The starting point is usually obvious – the evacuation order. The end point, duration, and overall effect may be less clear. If the IT company has disaster management and remote working capabilities, some people may be able to resume work before the storm damage is cleaned up and the office reopened. But these people are likely to be less efficient than when the full team is working together in a fully equipped office. A proper assessment of the full delay requires the inefficiency caused by loss of productivity to be granted as a justifiable delay in addition to the period of 100% shutdown.

This means any assessment of the total delay needs to consider the percentage of resource effort lost on each day. In this example assume 8 out of the 10 people on the team can work remotely, and their productivity while working remotely is assessed at 75% of normal. This means when working remotely the team is achieving 80% x 75% = 60% productivity per day (a 40% loss of productivity).

Therefore, if everything was stopped by the storm for 2 days, followed by 10 days of remote working before returning to the office, the delay is calculated as:

- Period of 100% delay = 2 Days
- Loss of productivity during remote working = 10 days * 40% = 4 Days
- **Total delay = 6 Days**

3. Driving resource workflow delays

In other Class 3 projects, typically hard projects[27], the work is delivered by a series of discrete resource teams working in coordination. The members of each team are generally not interchangeable, having different qualifications and skillsets. In this situation assessing the disruption to the key resource workflow may be a more appropriate way to measure delay.

[26] ***Soft projects*** are ones where the majority of the work has a degree of flexibility on how the required functionality is achieved: https://mosaicprojects.wordpress.com/2023/01/21/hard-v-soft-projects/

[27] ***Hard projects*** are ones where the majority of the work is dependent on a finalized design being complete prior to work starting on that element: https://mosaicprojects.wordpress.com/2023/01/21/hard-v-soft-projects/

In a typical hard project, there will be a number of trade contractors, each responsible for a discrete element of the overall product. Normally, one of these trades is the driving resource that controls the rate of work of all of the other trades working concurrently. For example:

- When constructing a concrete frame building, the overall rate of progress is typically controlled by the formwork crew; all the other trades such as steel fixers (reinforcement) and concrete placers work intermittently.
- In an IT project, QA and independent testing resources may have an important role to play, but they can only perform their function once working modules of code are handed over from the team developing the software. Apart from the final tests at the end of the project, progress is controlled by the rate of production of the software development team.
- On a windfarm, during tower erection and commissioning, the speed of work is controlled by the productivity of the crane responsible for the heavy and high lifts.

On many projects, the driving resource that controls the overall rate of progress is likely to change throughout the project. In a windfarm the driving resource are usually:

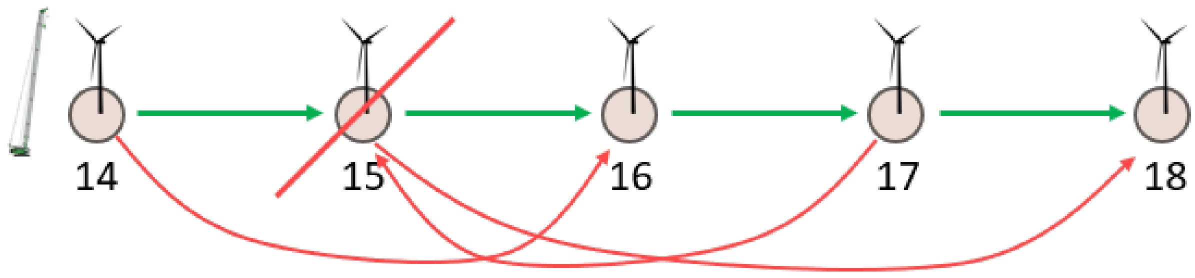
- Initially the progress of work will be controlled either by the civil engineering preparation on-site, or the tower manufacture off-site. Deciding which depends on the the project.
- Control shifts to the main crane once tower erection commences.
- The final element is the people responsible for commissioning and reliability testing.

Peripheral activities such as the building of the switchyard, commissioning the control systems, and installing HV transmission lines, are unlikely to cause project delay. In CPM language, these activities have float. Delays or disruption affecting these sub-critical workflows are expensive but are unlikely to delay overall completion. If the work of a sub-critical crew is delayed to the point where the overall project is delayed, the delay manifests in a delay to the driving resource.

The difference between a CPM project and a Class 3 project is if the controlling resource crew cannot work on one element (eg, a particular turbine tower), they can often simply relocate to another, work is continuous but may be less efficient. Therefore, the extent of a delay is not measured by the time work on a specific activity is stopped, rather by its effect on the driving resource.

For example, the main crane working on tower erection is currently planned to work on tower erection in the sequence 14, 15, 16, 17, and 18. The planned time to relocate the crane and erect each tower is 2 days which includes the 500 meters travel between towers.

In this scenario, the crane has just finished Tower 14 and is derigging ready to relocate to Tower 15 when a major defect is identified in a component for Tower 15 preventing the tower being completed. Defect rectification is expected to take 4 days.



In a CPM schedule, the delay of 4 days to Tower 15 would show as a 4-Day delay to the project.

In a Class 3 project there will be delays, but the sequence of work now becomes 14, 16, 17, 15, 18. There is no downtime. The delays are caused by inefficiencies:

- There is 500 meters of additional travel distance and time between Towers 14 and 16.
- There is 500 meters of additional travel distance and time between Towers 17 and 15.
- There is 1,000 meters of additional travel distance and time between Towers 15 and 18.

The number of crane moves is the same, the delay is the time needed to travel the additional distance – the rate of travel of big cranes is measured in meters per hour. Assuming the towers are evenly spaced at 500 meters apart, the distance involved is:

- Original distance = 2000 meters
- Revised distance = 4000 meters
- Additional travel = 2000 meters @ 400 meters per hour = **5 hours delay**.
- Plus depending on the time the defect was noticed, there may also be loss of time and additional costs based on preparatory work done at Tower 15, and the need to relocate this preparatory work to Tower 16.

In Class 3 projects, the assessment of any delay has to be separated from the cost of the disruption caused by the same intervening event. Some delay events (eg, wind of 15 m/sec on a wind farm) may delay the primary crane but the wind will only affect the crane if it is engaged in a heavy / high lift, not if it is in the process of relocating to the next turbine. And, where a delay affects the primary crane, it will flow onto fit out, commissioning, and completion; but will have no effect on civil works, deliveries, and the tower base erection. Whereas other events, (eg, a severe thunderstorm) will shut down all external works[28].

The effect of the delay has to be real. Consider an IT project where the next sprint is intending to complete a module from the backlog involving credit card validation. There are many other work-items, the card validation just seems to be a sensible thing to do

[28] A detailed discussion of the controls challenges on windfarms starts page 12 of ***Scheduling Challenges in Agile & Distributed Projects***: https://mosaicprojects.com.au/PDF_Papers/P208_Scheduling_Challenges_in_Agile_+_Distributed_Projects.pdf

next. Then the client asks for this module to be put on hold, they are looking at decreasing the number of card types. A couple of weeks later the hold is lifted. In this situation, the only disruption is rethinking what is best to include in the next sprint, the reselection occurs and work goes on. Agile focuses on flexibility and in this situation being flexible removes the delay. It is only after the hold has been kept in place long enough to cause an effect on the work of the resources that a delay may occur.

Managing driving resource delays. The keys to applying this type of assessment to determine project delays are:

1. Agreeing in advance the driving resource for each stage of the project and the transition points (transition points need to be based on physical progress, not dates)
2. Confirming the driving resource at each progress meeting (typically monthly)
3. Good record keeping. Records should be agreed by both parties.
4. Detailing the delays contemporaneously – the information should be agreed even if the consequences are not.

The only significant difference between this approach and standard contract EOT clauses, is the effect of the delay is measured against resource productivity rather than CPM activities.

4. Work volume delay assessment

Some changes do not have an immediate effect on productivity or require changes to the short-term work sequence but will delay the project. These are usually changes in scope. An IT project has additional features added, a windfarm project has a couple of additional towers added. Provided the change is made sufficiently early in the project, the only consequence is the team has more work to do.

Delays caused by changes in volume of work can be assessed based on the planned rate of production:

- Considering the windfarm project discussed above, when the client orders 2 additional towers. We know the driving resource is the main crane tower erection and each tower takes 2 Days. Provided the order is received in time for the work to be included in the off-site manufacturing the delay will be 2 * 2 = 4 Days assuming manufacture is a local activity and the towers are trucked to site.
  If the manufacture is overseas, and the towers are shipped as a batch, there may be an additional delay caused by a delayed shipment, this will depend on circumstances.
- If the client orders additional features on a software development, the effect can be calculated as follows:
  - Establish the production rate of the driving resource. In this case:
    - The project currently includes 160 story points (all approximately the same size)
    - The sprint teams are expected to deliver the 160 points in 40 days – an average of 4 story points per day
    - The start up and close down activities at the beginning and end of the

project are
unaffected.

- The new features are estimated to involve 20 story points.
- The additional time required is 20/4 = 5 Days.

Note 1: Generally, contract law will not require a project to increase its resources to compensate for additional work. This arrangement can always be negotiated, but the legal requirement is to minimize the effect of the disruption using the available resources. Where additional or new resources are required, there is generally cost considerations.

Note 2: In all of the above examples, the entitlement to reimbursement of costs for the delay will depend on the risk allocation in the contract.

The way forward

Recognizing the need for processes other than CPM to effectively assess delay and disruption is becoming increasingly important. While it is possible to develop an 'as-built' CPM schedule for almost any project after completion, the *White Constructions v PBS Holdings* judgement demonstrates this can be a highly subjective process. More important, effective contract management requires the effect of any intervening event to be assessed contemporaneously.

This paper has demonstrated CPM cannot provide a valid basis for assessing delay and disruption in a wide range of projects including:

- Projects managed using an agile or iterative approach to development. A key tenet in the agile concept is an assumption that the client, end user, and delivery team work together to proactively solve problems and create success. The delay assessment approaches outlined in this paper fit into this model, and if the relationships break down, still provide an effective process for assessing delay and disruption.
- Distributed projects where there is no particular requirement for large parts of the work to be completed in any particular order. Both *White Constructions v PBS Holdings* and *Costain Ltd v Charles Haswell & Partners* show the courts are increasingly looking for practical proofs of delay rather than arbitrary calculations based on an assumed work sequence in a CPM schedule.
- Projects managed using Lean Construction and similar approaches where the forward planning is iterative and short term. The work sequence is deliberately flexible, but the work to be accomplished and the resources are constant, therefore the concepts outlined in this paper will provide a valid basis for assessing delay and disruption.
- Finally, emerging technologies such as generative AI[29], BIM[30], Digital Twins, etc., have the potential to render traditional CPM obsolete. These approaches

[29] For more on ***AI in project management*** see: https://mosaicprojects.com.au/PMKI-SCH-033.php#AI

[30] For more on ***BIM (Building Information Modelling)*** see: https://mosaicprojects.com.au/PMKI-ITC-011.php#BIM

are moving towards an adaptive, integrated approach to the design, planning, and control of projects. As this occurs, it is likely the discipline of CPM scheduling will merge into the workflows embedded in the digital model[31]. When this happens, it will not need much adaptation to use the concepts outlined in this paper to provide a valid basis for assessing delay and disruption.

The biggest challenge moving forward will be to overcome 65 years of practice welded to the view CPM is the only way to develop and manage schedules, control projects, and assess delay and disruption. Gaining recognition Class 3 and 4 projects need a different approach to Class 1 and 2 projects will be difficult. Class 3 and 4 projects need a different approach that complements the way work on the project is actually being managed. This paper offers one solution, there may be others.

Conclusions

There is more work needed in this area:

- In many situations, traditional contracts are not fit for purpose, CPM does not work on agile and distributed projects, but contract changes are required to allow the use of improved management and controls processes.
- Protocols need to be developed for dealing with the issues discussed in this paper pragmatically within existing forms of contract. Currently, the only management approach for dealing with continual change in Class 3 projects is to:
    - Keep rigorous and detailed records of everything
    - Provide all of the notices and determinations in the time required
    - Try to sort the mess out afterwards by negotiation or mediation.
- The project controls community needs to be willing to move on from CPM in the large numbers of projects where it simply does not work.

[31] Some of the possibilities for integrated controls are discussed ***in Projects controls using integrated data – the opportunities and challenges!*** https://mosaicprojects.com.au/PDF_Papers/P200_Projects_controls_using_integrated_data.pdf

About the Author

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Patrick Weaver, PMP, PMI-SP, FAICD, FCIOB, is the Managing Director of Mosaic Project Services Pty Ltd, an Australian project management consultancy specializing in project control systems. He is a Fellow of the Chartered Institute of Building, Australasia (FCIOB) and a Fellow of the Australian Institute of Company Directors (FAICD). He is a member of the PMI Melbourne Chapter (Australia), as well a full member of AIPM, and the Project Management College of Scheduling (PMCOS).

Patrick has over 50 years' experience in Project Management. His career was initially focused on the planning and managing of construction, engineering and infrastructure projects in the UK and Australia. The last 35 years has seen his businesses and experience expand to include the successful delivery of project scheduling services and PMOs in a range of government, ICT and business environments; with a strong focus on project management training.

His consultancy work encompasses: developing and advising on project schedules, developing and presenting PM training courses, managing the development of internal project control systems for client organizations, and assisting with dispute resolution and claims management.

In the last few years, Patrick has sought to 'give back' to the industry he has participated in since leaving college through contributions to the development of the project management profession. In addition to his committee roles, he has presented papers at a wide range of project management conferences in the USA, Europe, Asia and Australia, has an on-going role with the PGCS conference in Australia and is part of the Australian delegation to ISO TC258.

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