THE IMPROVEMENT OF DELAY ANALYSIS IN THE UK CONSTRUCTION INDUSTRY

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Declaration

This work or any part thereof has not previously been presented in any form to the University or to any other body whether for the purposes of assessment, publication or for any other purpose. Save for any express acknowledgment references and/or bibliographies cited in the work, I confirm that the intellectual contents of the work are the result of my own efforts and no other person.

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ABSTRACT

Delays are a common feature of construction projects and frequently lead to disputes between the parties. In resolving these disputes it is essential to have a robust methodology for analysing delays. It is argued that current understanding of available delay analysis methodologies is inadequate and hindered by taxonomic confusion. There is a need for guidance on available delay analysis methodologies and an explanation of how these are implemented, and, as a result, models have been proposed that aid practitioners in the selection of a defendable and most appropriate delay analysis method under the specific circumstances of a project. This suggests an element of choice over the method to be selected: for example, the Society of Construction Law recommended the Time Impact Analysis methodology for undertaking a retrospective delay analysis. The question is whether this or any such methodology is necessarily appropriate.

There is general confusion over the selection of delay analysis methodologies. Here, it is proposed that this confusion can be reduced and delay analysis improved by an analysis of the latest research on the status of delay analysis in the UK, an analysis of common law guidance on methodology, an assessment of professional and research literature on delay analysis and research into what is being currently undertaken by experts in the field of delay analysis. This has been done using a mixed methods approach that included: (i) analysis of a questionnaire survey by the CIOB to understand the current state of time management in the UK construction industry; (ii) analysis of the industry guidance on delay analysis methodologies; (iii) a comprehensive review of related English Case Law; and (iv) an analysis of 27 case studies comprising programming expert reports that were presented as evidence in arbitrations. These multiple sources enabled the researcher to ascertain, in the case of each delay analysis methodology: (a) the dominant method actually used in disputes; (b) the details of its application; (c) the reasons for its selection; and (d) its level of accuracy and subsequent acceptability.

The research demonstrates that when time claims are accompanied by cost claims there is a dichotomy in the choice of appropriate methodology. There is a clear preference for prospective analysis of time issues, but a retrospective approach for claims that involve finance. At the same time, when a claim contains both elements, the courts appear to prefer a single approach, namely, the retrospective approach. This has resulted in the recommended method of undertaking delay analysis by the Society of Construction Law being not supported by English common law and ultimately to an increase in confusion within the Industry.

Given the courts' fundamental opposition to a method that better accords with forensic logic, it is expedient to recommend a 'best of the rest' method for delay analysis rather than adopt a formulaic approach to selecting the appropriate delay analysis methodology. Case study reviews have shown the Windows Analysis methodology is widely used and this is also widely accepted as the most accurate and appropriate methodology, although less well known than other less appropriate delay analysis methodologies.

Apart from its theoretical significance, the research should improve construction practitioners' understanding of delay analysis, and provide clarity on the evidence required to support a claim for an extension of time. It has the potential to reduce disputes over selection criteria and promote harmony between the construction and the legal professions over the appropriate method of resolving delay claims.

NOTE:

Near the completion of this research, the Society of Construction Law have started to reconsider their recommended retrospective delay analysis methodology within their Delay and Disruption Protocol. This is in recognition of the changing landscape of English common law, as set out in this thesis. The researcher has expressed his views as part of the Industry Review of the proposed revision. The communication between the researcher and the Society of Construction Law is contained in Appendix A to this thesis.

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CHAPTER 1

1 INTRODUCTION

1.1 Background to the research

Construction is one of the largest sectors of the UK economy. It contributes almost £90 billion to the UK economy (or 6.7%) in value added and comprises over 280,000 businesses covering some 2.93 million jobs, which is equivalent to about 10% of total UK employment (Department for Business Innovation and Skills, 2013). A study by the National Audit Office (2001) of the performance of government construction projects, which amounted to £7.5 billion expenditure, showed 70% of the projects were delivered late.

This thesis concerns the analysis of delays to the late completion of projects in the UK construction industry.

According to American composer Leonard Bernstein:

> *…To achieve great things, two things are needed; a plan, and not quite enough time…*

This is perhaps the view of some employers on construction projects. The completion date is not generally set by the specialist, i.e., the contractor, and based on a reasonable time to complete the scope of works within, but is often, instead, determined by the employer based on commercial needs, sometimes without a full appreciation of the time needed. When assessed by contractors this tends to be shorter than the time they think it ought to take to carry out the works (Winch & Kelsey, 2004). Yet the contractor, and indeed the employer, is often held to it.

The main need for delay analysis is in order to protect the right to impose damages in the event that completion is delayed beyond the stipulated date (Ackoff, 1983).

Delay is the measure of actual progress against the planned approach or conversely the assessment of delay events on the actual progress of the works. Generally, delay analysis is considered as a subset of programming and planning, although it is accepted that different skill sets are required to undertake delay analysis (AACE, 2007). However, to understand the context of delay analysis it is first necessary to understand the philosophy of planning.

1.2 Planning

On the matter of planning the CIOB (1991) declared that:

> *…the ability to control must emanate from a plan - a way of proceeding - for without a plan only chaos would ensue…*

Planning has been defined as ‘a decision-making process performed in advance of action which endeavours to design a desired future and effective ways of bringing it about’ (Ackoff, 1970). More succinctly, planning can be described as 'predict and prepare' (Ackoff, 1983) and includes:

(i) Forecasting future environment;

(ii) Deciding what goals must be achieved to best cope with the forecast environment; and

(iii) Identifying the means or resources needed to attain those goals.

Gardiner and Ritchie (1999) states that the difference between the good project manager and the poor project manager is planning. Planning is the identification of what needs to be done to meet a project's objectives.

According to Laufer and Tucker (1987), most construction companies doing formal planning focus on time planning, and to a lesser extent on resource allocation and its cash-flow implications. While cost is more important for the commercial success of the company, management's involvement is often perceived to have a greater influence on the time for completion**.** This stems from, among other things, the additive nature of construction costs: a cost change of one item will not significantly affect the cost of most others (particularly as material often comprises more than 50% of construction costs). This contrasts with the high degree of interdependence between the timing and duration of construction activities, whereby a delay to one activity can trigger a chain of delays and disruption in many others.

Management of time is generally done by way of scheduling in the form of a programme. Such a programme may be a simple bar chart, but following the advent of common software packages, tends to be in the form of a linked network of bars, utilising Critical Path Methodology, which is described further below. The programme is produced for at least three main purposes (Laufer & Tucker, 1987): to execute the construction project (i.e. to provide guidelines for site management to make operational decisions upon); to coordinate and communicate with the many parties involved in the realisation of a construction project, i.e. the owner, designers, licensing and permitting authorities, subcontractors and suppliers, and numerous specialists and functionaries on site and in the office; and to facilitate project control and forecasting. If planning establishes targets and the course to reach them, controls is the process that ensures the course of action is maintained and desired targets are reached.

This has been extended by Gardiner and Ritchie (1999) to include the following purposes of the programme:

(i) Eliminate conflicts between discipline managers;

(ii) Eliminate conflicts between discipline management and programme management;

(iii) Provide a standard communication tool throughout the lifetime of the project;

(iv) Provide verification that the project provider understands the customer's objectives and requirements;

(v) Provide a means for identifying inconsistencies in the planning phase;

(vi) Provide a means for early identification of problem areas and risks so that no surprises occur downstream; and

(vii) Provide a basis for progress analysis and reporting.

In essence, forecasting or planning is an operation of processing collected information, primarily of past performance, the result of which defines the approach to the future, and serves as a decision-making instrument, as its effects on the future can be calculated.

Alnaas *et al* (2014) added that the initial programme may be considered to be the non-impacted benchmark for any future claim, thus giving it some commercial as well as project management value.

1.3 Critical Path Analysis

Critical Path Analysis (CPA) or Critical Path Methodology (CPM) is a technique used in planning. A CPM programme essentially involves breaking a project down into a number of distinct activities and then connecting these activities into logical sequences, with each activity commonly having one or more predecessor and successor links to other activities, termed relationships. The level of activity breakdown is dependent on the information available and the purpose of the programme. The resulting matrix of activities and relationships is then time-analysed by calculation. These calculations can be done manually, though they are now normally undertaken by computer. The computer software calculates the earliest start and finish dates for each activity, working from the specified start or progress date of the programme, i.e. the date at which the programme is effective (known as the ‘data date’) forwards through the activities and relationships. Having calculated the earliest dates at which activities can be carried out, the software then carries out a further calculation, working from the latest finish date for the last activity in the project and then working backwards, calculating the latest start and finish dates for each activity. A comparison of the earliest and latest dates for an activity will determine the amount of float[1] for that activity, i.e. the amount that an activity can be delayed without affecting the completion date of the whole project. Where the early and late dates for an activity are identical, then the float will be zero and the activity is indicated as 'critical'. A CPM programme is therefore the development of a logic-linked network that enables the calculation of the critical path(s) to completion and the margins other activities have before becoming part of the critical path(s).

BS.6079 2.2000 Part 2, 2.41 defines a critical path as:

> *…the sequence of activities through a project network from start to finish, the sum of whose durations determined the overall project duration…*

Activities on the critical path have no float; conversely, an activity not on the critical path will have float. Float is the amount of time an activity can be delayed without it becoming a critical path activity. Any activity on the critical path that experiences a delay will consequently delay the project completion date (Gibson, 2008).

More technically speaking, Zhang (2002) states that CPM is used to determine the project duration, the critical path and allowable delay without affecting the planned project duration through performing forward pass and backward pass algorithms, which depend on the duration of activities and their logical dependencies graphically described by the network. This explanation, although somewhat more complex, is appealing as it reminds us that the CPM is a model and the effect of delay will only be illustrated to the degree the model allows it to be.

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[1] In programming lexicon this is described as "total float"

In the field of construction delay analysis, CPM is widely used, but not without criticism, as it is alleged that CPM has many limitations. These mainly involve its lack of flexibility in handling complexities in the construction project and include:

(i) CPM lacks consideration of resource utilisation by assuming unlimited resource availability, which makes it impossible to analyse the impacts of resource quantities on the project so as to plan for resources allocation (Schultmann & Sunke, 2007). This has been explained in a wider context to cover its inability to cope with any non-precedence constraints (Sriprasert & Dawood, 2002).

(ii) CPM does not consider dynamic and stochastic characteristics of construction projects due to its deterministic and static representational nature (Zhang, Tam, & Shi, 2002).

(iii) CPM is suitable for 'sequential' operations which characterise an erection type of work. It is not suitable for 'bulk' operations which is typical of an installation type of work, where detailed sequencing of activities is often irrelevant or unimportant (Laufer & Tucker, 1987).

(iv) CPM does not easily model the repetitive operations of activities, which is often encountered in construction that contains several identical or similar units of work (e.g. tasks for each floor in multi-story buildings), as CPM needs to show all activity units and all linking arrows resulting in a very large and complicated network (Zhang, Tam, & Shi, 2002).

(v) CPM has difficulty in evaluating and communicating interdependencies, requiring project participants to mentally associate the programme information with the description of the physical building (Sriprasert & Dawood, 2002).

Gardiner and Ritchie (1999) pointed out that after more than two decades of applying CPM as a planning and scheduling technique there was growing doubt about some of the advantages initially attributed to it. The complexity of CPM is the main application problem. This is the reason for its rejection and nonacceptance by some users. Also CPM is considered a poor means of communication; its outputs not being widely understood.

It has also been suggested that CPM cannot accurately be used to measure delays, as it is considered a static scheduling technique and the project delay, if based on a comparison between the planned approach and the actual approach, is necessarily the result of uncertainty encountered from deviations between the plan and the actual work. Such uncertainty can arise from many factors, among which are variability of the task duration, resources, and the interdependency of logically related tasks. A proposed solution to this uncertainty is the adaption of fuzzy logic (Tan, Al-Humaidi, & Hadipriono, 2010). However, this suggested improvement is related to prospective programme analysis (i.e. forward looking) not retrospective delay analysis (i.e. backward looking).

Elmahdi *et al* (2011) suggests that the stochastic nature of construction processes, the principles behind allocation of resources, as well as the respective interaction between the resources and the associated workspace requirements for the different trades cannot be managed efficiently using traditional planning tools. These tools, which include bar charts and network diagrams are two-dimensional and are therefore not capable of considering the different influencing parameters of construction operations such as the attributes of component installation and their spatial information as well as the impact of weather. Instead, a simulation model is recommended. This can be used to examine the impact of possible disturbances to construction processes and to compare all possible strategies and methodologies for task execution so project managers can identify the actual encountered problems and analyse their impact. However, Gardiner and Ritchie (1999) notes there are clearly gaps in how this technology can be used cost effectively and how far the concept of a virtual world should be taken as a replacement for more traditional, two dimensional and symbolic, methods of communicating information.

Although these criticisms have some merit, they are improvements to consider when interpreting or reviewing the results from a programme, rather than a replacement of it. The production of a programme is the starting point to any prospective or retrospective time analysis, as it sets out graphically, even prior to logic links being added, how the works will be undertaken, identifying the route through the various work streams leading to completion. Only after this stage can the refinements, set out as criticisms, be applied.

Despite its shortcomings, Bubshait and Cunningham (1998) point out that CPM methodology is widely accepted as the best method available of producing a forward-looking plan and by 1994 this was used by some 88% of contractors in the UK and even more in the US (Aouad & Price, 1994). Being a forward looking plan, it is the combination of the estimated duration of activities and an assessment of the logical constraints to each activity starting, finishing or continuing. In this sense it must be appreciated that a well-constructed programme may be one method, but not necessarily the only method, for completing the remaining work. The programme ought to be considered as a management guide as to how the contractor may perform the work.

Activities can and do take different times to complete than shown on the programme, which is why they are rarely given contract document status in most standard forms of contract requiring the parties to work to each activity duration. In *Glenlion Construction Ltd v Guinness Trust* (1987) 39 BLR 94 the court refused to imply an obligation on the employer to assist with an accelerated program. The distinction made in that case was that while the contractor was *entitled* to complete early, it was not *obliged* to do so, because the programme in question was merely descriptive and did not constitute a contractual obligation. This does not mean an employer can prevent a contractor completing (see **Chapter 1.6** below). It therefore follows that not completing an activity by the duration included in the programme does not constitute an actual delay to the completion date but may constitute a reasonable forecast of a delay.

One of the primary aims of adopting CPM in planning is to minimise the project finishing time. This is desired due to the following reasons (Kolisch, 1996): (i) the majority of income payments from projects occur at the end of a project or at the end of predefined project phases. Finishing the project early reduces the amount of tied-up capital; (ii) the quality of forecasts tends to deteriorate with the distance into the future of the period for which they are made. Minimising the project duration reduces the planning horizon and, therefore, the uncertainty of data; (iii) finishing products as early as possible lowers the probability of time-overruns of the project; (iv) by freeing resource capacity as early as possible, the flexibility of the company can be raised in order to better cope with changes of the economic environment; and (v) high resource utilisation at the beginning of the planning horizon leads to a larger amount of free resources at the end of the planning horizon and, thus, rises to ability to accept and process new projects.

It is in the interests of all parties that completion should be achieved on time or at least at the earliest opportunity (Jenkins & Stebbings, 2006). Producing an adequate programme provides the framework to measure progress against the completion target. This comparison identifies programme slippage so that suitable action can be taken to recover delays. Claims are abundant when project planning is not taken seriously enough to produce an adequate project programme (Bubshait & Manzanera, 1990).

1.4 Construction Project Delays

Various controllable and uncontrollable factors can adversely affect the project programme and cause delays (Gibbs & Nguyen, 2007). Construction projects involve complex packages of work, for which design and contracting organisations are responsible; the product is generally large, discrete and prototypical. The construction industry differs significantly from other industries because of changing production sites, multiple simultaneous projects and the associated allocation of resources from site to site. Schultmann and Sunke (2007) identify the main peculiarities of the construction industry and its projects as: Design-to-order production; Shifting production sites; Spatial constraints; Seasonal dependency; Construction specific legislation, in particular environmental legislation; Time/resource trade-offs; Simultaneous multiple projects; and a combination of multiple objectives of time, cost, quality and resource levelling.

A construction project generally involves, as a minimum, a contractual relationship between an employer / owner who wants a building and a contractor / builder who constructs the building. This relationship between the parties is governed by a construction contract. A feature of construction contracts is that they tend to include an express obligation to complete the project by a specified time. In the absence of such an express obligation, the project is to complete within a reasonable time. [2]

The construction industry has a consistently poor record with respect to the completion of projects on time (Briscoe, Dainty, Millett, & Neale, 2004). World Bank figures show that for 1,627 projects completed between 1974 and 1988 the overrun varied between 50% and 80% (World Bank, 1990). The average time overrun for UK Government construction projects for the period 1993 to 1994 was 23.2% (HMSO, 1995). In a review of 67 projects, 85% of the projects overran the contract period for completion, and 76% of the projects delays had excusable delays (Yogeswaren, Kumaraswamy, & Miller, 1998). The more complex a construction project, the more likely it is to encounter time delays, which may result in adverse financial implications (CIOB., 2008).

Delays can be defined as an unanticipated extension to the overall planned time period and/or the incident which prolongs the duration of an activity without affecting the overall project duration (Bramble & Callahan, 2000). They are very common in construction (Ng, Sitmore, Deng, & Nadeem, 2004) and the most costly problem encountered on construction projects (Conlin & Retick, 1997).

Delays may be attributed to the employer/owner, to the contractor, or to neither party. These are known respectively as (i) excusable delay events; (ii) non-excusable delay events; and (iii) neutral delay events (Scott S. , 1993). The events are caused by the realisation of a risk, the responsibility for which ought to have been allocated between the parties within the construction contract. Examples of risk events are described by Charoenngam (1999) and are categorised as (a) construction-related risk (b) physical risk (c)

[2] Supply of Goods and Services Act 1982 s14

contractual and legal risk (d) performance-related risk (e) financial and economic risk and (f) political and societal risk. As an example of the nature of construction delays, from a survey of 93 construction professionals within the UAE construction industry, Faridi (2006) noted the most significant causes of delay were (ranked in order of significance):

(i) Preparation and approval of drawings;

(ii) Slowness of the owner’s decision-making process;

(iii) Financing by contractor during construction;

(iv) Shortage of manpower;

(v) Inadequate early planning of the project;

(vi) Skill of manpower;

(vii) Non-availability of materials on time;

(viii) Productivity of manpower;

(ix) Poor supervision and poor site management;

(x) Obtaining permit/approval from the municipality/different government authorities;

(xi) Unsuitable leadership style of construction/project manager; and

(xii) Delays in contractor’s progress payment (of completed work) by owner.

Lo *et al* (2006) also summarised the main causes of delay in the international construction industry and added to the above list with the following five causes: (1) inclement weather; (2) restrictive access; (3) changes to design; (4) unforeseen ground conditions / utilities; and (5) unrealistic contract duration.

The analysis of construction delays has become an integral part of the construction project. Even with computerisation and managements' understanding of project management techniques, construction projects continue to suffer delays and project completion dates still get pushed back (Alkass, Mazerolle, & Harris, 1996). In a study by Kikwasi (2012), the four highly ranked effects of encountering delays were (a) time overrun; (b) cost overrun; (c) negative social impact; and (d) idling resources and disputes.

Indeed, delays are costly to all parties involved in the construction industry and often result in dispute resolution through adjudication, arbitration and litigation. Akintoye (1991) suggests that the costs caused by delays can have far reaching effects on the annual profitability of a contractor, as a single project could represent a sizeable proportion of a firm's annual turnover. The contractor's work programme is one of the contractor's profitability factors according to Skitmore (1992).

The cost of delay could be incurred due a number of reasons, including: delay in receipt of payment (interest costs); the cost of prolonged site activity (overhead type costs); or the imposition of damages related to the late handover of the project back to the employer (Ndekugri, Braimah, & Gameson, 2008). For the employer, the cost of delay can be the delay in return on an investment, which is directly related to the length of the construction period (Semwogerere, 2011). Indeed, research by Scott (1993) shows that delay related claims are almost always accompanied by a claim for increased overhead costs. The benefits of reducing the cost of implementation of the UK's economic infrastructure (which includes the reduction of delays and disputes) have been identified in governmental studies (Infrastructure UK, 2010) as follows:

> *…Reducing the costs of infrastructure delivery will allow the UK to renew and build more for less and provide more resilient infrastructure as a key plank for wider economic growth.*

> *It will also support growth by giving confidence to international investors in UK infrastructure, and improve the competitiveness of the UK construction industry by addressing concerns about higher costs, lower productivity and skills and wasteful processes…*

It is not solely the cost of delays found to be a contractor's fault, i.e., culpable delays, that will affect the contractor's profitability, but also the cost of proving responsibility for delays for which he is not culpable. In the 2008 case to resolve delays in completing Wembley Stadium,[3] Mr Justice Jackson referred to the 550 ring-binders of documents, the £1 million photocopying bill and some £22 million of costs overall, which expenditure he noted "*far exceeds the sums which (after stripping out the froth) are seriously in dispute between the parties*".

Similarly, in a Water Pumping Station Project,[4] for an eventual claim of £1.25 million (down from an initial claim of £3.5 million) for delay caused by the negligent design of foundations, the associated legal costs amounted to £2.9 million. Moreover, in that case, Mr Fernyhough QC (Sitting as a Deputy High Court Judge) noted as part of his review of costs in regard to the potential success of the claim:

> *…as everyone experienced in this field knows, litigation is an unpredictable pursuit…*

The avoidance of disputes is paramount to the improvement of the construction industry to prevent disproportionate costs and unpredictable conclusions.

3 Multiplex Constructions (UK) Ltd v Honeywell Control Systems Ltd (2007) BLR 195

4 Costain Ltd v Charles Haswell & Partners Ltd (2009) EWHC 2350 (TCC)

1.5 Completion Date

When the completion date is missed, it is a matter of how the contract is construed as to whether the obligation to achieve it is a condition such that:

(i) There has been a fundamental breach: entitling the innocent party to rescind or terminate the contract; or

(ii) Whether time is not of the essence, meaning only an action for damages lies.

Where the contract includes a clause that “time is of the essence”, the courts generally apply a strict approach to enforcing the clause, even in the face of potentially harsh results. For example, in *Union Eagle v. Golden Achievement* (1997),[5] the purchaser in a conveyance transaction delivered a deposit cheque ten minutes late. In response, the vendors elected to rescind the contract, relying on the missed time deadline and the "time is of the essence" clause in the contract. The court upheld the vendors' rescission of the contract on the basis the parties made express provision for the event and commercial certainty demanded the contract be enforced. The court held:

> *...In many forms of transaction it is of great importance that if something happens for which the contract has made express provision, the parties should know with certainty that the terms of the contract will be enforced. The existence of an undefined discretion to refuse to enforce the contract on the ground that this would be "unconscionable" is sufficient to create uncertainty. Even if it is most unlikely that discretion to grant relief will be exercised, its mere existence enables litigation to be employed as a negotiating tactic. The realities of commercial life are that this may cause injustice which cannot be fully compensated by the ultimate decision in the case…*

[5] Union Eagle Ltd. v. Golden Achievement Ltd.(1997) 2 All E.R. 215 (P.C.), paragraph 9

According to Duncan-Wallace (1995), in examining a contractor's obligation to complete his work by a fixed time, construction contracts differ very markedly from nearly all others, as the contractor can be expected to have expended very heavily in performing the contract prior to any relatively trivial delay to completion. He also notes that upon fixing of the work to the soil, the property will have passed to the owner, irrespective of the degree of payment, thus conferring a major and irretrievable benefit on the owner as against a possibly only minor or nominal loss suffered by him. For these reasons, he notes the courts have shown an exceptional assiduity in avoiding a ‘time of the essence’ interpretation of the contractor's completion obligation in construction contracts. This, he states, would seem the position even in cases where express language has been used in the contract.

Therefore, on construction projects the completion date is typically stated in the contract and is the latest date by which a project needs to be complete or at least substantially complete.[6] The completion date can be expressed as:

(i) a specified date; or

(ii) a period in which to complete the project, which, when added to the commencement date, determines the completion date.

Where the contractor acts in the course of a business, it will be an implied term of the contract that he will complete the works within a reasonable time. Failure to achieve completion by the completion date or within the time for completion or within a reasonable time is a breach of the contract terms and will entitle the employer to seek recovery of its loss, often termed “damages”. The actual loss incurred due to this breach will have to be proven by the employer. As proving such a loss is complex, employers often seek to ascertain these losses in advance and define them in the construction contract. The pre-estimate of loss is termed “liquidated damages”.

[6] As defined in Sage v. Secretary of State (2003) UKHL 22

As was stated by Diplock CJ in *Robophone Facilities Ltd v Blank* (1966) 3 All ER 128 CA, a liquidated damages clause:

> …[enables] *parties to agree at the time when they enter into a contract upon a fair and easily ascertainable sum to become payable by one party to another as compensation for the loss which the latter will sustain as a consequence of its breach. It is good business sense that parties to a contract should know what will be the financial consequences to them of a breach on their part, for circumstances may arise when further performance of the contract may involve them in loss. And the more difficult it is likely to be to prove and assess the loss which a party will suffer in the event of a breach, the greater the advantages to both parties of fixing by the terms of the contract itself an easily ascertainable sum to be paid in that event. Not only does it enable the parties to know in advance what their position will be if a breach occurs and so avoid litigation at all, but if litigation cannot be avoided, it eliminates what may be the very heavy legal costs of proving the loss actually sustained which would have to be paid by the unsuccessful party…*

One of the purposes of such a clause is to relieve the beneficiary of the liquidated damages of the difficulty and expense of proving actual damages occasioned by delay. However, that is not to say a contractor can deliberately breach the contract in delivering the works late, as the liquidated damages is not the price of the breach, as explained in *AB v. CD* (2014) EWCA Civ 229:

> *…A contractual limitation on liability (namely, a liquidated damages clause) did not constitute an agreed price in respect of the contractor's breach. An agreement to limit recoverability of damages is not an agreement to excuse performance of the primary obligation. Where a party breaches his contract the Court will take into account all the circumstances of the case in deciding whether he should be able to continue his breach and leave the claimant to rely on his claim for (limited) damages or whether the justice of the case requires that an injunction*

> *should be granted. If a claimant can demonstrate that its overall commercial interests are being harmed by the continuing breach, then its prospects of securing an injunction will be the greater…*

To ensure these liquidated damages are recoverable, they must be a genuine pre-estimate of the employers' loss and not considered a penalty for being late, which exceeds that loss (*Dunlop Pneumatic Tyre Co Ltd v New Garage & Motor Co Ltd* (1914) UKHL 1). To secure the ability to impose liquidated damages, the construction contract must enable the specified completion date to be adjusted if there was a delay event caused by the employer or was not at the contractor's risk. This is to overcome what is termed as the 'prevention principle'.

1.6 Prevention Principle

In that the obligation to complete within a reasonable time is an implied term if a completion date is not specified, it is also an implied term that the employer will not perform any act that prevents the contractor from completing the works. It is an accepted proposition that an act of prevention by the employer will release the contractor from his obligation to complete the works within, or by, any fixed period or date unless there is provision to extend the completion date. In *Multiplex*,[7] it was held by Mr Justice Jackson:

> *..In the field of construction law, one consequence of the prevention principle is that the employer cannot hold the contractor to a specified completion date, if the employer has by act or omission prevented the contractor from completing by that date. Instead, time becomes at large and the obligation to complete by the specified date is replaced by an implied obligation to complete within a reasonable time. The same principle applies as between main contractor and sub-contractor.*

[7] Multiplex Construction (UK) Ltd v Honeywell Control Systems Ltd (2007) 111 Con LR 78 (TCC) (paragraph 48)

> *It is in order to avoid the operation of the prevention principle that many construction contracts and sub-contracts include provisions for extension of time. Thus, it can be seen that extension of time clauses exist for the protection of both parties to a construction contract or sub-contract…*

At paragraph 56 of the judgement, the court reviewed prior authority relating to delays by the employer, and helpfully summarised the three propositions related to the prevention principle as follows:

(i) Actions by the employer which are perfectly legitimate under a construction contract may still be characterised as prevention, if those actions cause delay beyond the contractual completion date;

(ii) Acts of prevention by an employer do not set time at large if the contract provides for extension of time in respect of those events; and

(iii) In so far as the extension of time clause is ambiguous, it should be construed in favour of the contractor.[8]

Acts of prevention include issuing variations. In the same *Multiplex* judgement, Mr Justice Jackson, at paragraph 61, clarified:

> *…if Multiplex issues a direction under clause 4.2 which constitutes a variation and which leads to completion on a later date, then such variation prevents Honeywell from completing on the due date. Thus, such a direction constitutes an act of prevention within the meaning of clause 11.10.7. The fact that such a direction is permitted by the contract does not prevent it being an act of prevention…*

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8 In regard to this, Mr Justice Jackson advised care to be taken, and suggested it more appropriate that where two constructions of an instrument are equally plausible, upon one of which the instrument is valid and upon the other of which it is invalid, the court should lean towards that construction which validates the instrument. The court should lean in favour of a construction that permits the contractor to recover appropriate extensions of time in respect of events causing delay.

> *…If a variation instruction affects the date upon which Honeywell is going to complete by a small period, one may say that this is a hindrance; it does not in any sense make the installation of the electronic systems impossible. On the other hand, that matter does prevent completion on the due date and it should be characterised as "prevention"…*

In the event there is no provision in the construction contract to adjust the time for completion, or the provision is inoperable, then the obligation to complete by the specified completion date is replaced with an obligation to complete within a reasonable time. This is sometimes called setting "time at large". Here Mr Justice Jackson set out the subcontractor's (Honeywell) claim as follows:

> *...The central issue in the present action is whether time has been set at large under Honeywell's Sub-Contract...By "time at large", Honeywell means that its contractual obligation to complete within 60 weeks (subject to any grant of extension of time) has fallen away. Instead, Honeywell's only obligation in this regard is to complete within a reasonable time and/or reasonably in accordance with the progress of the main contract works…*

This is an established position. In the Court of Appeal case of *Trollope & Colls Limited v North West Metropolitan Regional Hospital Board* (1973) 1 WLR 601 - 607, Lord Denning MR said:

> *…It is well settled that in building contracts - and in other contracts too - when there is a stipulation for work to be done in a limited time, if one party by his conduct - it may be quite legitimate conduct, such as ordering extra work - renders it impossible or impracticable for the other party to do his work within the stipulated time, then the one whose conduct caused the trouble can no longer insist upon strict adherence to the time stated. He cannot claim any penalties or liquidated damages for non-completion in that time…*

This follows the principle that the promisee cannot insist upon the performance of an obligation which he has prevented the promisor from performing. The occurrence of such an act makes ‘time at large’ such that the original obligation to complete the works by a fixed date is replaced by an obligation to complete within a reasonable time. In *Holme v Guppy* (1838) 3 M&W 387 (Exchequer), Parke B, delivering the judgment of the Court of Exchequer, said:

> *…On looking into the facts of the case we think no deduction ought to be allowed to the defendants. It is clear from the terms of the agreement that the plaintiffs undertake that they will complete the work in a given four months and a half and the particular time is extremely material because they probably would not have entered into the contract unless they had had those four months and a half within which they could work a greater number of hours a day. Then it appears that they were disabled by the act of the defendants from the performance of that contract. There are clear authorities that if the party be prevented by the refusal of the other contracting party from completing the contract within the time limited he is not liable in law for the default ... It is clear, therefore, that the plaintiffs were excused from performing the agreement contained in the original contract and there is nothing to show that they entered into a new contract by which to perform the work in four months and a half ending at a later period. The plaintiffs were therefore left at large. Consequently they are not to forfeit anything for the delay…*

To avoid the operation of the prevention principle, most construction contracts and sub-contracts include provisions for the time for completion to be extended. This provision should account for:

- Delay events that are specified by the parties; and/or
- Delay events that are the risk/responsibility of the employer; and/or
- Delay events that occur before or after the completion date.

Taking each of these in turn:

The first provision should be provided; as it is open to the parties to identify those particular event(s), which if they occur and delay the works, lead to an adjustment to the time for completion.

The second provision is necessary; as to retain the right to recover liquidated damages the provision must be sufficiently wide to cover all employer risks. In the Court of Appeal case of *Peak Construction (Liverpool) Limited v McKinney Foundations Limited* (1970) 1 BLR 111, pages 121-122, Salmon LJ said:

> *…The liquidated damages clause contemplates a failure to complete on time due to the fault of the contractor. It is inserted by the employer for his own protection; for it enables him to recover a fixed sum as compensation for delay instead of facing the difficulty and expense of proving the actual damage which the delay may have caused him…*

> *…If the employer wishes to recover liquidated damages for failure by the contractors to complete on time in spite of the fact that some of the delay is due to the employers' own fault or breach of contract, then the extension of time clause should provide, expressly or by necessary inference, for an extension on account of such fault or breach on the part of the employer...*

The third provision is necessary following the case of *Balfour Beatty Building Ltd v. Chestermount Properties Ltd* (1993) 62 BLR 1. Here, Chestermount employed Balfour Beatty (the contractor) to construct an office building. The contract commencement date was 18 September 1987 and the contract completion date was 17 April 1989. In October 1988, the Architect granted an extension of time, which made the completion date 9 May 1989. The project was not completed by this extended time. Between 12 February 1990 and 12 July 1990 the architect issued variations. Practical completion was achieved on 12 October 1990; 22 weeks later than the revised contract completion date. The contractor submitted two arguments:

(i) the effect of variations issued after completion set time at large, meaning the contractor had to complete within a reasonable time; or

(ii) in the circumstances, the architect should have fixed a new completion date by which the works could fairly and reasonably have been expected to complete having regard to the date when the variation was ordered (and thus ignore the contractor's delays prior to the variances being issued).

The court held the 'net method' and not the 'gross method' (which was that suggested by the contractor) was the appropriate approach. This is sometimes referred to as the 'dot-on principle'. This allows the incremental time lost for the new event to be added to the previously extended completion date. Mr Justice Coleman considered the architect's obligation was as follows:

> *…His [the Architect's] yardstick is what is fair and reasonable [based on the terms of the contract]. For this purpose he ought to take into account, amongst other factors the effect that the relevant event had on the progress. Did it bring the progress of the works to a standstill? Or did it merely slow down the progress of the works? If the variation works can reasonably be conducted simultaneously with the original works without interfering with their progress and are unlikely to prolong practical completion, the architect might properly conclude that no extension of time was justified…*

To understand the approach to the assessment of EOT, it is necessary to review the provisions of the contract terms, as these set out the agreement between the parties in the event of the happening of a delay event.

1.7 Assessment of Extensions of Time

The amount of time to be added to the contract period for employer responsible delaying events that have caused delay to the completion date should be calculated logically and methodically by the contract administrator and this judgement must be made impartially and objectively. This means, if it comes to a dispute as to whether a fair and reasonable EOT has been granted, and the contract administrator has determined the period of that extension of time instinctively, intuitively, or under the instructions of one of the parties, his decision is likely to be overturned. This was set out in *John Barker Construction Ltd v London Portman Hotel Ltd* (1996) 83 BLR 31.

This requirement for a methodological approach implies the need to apply a method. However, none of the standard forms provide any indication of the sort of information or expressly dictate the delay analysis technique upon which such a logical and methodical approach to an extension of time should be based.

For example, JCT98 requires the contractor to identify any cause of delay or likely delay to progress, and requires the contractor to estimate the effect on the date for completion for each delay event and to provide all the necessary particulars demonstrating how such an effect has been calculated. However, it does not say how to calculate the effect, i.e. which EOT assessment technique should be used to demonstrate delay to the date for completion.

It is for the Contractor to make an application for an EOT in order:

- To avoid/reduce liquidated damages that could otherwise arise from unclaimed excusable delays; and/or
- To establish an entitlement to monetary compensation (e.g. for overheads incurred) during the extended period (Scott S. , 1993).

Although these two assessments may be different in a prospective analysis (as an EOT can be awarded if it is likely to delay the works, whereas a claim of loss and expense due to extended preliminaries requires actual loss to be incurred) in a retrospective analysis they are more closely aligned. However, it may be logical for contractors to split these two aims as (i) claims for money tend to be more difficult for employers to accept (Alnaas, Khalil, & Nassar, 2014); and (ii) as EOT provisions are for the benefit of employers to impose their liquidated damages, it may be the stricter burden of proof would fall on the employer, whereas the recovery of associated costs is for the benefit of the contractor and as such the stricter burden for this element of the claim would fall on the contractor.

Provisions within the standard forms of contract may encourage, and in cases, such as NEC3,[9] require a prospective approach to the analysis of delays, however in practice, these tend to be assessed retrospectively. The various examples of contract requirements are considered below (**Chapter 5.1**). When this delay is analysed retrospectively the assessment is termed ‘forensic delay analysis’.

1.8 Forensic Delay Analysis

Delay analysis in respect of a construction dispute is the process in a claim or claim defence through which the contractor or employer has to go in order to be able to:

- Establish lines of research and investigation;
- Demonstrate the contractor’s (or employer’s) entitlement to claim (or to reject a claim against it or to counterclaim); or
- Present the claim (or claim defence) effectively.

The term ‘delay analysis’ is used for both extension of time submissions and any time-related aspects of delay claims (Gibson, 2008). It may be that these are separate and distinct assessments. It is the analytical process through which a professional employs CPM, together with a forensic review of project documentation and other pertinent data, to evaluate and apportion the effects of delays and other impacts on the project programme (Holloway, 2002). In short, delay analysis may be simplified as:

- A forensic investigation into the issue of what has caused a project to run late (Farrow, 2001); or
- The task of investigating the events that led to project delay for the purpose of determining the financial responsibilities of the contracting parties arising from the delay (Ndekugri, Braimah, & Gameson, 2008)

Al-Saggaf (1998) describes a formal programme analysis procedure with the following five steps:

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(i) Data gathering;

(ii) Data analysis;

(iii) Identification of the root cause;

(iv) Classification of the type of delay; and

(v) Assigning responsibility.[10]

Undertaking delay analysis is a formidable challenge (Gibbs & Nguyen, 2007). Problems arise in unravelling "cause" and "effect" patterns, given that many delays are inter-related and may also overlap, or in certain circumstances be "concurrent" with one another. The question of causation concerns the need for a claimant to prove not only that a risk allocated to the other party occurred, but also that it caused the complained of delay.

The time and expense incurred to prepare a claims document can, in itself, be substantial. There is room for improvement in present practices for keeping track of delays (Alkass, Mazerolle, & Harris, 1996). Most disputes about extensions of time arise after the works are complete, once the contract administrator has completed his final review of the EOT due to the contractor (Burr & Palles-Clark, 2005). Therefore, analysing construction delays has become an integral part of the construction project's life (Alkass, Mazerolle, & Harris, 1996).

In construction contracts, delay disputes are generally resolved either by an independent certifier (architect / engineer) acting in a decision making capacity, an arbiter (adjudicator / arbitrator / dispute review board) or the courts. The task for the court is more likely to involve looking at what actually happened, therefore requiring some sort of As-Built programme. This is discussed below (**Chapter 5.2**).

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10 This is generally considered outside the expertise of the delay analyst

Braimah and Ndekugri (2008) state that the factors that influence the selection of the appropriate methodologies are a matter of great importance, and notwithstanding this, the UK courts have not generally gone into any great depth as to what method of proof is acceptable in particular circumstances (or, when a method of analysis has not been accepted, the reasons for its rejection).

The production of a formal programme yields many indirect benefits. These include its use in litigation, where CPM programmes can be useful in establishing the facts and the intentions of the parties (O'Brien, 1976). Some go as far as to claim it is for this reason that CPM has been increasingly used as an administrative and legal tool rather than as a planning instrument (Royer, 1986). Scott (1993) states that in the UK, it is recognised that the analysis of construction delays lend themselves to a solution using CPM, but that no clearly defined procedure for arriving at such solutions has been found. By contrast, in the US, there is a history of adopting CPM for dealing with delay claims and a recognised approach has been in use for some time (Wickwire & Smith, 1974).

The forensic examination, identification and analysis of criticality in construction projects tend to employ CPM. Expert delay analysts can use various techniques (manual or software-based) to demonstrate delay. CPM programming is a useful evidential tool, but it is not determinative, as found in *London Underground Ltd v Citylink Telecommunications Ltd* (2007) EWHC 1749 (TCC). It also has limitations. These include the fact that two analyses can produce different results; whether or not the same data and methodology was used. Even experts using the same method can reach different conclusions due to the amount of assumptions and level of subjectivity involved in determining logic links and interpreting results.

CPM relies on the facts and data fed in to the analysis. Thus, if that information is unreliable, the results will be too. In *Skanska Construction UK Ltd v Egger (Barony) Ltd* (2004) EWHC 1748 (TCC) for example, the baseline programme used in the analysis was held to be of no evidential value as it contained a fundamental error. Likewise, in *Ascon Contracting Ltd v Alfred McAlpine Construction Isle of Man Ltd*

(1999) 66 Con LR 119 the contractor’s delay analysis was rejected because it was proven to be factually incorrect. One of the facts found to be incorrect was based on an incorrect assumption as to the rate at which concrete could be poured.

In the Scottish Court of Session Extra Division, Inner House, decision in *City Inn Ltd v. Shepherd Construction Ltd* (2010) BLR 473 the case concerned how to assess the issue of a fair and reasonable extension of time, under clause 25 of the JCT standard form, in a case of delay caused concurrently by ‘relevant events’ (for which there would be an entitlement to an extension of time) and matters for which the contractor was responsible (for which there would not). The majority of the Inner House held that, where there was delay caused by two concurrent causes and only one of which was a ‘relevant event’, the decision-maker may apportion the delay as between the relevant event and the other event (described further in **Chapter 5.4**).

In addition, it has been held that the effect of relevant events on completion ought not to solely consider the time the contractor actually required, but the period the contractor ought to have to complete the works within.

It is the role of a delay analysis methodology to consider, as least, the principles behind the issues described above.

1.9 Problem Identification

The research problem that motivates this study is how to improve on the current approach to delay analysis. The Delay and Disruption Protocol (the Protocol) issued by the Society of Construction Law in 2002 emphasised that delay issues that should be managed within the contract all too often become disputes that have to be decided by third parties (adjudicators, dispute review boards, arbitrators, judges etc.). The number of such cases could be substantially reduced by the introduction of a transparent and unified approach to the understanding of programmed works, their expression in records, and identifying the consequences of delay (Society of Construction Law, 2002).

It is accepted that perhaps the most difficult aspect that must be dealt with when assessing claims for extensions of time is the mechanism used to show the impacts of various delays on project completion (Scott, Harris, & Greenwood, 2004). Indeed, many projects still end up in disputes regarding extensions of time claims and/or prolongation claims after the project has finished and this situation is unlikely to change in the future (Carmichael & Murray, 2006).

The Protocol (2002) explained four delay analysis methodologies (explained in **Chapter 4** below) that can be used to identify the consequences of a delay. These are:

(i) As-planned v As-Built analysis;

(ii) Impacted As-Planned analysis;

(iii) Collapsed As-Built analysis; and

(iv) Time Impact Analysis.

The Protocol notes that Time Impact Analysis is based on the effect of delay events on the contractors' intentions for the future conduct of the work in the light of progress actually achieved at the time of the delay event. It can also be used to assist in resolving more complex delay scenarios. Time Impact Analysis, according to the SCL Protocol (at Clause 4.8) is:

> *…the best technique for determining the amount of EOT that a contractor should have been granted at the time an employers' risk event occurred…*

The importance of the Protocol has been underlined by the Australian case *Alstom Ltd V Yokogawa Australia Pty Ltd & Anor (No 7)* (2012) Sasc 49, which related to delays to the refurbishment of a coal-fired steam turbine power station at Port Augusta. The core issue was the question of delay and who was responsible for it. In assessing the two delay experts' approaches to delay analysis, Justice Bleby stated:

> *…The methodology used by Mr Lynas in analysing delays for Stage 1 Mechanical Completion was a process known as Resource Analysis…*
>
> *… A number of delay analysis methods are available to programmers. In his first report Mr King identified four different recognised methods. These methods were also recognised as such in the Society of Construction Law Delay and Disruption Protocol ("the Protocol"). The methods are As-planned Impacted, As-built Collapsed, Time Impacted/Windows Analysis and As-planned v As-built Analysis. In his first report Mr Lynas identified an additional method known as Resource Analysis. There was disagreement between Messrs Lynas and King as to the appropriate method to be adopted in this case…*
>
> *… Two of them can, however, be quickly disposed of. There was agreement between Mr Lynas and Mr King that the As-planned Impacted and As-built Collapsed methods were inappropriate for use in this case. It would seem that they are both inappropriate for programmes of this complexity and where substantial but necessary variations from the initial program may occur during the course of the project, or where all necessary logic is not present. Both experts therefore declined to adopt either of these methods for their analysis, and neither party seeks to rely on them…*
>
> *…The method used by Mr Lynas to assess delays to Mechanical Completion for both Stages 1 and 2 was an approach based on Resource Analysis. It is not a method referred to in the Protocol…*
>
> *…The first problem with this method is that it is not an accepted method of delay analysis for construction programming practitioners. Mr King had never encountered this particular*

> *method before. It is not mentioned in the Protocol as a recognised method of delay analysis. Mr Lynas also agreed that this method, to the best of his recollection, was not mentioned in the text Delay and Disruption in Construction Contracts by Keith Pickavance, which Mr Lynas himself described as the most comprehensive work on the subject of which he is aware, and an extract from which was relied on by Alstom for other purposes. Nor was Mr Lynas aware of any documented reference to this particular method in any other text on construction law. It seems to have been a creature of TBH alone. I am satisfied that the Resource Analysis method is not a method recognised within the engineering profession. It should be rejected for that reason alone…*[11]

The judgment was on the basis that use of a delay analysis methodology that is not recognised in the engineering profession is in itself a reason to reject its application. As to what *is* a recognised methodology, the Judge referred to: the SCL Protocol; text books; and texts on construction law.

Methodology therefore appears paramount, yet although the proper assessment and resolution of delay claims has attracted a considerable amount of attention, in practice, parties in the UK have little or no guidance (Scott, Harris, & Greenwood, 2004). There is a lack of readily available information regarding all delay analysis techniques. Most practitioners gain their knowledge through their own direct experience or are self-taught (Bordoli & Baldwin, 1998).

According to Ndekugri *et al* (2008) there is need for more empirical research to complement and extend existing knowledge, understanding and use of the most common methodologies. Ndekugri *et al* concluded that the three most well-known methodologies are the (i) As-Planned versus As-Built; (ii) Global; and (iii) Net Impact methodologies. The extent of their usage generally corresponded to the degree of awareness of the techniques. Although these three methods are the most prone to challenge

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[11] Paragraphs 1265 to 1282

they are also those that most frequently lead to winning claims. This is perhaps the consequence of a relatively very low usage of the most accurate techniques (Ndekugri, Braimah, & Gameson, 2008). This position is untenable in terms of the overall aim of avoiding litigation in the UK construction industry. It cannot be appropriate to select a less reliable delay analysis methodology simply because the knowledge or skills are not available in the industry to (i) understand which is the more accurate or reliable delay analysis methodology; and (ii) understand how to apply the more accurate or reliable delay analysis methodology.

Arditi (2006) seeks to establish selection guidelines for delay analysts. Critchlow *et al* (2006) state this is especially important as it has been suggested that parties are likely to adopt those delay analysis methods that best suit their respective positions. Braimah and Ndekugri (2008) state the appropriateness of the methodology applied in producing a delay claim is often hotly contested and the factors that influence the selection of the appropriate methodologies are a matter of great importance. They undertook research by way of a questionnaire that sought feedback on the degree of importance in their decision-making as to the appropriate delay analysis methodology to adopt in any given situation. Braimah (2008) proposed a formulaic approach to the selection of methodology to demonstrate the "choice" of methodology was not selected based on a perceived bias to the intended outcome.

1.10 Problem Definition

There is confusion and uncertainty over the taxonomy of delay analysis methodologies and the approach to the selection of the appropriate method. This confusion can be reduced and delay analysis improved by an analysis of the latest research on the status of delay analysis in the UK, an analysis of common law guidance on methodology, an assessment of professional and research literature on delay analysis and research into what is being currently undertaken by experts in the field of delay analysis and why.

1.11 Aims and Objectives

The aim of this research is to improve the current practice of delay analysis. The objectives which support the aim are to:

(i) Identify the current state of time management in the UK;

(ii) Identify whether there are any common methodologies available for retrospective delay analysis;

(iii) Assess whether it is appropriate to have a selection criteria for the selection of a delay analysis methodology;

(iv) Assess whether the selection of methodologies is influenced by common law;

(v) Identify (a) the method of delay analysis actually used in resolving disputes; and (b) the reasons for that selection; and

(vi) Contrast the findings from the above five aims with the recommendations contained within the SCL Protocol (2002).

1.12 Structure of the Thesis

The thesis is organised in three (3) parts containing nine chapters. These are briefly described below.

Part I – Research Problem

Chapter One – Introduction: This provides a background to planning, delay analysis and extensions of time. It provides the identification of the research problem, the research aims and objectives.

Chapter Two – Research Methodology: This explains the research methodologies available for the collection and analysis of data as part of the research and identifies the main techniques employed in this research in particular.

Part II – Evaluation of Documentary Data

Chapter Three – Status of Time Management in the UK: This considers in detail the study undertaken by the CIOB as part of a survey of its members. It uses the raw data provided by the CIOB and analyses this in a detailed approach to supplement the analysis and conclusions by CIOB.

Chapter Four – Types of Delay Analysis Methodology: As the subject matter is technical there is a need to explain the delay analysis methods available to allow their different approaches to be understood. This section identifies the studies undertaken on the delay analysis methodologies, identifies the common ones and provides an explanation of those common delay analysis methodologies. This chapter also examines research on the effect of choosing a different methodology and considers the proposal to use a formulaic model in the selection of delay analysis methods against the use of a flow chart process.

Chapter Five – Common Law Decisions: This section reviews the numerous legal decisions over the last 25 years and by analysing each judgement seeks to identify guidance on how to undertake and present a delay analysis that is acceptable to the courts.

Chapter Six – Case Studies: This section uses case studies to test the results of previous research regarding the criteria for selecting delay analysis methodologies. This was done by way of a matrix developed to capture the core information contained in each case study. It identifies the retrospective delay analysis methodology used by industry experts in programming and relies upon the adversarial nature of disputes to determine consensus in the Industry on the most appropriate delay analysis methodology.

Part III – Analysis, Conclusions and Recommendations

Chapter Seven – Analysis: This contains analysis of the data from the chapters within Part II.

Chapter Eight – Conclusions: This contains the conclusions from the analysis and contrasts these to the objectives in Chapter One.

Chapter Nine – Recommendations: This section provides recommendations based on the results of the research. It explains the main achievement of the research and its contribution to knowledge. It also identifies areas of further research.

This is followed by a bibliography containing the references to source material referred to in this thesis and a list of cases analysed within the thesis.

CHAPTER TWO

2 RESEARCH METHODOLOGY

2.1 Research Methodology Introduction

This research is in the field of social science, which encompasses law and human decision-making, as opposed to natural science. Social science has been defined as 'the attempt to explain social phenomena within the limits of available evidence' with evidence traditionally understood as data collected, for example, through responses or observations. However, attitudes about what constitutes valid and reliable knowledge, research and evidence have changed as social research has developed (Phillmore & Goodman, 2004).

Thus, the traditional view of the method of data collection offers two approaches, namely: (i) quantitative data, which tends to be the approach used in the natural sciences; and (ii) qualitative data, which is more recently used in social sciences. The traditional stance was that these approaches should not be mixed. However, according to more recent commentators, e.g. Bryman *et al* (2008), a third possibility is a mixed method. Choosing one data strategy over the other will have both positive and negative impacts; as each has its strengths and weaknesses (Schulze, 2003).

However, before identifying an approach to data collection strategy, the researcher needs to develop a philosophical standpoint from which to assess the data. Expressing a standpoint on fundamental beliefs about the nature of both society and science does this. This standpoint will determine whether an objectivist or a subjectivist approach to the research is appropriate. This philosophical viewpoint is explained below in the shortened table from Morgan and Smircich (1980) showing the range of ontological and human nature assumptions, the epistemological stance and the research methods on a scale of subjectivism to objectivism:

Subjectivist Approaches to Social Sciences ⟷ **Objectivist Approaches to Social Science**

Core Ontological Assumptions	Reality as a projection of human imagination	Reality as a social construct	Reality as a realm of symbolic discourse	Reality as a contextual field of information	Reality as a concrete process	Reality as a concrete structure
Assumptions About Human Nature	Man as pure spirit, consciousness, being	Man as a social constructor, the symbol creator	Man as an actor, the symbol user	Man as an information processor	Man as an adopter	Man as a responder
Basic Epistemological Stance	To obtain phenomenological insight, revelation	To understand how social reality is created	To understand patterns of symbolic discourse	To map contexts	To study systems, process, change	To construct a positivist science
Research Methods	Exploration of pure subjectivity	Hermeneutics	Symbolic analysis	Contextual analysis of Gesltalten	Historical analysis	Lab experiments, surveys

Figure 1 – Simplified table of research philosophical viewpoint (Morgan & Smircich, 1980)

These concepts from Figure 1 are discussed in detail below before discussion of the research strategy adopted in this thesis.

2.1.1 Ontology and Epistemology

Ontology, literally the science of ‘what is’, considers the kinds and structures of objects, properties, events, processes, and relations in every area of reality. Ontology is, put simply, about existence (Welty, 2003). It dictates what constitutes reality and how can we understand existence. It ranges from reality as a projection of human imagination to reality as a concrete structure.

Epistemology is the philosophy of what constitutes valid knowledge and how we can obtain it. As a large part of quantitative / qualitative distinctions derives from epistemological issues it is necessary to understand what constitutes adequate knowledge. This swings from (i) an emphasis on a positivistic and objective form of knowledge that specifies laws, regularities and relationship measures as social facts; to (ii) an epistemology that emphasises the importance of understanding the process through which human beings concretise their relationship to the world; challenging the idea of any form of objective knowledge on the basis that it is an expression of the manner in which a scientist as a human being has arbitrarily imposed a personal frame of reference on the work. The grounds for knowledge are different because the fundamental conceptions of social reality are poles apart (Morgan & Smircich, 1980).

2.2 Research Stance

There are generally considered two research stances, namely: (i) Positivism; and (ii) Interpretivism. A third position, Postpositivism, may be said to represent a middle ground between the two extremes.

2.2.1 Positivism

Positivism is sometimes known as deductive research. Positivists believe that there is an objective real world beyond the individual's body that can be known and described. All conclusions about reality are based on empirical observations that can be publicly verified by, for example, use of the senses. The research is determined by scientific procedures, with the researcher being an objective outsider to the research (Schulze, 2003).

2.2.2 Interpretivism

Interpretivism is also called post modernism and is often described as an inductive or adductive method. Bryman (1984) closely associates this with qualitative research.

Inductive research is a “bottom-up” approach to knowing and involves the search for pattern from observation and the development of theories for those patterns through series of hypotheses. The research starts without any theories and the researcher is free to change the direction for the study after the research process has commenced. Generalisations are formulated towards the end of the research, as the researcher is unsure of the type and nature of the research findings until the study is completed.

2.2.3 Postpositivism

Postpositivism refers to the thinking after positivism; challenging the traditional notion of the absolute truth of knowledge and recognising that we cannot be "positive" about our claims of knowledge when studying the behaviour and actions of humans (Cresswell, 2003). Adherents of a post-positivist approach take a broadly positivist view of the objective nature of knowledge but also believe that researchers are necessarily influenced by their own subjective selves in their research. Conclusions about reality therefore reflect the viewpoints of both the investigator and the investigated. Moreover, the more researchers admit their own biases, the more objectively they can approach their task (Schulze, 2003).

2.3 Data Typology

Established data typologies include:

(i) Quantitative data;

(ii) Qualitative data; and

(iii) Mixed data.

Quantitative research, where the data are in the form of numbers, tends to involve relatively large-scale and representative sets of data. It seeks the facts/causes of social phenomena, obtrusive and controlled measurement. It employs strategies of enquiry such as experiments and surveys and collects data on predetermined instruments that yield statistical data (Cresswell, 2003).

Qualitative research is where the data are not in the form of numbers, but based on individual experiences or participatory perspectives or both. This approach allows the researcher to explore the depth and complexity of a phenomenon, identify and describe its components and their relationships and develop a picture of the whole that can enhance and guide practice and future research. It uses strategies of enquiry such as narratives, phenomenologies, ethnographies, grounded theory studies or case studies. The researcher collects open-ended emerging data with the primary intent of developing themes from the data (Cresswell, 2003). It is concerned with understanding behaviour from the actors' own frames of reference.

Mixed Data is not a research methodology in the strictest sense; it only denotes that more than one methodology can be employed while conducting research (Jonker & Pennink, 2010). A mixed methods approach is one in which the researcher tends to base knowledge claims on pragmatic grounds (e.g., consequence-oriented, problem-centred and pluralistic). It employs strategies of inquiry that involve collecting data either simultaneously or sequentially to best understand research problems. The data collection also involves producing both numerical information as well as text information so that the final database represents both quantitative and qualitative information.

Triangulation (an aspect of mixed data) is the operationalisation of a concept in several different ways and seeking evidence on hypothesis with several different methods. This is often regarded as an important strategy in the argument that there is no research method without bias and when evidence can be obtained using two or more different methods, there can rightfully be more confidence in its accuracy than when only one method is employed (Cresswell, 2003).

2.4 Data Collection Methods

Data collection methods of the above three methodologies are: Observation; Survey; Grounded theory; Action research; Ethnography; Case Study; Questionnaire; Interview; and Focus Groups.

A study is said to have been carried out by a methodology because of the data collection methods that have been used during the research. These methods of data collection are described below.

2.4.1 Observation

One of the most common research methods is observation. This involves the researcher watching, recording and analysing events of interest. In social science research there are two parameters along which observation can be categorised as a research tool; these are participant and non-participant observation (Jonker & Pennink, 2010). In non-participant or passive observation, researchers just watch and record. In participant or active observation, researchers get involved in the group behaviour. Participant observation can be further classified as overt (when participants disclose whether they have joined the group) or covert (when participants do not disclose why they have joined the group).

2.4.2 Survey

The term survey describes a type of study that consists of asking people to respond to questions using formats like personal interviews, telephone interviews, mailed questionnaires etc (Totten, Panacek, & Price, 1999). Paper questionnaires are the most common approach and are generally familiar to both potential subjects and scientific readers.

The strategy involved in a survey is that the same information is collected about all cases in a sample and usually the cases are individual people being asked the same questions. Standardisation lies at the heart of the survey method, as the whole point is to get consistent answers to consistent questions so that they can be compared.

2.4.3 Grounded theory

Grounded theory is drawn from data, systematically gathered and analysed through the research process. In this method, data collection, analysis and eventual theory stand in close relationship to one another. The researcher does not begin a project with a preconceived theory in mind (unless their purpose is to elaborate and extend existing theory). Rather, the researcher begins with an area of study and allows the theory to emerge from the data. Theory derived from data is more likely to resemble the "reality" than is theory derived by putting together a series of concepts based on experience or solely through speculation. (Strauss & Corbin, 1990). The aim is to generate comprehensive explanations of phenomena that are grounded in the systematically gathered and analysed data (Jonker & Pennink, 2010). The investigator approaches a research problem in a very open manner and refines the study as the specific nature of the problem begins to emerge. The usual method of data collection is the in-depth interview. Initial interviews may have very little structure but as the researcher begins to develop ideas from the data this helps to give structure to interviews with future participants. The goal of grounded theory is to generate a theory that emerges from and explains the data that has been collected.

2.4.4 Action research

Action research method is a complex, dynamic activity involving the best efforts of (i) members of communities or organisations (stakeholders); and (ii) professional researchers. It involves the parallel role of generating new information while undertaking analysis with actions aimed at transforming the situation in democratic directions.

Together, the professional researcher and the stakeholders define the problems to be examined, cogenerate relevant knowledge about them, learn and execute social research techniques, take action, and interpret the results of actions based on what they have learned (Greenwood & Levin, 2007).

2.4.5 Ethnography

Ethnography can be defined as the study of people in natural occurring settings or fields by means of methods which capture their social meanings and ordinary activities, involving the researcher participating directly in the setting in order to collect data in a systematic manner but without meaning being imposed on them externally. Its objectives are to understand the social meanings and activities of people in a given field or setting, and its approach involve close association with, and often participation in, this setting (Jonker & Pennink, 2010).

Ethnographic studies are carried out to satisfy three simultaneous requirements associated with the study of human activities: (i) the need for an empirical approach; (ii) the need to remain open to elements that cannot be codified at the time of the study; and (iii) a concern for grounding the phenomena observed in the field.

2.4.6 Case Study

The all-encompassing feature of a Case Study is its intense focus on a single phenomenon within its real-life context (Yin, 1999). The Case Study is the preferred strategy when "how" and "why" questions are being posed and when the investigator has little control over events, and when the focus is on is a contemporary phenomenon within some real-life context (Ghauri & Gronhaug, 2005). According to Sarantakos (2013) a Case Study can be:

(i) Intrinsic, i.e. conducted for its own case, to learn about the case only and no expectation that the results will be generalised to explain similar case; or

(ii) Instrumental, i.e. used to inquire into a social issue or to refine a theory and the results would have a wider application beyond the study itself; or

(iii) Collective, i.e. includes a number of single studies investigated jointly for the purpose of inquiring in an issue, phenomenon, group or condition and it would normal include several instrumental case studies.

The researcher often use their own experiences to give meaning to the case reports, using judgment to enhance their understanding of the case and comparing that to similar cases encountered (deMarrais & Lapan, 2004). The approach relies on the integrative powers of research: the ability to study an object with many dimensions and then to draw the various elements together in a cohesive interpretation.

In terms of identifying the unit(s) of research interest, the first stage is to assess the accessible population, the population to which access is available (Cooper, 1984). Out of this accessible population the next step is to select one or few cases, objects or firms, for study. This selection should be based on criteria that are consistent with the research problem. The cases should correspond to the theoretical framework and the variables being studied (Ghauri, 2004).

2.4.7 Questionnaire

The questionnaire is traditionally in the form of a printed document and is essentially a list of questions. The defining features of the questionnaire are that the design itself is highly structured and that the same instrument is administered to all the participants in the survey. Questionnaires may be made up of open-ended questions, closed ended questions, or a mixture of both (Sarantakos, 2013). The use of closed ended questions was used effectively by the CIOB to provide information related to the state of time management in the UK construction industry, which has been analysed as part of this research, and is useful to compare the results from participants' answers.

2.4.8 Interview

Another commonly used data collection method is the interview: a social interaction between two people, one of whom wants to get information from the other and attempts to do so by asking questions. The interaction between interviewer and interviewee is what differentiates the interview from a questionnaire, even when the questions and possible answers may be identical. During this social interaction, the interviewer initiates varying controls during the exchange with the interviewee, for the purpose of obtaining information bearing on predetermined objectives. There are several different subtypes of research interviews. Two most popular types are:

(i) Qualitative interview, which has the freedom to adapt the questions and question ordering to what a particular respondent has already said as long as the general purpose of the interview is adhered to and the respondent is encouraged to discourse at length on the topics raised by the interviewer; and

(ii) Standardised interview, in which the interviewer must ask each question precisely as it is worded and cannot vary the order of the questions and the respondent, in turn, must typically respond by selecting one of a limited number of predetermined answers to each question (Sarantakos, 2013).

This type of research was considered unhelpful in the research due to the confidential nature of the subject matter.

2.4.9 Focus group

A focus group is a group interview or a group discussion. It consists of a small group of individuals, usually numbering between six and ten people, who meet together to express their views about a particular topic defined by the researcher. A facilitator or a moderator leads the group and guides the discussion between the participants. The focus group enables the researcher to explore participants' views and experiences on a specific subject in depth. This method differs from the individual interview in that the focus group is dependent upon interaction between participants. The hallmark of the focus group is the explicit use of the group interaction to produce data and insights that would be less accessible without the interaction found in a group (Jonker & Pennink, 2010).

2.5 Methods Adopted in the Current Study

2.5.1 Role of the Researcher

The research is postpositivistic in nature, is mainly qualitative, but may also be said to use a mixed approach: combining the use of quantitative and qualitative data. Bauer & Gaskell (2003) noted that what is needed in social research is a more holistic view of the process (as opposed to a single instrument view). This includes defining and revising a problem, conceptualising it, collecting data, analysing data and writing up the results. The reasons for selecting a social research mixed methods approach are as follows:

(i) The first stage of the research that mainly dealt with problem definition and investigation was tackled using the qualitative methodology for data collection and analysis.

(ii) The review of English common law required the reading and assessment of primary sources of the legal decisions, as the ‘sound-bites’ otherwise included in secondary reporting were often found to be out of context. It was recognised in this element of the research that the experience of the researcher was being used to extract the key element of the decision from a delay analysis perspective and is likely to be participant and subjective. To avoid any exaggerated interpretation, the relevant part of the legal decision has been quoted *verbatim* so the conclusions to be drawn can be distinguished from the decision itself.

(iii) Part of this research was using survey data collected by an institutional body, which was analysed using quantitative based methods. This approach was deemed important because of the need to adequately understand the situation and the problem being studied in order to propose a solution that can be used to tackle the problem.

(iv) Case studies were used on a collective and instrumental basis to ascertain the delay analysis methodologies actually used in the field of delay analysis. The results were analysed qualitatively and quantitatively.

The research adopted in this thesis is more aligned to business research. Walker (1997) noted business research was *the systematic and objective process of gathering, recording and analysing data for aiding making business decisions.* He further observed that 're-search' literally means to 'search again', which suggests that part of the process is to review problems from different perspectives.

2.5.2 Observation

Although in the strict sense, observation research has not been employed, the principle behind this method is to isolate the researcher from the data analysis. In this way, this thesis has adopted this approach, with specific aims of removing the influence of the researcher’s views from the analysis by relying on the views of industry experts rather than the researcher’s own experience, although the researcher is aware of his involvement in some of the expert reports is greater than otherwise anticipated as a non-participant observer.

2.5.3 Survey

Delay claims are so complex that few individuals have a comprehensive understanding of the associated issues. During a pilot study, simple one-to-one question and answer research methods, administered via questionnaire and interview proved somewhat limited (Gorse, Ellis, & Hudson-Tyreman, 2005). In addition, confidentiality issues prevent widespread access to information and data. This research does not therefore rely on primary survey data.

Although no direct survey has been undertaken as part of this research (due to the confidential nature of the study and the likely unwillingness of participants to answer accurately to a survey presented by an researcher within the industry) this method has been employed in part of the research by analysing the primary research survey data produced by an industry body. This data had not been previously analysed beyond percentage analysis due to the untimely death of the main researcher. As part of this quantitative research, the Spearman rank order correlation coefficient was utilised to compare ranking of results.

2.5.4 Case Study

Case studies have been undertaken as part of this research. The approach has been collective and instrumental in that they were reviewed as a group to (i) inquire into an issue; and (ii) refine a theory, the results of which are applied to the construction industry in general.

The situation of the researcher is as a practising delay analyst and, as such, has access, through professional associates, to numerous expert reports produced in the field of programming that have been presented as part of expert witness evidence in national and international arbitrations. The authors of the differing expert reports are recognised leading industry experts. Indeed, as part of their report, the expert explains their academic and professional qualifications and experience that enable them to be considered as experts. It was recognised that this was an invaluable source of industry guidance and therefore formed part of the data collection. The case studies involved the analysis of 27 programming expert reports, each submitted as part of the arbitration process. This was the number of reports available to the researcher. The purpose of the case study review was to address two main questions:

(i) How do experts retrospectively analyse construction delays to a dispute resolver? and

(ii) Why do they choose that delay analysis methodology?

The researcher was involved in some of the cases with which data was available. To avoid potential bias in the collection of results, two steps were introduced:

- Cases where the researcher was the primary decision maker on methodology were removed from the expert reports studied; and

- Focus was given on case studies where there was an expert report from a Claimant and a Respondent.

The research started with a descriptive explanation of the case studies. However, at the stage of analysis, comparison was complex. It was recognised that qualitative research was less useful for comparing case studies and a quantitative analysis was preferred. As suggested by Yin (1999), each case study is considered as a unit in the same way as an experiment is considered as a unit. Under this assumption, the problem of generalising from case studies is no different from the problem of generalising from experiments.

To collate the data from the case study, a matrix model was developed based on the research by Braimah & Ndekugri (2008). This ensured a standard approach to the review of each case study. So as not to limit the findings through a rigid approach to interrogation, flexibility as was added to allow further information to be added to the matrices.

The qualitative analysis was turned into quantitative analyses by including descriptive statistics attained with the aid of frequency counts and percentages. Associative and causative statistics were also utilised for data analysis. This was necessary to identify issues within the data and extrapolate into wider industry issues.

2.6 Ethical Considerations

The main ethical considerations were based on confidentiality. The case studies researched were actual expert reports used in arbitration, which is a confidential process. To maintain this confidentiality, it was necessary to remove the names of the parties from the case study summaries and any information that may otherwise identify the project with which the expert reports relate. These have been retained by the author as part of this research but are not available in their present format to the wider community due to (i) the names of the parties being included in the expert reports; (ii) the names of the project being included; and (iii) the names of the expert author being included, all of which are confidential.

No ethical considerations were needed for the common law review as these cases are reported and in the public domain.

PART II - EVALUATION OF DOCUMENTARY DATA

CHAPTER 3

3 STATUS OF TIME MANAGEMENT IN THE UK

Between December 2007 and January 2008, the Chartered Institute of Building (CIOB) conducted a survey of the construction industry's knowledge and experience of different methods of project control, time management, record keeping, monitoring and training. Respondents were also invited to report on how their current projects, and projects that they have been involved with, which had completed during the past three years, were dealt with in terms of extensions of time and compensation for delay related costs.

The main purpose of the research was stated to:

- Further awareness in the industry of time-management issues; and
- Identify the current level of understanding of the importance of project engineers and project schedulers in the management of time.

However, the research also helped identify the:

- Degree of incidence of unresolved delay in different types of building and building contracts; and
- Degree of understanding in the industry of project control techniques by different disciplines.

The results of the research showed:

- The more complex the project, the less likely it is that it will be completed either on time or shortly after the completion date.
- Low-rise hospital, clinic and health-related buildings, prisons and security buildings, stadia and sports-related buildings and railway stations are the types of projects that currently are most likely to be substantially delayed in their completion.

- High rise building projects and complex engineering projects also have a low chance of being finished on or before the completion date, and the majority reported upon were likely to be substantially delayed in their completion.

- In more than a third of building projects and four-fifths of engineering projects, it was perceived that the contractor was predominantly held to be to blame for any delay to completion.

- In around two-thirds of building projects, and half of engineering projects, the respondents perceived that the delay-related costs were predominantly at the liability of the contractor.

The raw survey data collected by the CIOB was not fully analysed contemporaneously.[12] The raw data was provided by the CIOB to the researcher and is analysed as part of this thesis.

3.1 Analysis of CIOB Survey

The CIOB survey was published in 2009 but analysis of its findings was restricted and largely descriptive for reasons already mentioned. The following section takes this analysis further by using the survey as a secondary data source. There were 72 responses to the survey. The survey asked the following questions, which have been indicated as relevant (or not) to this research:

Question No	Question	Relevant
Question 1	Which of these job descriptions most closely fits your principle role in the construction industry?	Y
Question 2	Which of these trade descriptions most closely fits your principle business in the construction industry?	Y
Question 3a	In the past 3 years approximately how many low rise building projects (1-6 storeys) have been completed in each category?	Y
Question 3b	On the scale of 0-10, in relation to the perceived delayed completion, indicate the extension of time and compensation awarded to date.	Y
Question 3c	In the past 3 years approximately how many high rise building projects (above 7 storeys) have been completed in each category?	Y
Question 3d	On the scale of 0-10, in relation to the perceived delayed completion,	Y

[12] Due to the sad loss of one of the CIOB staff leading the research

Question No	Question	Relevant
	indicate the extension of time and compensation awarded to date.	
Question 3e	In the past 3 years approximately how many engineering projects have been completed in each category?	Y
Question 3f	On the scale of 0-10, in relation to the perceived delayed completion, indicate the extension of time and compensation awarded to date.	Y
Question 4	In relation to one of the projects from section 3 that you are currently involved with, or if company-wide, one started within the last six months, please answer the following questions:	Y
Question 4b	What procurement method is used?	N
Question 4c	How is the timing of the works managed on site?	Y
Question 4d	In what form is your principle tool for time management produced?	Y
Question 5a	When identifying the construction process to be followed, how is the planned sequence determined?	Y
Question 5b	If the planned sequence is determined by a method statement, which of the following usually participate in the writing of it?	Y
Question 5c	If the planned sequence is determined by meetings, which of the following are usually involved in the meeting?	Y
Question 6a	Do you have occasion to write, read or consider construction programmes?	Y
Question 6b	When considering the most recent programme to be used for construction what software is used?	Y
Question 6c	How are the durations of activities arrived at?	Y
Question 6d	How is the value of the activities identified?	Y
Question 6e	How is the logic in the programme developed?	Y
Question 6f	How are the date constraints used?	Y
Question 6g	How are the float constraints used?	Y
Question 6h	What method is used to control the quality of the programme?	Y
Question 7	Do you work with short term programmes?	Y
Question 7b	When considering the most recent short-term programme what software is used?	Y
Question 7c	What type of software is used for short term programme?	Y

Question No	Question	Relevant
Question 7d	How are the durations of activities arrived at?	Y
Question 7e	How is the value of the activities identified?	Y
Question 7f	How is the logic in the programme developed?	Y
Question 7g	How is the short term programme related to the base line programme?	Y
Question 7h	What method is used to control the quality of the short term programme	Y
Question 8a	Do you write, read or consider records of progress achieved?	Y
Question 8b	When considering the most recent example of records of progress of the works on site how are the progress records kept?	Y
Question 8c	What labour records are usually kept?	Y
Question 8d	What plant/equipment/machineries records are usually kept?	Y
Question 8e	What records are kept of work that is different from that contracted for?	Y
Question 9	Do you write read or consider monitored or updated programmes?	Y
Question 9b	When considering the most recent example of a monitored or updated construction programme are there any design activities in the programme?	Y
Question 9c	How is the progress of design/engineering activities assessed?	Y
Question 9d	How is the progress of work activities assessed?	Y
Question 9e	How is the progress of the project assessed?	Y
Question 9f	Is a programme update carried out?	Y
Question 9g	How are the programme updates presented?	Y
Question 9h	If updated from as status line and progress is inconsistent with the planned programme sequence is this dealt with by?	Y
Question 10a	In regard to the most recent project if delay to progress is identified is this immediately notified?	N
Question 10b	If delay to progress is not immediately notified is this because?	N
Question 10c	To whom is delay to progress usually notified to?	N
Question 10d	Of what does notice usually consist of?	N
Question 10e	By whom are events that give entitlement to time or money usually identified?	N

Question No	Question	Relevant
Question 11a	Do you think there is a difference between the desired skills and experience of a planning engineer and those of a project programmer/scheduler?	Y
Question 11b	In your experience, how are planning engineers trained?	Y
Question 11c	On a scale of 0-10 do you think the quality of education and training of planning engineers is satisfactory at the moment?	Y
Question 11d	What qualifications can a planning engineer achieve by way of accreditation?	Y
Question 11e	Is there a current need in the industry for more training and accreditation of planning engineers?	Y
Question 12a	In your experience how are project programmers/schedulers trained?	Y
Question 12b	On a scale of 0-10 do you think the quality of education and training of project programmers/schedulers is satisfactory at the moment?	Y
Question 12c	What qualifications can a project programmer/scheduler achieve by way of accreditation?	Y
Question 12d	Is there a current need in the industry for more training and accreditation of project programmers/schedulers?	Y
Question 12e	Would you be prepared to support a formal training and accreditation scheme for planning engineers and or project programmers/schedulers?	Y

The above questions can be considered as being divided into three groups:

(i) Project delays and recovery of costs;

(ii) The production and management of programmes; and

(iii) Skills and training of project programmer / scheduler.

Each of these is addressed below.

3.2 Project delays

The respondents were asked in relation to low rise buildings, high rise buildings and engineering projects:

Question 3a	In the past 3 years approximately how many low rise building projects (1-6 storeys) have been completed in each category?
Question 3b	On the scale of 0-10, in relation to the perceived delayed completion, indicate the extension of time and compensation awarded to date [with 0 being none and 10 being full recovery].

Low Rise Buildings had the greatest level of response (83%) for EOT score and compensation score. The 'delta' or numerical difference between the two scores is illustrated below:

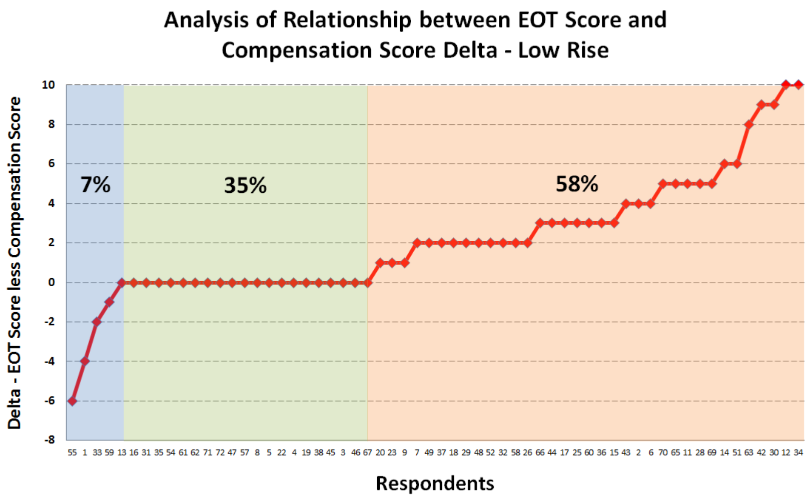

Figure 2 – Relationship between EOT score and Compensation score (Author's analysis)

The analysis in *Figure 2* shows that more respondents perceived recovery of a greater award of time than costs. In 7% of the cases, the respondents received a lesser award of time than costs and in 35% of the cases the respondents received an equal award of time and cost. Based on this analysis there are two main observations:

(i) Time claims are frequently (83%) submitted together with cost claims; and

(ii) A greater recovery of time was awarded than cost.

The above analysis compares the delta between the EOT Score and the Compensation Score. Further analysis is based on the amount of recovery, as shown below (with blue squares being the EOT Score, black diamonds being the Compensation Score and green bars representing the numerical difference between the scores):

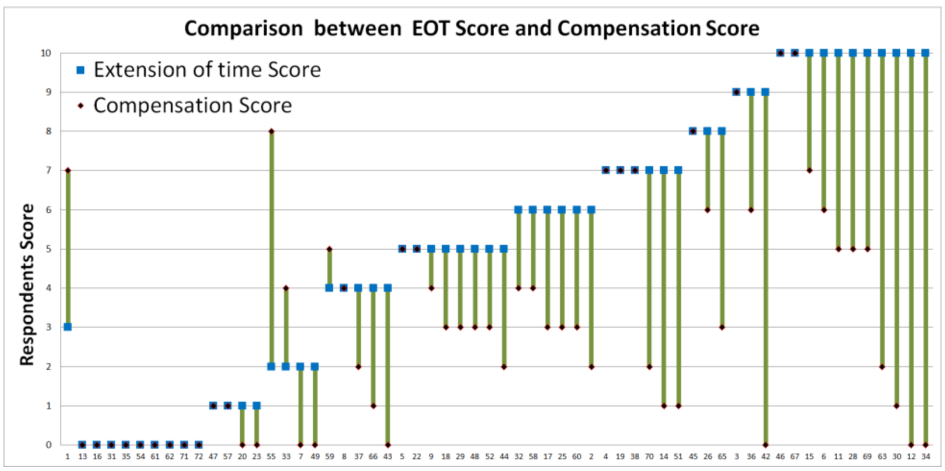

Figure 3 – Comparison between EOT score and Compensation score (Author's analysis)

The comparison between the EOT Score and the Compensation Score in *Figure 3* shows the following:

- There is an obvious correlation where there is no time or compensation recovery;
- There are cases where there is no recovery of compensation but good recovery of time; and
- Generally, where time is recovered, then so is compensation.

From an analysis of the EOT Score alone, 21% of the respondents were awarded complete EOT recovery (Score = 10). On analysis of this sub-set of respondents, 80% of these respondents used a complex planning tool (either: Primavera, MS Project or Asta Power Project) to develop the baseline programme. Furthermore:

- Where the score was between 0 and 5, 55% of respondents used a complex planning tool (either: Primavera, MS Project or Asta Power Project).

- Where the score was between 6 and 10, 72% of respondents used a complex planning tool.

From the above analysis, it is concluded that where respondent's used complex planning tools they were more successful in terms of the amount of EOT awarded.

3.3 The Production and Management of Programmes

Over 88% of the respondents reported that they would have occasion to write, read or consider construction programmes. The interaction between construction professionals and programming is therefore very high.

The EOT Score is compared to the production and management of programmes as follows:

- The average EOT Score is calculated by taking the EOT Score from each respondent and deriving an average score by dividing the sum of all EOT Scores by the number of respondents. The average EOT Score is 5.33.
- The average EOT Score when using complex programming tools is 5.64.
- When the programme is updated weekly or monthly, the average EOT Score is 6.19, compared to 5.34 when it is not.
- When the programme has been independently reviewed, the average EOT Score is 6.34, compared to 4.19 when it was not.
- When the programme is independently reviewed and the updating is based on percentage complete or remaining duration (suggesting accurate updating) the average EOT Score is 6.8.

From the above analysis it can be concluded that, using complex planning tools, having an independent review of the programme and accurate updating of the programme results in the greatest award of an EOT.

3.4 Skills and training of project scheduler

The role and perceived skills of a project scheduler was questioned to identify the respondents experience on how project schedulers were trained. Out of 72 respondents:

- 38% were experienced of planners being trained either part time or full time; and
- 47% were experienced of planners being trained on the job;

Of the 47% who were experienced of planners being trained on the job:

- 65% of them did not know of any other qualifications for a project scheduler; and
- 70% of them support the need for more training and accreditation of project schedulers.

The survey shows that over half of the planners had no formal training and were trained ‘on the job’. This was in the context of the greater number of respondents being unclear as what qualifications and training was available, but acknowledging there was a perceived need for more training and control of qualification through an accreditation scheme.

3.5 Statistical method of analysis

To study the strength of relationship between two sets of ranking of time recovery and compensation recovery, the Spearman rank correlation coefficient (denoted by r or simply r_s) was used. A Spearman rank correlation coefficient of +1 indicates a perfect association of ranks; Zero indicates no association between ranks; and -1 indicates a perfect negative association of ranks.

The closer r_s is to zero, the weaker the association between the ranks. The Spearman rank correlation coefficient is calculated using the equation below (Kottegoda & Rosso, 2008):

The formula to use when there are no tied ranks is:

$$r_s = 1 - \frac{6\sum d^2}{(N^3 - N)}$$

Where:

- r_s = Spearman rank correlation coefficient;
- d = Difference in ranking between EOT and Compensation;
- N = Number of variables (Score) = 10

However the formula to use when there are tied ranks is:

$$\rho = \frac{\sum_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_i (x_i - \bar{x})^2 \sum_i (y_i - \bar{y})^2}}$$

Where:

- *i* = paired score.

The comparison analysed is between those respondents that ranked receipt of an EOT ranging from 0 to 10, with 10 being a full EOT and 0 being no EOT with the ranking of the level of compensation awarded.

This analysis resulted in a Spearman's correlation coefficient of 0.109, indicating there was no linear correlation between the award of time and compensation. The Pearson's correlation co-efficient is 0.145. As the Spearman's coefficient was closer to zero than the Pearson's co-efficient, the sets of results are more independent (i.e., less correlated).

The amount of time recovery does not therefore correlate to the amount of compensation recovery. This reinforces the maxim that these should be considered separately.

CHAPTER 4

4 TYPES OF DELAY ANALYSIS METHODOLOGY

The common aim of all delay analysis methodologies has been to investigate how delays experienced by the various project activities affect other activities and the project completion date, then to determine how much of the overall project delay is attributable to each party. By this, time and/or cost compensations for the contracting parties, as a result of the project delay, can be apportioned (Ndekugri, Braimah & Gameson 2008).

The stages to the forensic analysis of delay to a completed project may be simply described as:

(i) Start with what was planned. This is likely represented by the contractor's original baseline programme if available and appropriate. From this baseline, identify the as-planned critical path.

(ii) Establish what happed. This is likely represented by the As-Built programme. From this, identify the As-Built critical path. This may be done in time slices if the critical path has changed and would require interim updates to the baseline programme.

(iii) Compare the planned approach against the actual approach. A simple comparison of planned and actual progress does not tell you why a delay has occurred but it is a valuable reference that may allow the analysis to be focused, for example if there was no delay in early stages of the project, then a detailed analysis need only be performed on the later stages of the project.

(iv) Undertake factual research to identify the events causing critical delay, following on a detailed review of the activities in the programme which measure the delay and may show the effect rather than the cause.

(v) For each causative event, establish the facts (using records or witnesses) concerning the delay, its cause, the duration of the delay, the chronology of events that led to the delay and the activities that were directly affected.

(vi) Establish the effect of the delay on subsequent events and ultimately on the completion date, from a programming and factual basis.

Schumacher (1995) proposed four questions to help delay analysts clarify delay problems: (1) What was supposed to happen? (2) What did happen? (3) What were the differences? (4) How did they affect the project schedule? In answering these questions, Bordoli (1998) states an appropriate method should: be responsive to different contract conditions; take account of current case law; be applicable to all types of project; be applicable to all sizes of project; be of equal use to contractor and employer; should adopt a format that is easy to process; communicate the results in a straightforward manner; and be capable of accommodating different categories[13] of construction delay and different types[14] of delay.

There may be a significant difference in approach to analysing the effect of delay depending on whether the project is in progress at the time of determining the entitlement or whether it is complete. In the former instance, the ultimate effect of the events claimed as causing delay can only be estimated at the time of the determination, and some sort of prospective method of delay analysis has to be relied upon. This is the approach required under the NEC contracts for example. In the latter case it is known when the project was complete and it is then possible to look back at what has actually occurred. While a dispute about a delay may be referred to adjudication before the completion of the works, requiring some

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13 Categories of delay meaning (i) excusable and compensable (ii) excusable and non-compensable (i.e. neutral events) and (iii) non-excusable

14 Types of delay meaning (i) Date delays (where an activity cannot start or finish irrespective of predecessors and successors); (ii) Total delays (complete stoppages); (iii) Extended delays (where an activity has increased in duration (iv) Additional works delay (where new construction activities are added to the planned scope; (v) Sequence delays (where an activity cannot be carried out in its planned sequence; and (vi) Progress delays (where an activity suffers from lack of progress.

degree of prospective approach to modelling the effect of the delay, in the main a dispute about delay that comes before the tribunal or court will arise out of a project that has been completed.

According to Khalid (2011), although the source for this conclusion is not provided, the most common issues in delay analysis methodologies are:

- Real time delays, i.e. delays that were on the critical path at the time;
- Concurrent delays;
- Acceleration credit; and
- Pacing delay.

However, there is no single method for analysing the impact of delays on construction work (Baldwin & Bordoli, 1998). Indeed, there are said to be various types of delay analysis methodologies.

Many techniques have been used in the courts to demonstrate the criticalities of a delay event on the project programme (Tan, Al-Humaidi, & Hadipriono, 2010), however, even in the US where there is a larger prominence of delay related case law, there is no standard method to analyse a delay claim (Al-Gahtani & Mohan, 2011). This is perhaps not surprising as it has been argued that one delay analysis technique does not suit every situation (Bubshait & Cunningham, 1998). However, there is agreement that the amount of delay attributable to the employer and the contractor can depend on the delay analysis technique employed. Although due to the recent court case of *Walter Lilly v Giles Patrick Mackay* (2012) EWHC 1773 TCC, para 380, it may be thought that the methodological issue has less relevance, as Akenhead observed:

> *…the debate about 'prospective' or 'retrospective' approaches to delay analysis was also sterile because both delay experts accepted that, if each approach was done correctly, they should produce the same result…*

An explanation of the facts of the above case means this statement will unlikely be of general application, but was relevant only to the facts of that particular case, where the issues in dispute occurred towards the end of the project when the bulk of the works were substantially complete (Marshall, 2013).

Accordingly, the UK Society of Construction Law (SCL) Delay and Disruption Protocol was published on 16 October 2002 in response to widespread dissatisfaction with the way delay and disruption was being dealt with (Gorse, Ellis, & Hudson-Tyreman, 2005).

The selection of the appropriate delay analysis methodology may be essential to the success of a claim. In the Australian case of *Alstom*, the judge rejected outright the claimant’s novel resource-based approach used to prepare its delay claims, not on its merits, but rather because the approach is not mentioned in both the Protocol (2002) and the leading text on this subject, as one of the recognised acceptable approaches for delay analysis.

This can be contrasted to *Adyard Abu Dhabi v SD Marine Services* (2011) EWHC 848 (Comm), where, at paragraph 289, the use of the Protocol (2002) is questioned:

> *…Adyard's delay expert, Mr Swan, suggested that, at least in relation to its claim for an extension of time, Adyard's contract completion date approach was supported by the SCL Protocol. However, as Mr Swan agreed in evidence, the SCL Protocol is not in general use in contracts in the construction industry and nor has it been approved in any reported case. There was no evidence that the parties were aware of it or that they contracted with it in mind. Further, the SCL Protocol itself says that "it is not intended to be a contractual document. Nor does it purport to take precedence over the express terms of a contract or be a statement of law". In such circumstances the SCL Protocol can be of little assistance in relation to the legal causation issues which arise in this case…*

Nevertheless, the Protocol's aim was to set out the common delay analysis methodologies and provide guidance on their usage. This is an appropriate aim, as decision-making on the most appropriate methodology is more likely to be implemented where the decision was reached through consensus rather than conflict (Schweiger, Sandberg, & Ragan, 1986). The starting point of understanding delay analysis is therefore to understand the methodologies available. By reviewing the strengths and weaknesses of the various methodologies, and reviewing consensus on the most appropriate methodologies, decisions can be made on their selection.

Forensic programme analysis methods and approaches are known by various common names. Current usage of these names throughout Industry is however loose and undisciplined. The titles, explaining apparently similar methodologies vary, thus giving the impression of greater variability than may actually exist. This terminology issue was considered sufficiently important for a leading professional organisation, the AACE International (formally the Association for the Advancement of Cost Engineering) to publish a Recommended Practice Note to correlate the common names with a taxonomic classification to provide a unifying technical reference for the forensic application of critical path method of scheduling (AACE, 2007).

4.1 Recommended Practice

The AACE (2007) identifies five layers of hierarchal nomenclature.

The first layer is timing:

- Whether the analysis is prospective, produced during the works, or retrospective, produced after completion of the works. This may not be seen as a layer at all, but nevertheless is a useful distinction on the timing the analysis and therefore the context of the analysis.

The second layer is whether the delay analysis is observational or modelled:

- Observational means analysing the programme itself or in comparison with another. Modelled means that the analyst introduces changes to the programme to simulate a certain scenario, for example, inserting a delay event to show before and after effects of the event on the programme.

The third layer is for specific methods of analysis:

- Under observational there are two types: (i) Static Logic Observation; and (ii) Dynamic Logic Observation. The Static Logic compares a plan consisting of one set of network logic to the as-built state of the same network. The Dynamic Logic involves comparing programmes whose logic differ to varying degrees from the baseline and from each other.

- Under modelled there are two types: (i) Additive; and (ii) Subtracting. Under Additive, the analyst adds delay events to a programme to compare the effect. Under Subtractive, the analyst removes delay events from a programme to compare the effect.

The fourth layer is Basic Implementation and attempts to list the different methods of implementing the second and third layer. It provides four methods: (i) Gross Mode or Periodic Mode; (ii) Contemporaneous / As-is or Contemporaneous Split; (iii) Modified or Recreated; or (iv) Single Base, Simulation or Multi Base, Simulation. These are explained below:

- Gross Mode considers the entire project duration as one whole analysis period without any segmentation. This compares to the periodic mode, which breaks the duration into two or more segments.

- The As-is method uses the contemporaneous programmes and compares the different programmes in their unaltered state. The Split method separates the comparison between different contemporaneous programmes into: (a) the effect of progress; and (b) the effect of revisions such as logic changes.

- The Modified or Recreated method is used where extensive modification or recreation of the contemporaneous updates is undertaken.

- Single Base or Multi Base is whether delay events are added and removed from a single programme or a series of programmes.

The fifth and final nomenclature level is to do with Specific Implementation:

- Whether this involves (i) Fixed Periods or Variable Periods; and
- Whether the modelled effect is done globally (all at once) or stepped (sequential).

This taxonomic classification is helpful; however, as these terms are not readily used in Industry, their immediate assistance to Industry is questionable. The AACE (2007) correlated their new taxonomy with 'common names' to improve their familiarity. These common name methodologies are explained in **Chapter 4.3** to **Chapter 4.7** below. Under 'Observational Methods' the following taxonomy is tabulated:

Taxonomy	1	Retrospective						
	2	Observational						
	3	Static			Dynamic Logic			
	4	Gross	Periodic		Contemporaneous Updates		Reconstructed Updates	
	5		Fixed Periods	Variable Windows	All Periods	Grouped Periods	Fixed Periods	Variable Windows
Common Names		As-planned v As-built	Windows Analysis		Contemporaneous Period Analysis Time Impact Analysis / Windows Analysis			

Figure 4 – Observational Methods: Classifications of programme techniques (AACE, 2007)

Under the 'Modelled Methodologies' the following taxonomy is tabulated:

Taxonomy	1	Retrospective					
	2	Modelled					
	3	Additive				Subtractive	
	4	Single Base		Multi Base		Single Simulation	
	5	Global Insertion	Stepped Insertion	Fixed Periods	Variable Windows	Global Extraction	Stepped Extraction
Common Names		Impacted As-planned	Time Impact Analysis Impacted As-planned	Time Impact Analysis	Windows Analysis Impacted As-planned	Collapsed As-built	Collapsed As-built[15]

Figure 5 – Modelled Methods: Classifications of programme techniques (AACE, 2007)

15 Time Impact Analysis has been removed from this section of the table to coincide with the more usual view that this is an additive approach.

The use of the ‘common names’ in the Recommended Practice is contrasted to the variety of alternative names shown in the following table by Ndekugri *et al* (2008) and produced based on his literature review:

Names of Existing Delay Analysis Methodologies			
	Common name	Literature review	Alternative names used by different authors
Non-CPM Based Techniques	S-Curve	Rubin *et al.* (1999)	Dollar-to-Time Relationship (Trauner, 1990)
	Global Impact technique	Leary and Bramble (1988); Alkass *et al.*, (1995; 1996); Pinnell, (1998)	
	Net Impact	Leary and Bramble (1988); Alkass *et al.* (1995, 1996)	Bar chart analysis (Zack, 2001; Lucas, 2002) As-built bar chart (Bordoli and Baldwin, 1998)
	As-planned vs. As-built [16]	Stumpf (2000); Lucas (2002); Lovejoy (2004); Pickavance (2005)	
CPM Based Techniques	Impacted As-Built CPM	(Pinnell, 1998)	Adjusted as-built CPM (Leary and Bramble, 1988; Alkass *et al.*, 1996) Total time (Zack, 2001; Wickwire and Groff, 2004)
	As-Planned but for	Alkass *et al.* (1996); Pinnell, (1998)	
	As-planned vs. As-built	Stumpf (2000); Lucas (2002); Lovejoy (2004); Pickavance (2005)	
	Impacted As-planned	Trauner, (1990); Pinnell (1998); Lucas (2002); Lovejoy (2004) Pickavance (2005)	What if (Schumacher, 1995) Baseline adding impacts (Bordoli and Baldwin, 1998) As-planned-plus delay analysis (Zack, 2001; Chehayeb *et al*, 1995) As-planned CPM (Pinnell, 1998)
	Collapsed As-built	Pinnell (1998); Stumpf (2000); Wickwire and Groff (2004); Lovejoy (2004)	But-for (Schumacher, 1995; Zack, 2001; Lucas, 2002; Alkass *et al.* (1996) As-built but-for (Pickavance, 2005) As-built subtracting impacts (Bordoli and Baldwin, 1998) As-built-minus analysis (Chehayeb *et al*, 1995)
	Window Analysis	Galloway and Nielsen (1990); Bordoli and Baldwin (1998); Finke (1999); Lovejoy (2004); Pickavance (2005)	Contemporaneous Period Analysis (Schumacher, 1995; Lucas, 2002) Snapshot (Alkass *et al.*, 1995; 1996) Periodic update analysis (Chehayeb et al., 1995) Watershed (Pickavance, 2005)
	Contemporaneous Period Analysis[17]	AACE (2007)	

16 This has been adjusted from that suggested by (Ndekugri N, 2008) and also included in the Non-CPM based methods, as it is also a static method of analysis and can be undertaken without CPM

Names of Existing Delay Analysis Methodologies			
	Common name	Literature review	Alternative names used by different authors
	Time Impact Analysis	Leary and Bramble (1988); Alkass *et al*. (1996); Pickavance (2005).	End of every delay analysis (Chehayeb *et al*, 1995) Time Impact Technique (Alkass et al., 1991, 1993) Chronological and cumulative approach (Wickwire and Groff, 2004)

Figure 6 – Adjusted Table of Names of Existing Delay Analysis Methodologies (Ndekugri, Braimah, & Gameson, 2008)

From reviewing the above adjusted Ndekugri *et al* (2008) table and the AACE (2007) classifications of the type of programme techniques used, the methodologies can be grouped as:

(i) Critical Path Method ("CPM") or Modelled based techniques; and

(ii) Non-CPM based or Observational techniques.

Within the above grouping: one relies on a programme or model to calculate the effects of the analysis; the other is a comparative reading of the data and does not rely on calculations within the programmes to undertake the analysis.

However, to some degree the As-Planned v As-Built approach can also be reliant on a CPM programme to produce the planned approach. It is therefore necessary with this approach, when making the comparison, to consider the logic included in the plan.

Perhaps due to the universal use of and access to computers (Carmichael & Murray, 2006), CPM techniques are often demanded by dispute decision makers to demonstrate the effect of delays: possibly because of their ability to be adjusted in real time, meaning they can respond to facts as they become

[17] This has been added to the table suggested by Ndekugri et al (2008) as it is the only other "common name" mentioned in the AACE Recommended Practice that was otherwise not included

clearer. In addition, the development of more 'off-the-shelf' software programming packages, of which there were said to be around 50 available in the UK (Gardiner & Ritchie, 1999), has contributed to the widespread use of CPM techniques during the life of the projects, although not necessarily improving the accuracy of the planning phase.

The non-CPM based techniques, particularly bar charts, are of limited help in proving the impact of delays because of their inability to show the true effects of delays on project completion (Wickwire & Groff, 2004). However, they can be successfully used to analyse some types of delay claims particularly those involving fewer activities and simple relationships (Pickavance, 2005). Notwithstanding this preference of CPM over non-CPM techniques, the present state of Industry is such that non-CPM techniques are still overwhelming employed in assessing delays (CIOB., 2008).

Despite the AACE Recommended Practice (2007) aim of identifying all options, clarity is needed on which are the most common delay analysis methodologies.

4.2 Common Delay Analysis Methodologies

According to Ndekugri *et al* (2008), there is need for more empirical research to complement and extend existing knowledge, understanding and use of the most common methodologies.

Scott (1993) states it is well accepted by boards of contract appeals and courts in the US that the preparation of four CPM diagrams is necessary to determine each party's rights in a project where delays have occurred. These are:

(i) A reasonable 'As-Planned' CPM;

(ii) An 'As-Built' CPM;

(iii) An 'As-Built' CPM reflecting all delays - those for which the Employer, the Contractor and neither party are responsible; and

(iv) An 'adjusted' CPM to establish the time for completion of the project in the absence of Employer delays (akin to the ‘but-for’ type of analysis).

This is supported by Ng (2004) who states the analysis of construction delays is carried out by comparing the ‘As-Planned’, ‘As-Built’ and ‘adjusted’ programmes.

Alkass (1996) lists several techniques used by experts in the domain of claim analysis to determine the impact of delaying events upon the overall project completion date. These are listed below, with a suggested common name allocated to it:

No	Alkass Technique	Common Methodology
1	**Global impact technique**	**As-built**
2	**Net impact technique**	**As-planned v As-Built Analysis**
3	**Adjustment As-Built CPM technique**	**Not common**
4	**‘but for’ or collapsing technique**	**Collapsed As-built Analysis**
5	**Snapshot technique**	**Windows Analysis**
6	**Time impact technique**	**Time Impact Analysis**

Figure 7 – Expert Techniques (Alkass, Mazerolle, & Harris, 1996) correlated to Common Names

Alkass (1996) accepts that the first three techniques are simplistic and the courts would not accept such simplistic techniques. The more detailed (4), (5) and (6) techniques are more reliable and are the preferred methods for preparing delay analysis.

Bordoli (1998) lists the CPM methods used by contractors in the UK and US as:

(i) As-planned v As-built (which he identifies as the most used);

(ii) Collapsed As-built (which he calls As-built subtracting impacts);

(iii) Impacted As-planned (which he calls Baseline adding impacts); and

(iv) Windows Methodology.

In the UK, the Society of Construction Law (2002) provided a classification of common methods used in delay analysis. These are:

- As-planned v As-Built;
- Collapsed As-built;
- Time impact analysis; and
- Impacted As-Planned.

Arditi (2006) reviews 20 research studies and identifies four methods that are often mentioned in construction literature that are professionally acceptable. These include the:

- As-planned vs. As-built analysis method;
- Impacted As-Planned analysis method;
- Collapsed As-built analysis method; and
- Time Impact Analysis method.

Braimah and Ndekugri (2008) also identify various delay analysis methods available for undertaking delay analysis and note the methodologies frequently commented upon in literature are:

- As-Planned v As-Built Analysis;
- Collapsed As-built Analysis;

- Time Impact Analysis;
- Impacted As-Planned Analysis; and
- Windows Analysis.

A comparison of the above studies with the AACE Recommended Practice (2007) and the Protocol (2002) support the listing by Braimah and Ndekugri (2008) as a comprehensive list of the common methods available. Each of these is discussed below.

4.3 The As-Planned v As Built Method

Before discussing the As-Planned v As Built Method, it has been suggested that each (the As-Planned and the As-built) can be a stand-alone methodology (although these are not common methods). These are discussed first below.

4.3.1 The As-Planned Method

The As-planned CPM chart is prepared in order to establish the time in which the project could have been completed absent any delays.

The As-planned Method[18] measures the effect of the delay on the contractors' planned performance rather than on the actual performance. It is important to determine precisely the time, programme and construction sequence the contractor intended to use. According to Wickwire and Smith (1974) this chart should take into account:

- Significant time saving techniques even when discovered post contract;

[18] This is the original methodology developed by A James Waldron in the late 1960s

- Adjustments to correct errors in logic or duration; and
- The As-planned chart must be validated.

Correction of errors may be resisted if the programme was submitted by the contractor and approved by the employer early in the project. The As-Planned analysis must at least:

(i) Show and demonstrate the critical path;

(ii) Establish the source and basis of:

  - Sequence of events;
  - Man-loading; and
  - Duration of activities.

(iii) Detail changes to any of the above (either contemporaneous or subsequent) and include these into the As-planned chart.

The reasonableness of the As-planned chart may be established by expert testimony.[19]

The contractor is entitled to an extension of time calculated as the difference between the reasonable As-planned programme and the actual completion date.

According to Pickavance (1997) there are a number of advantages in using this method, for example:

- It does not rely exclusively on the existence of As-built data. An As-built chart may be used as a cross check and does not necessarily form the basis of analysis. In theory the method could be used without any As-built data other than the actual completion date;

[19] In the Australian case of Thiess Properties Pty. Ltd v Ipswich Hospitals Board (No 2), ((1985) 2 Q.R.318) it was found that reliability may be demonstrated by testimony of an expert or the contractor and that schedule analysis was recognised to be within the field of expertise of a Quantity Surveyor.

- It can produce an answer even where the amount of analysis is limited by time or financial constraints; and
- It is capable of producing a clear and concise presentation.

The AACE (2007) publication described earlier provides guidelines for appropriate steps in the selection, validation and rectification of the baseline programme, as it noted that the baseline programme is the starting point to most types of forensic programme analysis.

4.3.2 The As-Built Method

The As-built CPM is produced to show how the project was actually constructed and to demonstrate the actual completion date. This is analysed to assess the delays that prevented the completion date from being achieved sooner.

Given proper records, production of an As-Built critical path should be a mechanical task requiring little interpretation (Wickwire & Smith, 1974). Actual dates and durations may be available from the updated CPM. The updated CPM must be checked against the project records.

The identity of the As-Built critical path is a matter of fact. The process of identification involves starting at the last activity prior to completion and asking the questions:

- Why did this activity commence at this date?
- Why not earlier?
- What was preventing it being commenced?

The answer to these questions will reveal a preceding activity that had to be completed before the next activity could commence. The same questions must then be asked of this preceding activity. In many cases, the identification of the preceding construction activities is fairly straightforward. In other cases, there may be several possible activities and it becomes necessary to examine the facts in more detail to ascertain which, in the end, was the last to be completed and was therefore critical. By continuing the process above, the as-built critical path for the whole of the works on site can be identified. The as-built critical path identifies the sequence of dependent activities that in the end determined when actual completion took place. In other words, if the planner had known in advance all of the activities, durations and delays that would define the project and had planned the project to include all of those matters, the critical path so planned would be the same as the final as-built critical path.

Having identified the as-built critical path, the sequence of activities along the path is examined to find evidence of delays and their cause. The duration of such delays is ascertained using whatever factual records have been kept. It is not generally necessary to consider whether the contractor's baseline or planned programme allowed adequate activity duration because only actual delay to critical activities is taken into account. Any delay to the as-built critical path will have caused a delay to completion of the works.

This method has a number of advantages over some of the other methods. These include the following:

(i) Firstly, it does not rely heavily on a baseline programme which may not be accurate or achievable;

(ii) Secondly, it does not produce theoretical prospective projections of delay that depend upon the adequacy of the programme; and

(iii) Thirdly, there is some certainty about cause and effect; because the as-built critical path is the path of activities that ultimately drove completion, any delay identified on that path will have directly delayed completion.

The following criticisms can be raised in regard to the as-built critical path method:

- It ignores that the critical path often changes during the project;
- They are costly and time consuming to prepare because of the amount of research which is likely to be necessary to establish actual dates;
- Considerable judgement may be required because comprehensive records are rarely available;
- Available records rarely correspond to the theoretical activities used in the original network;
- Establishing the actual relationships and sequences is extremely difficult if not impossible because such information is rarely recorded;
- Sequencing and relationships may have changed over time which is not captured within this methodology;
- The need to exercise so much judgement makes the method prone to manipulation and distortion;
- It is not capable of easily resolving issues of concurrency; and
- There is, in any event, no clearly defined and accepted As-Built methodology.

Because the As-built programme focuses on actual progress to define the critical path and to show which delays impacted project completion it may be suitable where only one party contributed to the delays.

Even if an As-built chart or analysis were not capable of demonstrating delay as a stand-alone method, the As-built chart is an essential part of retrospective analysis. The distinction between this and other methods is the extent to which hindsight is used to affect EOT entitlement.

The Recommended Practice (AACE, 2007) also provides guidelines for appropriate steps in the selection, validation and rectification of the As-Built programme.

The decision in *Balfour Beatty v. Chestermount* confirms that a non-culpable delay occurring in a period of otherwise culpable delay should be measured on a net rather than a gross basis. This requirement in itself may tend to dismiss any analysis premised on an “ultimately critical” basis as there is no analysis of why it became critical.

4.3.3 As-planned versus As-built

The As-planned versus As-Built method compares the baseline programme with how the work was actually completed, the As-Built programme. The difference between the two is investigated to arrive at an explanation of the increase in project duration.

The starting point of this method is also the baseline programme. However, this method compares the baseline programme with how the work was actually completed, the As-Built programme. The As-Built programme can be compiled either using contemporaneous records, actual dates recorded in the programme, or both. By comparing the As-Planned programme with the As-Built programme the variances from the planned performance can be identified. This method makes it easy to assess either the differences between individual activities or the differences between the overall completion dates. Once the variances are identified, the causes of the variances can be assessed.

Although this may make use of CPM developed programmes, in its simplest form, it does not rely on the programme to calculate the result; as such, it may be considered an observational analysis. As no analysis is carried out using critical path techniques, it does not determine what effect any delayed activity or additional works had on other activities and hence on the completion date of the project. It can be used for identifying delays to progress and is useful as a starting point in relation to other, more complex methods of analysis (Society of Construction Law, 2002).

Braimah and Ndekugri (2008) state this methodology compares the activities of the original CPM baseline programme with those of the As-Built programme for detailed assessment of the delays that occurred. The main advantages of this methodology are that: it is inexpensive, simple and easy to use or understand. Its limitations include failure to consider changes in the critical path and inability to deal with concurrent delays and other complex delay situations.

The comparison progresses from the earliest activities' planned dates to later dates in a chronological manner. According to Arditi (2006) this method identifies the as-built critical path, but the comparison sequence can be against the as-planned sequence or the as-built sequence. The analysis then concentrates on identifying, either for each activity or for critical activities, the following:

(i) Delayed starts;

(ii) Extended durations; and

(iii) Delayed completions.

This enables the analyst to identify where the most significant delays occurred through individual activities or sequences of the works. An advanced form of this methodology requires the analyst to identify the as-built critical path and assess the difference between the as-planned critical path and the as-built critical path.

This method can be gross, i.e. over the entire project, or periodic. One of the criticisms of this methodology is that when applied grossly, the further along the analysis through the planned sequence the less reliable the comparison, as it is more likely the planned intention would have changed.

An improvement on the gross method is therefore not to solely use the original baseline programme, but the regular updates to the baseline at periodic intervals, therefore considering a moving and changing plan. This addresses the concern of relying on one plan for too long a period and has the advantage of contrasting the contemporaneous position with the as-built position. The further benefit to considering the project in discreet periods of time is to enable the analyst to focus on smaller groups of activities perhaps up to when a significant milestone has been achieved.

As this methodology does not rely on a computational CPM, the methodology relies more extensively on expert evaluation. Although this method is easy to understand, its drawbacks include (Lovejoy, 2004):

- It makes no allowance for mitigation of delay;
- It assumes that the baseline programme logic holds; and
- It fails to identify the critical path.

Indeed the AACE (2007) consider the method applicable only to relatively simple cases and should not be used for long duration cases or where there are significant changes between the original planned work scope and the final as-built scope.

4.4 Collapsed As-Built Method

When the As-built network incorporates delaying events as separate activities, this approach is to collapse the programme to assess the effect on the completion date by removing the delay activities in stages.

This method uses, as its starting point, an As-built programme and is an extension of the As-built method. It is undertaken by reducing activity durations or amending logic ties. The delays caused by each party are removed in stages. The resultant completion date is allegedly the date the project would have been completed "but for" other party delays.

The Collapsed As-Built is based on the effect of the delay event on the programme of work as it was actually built. Similar to the As-Planned v As-Built, the use of this technique is restricted by its inability to identify concurrency, re-sequencing, redistribution of the resources or acceleration. This is particularly the case when the nature of the as-built logic is complex, requiring subjective reconstruction of as-built logic. Where acceleration, redistribution of resources or re-sequencing has taken place during the course of the works to overcome the effects of events, this form of analysis may produce unreliable results (Society of Construction Law, 2002).

Braimah and Ndekugri (2008) state the advantage with this approach includes producing results of good accuracy. Its limitations, however, include: ignoring any changes in the critical path and the great deal of effort required in identifying the as-built critical path. Harris (1991) provides a different description for this method and appears to confuse the method with using as-planned data, which it does not require.

However, the principal benefit of this method is that it produces a verifiable method of comparing an "as-built" record programme to model what would have transpired had none of the events occurred (for which additional time and / or money is claimed). This makes the analysis easier to understand in disputes. This approach is a method of choice when a contractor lacks an acceptable programme during the project, or when no as-planned programme was required in the contract (Arditi & Pattanakitchamroon, 2006).

This is more onerous than the As-Built method as it requires a dynamic programme be created from as-built records to model the effect of removing the delay activities. Also, the same programme produced with owner delays and contractor delays will likely show different results. The method is illustrated as follows:

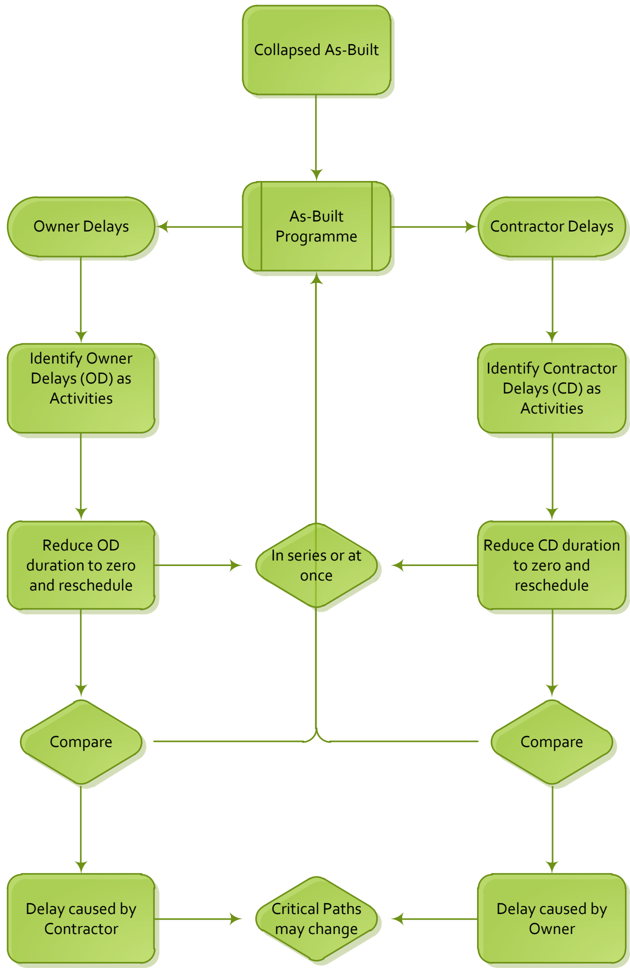

Figure 8 – Approach to Collapsed As-Built Method (Author's illustration)

Despite its acceptability, the traditional Collapsed As-Built method (described often as the "but-for" method) suffers from serious drawbacks; namely its narrow focus on the point of view of a single party and its inability to accurately consider concurrent delays (Mbabazi, Hegazy, & Saccomanno, 2005).

The Collapsed As-built method also suffers from the following problems:

- The collapsed programmes assume that the project would have been constructed in exactly the same manner even without the delays (Zack, 2001);

- It does not take into account any changes in the programme during the course of the project, whereas the critical path will most certainly change during the course of the project (Alkass, Mazerolle, & Harris, 1996);

- The extraction of arbitrarily established delays from the As-Built Programme and manipulation of the extraction process can conceal the effect of the contractors' delays. These deficiencies can usually be discovered, however, by running several "what if" scenarios of the "but-for analysis", extracting employer-caused and contractor-caused delays separately and jointly, and evaluating more accurately the impact of each party's delays to the project completion date (Lane, 1994);

- While the As-built programme is analysed at completion, the critical path which contains the delaying activities will be the primary critical path at that date. However, when the events occurred, the critical path may have been quite different simply because of changes to the construction logic during the course of construction (Lane, 1994); and

- Durations of delays are usually arbitrarily established; a process often manipulated to cover up the effect of a claimants delay (Gothand, 2003).

According to Kao (2009) delay analysis methodologies should consider the fluctuation that occurs in the critical path(s) as events evolve on site and indeed delay analysis methods might produce incorrect results if it cannot identify the critical path change correctly. For the above reasons, the Collapsed As-built method, although steeped in actual data, produces a theoretical result.

4.5 Impacted As-Planned Method

The Impacted As-Planned (IAP) Method is based on the effect of delay events on the planned programme of work. This method of analysis requires the identification of excusable delays (as discrete, time-duration activities) and the impact of these upon the original As-Planned Programme (AP). The programme is then recalculated to form the IAP

The method is essentially as follows:

(i) Identify a planned activity affected by an excusable event or create a 'fragnet'[20] to represent the event;

(ii) Extend the planned activity by the period of the excusable event or link the planned activity to the fragnet; and

(iii) Recalculate the programme to ascertain a new completion date.

The impact of excusable delays on the contractor's work is then portrayed through a comparison between the original as-planned date for completion and the completion date calculated from the simulated IAP.

As the IAP does not account for progress, it takes no account of acceleration or delays during the progress of the works in calculating the completion date. Instead, it determines the forecast amount of EOT due to excusable delays.

The premise of this method is that the resultant IAP is what the initial (or baseline) programme would have looked like if the impacted excusable events had been known at the time, it would have been the basis of the calculation of the contract period at the start of the project.

The IAP analysis is a CPM-based method commonly used in the construction industry to demonstrate the effect on completion of excusable delays and has been a popular technique used by contractors for demonstrating delay in the US (Lane, 1994). This is thought to be the simplest form of delay analysis using CPM techniques since it involves the least amount of variables (Society of Construction Law, 2002).

Applying an isolated set of delays to the As-Planned logic may, at first, seem appealing; however, criticisms of this method are as follows:

[20] This connotes a sub-network of activities used to represent the delay event that can be tied into the As-Planned programme

- Any technique which impacts the As-planned programme and ignores the status of the programme is likely to result in the delaying events being considered out of context and time (Bordoli & Baldwin, 1998);
- It is highly subjective (Lovejoy, 2004);
- The actual sequence and progress may have been significantly different from the planned schedule (Gothand, 2003);
- The critical path may already have been changed by events other than those under consideration (Bordoli & Baldwin, 1998);
- It relies on a hypothetical outcome which, at best, might have been the result and places too much reliance on theory; and
- It is often assumed in applying this technique that the claimant is not responsible for any concurrent or critical delays.

The first criticism is potentially the most serious problem with this technique. Overall, the usefulness of the IAP technique is restricted due to the theoretical nature of the projected delays that are determined using this technique and uncertainty as to the feasibility of the contractor's as-planned programme (Society of Construction Law, 2002). However, it is precisely because the impact to the baseline programme is an objective assessment of the likely effect of the event rather than the actual effect that it does not require as-built records in order to produce it.

The contractor may be entitled to an extension from (i) the end date calculated by the IAP including contractor responsible delays; and either (ii) the actual completion date or the end date calculated by the IAP including owner responsible delays, whichever is the earlier.

One method of demonstrating the conclusions reasonably to be drawn from the data is to run the programme three times to demonstrate the delays impacting the As-Planned programme as a result of inexcusable delays, then excusable delays, then incorporating any logic changes by way of mitigation and, finally, the two together a (with adjustments made for any actual resource or logic changes to minimise delays by way of mitigation). This would be undertaken with the following steps:

(i) The As-Planned programme is impacted with excusable delays;

(ii) The durations of the excusable delays are then set to "zero" – any delays caused by the Contractor are indicated as positive durations and the second IAP completion date is calculated; and

(iii) The As-Planned is impacted with both excusable and inexcusable delays (to produce a possible third IAP completion date is calculated).

When all the impacts have been added, the path can then be analysed and the responsibility for the extent of individual delays on the critical path attributed. This is illustrated below:

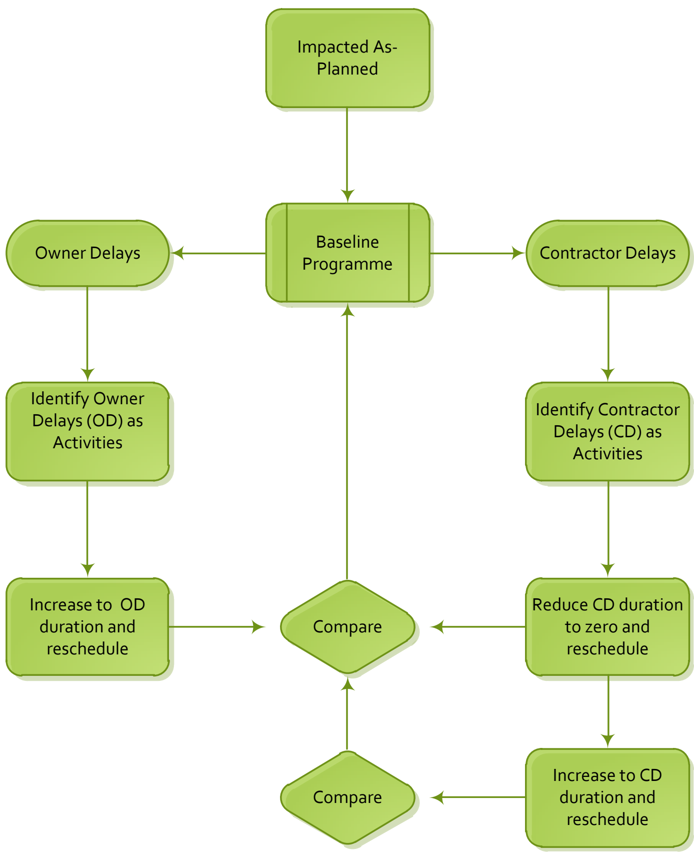

Figure 9 – Approach to Impacted As-Planned Method (Author's illustration)

Not all excusable delays will necessarily be on the critical path or affect the contract completion date. Some delays may occur on parallel paths or affect activities which are planned to be in float.

A study by Arditi (2006) of literature from 1987 to 2004 identified that the Impacted As-Planned Method was the least favoured approach.

4.6 Time Impact Analysis

This method is a development of the Impacted As-planned Method, but with this approach, the as-planned programme is first updated with actual progress at the time of the event, then the effect of the event is calculated by impacting it on the programme updated at that time

The Time Impact Analysis ("TIA") is perhaps the best technique for determining the amount of EOT that a contractor should have been granted at the time a delay event occurred. In this situation, the amount of EOT may not precisely reflect the actual delay suffered by the contractor. This technique is the preferred method to resolve complex disputes related to delay and compensation for that delay (Society of Construction Law, 2002). From a forensic perspective, it is not as probative as an As-Built analysis, which explains what actually happened (AACE, 2007).

The TIA uses the baseline programme to assess the effect of a delay upon the completion date and can only be used where the programme is a fully linked critical path network, that is to say, one in which all necessary activities have been defined and linked to dependent activities. This methodology has at least four steps:

(i) Enter the progress status of all activities at a time just before the delay event occurred. Once progress has been entered, the programme can be re-calculated to determine the current anticipated completion date and to identify the critical path through to completion. The idea being to obtain a ‘stop-action’ picture of the project before and/or after a major delaying event has occurred (Alkass, Mazerolle, & Harris, 1996).

(ii) Enter the delay event (using a ‘fragnet’) into the programme to model the delay. This may be done by adding a new activity with appropriate logic, or by changing the sequence or durations of existing activities, or a combination of both.

(iii) Recalculate the programme to determine the new anticipated completion date, which relies on the planned durations and sequences for the remaining work.

(iv) Once all activity delays have been quantified, the origins and causes can then be researched and responsibility for each apportioned. The contractor may be entitled to an EOT for the difference between (i) the revised completion date after the event; and (ii) the completion date before the event (if the delay event was excusable).

This is a programme-analysis technique designed to identify and quantify programme impacts contemporaneously through an analysis of the status of the project at the time critical events occurred[21] during the course of construction. The as-built history of the project, including contract changes and time impacts is established up to the date of the event and the programme is recalculated. The as-planned or uncompleted portion of the programme is then used to forecast the duration of the outstanding work. The anticipated impact of any delay-causing event can then be assessed by comparing the newly established completion date to the previously as-planned completion date. Arditi (2006) notes that the Time Impact Method incorporates both party responsible delays into the analysis, however, this appears an adaption to the methodology that is not supported by other commentators.

[21] The status date of the programme is the “data date”

Braimah and Ndekugri (2008) state this approach has significant merit making it probably the most reliable technique. However, it is time-consuming and costly to operate, particularly in situations where large numbers of delaying events are involved. Alkass (1996) also considers this technique provides a systematic and objective method of quantifying the effect of delays on a project, since it considers the effect of the delays in the context of time and CPM programme. However Alkass (1996) notes some downfalls with the TIA method:

(i) This method does not scrutinise delay types prior to the analysis, therefore further analysis to apportion entitlement is required.

(ii) Since each delayed activity is analysed individually, the effects of concurrent delays in the project are not immediately addressed making the approach unrealistic. Further analysis is also required to address this issue.

(iii) The accuracy of this technique is a function of the number of analyses performed, however it may become too cumbersome if there are an overwhelming amount of delay-causing events.

The most significant criticism is, while the TIA method may be appropriate for prospective analysis, if it is assumed that a retrospective analysis should consider what actually happened, this step does not form part of the methodology. In this respect the analysis approach may be considered flawed (Cummins, 2003).

The TIA is one of the only methods that is implicitly required by a standard form of contract, namely the NEC, as this requires a prospective analysis at the time of the delay event. Although this form of analysis can be used retrospectively, it is best used contemporaneously, assessing delay as each programme is updated. The main reason TIA is most effective when done contemporaneously is because the assessment is triggered by the occurrence of each delaying event. When the delay event is placed into the contemporaneous programme, its effect can easily be quantified. Some commentators believe this ought to be done on a day-by-day basis (Arditi & Pattanakitchamroon, 2006).

It has been held[22] that, when applying this method, it is preferred to update the programme retrospectively, rather than rely on the contractor's monthly programmes, as this eliminates any subjective distortion or manipulation (either advertent or inadvertent) in the production of the monthly progress programmes and is often done retrospectively with more rigour.

A study by Arditi (2006) of literature from 1987 to 2004 identified that TIA method was the most supported approach. Although he did not research the Windows Analysis method, it is noted he often confused the two (as did other commentators, e.g., (Gothand, 2003)). He produced the following summary (although it is unclear whether this was from a prospective or retrospective analysis):

Assessment of Time Impact Analysis	
References	Comments
Lovejoy (2004)	Very good
Sagarlata and Brasco (2004)	Useful for prospective analyses, but minimal utility supporting claims
Sandlin et al. (2004)	Overcomes some disadvantages of others
Gothand (2003)	Reliable
SCL (2002)	Most reliable when available
Harris and Scott (2001)	Used by claims consultants
Zack (2001)	Accurate but expensive
Fruchtman (2000)	Contemporaneous basis, but no future changes considered
Stumpf (2000)	Reliable, but time consuming
Finke (1999, 1997)	Most reasonable and accurate

22 Mr Richard Fernyhough QC in Costain Ltd v Charles Haswell & Partners Ltd (2009) EWHC 3140 (TCC), Para 180

McCullullough (1999)	Dependent on baseline schedule, accurate
Zack (1999)	Suitable
Bubshait and Cunningham (1998)	Acceptable, dependent on availability of data
Levin (1998)	Dependent on how the method is applied
Alkass et al. (1996)	Some drawbacks/propose modified method
Schumacher (1995)	Effective method
Baram (1994)	Most desirable approach
Wickwire et al. (1991)	Recommended

Figure 10 – Commentator's Views on Time Impact Analysis (Arditi & Pattanakitchamroon, 2006)

TIA can be used as a sub-method in tandem with the Windows Analysis method (which perhaps explains the confusion) to assess the effect of additional scope on the programme at the time the additional scope was known. This may be necessary to demonstrate a change to the critical path due to increased scope at the time it was instructed rather than when its effects were realised.

The TIA method does not reassess the impacted effect of the delay event on the updated programme at the time of the event. This results in the delay analysis not matching the actual delay, which is alleged to be appropriate as it is measuring entitlement not need (Society of Construction Law, 2002).

4.7 Windows Analysis

The Windows Analysis method evaluates progress and delay at regular intervals by reference to the contemporaneous critical path, as opposed to the final as-built critical path. The period between the intervals is the window.

The Windows Analysis method is retrospective, and requires a baseline programme, regular programme updates, with, ideally, a reliable fully linked critical path programme and a complete set of as-built data.

This technique requires the total project duration to be divided into digestible time periods, called windows, and to analyse the delays that occurred in each window successively (i.e., deviation from previous window), with focus on the critical path(s). Usually, the selection of window size coincides with milestones, major programme updates, or major delay events (Hegazy & & Zhang, 2005).

The periods analysed can be the same periods of time as those when the project was updated, which makes the Window Analysis especially helpful (Nielsen & and Galloway, 1984). For instance, if the project was updated monthly then the Window Analysis could be performed on a monthly basis. In this case, the Windows Analysis method starts by comparing the baseline programme with the first update, with the first update being the end of the first window (Window 1). The change in the project completion date is noted, as is the critical path at the start and end of Window 1. If the completion date is delayed, then the activities causing that delay in Window 1 can be identified. This process is repeated until the final update is compared with the As-Built programme. At the end of the analysis, the summary of all delays on each window becomes the project total delays. It necessarily follows that each programme must be compatible with the others so that they may be readily compared i.e., they must have generally equivalent activities, although it can be performed from a static and observational perspective.

If all of the required information is available, the Windows Analysis method provides a measure of delays as they happened during the life of the project. The method assesses delay on the contemporaneously perceived critical path and therefore, as the critical path may move, the work sequence that is perceived to be critical in one window may differ from what is perceived to be critical in the next window.

At the close of each window it will be necessary to list those events found in the window which, in relation to what was expected at the beginning of the window, represent the:

- Addition of a new activity; or
- Omission of an activity.

Or have, in relation to the status of the previous window:

- Taken longer to complete;
- Been completed earlier;
- Started later than planned; or
- Starter earlier than planned.

If contemporaneous periodic updates are not available, it is then necessary to reconstruct the windows. This is undertaken by choosing various milestones through the project which dictate the course of the project or decisions which change the course in some way. Such an approach is helpful in keeping down the size of the analysis and it tends to bear a closer relationship than other methods with a “common sense” approach in terms of what the parties consider to be important (Fenwick-Elliot, 1993).

Because the Window Analysis method focuses on sequential periods of project performance and on the contemporaneous critical path, this method of analysis has significant benefits over those which deal with the project period as a whole (Lane, 1994). While each window may contain a number of conditions affecting progress, because the window necessarily represents a limited period of time, it will affect fewer activities. In addition, this method considers events at the time they arose and consider what was the likely entitlement at each window (this can be contrasted with the as-planned v as-built method which seeks to justify the overall plan with the overall as-built in one step). This is the principal advantage of Window Analysis, with it probably being the most robust and extensive analyses (Farrow, 2001).

In principle, there is no reason why Window Analysis methodology should not be used to analyse any delay, whether it be a delay to the critical path or otherwise. The essence of Window Analysis is not in what is analysed or how, but in the point at which it is analysed. It has been suggested that entitlement obtained in one window is not negated by what happens in the next window. The Windows Analysis technique appears to be the most reasonable and accurate option with which to conduct the analysis of compensable delays (Finke, 1999) and is among the most highly respected method of demonstrating delay claims (Lovejoy, 2004).

There is some confusion with this method, as some commentators see this as a variation of the Time Impact Analysis (Arditi & Pattanakitchamroon, 2006). In its purest form it is not; as it is a periodic comparison between the As-Planned and As-Built and as noted by the AACE (2007) there are four possible variants:

(i) The As-is method - this uses the contemporaneous programmes and compares the different programmes in their unaltered state;

(ii) The Split method separates the comparison between different contemporaneous programmes into (a) the effect of progress and (b) the effect of revisions such as logic changes;

(iii) The Modified or Recreated method is used where extensive modification or recreation of the contemporaneous updates is undertaken; and

(iv) Single Base or Multi Base is whether delay events are added and removed from a single programme or a series of programmes (which is akin to the Time Impacting suggested by Arditi).

According to Hegazy *et al* (2005) the preferred delay analysis techniques are the "but-for" technique and the Windows Analysis technique. Of these two methods, the Windows Analysis is considered to be more accurate although it requires more time and effort for the analysis. Hegazy *et al* identified the following "serious" drawbacks:

(i) While the as-built is the key to accurate delay analysis, it is widely recognised that it is manually done after the fact (after the project ends) and not as the events evolve, due to the difficulty in site-data recording. Accordingly, the As-Built programme may be subjected to errors and omissions that hinder accurate delay analysis;

(ii) With the window span being in the form of weeks or months, the focus is on the critical path(s) that exists at the end of the window time. Thus, the technique does not consider the fluctuations that occur in the critical path(s) as events evolve on site. As such, the decisions related to delay responsibility will certainly differ with the variation in window size;

(iii) As a consequence of the above point, the technique loses sensitivity to the time at which the owner/contractor cause project delays within the window. Also, it loses sensitivity to the events of speeding or slowdowns within the window; and

(iv) The delay representation of existing software systems makes the application and automation of the windows technique a difficult task.

Hegazy's solution, to capture and consider all variations in critical path(s), is to use as small a window size as possible. He therefore promotes a daily Window Analysis. This approach may address item (ii) above but it exacerbates the difficulty of item (i) above. In practice, as-built data is not always accurate to within one day. Indeed, it is necessary for the analyst to take a pragmatic approach to the level of accuracy their analysis can be considered within.

Take for example a concrete slab. Is the start of the activity reinforcement prefabrication or when the reinforcement starts to be fixed? Similarly at the end of the activity: is the finish date (a) the pouring of concrete? or (b) the curing of concrete?

These subjective decisions, multiplied by the number of times they are made, results in an inherent level of accuracy to which the as-built dates can be said to achieve. On projects spanning many years, it is possible the accuracy is no greater than to within two-weeks. Therefore, while producing a daily calculation of progress may address the concern that the critical path has changed during the window, it relies to a greater degree on the accuracy of the as-built dates, which even with good records and experienced analysts, is difficult to be accurate to within one day. It is also unlikely, on a true understanding of criticality (rather than a strict reliance on a numerical result), that the critical path would change on a daily basis.

A suggested practical refinement, to address the concerns over capturing changes in critical paths between windows, is to first compare the critical path at the start of Window 1 with the critical path at the end of Window 1. Only if it has changed would there be a need to create a sub-window, i.e., Window 1.5, to capture this change.

Having identified a period of delay or mitigation in the window in question, the remaining task is to assess the causative event or events. This can be done in a variety of ways. One way is a detailed visual inspection (i.e. expert assessment). This approach is unconventional (Alkass, Mazerolle, & Harris, 1996) as when analysing delays, the conventional approach is to ask the question:

> *This event occurred; what delay did it cause to the project?*

However, with the Windows Analysis,[23] the analyst asks:

> *This delay occurred; what event or events caused it?*

This less conventional approach is persuasive in its presentation in a dispute, as the analyst does not start with a predetermined result that they are trying to model, but starts with an analysis of the data and assesses the delays against the findings.

[23] Here the Windows Analysis has been aligned with what was described by Alkass as a Snapshot Analysis

A second way is by creating, impacting and analysing fragnets (e.g., small critical paths that model a single programme activity in greater detail).

The strength of this approach is that it forces the analyst to consider actual progress and revised programme intent in a logical manner. It produces a result which cannot be easily rejected as contrived because it is practical rather than theoretical. Issues such as mitigation, criticality, concurrency and dominance are all taken into account in a transparent manner, leading to better understanding of what occurred and the circumstances at the time.

According to Gibbs (2007) the Windows Analysis method could be enhanced by reflecting and capturing the practice of resource allocation.

A further enhancement to the Windows Method is combining the method with impacting. Whereas the window/update method establishes delay or mitigation in each window period and leaves the assessment of causation as a separate debate, the impact/update method introduces the causative event into the delay analysis. That is to say, this method applies events to the as-planned model on a month by month basis (the windows) to derive the monthly entitlement but then considers the actual monthly production, i.e. to contrast the contractor's actual performance, in terms of culpable delay or mitigation. This is an appropriate way to address additional scope, as it reflects what the contractor could have foreseen at the time of the event, and supports the philosophy of putting the contractor into the position he would have been in but for the delay event, required by the law of restitution.

A delay programme is drawn up before the analysis proceeds and this will list the delay events alleged to give rise to the contractual entitlement. For each of the window periods, the delay events that are alleged to have arisen in the period in question are impacted on the planned model and time analysed. The resultant project end date at the end of the window will reflect the notional entitlement, at that time, to an extension of time. The contractor's culpable delay events that are alleged to have arisen in the period in question may also be impacted on the model and time analysed. The resultant project end date will reflect the additional delay, if any, caused by the contractor in that month.

Following the analysis, the progress records are imposed on the planned model and the programme time analysed again. The resulting end date will represent the overall delay to completion actually occurring in that window period. This will allow for excusable delay events, compensable delay events, culpable delay events and contractor's mitigation due to changes in programme or faster progress.

The final refinement of the Windows Analysis method is to consider what happens to the paths in successive windows where contractor delay was incurred. This is a key issue, as otherwise, if what happens in one window is not negated by what happens in the next window, then contractor delays would be accumulated in each window as if 'set-in-stone', whereas the contractor ought to have the entire project period to reduce his own delays and would seek to do so: perhaps by increasing resources. This is an action a contractor is unlikely to be required to do to mitigate employer delays.

This methodology is illustrated below (showing options for the 'Modified' or 'As-is' alternatives):

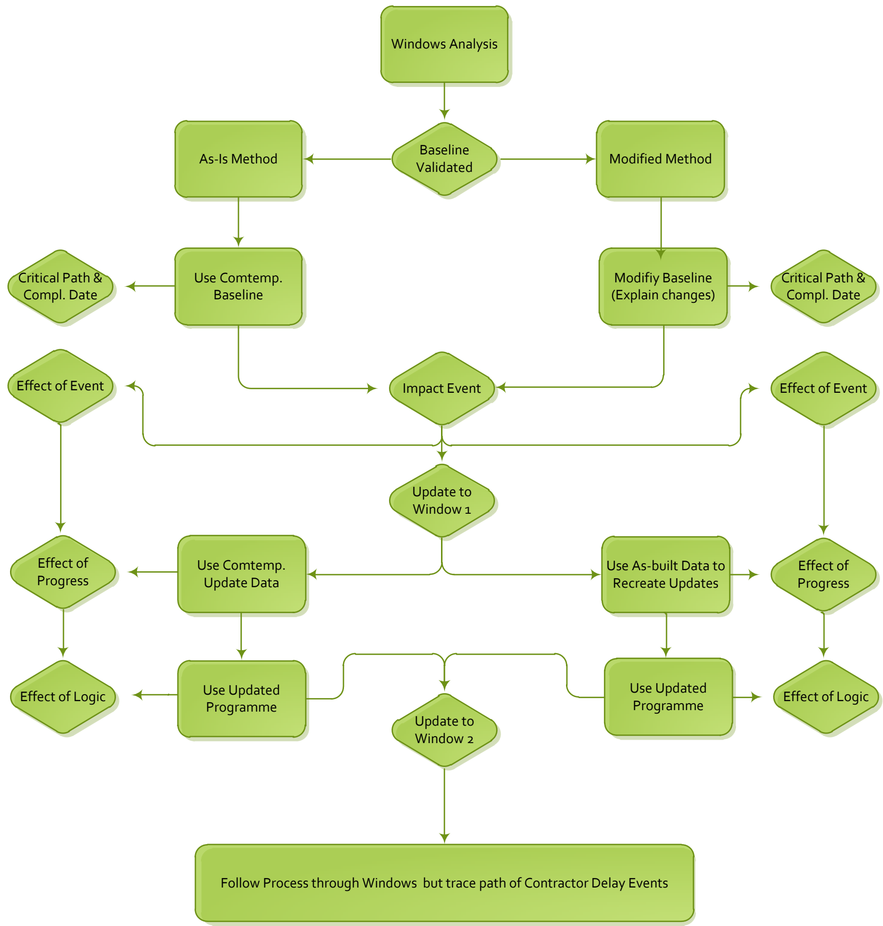

Figure 11 – Approach to Windows Method (Author's illustration)

The Windows Analysis approach requires a baseline programme and either contemporaneous updates (progress and logic changes), or as-built data to allow updates to be created.

4.8 Records

The common delay analysis methodologies described in various literature examined above stopped one step short of what is undertaken as part of the delay analysis methodology in practice. However, that step is an extremely important one, and in the review of the case studies, was found to be the key. That is: assessing the results of the delay analysis methodology against the facts.

Delay analysis is not undertaken in a vacuum. The programme is an important source, but ultimately just one of the sources, available to explain the delay. It is therefore to be expected that the delay analysis results ought to accord with other contemporaneous records. This is possibly why the Windows Analysis receives support, as it necessarily considers actual progress and revised programmes, allows for matters of concurrency, dominance and mitigation to be debated, and limits the degree of initial subjectivity to the logic links within the model (as the baseline can change in each window).

The need to assess the results against the facts was alluded to by Bordoli (1998) where he noted:

> *…The authors recognize that the proposed method demands accurate documentation if the results are to be accepted by all parties. However, this is the situation with respect to any method of delay analysis that is adopted. Contractors must recognize the importance of comprehensive, accurate records if their claims are to be upheld…*

The need for the delay analysis to be supported by the facts was also identified by Carmichael e*t al* (2006):

> *…The records kept on construction projects will be the main source of information on which claims for time or additional payments will be established by the contractor or assessed by the engineer or contract administrator. The importance of producing adequate delay documentation has been recognized for many years…good record keeping is crucial in helping to avoid or resolve claims...*

> *…Frequently the specifics of the change event are not recorded at the time and the project progresses until slippage in the programme manifests itself. At this point, if the contractor believes he has been subjected to some form of employer delay, he will submit a request for an extension of time using evidence based on progress information contained in the general project archive. Some of this information will have been submitted to the engineer/employer*

and some will not have been. The contractor administrator (the engineer in this example) will then attempt to make an assessment of the change event to determine if any EOT is deserved. And this can be where the problem starts. If none of the records in the general project archive have been directly related to the change event, the engineer must undertake an often complex assessment to determine cause and effect, in a relatively short period of time (time period being determined by the contract) in order to check the contractor's claim. Frequently the limited records available make an accurate assessment difficult, which leaves the door open for the contractor to quite legitimately question the engineer's analysis as lacking the conclusive evidence on which to reach an unequivocal decision…

…A separate process of investigating the event retrospectively then arises, often involving additional resources such as external consultants, and which frequently leads to arbitration and even litigation…

Scott and Assadi (1999) quote Major and Ranson (1980) observing:

…It is all too common, when seeking to establish what actually happened on a project, to find that even a considerable amount of investigation will produce only an incomplete picture. It will often be necessary to analyse minutes of progress meetings, valuations, diaries, and various charts and programmes which neither individually nor collectively enable an actual progress chart to be produced or a detailed history of the project to be written. This is a common and substantial area of failure in site and head office management…

The SCL (2002) suggests that contemporaneous material, as well as programmes and plans, should be used to evidence delays. Pickavance (2005) suggests that the factors which influence the strength of the contemporaneous data are timeliness, neutrality of records, approval and acceptance, first hand records collected at the time of the event, secure processing that prevents manipulation and corroboration of records.

4.9 Methods of Selecting a Delay Analysis Methodology

The method of selecting a delay analysis methodology is an important issue as it can produce different outcomes (Al-Gahtani & Mohan, 2011). Arditi (2006) also notes that the results of a delay analysis may be influenced by the method selected and therefore the selection of the most appropriate method is of importance to all parties concerned.

Alkass (1996) performed a study using differing methodologies, after correlating his descriptions to common names. The following table displays his results for compensable delay:

Alkass Technique	Common Methodology	Results from Test Case
Net impact technique	As-planned v As-Built Analysis	18 days
‘but for’ or collapsing technique	Collapsed As-built Analysis	9 days
Snapshot technique	Windows Analysis	18 days
Time impact technique	Time Impact Analysis	30 days

Figure 12 – Delay results after applying various methodologies (Alkass, Mazerolle, & Harris, 1996)

The above table from Alkass *et al* (1996) demonstrate that, when the less common delay analysis techniques are removed from the analysis, the results of the measure of excusable delay are the same when using the As-planned v As Built analysis and the Windows Analysis but differ significantly when using the Collapsed As-built Analysis or Time Impact Analysis. This is likely due to the As-planned v As Built analysis and the Windows Analysis methodologies reflecting actual delay.

Bubshait (1998) also performed a comparison, this time between three methods. These were (i) Impacted As-Planned (although he termed it As-Planned); (ii) As-Planned v As-Built (which he termed As-Built) and (iii) Modified As-built (which appears to be a Windows Analysis). The results of each analysis were as follows:

Bubshait Technique	**Common Methodology**	**Results from Test Case**
As-Planned	Impacted As-Planned	56 days
As-built	As-planned v As-Built Analysis	58 days
Modified As-built	Windows Analysis	87 days[24]

Figure 13 – Results after applying various methodologies (Bubshait & Cunningham, 1998)

Figure 13 above shows a close approximation of the delay when based on the As-Planned sequence, however this differs when periodic update are produced and assessed, as in the Windows analysis.

In a 2011 Case Study of a programme with 16 activities, the following results were found when undertaking an analysis of delays using four of the five common delay analysis methodologies (Al-Gahtani & Mohan, 2011):

Al-Gahtani Delay Analysis Technique	**Excusable Compensable Delay**	**Excusable Non-Compensable Delay**	**Non-Excusable Delay**
As-Planned v As-Built[25]	4 days	3 days	6 days
Impacted As-Planned	4 days	3 days	0 days
Time Impact	4 days	3 days	9 days
Window	5 days	3 days	7 days

Figure 14 – Results after applying various methodologies (Al-Gahtani & Mohan, 2011)

24 Bubshait tabulates this as 208 days, however he accepts the project completion date was delayed by 87 days, therefore this is the extent of the delay

25 The Study called this As-built technique, but described it as a comparison between the As-planned dates and the As-built dates

The study was actually based on a comparison of ten different methodologies, with the conclusion of the study being that none of the current techniques responds accurately to: (a) real time delay; (b) concurrent delay; (c) acceleration credit; and (d) pacing delay. The above table demonstrates that, when the less common delay analysis techniques are removed from the analysis, the results of the measure of excusable delay are the same or are similar. As the fundamental purpose of delay analysis is to assess the effect of excusable delay, it is suggested that this is an important correlation.

However, each of the above studies can be indicative only, as they were modelled on a very small sample of activities with a low number of logical relationships. In practice, delay analysis is undertaken on programmes with many hundreds if not thousands of activities. It is uncertain whether the results from the above research can be up-scaled.

Perera and Sutrisna (2010) explain that the selection of a methodology for forensic delay analysis relies on professional judgment and expert opinion of the practitioners. Therefore, it requires many subjective decisions and depends on number of criteria. These judgments invariably vary from one analyst to the other, as they are subjective, qualitative and impressionistic. Many disputes arise due to intuitive decision making in regard to the analysis method. Intuitive decisions are not supported by data and documentation and may appear arbitrary. It is difficult to get intuitive decisions accepted by others, particularly because decision maker is unable to justify it with persuasive logic.

Perera and Sutrisna note an area of improvements is in developing a model in order to aid the practitioners for the selection of a defendable and most appropriate delay analysis method under the specific circumstances of a project.

4.9.1 Previous Studies on the Method of Selecting a Delay Analysis Methodology

Kao (2009) considers some rules are required to select a suitable methodology. This was also the view of Bubshait (1998) who proposed an approach consisting of four scenarios involving various approved programmes with different evidence and progress reports. It was concluded that most appropriate methodology selection depends on:

- the time and available resources; and
- the accessibility of the project control documentation.

Their research has shown the As-Planned versus As-Built methodology was ranked as the most effective in ensuring success of claims followed by the Impacted As-Planned technique, although it was accepted that this latter methodology contradicted the opinions of some commentators that it was unreliable.

Farrow (2001) lists the factors that affect the selection and approach adopted as follows:

- The nature of the project or claim. He notes that the theoretical methods (particularly those relying on critical path analysis) are helpful. However, if the claim is for money as well, an approach based on what actually happened is warranted. This is because recovery of money suggests a positive assertion which the claimant has the burden to prove in a positive way;
- Available software;
- That CPA can be subject to manipulation;
- The status of the available records;
- Equality between the levels of activities being analysed and the progress details available to measure progress'
- The availability of a baseline programme; and
- Level of detail of Baseline programme.

The choice of selecting a methodology for a retrospective analysis of the delays is said in the Protocol (Society of Construction Law, 2002) to be largely dictated by:

- The relevant conditions of contract;

- The nature of the causative events;
- The value of the dispute;
- The time available;
- The records available;
- The programme information available; and
- The programmer's skill and familiarity with the project.

Arditi (2006) notes that the results of a delay analysis may be influenced by the method selected. Therefore the selection of the most appropriate method is of importance to all parties concerned. He notes that the selection of a suitable analysis method depends heavily on:

(i) The availability of scheduling data;

(ii) The familiarity of the analyst with the capabilities of the software used in the project;

(iii) Clear specifications in the contract concerning the treatment of concurrent delays and the ownership of float; and

(iv) Time and funds available for the analysis.

Braimah and Ndekugri (2008) state the appropriateness of the methodology applied in producing a delay claim is often hotly contested and the factors that influence the selection of the appropriate methodologies are a matter of great importance. They undertook research by way of a questionnaire; a methodology recommended by Rea and Parker (1997). This questionnaire sought feedback on the degree of importance in their decision-making as to the appropriate delay analysis methodology to adopt in any given situation. This enabled Braimah (2008) to provide a formulaic approach to selecting a delay analysis methodology.

4.9.2 A Recommended Method of Selecting a Delay Analysis

There are advantages to creating a model to select the Delay Analysis (Perera & Sutrisna, 2010). Braimah and Ndekugri (2008) identify the relative importance of delay analysis methodology selection factors by contractors and consultants with the top five being:

(i) Records availability;

(ii) Baseline programme availability;

(iii) The amount in dispute;

(iv) Nature of the baseline programme; and

(v) Updated programme availability.

To model this, Braimah (2008) proposes a formula with weightings attached to each criterion.

The advantage of creating a model to select the Delay Analysis (Perera & Sutrisna, 2010) is to avoid intuitive decision-making. However, it may be inappropriate to produce selection criteria for the adoption of one methodology over another on the basis of “choice”, as it is only the Windows Analysis methodology that is:

- Considered reliable by the courts (as explained in **Chapter 5** below);
- Considered the most appropriate and accurate in previous research (as explained in **Chapter 4** above); and
- Overwhelming used by experts in the Industry, as demonstrated by the Case Study review (see **Chapter 6** below).

CHAPTER 5

5 COMMON LAW DECISIONS ON DELAY ANALYSIS

The common aim of delay analysis is to investigate how delays, experienced on the various project activities, affect other activities and, specifically the project completion date, and then to determine how much of the overall project delay is attributable to each party and or an event. In most cases such determinations then act as the basis of a decision by a third-party arbiter (e.g. a contract administrator, arbitrator, or court, in order of escalation) on liability for a particular delay.

In circumstances where the project is complete it is true that delay is predominantly a question of fact, although there is a view that planning and delay analysis are subjective processes (Gorse, Ellis, & Hudson-Tyreman, 2005).

The attributes of a reliable delay analysis methodology are determined by:

(i) the contract (Farrow, 2001);

(ii) the common law (Burr & Palles-Clark, 2005); and

(iii) any recommended practice and guidelines.

This was also summarised in *Alstom Ltd v Yokogawa Australia Pty Ltd & Anor (No 7)* (2012) Sasc 49, as shown in **Chapter 1.9** above. The contract and the common law requirements are set out below. The recommended practice and guidelines have been set out in **Chapter 4** above.

5.1 Contract Provisions for Extension of Time

The various standard forms of construction contract all contain a clause or clauses to provide for extending the time for completion if the employer has prevented timely performance. This is known in Industry as the extension of time or 'EOT' clause.

Standard forms of contract have EOT provisions with similar but slightly different wording when defining the circumstances in which an EOT is to be granted (Hudsons, Atkin Chambers, 2010). For example, some contracts, such as the JCT 2011, require that completion is "likely to be" delayed; others refer to completion being "likely to be, or has been" delayed (as in JCT 63, JCT 98 with Contractor's Design, IFC98, GC/Works/1 IChemE and the FIDIC suite of contracts); and yet others refer to when completion of the works "has been" delayed (such as MF/1, ICE7 and NEC3). As explained in **Chapter 1.3**, delay to an activity does not necessarily result in delay to the Completion Date or completion of the works unless it is on the critical path.

The EOT clause sets out a number of possible contingencies or events, the risks of which are to be borne by the employer. If the occurrence of any of those contingencies or events occurs, so as to cause the works to take longer to complete, then, because those contingencies are not at the contractor's risk, that additional time must be added to the time for completion.

To provide an example of the how EOT clauses are constructed, three EOT clauses from the FIDIC, JCT, and NEC suite of standard forms are provided below.

The standard sub-clause from FIDIC Conditions of Contract for Plant and Design-Build First Edition 1999 is Sub-clause 8.4 (emphasis added):

> *…The Contractor shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to an extension of the Time for Completion if and to the extent that <u>completion</u> for the purposes of Sub-Clause 10.1 [Taking Over of the Works and Sections] <u>is or will be delayed</u> by any of the following causes*
>
> *a) a Variation (unless an adjustment to the Time for Completion has been agreed under Sub-Clause 13.3 [Variation Procedure]),*

b) a cause of delay giving an entitlement to extension of time under a Sub-Clause of these Conditions,

c) exceptionally adverse climatic conditions,

d) Unforeseeable shortages in the availability of personnel or Goods caused by epidemic or governmental actions, or

e) any delay, impediment or prevention caused by or attributable to a breach by the Employer, the Employer's Personnel, or the Employer's other contractor on the Site of its obligations under the Contract.

If the Contractor considers himself to be entitled to an extension of the Time for Completion, the Contractor shall give notice to the Engineer in accordance with Sub-Clause 20.1 [Contractor's Claims]. When determining each extension of time under Sub-Clause 20.1, the Engineer shall review previous determinations and may increase, but shall not decrease, the total extension of time.

The standard clause from the JCT'80[26] contract states (emphasis added):

25.3.1 If, in the opinion of the Architect… any of the events… stated… to be the cause of the delay is a Relevant Event, and… the <u>completion</u> of the Works <u>is likely to be delayed</u>… the Architect shall… give an extension of time… as he then estimates to be fair and reasonable.

[26] This has been superseded by JCT 2011, but the 1980 version has been quoted as this was the subject of the case law discussed in **Chapter 5**

This clause makes no mention of the requirement for events to have affected the completion date, but that: (i) there are events; and (ii) the completion date is likely to be delayed. This provides wide discretion to the architect in deciding on EOT during the course of the works. As a final assessment will be made after the works will have been complete, the overall effect of all the delaying events on the project will be known. This overall final assessment is therefore likely to be based on a consideration of what has actually happened (Burr & Palles-Clark, 2005).

The standard clause from the NEC3 Engineering and Construction Contract that concerns the assessment of EOT due to variations (or in NEC terminology 'compensation events') states (emphasis added):

> *63.3 A delay to the Completion Date is assessed as the length of time that, due to the compensation event, <u>planned completion is later than planned Completion as shown on the Accepted Programme</u>. A delay to a Key Date is assessed as the length of time that, due to the compensation event, the planned date when the Condition stated for a Key Date will be met is later that the date shown on the Accepted Programme.*

> *65.2 The assessment of a compensation event is not revised if a forecast upon which it is based is shown by later recorded information to have been wrong.*

The task of assessing the effect of the delay event on the time for completion is usually to be undertaken by the engineer, architect, project manager or contract administrator acting in a role of independent certifier (Hughes, Champion, & Murdoch, 2015). In making such an assessment, the requirements of the contract must be followed.

Comparison between each of the above EOT clauses may assist in explaining the requirements for any technique that is used in the assessment of an EOT. For example, the above clause from FIDIC is supplemented by a 'final review' clause, which implies that a retrospective analysis is needed. This is similar to the approach also required by the Joint Contracts Tribunal (JCT) Standard Building Contract. Under cl.2.28.5.1 of the JCT, the contract administrator should reassess all extensions of time and loss and expense awarded at the end of the project. The earlier awards are therefore, in effect, interim, as they may be revised at a later stage, although for reasons of fairness, cannot be reduced.

The retrospective position from the JCT can be contrasted to the NEC3 wording, which suggests a prospective approach is required. This suggestion is supported by four points (Robinson, 2012):

(i) First, the project manager and contractor should include risk allowances when making assessments, or preparing quotations, illustrating an awareness that the actual impacts will not be known when compensation is determined (cl.63.6).

(ii) Secondly, the extent to which the completion date is delayed must be evaluated against the "planned completion" date (cl.63.3) suggests that the drafters anticipated that compensation events would be dealt with prior to completion.

(iii) Thirdly, compensation events cannot be reassessed even if later records show that the forecasts they were based on were wrong (cl.65.2). The contractor takes the risk that its quotation (if accepted by the project manager) may be insufficient. Likewise, the employer is at risk if the project manager accepts a quotation that awards the contractor more than actual events later reveal him to have lost.

(iv) The absence of a final account procedure to assess all time and money due to the contractor at completion, which procedure is prevalent in FIDIC/JCT contracts.

Therefore under the NEC, compensation event assessments are not interim but final. The overall impression created by the philosophy and procedures of NEC3 is that it requires a prospective approach to delay analysis.

According to Burr (2005), what these clauses have in common is the intention that delaying events will be identified and an assessment made of their likely effect at the time the event occurs, and that an EOT is granted that is commensurate with the expected effect of the delaying event.

Similarly, the liquidated damages clause may assist in understanding when to undertake the assessment of an EOT. In *Multiplex Construction (UK) Ltd v Honeywell Control Systems Ltd* (2007) 111 Con LR 78 (TCC) (paragraph 104), the judge stated:

> *…In Gaymark non-compliance with the notice clause exposed the contractor to an automatic liability for liquidated damages (if the liquidated damages clause were upheld). In the present case, non-compliance with clause 11.1.3 [of a bespoke sub-contract] has no such automatic consequences. Even if (contrary to Mr. Thomas' submissions) Honeywell forfeits any entitlement to extension of time, that does not automatically make Honeywell liable to pay damages for delay. Under clause 12 of the Sub-Contract Conditions, Multiplex can only recover in respect of loss or damage "caused by the failure of the Sub-Contractor". If in reality the relevant delay was caused by Multiplex, not Honeywell, then (whatever the position under clause 11) Multiplex cannot recover against Honeywell under clause 12…*
>
> *If the facts are that it was possible to comply with clause 11.1.3 but Honeywell simply failed to do so (whether or not deliberately), then those facts do not set time at large. Honeywell is not entitled to the relief which it seeks in respect of the Gaymark point…*

This observation has significance: Mr Justice Jackson held that *Multiplex* had to consider the EOT due, whether or not adequate notice had been given, as otherwise *Multiplex* would be seeking to impose damages for delay of its own making. It is a common feature of the standard conditions of contract that the contractor must give notice for delay events. In some instances, the lack of such a notice can prevent the contractor from receiving an EOT (if it is found to be a condition precedent on making an EOT assessment, such as in FIDIC). However, the lack of ability to recover delay damages due to lack of notice may contravene the prevention principle and make an EOT assessment a prerequisite even if no notice has been provided.

In *Mutiplex*, Honeywell was arguing that time was at large, as the EOT mechanism was inoperable due to the lack of notice being provided. They relied on *Gaymark Investments Pty Ltd v Walter Construction Group* (1999) NTSC 143 where the Australian courts upheld an arbitrator's findings; that the contract failed to provide for the situation where Gaymark caused actual delays to Walter achieving Practical Completion by the due date, coupled with a failure by Walter to comply with the notice provisions of the contract. However, Mr Justice Jackson distinguished this decision (and in any event considered it unlikely to be followed in English Law). In *obiter*, he explained that the recovery of damages, in this specific contract, was if the loss was "caused by the failure of the subcontractor". Therefore, notwithstanding the notice provisions preventing the granting of an EOT, damages could not be taken by the contractor when the cause of the delay was not due to the Subcontractor. It seems therefore, depending on the Contract, a retrospective delay analysis may be needed even if the notice provision has not been operated properly for either:

(i) Granting of an EOT; and

(ii) The proper recovery of liquidated damages.

Each of the three contract EOT provisions (i.e. FIDIC, JCT and NEC) requires the contract administrator to assess whether a delay event is likely to have an effect on the completion date. As these clauses are intended to be operated during the contract, the test must be 'effect on the completion date known at the time'. For this to occur, it follows that the delay event must also be on the critical path known at that time.

Commentators have suggested that some delay analysis methodologies result in “entitlement programmes”, implying that a contractor may have an entitlement to an EOT event though such an EOT was not ultimately required (Alkass, Mazerolle, & Harris, 1996). Indeed it has been suggested that “entitlement programmes” might be to show the original contractual completion dates, how these completion dates have been impacted due to excusable delays, and the projected completion dates given the remaining work. These also depict the difference between the adjusted and the projected completion dates. Final entitlement programmes reflect the original, adjusted and actual completion dates used to establish the total time that the contractor or the owner is entitled to for compensation. Whether entitlement programmes are acceptable for EOT can be identified from a review of legal decisions related to cases for delay.

5.2 Common Law Direction for Delay Analysis

Disputes in construction contracts abound. This is because construction contracts involve multiple parties and contracts; have long durations; and involve large amounts of money. Skewed drafting of construction contracts worsens the situation (Nana & Wilkinson, 2009). Construction disputes were traditionally resolved through negotiation, arbitration, and litigation, although more recently structured mediation and adjudication have become common. Litigation is the only of these routes where the decisions by the dispute resolver are published.

The use of delay analysis is currently increasingly popular with the courts in identifying culpability and ascertaining damages (Carmichael & Murray, 2006). There is no stated guidance on how to present the nexus between cause and effect through any particular delay analysis methodology, as stated in *GMTC Tools,*[27] this is because*:*

[27] GMTC Tools and Equipment Ltd v Yuasa Warwick Machinery Ltd (1994) 73 BLR 107

> *…No judge is entitled to require a party to establish causation and loss by a particular method…*

However guidance on an appropriate delay analysis methodology may be obtained from a review of the reasoning within legal decisions, as decisions are used to establish legal principles by way of precedent (Farrow, 2001). Burr (2005) considered the extent to which common law provides guidance on the appropriate principles and techniques for the demonstration of the nexus between cause and effect in the context of delay claims:

(i) The use of critical path analysis techniques in proof of delay claims is a relatively recent innovation in the UK;

(ii) The use of these techniques in relation to the demonstration and proof of delay claims and the issues associated therewith is still a developing area of the common law; and

(iii) Part of this development has arisen from the need for courts (and other tribunals) to adapt to the new techniques because they have been made so accessible by computers.

Burr (2005) states that few cases have dwelt upon the use of the techniques to demonstrate delay and their usefulness in making a successful claim at law. He considers this is because delay cases are generally referred to arbitration and the outcomes of arbitration are not made public (which highlights the importance of the case study research in **Chapter 6**). Gould (2004) also noted there is a surprising lack of case law on the many issues that arise from delay and disruption in construction contracts. However, the key decisions related to EOT methodologies over the last two decades are addressed below. These reflect the development of construction common law. From a review of the decisions below, there is an apparent movement from the reliance on CPM.

Retrospective delay analysis was considered in the 1992 case of *McAlpine Humberoak v McDermott International Inc (No.1)* (1992) 58 B.L.R. 1, McDermott were contracted for the construction of the deck structure for use in the Hutton oil field. Construction of four of the nine pallets forming the deck structure was subcontracted to McAlpine. Two pallets were subsequently removed from McAlpine's scope. The remaining two pallets (W3 and W4), planned to be delivered in February 1982, were actually delivered by McAlpine in July and September 1982, i.e. up to seven months late. McAlpine claimed for costs associated with the delay in their delivery, citing the cause as substantial design changes, technical queries and variations. McDermott counterclaimed that McAlpine's late delivery of steel pallets delayed completion. At first instance, Judge Davies dismissed McDermott's analysis as an unhelpful "retrospective and dissectional re-creation" of the project and preferred McAlpine's analysis, which was described as follows:

> *…he [McAlpine's consultant] went through each of the VOs, and arrived at a number of days or weeks, based either on the time actually taken to carry out the extra work, or on a calculation. He then prepared two bar charts, one for W3 and one for W4, illustrating the cumulative effect of all causes of delay, including drawing revisions, VOs and TQs. These charts stood as Appendices C and D to the statement of claim. In this way [McAlpine's consultant] was able to account for the entire period between the placing of the contract and the final delivery of the two pallets. It was on the basis of this evidence that the judge was satisfied that the time taken by the plaintiffs was no more than reasonable...*

In making this finding, Judge Davies also found "time was at large", due to the late issue of drawings.

However, when this judgement was considered in the Court of Appeal, Lloyd L.J. found that there were two flaws with McAlpine's analysis:

(i) If one man was working for one day on a variation order the whole contract was held up for that day, which was tested by facts and found incorrect; and

(ii) It assumes that the whole of the workforce planned for a particular activity was engaged continuously on that activity from the day it started until the day it finished. On the facts, this was found hardly likely to be so.

Despite the hearing at first instance taking 92 working days, the judgement taking a year to be delivered and Judge Davies having seen and heard the witnesses, the Court of Appeal found the factual cause of delay to be different than previously decided.[28]

In reaching this view, Lloyd L.J. considered McDermott's "retrospective and dissectional re-creation" analysis was entirely appropriate and stated:

> *…The judge [at first instance] dismissed the defendants' approach to the case as being "a retrospective and dissectional reconstruction by expert evidence of events almost day by day, drawing by drawing, TQ by TQ and weld procedure by weld procedure, designed to show that the spate of additional drawings which descended on McAlpine virtually from the start of the work really had little retarding or disruptive effect on its progress". In our view the defendants' approach is just what the case required…*[29]

[28] This startling change in result may be due to the Court of Appeal trying to overturn the fact that Judge Davies held that the contract had been frustrated, which came as a surprise to the parties, since frustration had not been pleaded, or argued.

[29] Page 16 of the Judgment

> *…If a contractor is already a year late through his culpable fault, it would be absurd that the employer should lose his claim for unliquidated damages just because, at the last moment, he orders an extra coat of paint…*[30]

Commentators on this case distinguish two main points:

- Firstly, the court is interested in what actually delayed completion, rather than an artificial prediction; and
- Secondly, unless later events that might interfere with the impact of a compensation event are considered, the analysis will not prove the causal link between the compensation event and delay.

A further point is that a prospective technique may not prove causal connection. This is because, by its nature, a prospective analysis excludes later (perhaps yet unknown) events and, as a consequence, may generate a result that is inconsistent with known reality. However, for the next decade, the courts appeared to embrace CPM, using distinctions over float to determine entitlement to EOT.

In the subsequent decade there emerged a noticeable lack of reliance solely on the results from CPM. This may be perceived as an increasing aversion to what Yang *et al* refer to as a 'black-box' answer (Yang, Kao, & Lee, 2006) or as Barry terms it, a result of the 'dark arts' (Barry, 2009).

The relative 'rise and fall' of CPM as an accepted approach in litigation in the courts can be illustrated by *Figure 15* below:

[30] Page 20 of the Judgment

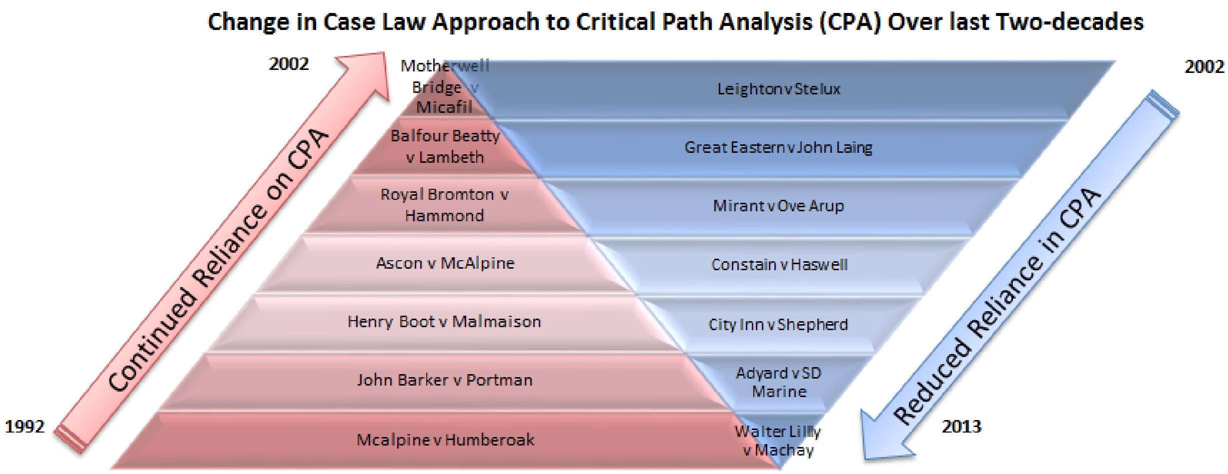

Figure 15 – Illustration of Change in Case Law approach to CPA (Author's illustration)

5.2.1 Summary of Cases with an Increasing Reliance on CPA

The decisions over the first decade, showing a strong reliance on CPM, are as follows:

- *1996* *John Barker Construction Limited v. Portman Hotel Limited*
- *1999* *Henry Boot Construction (UK) Ltd v Malmaison Hotel (Manchester) Ltd*
- *1999* *Ascon Contracting Ltd v Alfred McAlpine Construction Isle of Man Ltd*
- *2000* *The Royal Brompton v Hammond*
- *2002* *Balfour Beatty v Lambeth*
- *2002* *Motherwell Bridge Construction Ltd v Micafil Vakuumtechnik*

Phraseology from the above cases can be summarised to include:

> *…[what was needed was a] logical analysis in a methodical way of the impact which the relevant matters had or were likely to have on the Plaintiffs' planned programme…*[31]

> *…Delay has to exceed float to cause a delay. The main contractor…cannot recover from subcontractors the hypothetical loss he would have suffered had the float not existed..*[32]

> *…The critical path is almost certain to change during the works…Need to track the actual execution of the works…*[33]

> *…A valid critical path has to be established initially and at every later material point since it will almost certainly change…*[34]

> *…Is the delay on the critical path ? The results must be tested against to accord with common sense and fairness….* [35]

These extracts show that the courts' implied (or sometimes stated) requirements were for a logical analysis to assess the effect of delays on completion, as it is with CPM that critical delays are distinguished from delay to activities with float.

5.2.2 Summary of Cases with an Declining Reliance on CPM

Subsequent decisions over the last decade have seen a swing away from prospective CPM to a more common sense approach steeped in an As-Built analysis:

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[31] John Barker Construction Ltd v London Portman Hotel Ltd (1996)

[32] Ascon Contracting Ltd v Alfred McAlpine Construction Isle of Man Ltd (1999)

[33] The Royal Brompton Hospital NHS Trust v Frederick Alexander Hammond and Other (No.7) (2000)

[34] Balfour Beatty Construction Limited v The Mayor and Burgess of the London Borough of Lambeth (2002) BLR 288, p21

[35] Motherwell Bridge Construction Ltd v Micafil Vakuumtechnik (2002) 81 ConLR 44, p562

- *2004* *Skanska v Egger*
- *2004* *Leighton Contractors (Asia) Ltd v Stelux Holdings Ltd*
- *2005* *Great Eastern Hotel v John Laing*
- *2007* *Mirant v Ove Arup*
- *2007* *London Underground Ltd v Citylink Telecommunications Ltd*
- *2009* *Costain Ltd v Charles Haswell & Partners Ltd*
- *2010* *City Inn Ltd v Shepherd Construction Ltd*
- *2011* *Adyard v SD Marine Services*
- *2012* *Walter Lilly v Giles Patrick Cyril Mackay*

Extracts from the above cases include:

> *…Although timeslice may be appropriate, a theoretical or artificial result which had no regard to the as-built situation will be rejected…*[36]

> *…Rejection of prospective analysis because it ignored the actual events which occurred and gives rise to a hypothetical answer…*[37]

> *…Agreed that Delay event was critical at the time, but not proven whether the delay was mitigated, neutralised or event exacerbated by later events...therefore delay was a matter of speculation…*[38]

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36 Leighton Contractors (Asia) Ltd v Stelux Holdings Ltd, HCHK (2004)

37 Great Eastern Hotel (Great Eastern Hotel Company Ltd v John Laing Construction Company Ltd (2005) EWHC 181 (TCC) at 184

38 Costain Ltd v Charles Haswell & Partners Ltd (2009) EWHC 3140 (TCC) at 181

These more recent cases illustrate the courts reluctance to rely on an overly theoretical analysis produced by a critical path analysis without testing that analysis against the facts and against what actually happened. This is explained further below.

5.3 Reliance on Critical Path Methodology in Case Law (1992 to 2002)

An important review of the litigation system by Lord Woolf was undertaken in this period, and resulted in the introduction of The Civil Procedure Rules (1998). One of the key recommendations of this review was the concept of proportionality as an overriding objective in civil litigation. Part 1, Rule 1.1 states:

> ***1.1****—(1) These Rules are a new procedural code with the overriding objective of enabling the court to deal with cases justly.*
>
> *(2) Dealing with a case justly includes, so far as is practicable—*
>
> *(a) ensuring that the parties are on an equal footing;*
>
> *(b) saving expense;*
>
> *(c) dealing with the case in ways which are proportionate—*
>
> *(i) to the amount of money involved;*
>
> *(ii) to the importance of the case;*
>
> *(iii) to the complexity of the issues; and*

(iv) to the financial position of each party;

(d) ensuring that it is dealt with expeditiously and fairly; and

(e) allotting to it an appropriate share of the court's resources, while taking into account the need to allot resources to other cases.

Due to the recommendation towards cost savings and proportionality, the Woolf review of the legal system may have had an impact on the way that, in successive cases, there was a movement away from a requirement for such a 'day-by-day' type of analysis to a more proportionate type of analysis. Typically a CPM would achieve this. With CPM, only delays to the critical path need be analysed in detail, making the assessment more focused and therefore likely to be more proportional. However, as will be explained below, this does not appear to have been the result.

In the case of *John Barker Construction Limited v. Portman Hotel Limited* (1996) 83 BLR, Barker carried out refurbishment work to the London Portman Hotel. The work was delayed and there was an acceleration agreement. Further delays occurred and the contractor sued for greater extensions of time and payment in respect of the acceleration agreement. Mr Recorder Toulson (as he then was) had to determine whether an architect's certificate of EOT (made by Mr Miller) represented a valid exercise by him of the powers afforded to him under the contract. Barker adduced evidence from an expert relying on software-based critical path analysis. Mr Recorder Toulson said:

…I accept that Mr. Miller believed, and believes, that he made a fair assessment of the extension of time due to the Plaintiffs. It is fairly apparent that the Defendants were concerned by the overrun of the contract in time and costs, and I have no doubt that Mr. Miller was conscious of this, but I believe also that he endeavoured to exercise his judgement

independently. However, in my judgment his assessment of the extension of time due to the Plaintiffs was fundamentally flawed in a number of respects, namely:

1. *Mr. Miller did not carry out a logical analysis in a methodical way of the impact which the relevant matters had or were likely to have on the Plaintiffs' planned programme.*

2. *He made an impressionistic, rather than a calculated, assessment of the time which he thought was reasonable for the various items individually and overall. (The Defendants themselves were aware of the nature of Mr. Miller's assessment, but decided against seeking to have any more detailed analysis of the Plaintiffs' claim carried out unless and until there was litigation)…*

Commentators have considered this case to be an endorsement of software based CPM, as the methodology accepted was an As-Planned form of analysis (Pickavance, 1997).

In addition, the court held that there was an implied term in the JCT 1980 Form of Building Contract that the architect will act fairly and reasonably when considering applications for an extension of time.

In *Henry Boot Construction (UK) Ltd v Malmaison Hotel (Manchester) Ltd* (1999) 70 Con LR 33, Malmaison engaged Henry Boot to construct a new hotel in Manchester. The completion date was 21 November 1997, extended by the architect to 6 January 1998, but was not achieved until 13 March 1998. Malmaison deducted liquidated damages. Henry Boot sought a further extension of time. The contractor claimed, in an arbitration, an EOT as a result of delay said to have been caused by variations and late information (among other things). The employer pleaded in its defence firstly that the alleged variations did not cause any delay because they were not on the critical path and secondly that the true cause of the delay was other matters which were contractor-risk events. Dyson J held:

> *…The respondent was entitled to respond to the claim both by arguing that the variations, late information and so on relied on by the claimant did not cause any delay because they were not on the critical path and positively by arguing that the true cause of delay was other matters…*

He added (at paragraph 15) that:

> *…It seems to me that it is a question of fact in any given case whether a Relevant Event has caused or is likely to cause delay to the Works beyond the Completion Date...*
>
> *...Likewise, when considering the matter under the contract, the architect may feel that he can decide the issue on a limited basis, or he may feel that he needs to go further, and consider whether a provisional view reached on that basis of one set of facts is supported by findings on other issues. It is impossible to lay down hard and fast rules.*
>
> *In my judgment it is incorrect to say that, as a matter of construction of clause 25 when deciding whether a relevant event is likely to cause or has caused delay, the architect may not consider the impact on progress and completion of other events…*

Principles to be distilled from this decision include:

(i) Only delays on the critical path can affect completion;

(ii) The cause of delay is a matter of fact; and

(iii) The assessment of delay is based on what the Contract requires.

In the case of *Ascon Contracting Ltd v Alfred McAlpine Construction Isle of Man Ltd* (1999) 66 Con. L.R. 119, McApline was the main contractor for the construction of a five storey building along the seafront in the Isle of Man. Ascon was appointed as subcontractor for the concrete works. The subcontract period was 27 weeks, commencing on 28 August 1996, with completion by 5 March 1997. McAlpine considered completion of Ascon's work was not achieved until 16 May 1997, ten weeks late. Judge Hicks stated:

> *…That is self-evident if total delays against sub programmes do not exceed the float. The main contractor, not having suffered any loss…cannot recover from subcontractors the hypothetical loss he would have suffered had the float not existed…*

At paragraph 21, Judge Hicks stated:

> *…It is Ascon which is seeking an extension of time and must establish a cause of a quantified period of delay entitling it to that extension…*

In the case of *The Royal Brompton Hospital NHS Trust v Frederick Alexander Hammond and Other (No.7)*(2001) EWHC Technology 39, 76 Con LR 148, the project concerned the construction of a six-storey hospital in London for the Royal Brompton Hospital NHS Trust. Taylor Woodrow was the main contractor, and practical completion was certified as being achieved on 23 May 1990, 43 weeks and two days later than the original completion date for the project. In total the architect awarded an extension of time of 43 weeks and two days, thereby revising the completion date to 23 May 1990. In 1997 the Trust started action with the professional team involved with the project to recover the amount paid for the contractor for the delays. The Trust alleged that the architect had been negligent in awarding extensions of time as he had failed to determine the actual critical path of the contractor's works and that extensions of time awards had been given for non-critical path works. Judge Seymour stated at paragraph 32 (emphasis added):

…it was plain from the evidence called at the sub-trial on behalf of the Claimant, in particular that of Mr. Gibson, who, of course is a programming expert, that there are a number of established ways in which a person who wishes to assess whether a particular event has or has not affected the progress of construction work can seek to do that. Because the construction of a modern building, other than one of the most basic type, involves the carrying out of a series of operations, some of which, possibly, can be undertaken at the same time as some of the others, but many of which can only be carried out in a sequence, it may well not be immediately obvious which operations impact upon which other operations. In order to make an assessment of whether a particular occurrence has affected the ultimate completion of the work, rather than just a particular operation it is desirable to consider what operations, at the time the event with one is concerned happens, are critical to the forward progress of the work as a whole.

On the evidence of Mr. Gibson and Mr. Luder the establishment of the critical path of a particular construction project can itself be a difficult task if one does not know how the contractor planned the job. Not only that, but the critical path may well change during the course of the works, and almost certainly will do if the progress of the works is affected by some unforeseen event.

Mr. Gibson frankly accepted that the various different methods of making an assessment of the impact of unforeseen occurrences upon the progress of construction works are likely to produce different results, perhaps dramatically different results. He also accepted that the accuracy of any of the methods in common use critically depends upon the quality of the information upon which the assessment exercise was based. All of this does, of course, emphasise the vital point that the duty of a professional man, generally stated, is not to be right, but to be careful.... His conduct has to be judged having regard to the information available to him, or which ought to have been available to him, at the time he gave his advice or made his decision or did whatever else it is that he did…

He gave his view on the analysis that is required to demonstrate delay and the available float (emphasis added):

> *…All activities have potential or theoretical float (even if the period is negative). What is required is to track the actual execution of the works. On a factual basis this case requires no further discussion. In addition clause 25 refers to 'expected delay in the completion of the Works' and for the need for the Architect to form an opinion as to whether because of a relevant event 'the completion of the Works is likely to be delayed thereby beyond the Completion Date'. Under the JCT conditions, as used here, if there is unused float for the benefit of the contractor (and not for another reason such as to deal with p.c. or provisional sums or items) then the architect is bound to take it into account <u>since an extension is only to be granted if completion would otherwise be delayed beyond the then current completion date</u>…*

Judge Seymour therefore accepted that, where operations were carried out in series it was necessary to determine which operation was critical to the forward progress of the work as a whole. A method of calculating the critical path was therefore needed. He assessed that an EOT would only be provided if there was no float.

In the case of *Balfour Beatty Construction Limited v The Mayor and Burgess of the London Borough of Lambeth* (2002) BLR 288, p21 His Honour Judge Humphrey Lloyd QC said a critical path network was a logical method of analysis:

> *…In the context of a dispute about the time for completion a logical analysis includes the logic required for in the establishment of a CPN [critical path network]…*

He went on to say:

> *….From the material available to me it is clear that BB did little or nothing to present its case in a logical or methodical way. Despite the fact that the dispute concerned a multi-million pound refurbishment contract no attempt was made to provide any critical path. The work itself was no more complex than many other projects where a CPN is routinely established and maintained…*
>
> *…By now one would have thought that it was well understood that, on a contract of this kind, in order to attack, on the facts, a clause 24 certificate for non-completion (or an extension of time determined under clause 25), the foundation must be the original programme (if capable of justification and substantiation to shows its validity and reliability as a contractual starting point) and its success will similarly depend on the soundness of its revisions on the occurrence of every event, so as to be able to provide a satisfactory and convincing demonstration of cause and effect. A valid critical path (or paths) has to be established both initially and at every later material point since it (or they) they almost certainly change…*

His Honour Judge Humphrey Lloyd QC took the analysis of delays further by identifying that the critical path may, and almost certainly will change. These changes need to be identified to demonstrate that the event is a delay on the critical path at the material point in time.

In the case of *Motherwell Bridge Construction Ltd v Micafil Vakuumtechnik* (2002) 81 ConLR 44, p562, Micafil was engaged by BICC as main contractor for the construction of an autoclave (a large steel vessel) to be used in the manufacture of power cables. Micafil undertook the responsibility for the design work and subcontracted its construction to Motherwell Bridge. During construction, Motherwell Bridge raised many technical queries and a number of significant design changes were issued by Micafil. Delays occurred and Micafil deducted liquidated damaged. Motherwell Bridge sought an EOT to defend against the LDs. His Honour Judge Toulmin Q.C. CMG, at paragraph 562 said:

> *…Crucial questions are (a) is the delay on the critical path and, if so, (b) is it caused by Motherwell [the Contractor]. If the answer to the first question is yes and the second question is no, then I must assess how many additional working days should be included…*

He added at paragraph 564 that:

> *…I add that the approach must always be tested against an overall requirement that the result accords with common sense and fairness…*

His Honour Judge Toulmin Q.C. CMG continued the common law requirement to identify the critical path (although he does not clarify if the critical path could have changed) and identified this as the first crucial question in assessing the effect of any delay. At *Para 560* he said:

> *…the purpose of the power to grant an extension of time under cl 25.3 was to fix the period of time by which the period of time available for completion ought to be extended having regard to the incidence of the relevant events, measured by the standard of what is fair and reasonable. The completion date as adjusted was not the date by which the contractor ought to have achieved practical completion, but the end of the total number of working days starting from the date of possession within which the contractor ought fairly and reasonably to have completed the works…*

This decision by His Honour Judge Toulmin Q.C. seems often overlooked in other judgements; as explained below. The concept of providing the time in which the contractor ought fairly and reasonably to have completed the works is akin to the general law of restitution: the proper measure of damages for breach being as set out by Lord Jauncey of Tullichettle in *Ruxley Electronics v Forsyth* (1996) AC 344:

> *…to put the parties into the position they would have been in without the breach…*

In this regard:

(i) the completion date, as set originally in the contract, cannot reflect actual durations, nor can it take account of any contractor problems – it must be a forecast of the time in which to complete the works; similarly

(ii) the calculation of liquidated damages by the employer is a genuine <u>pre-estimate</u> of loss, i.e. another forecast; and

(iii) the breach or prevention event happens at the time it occurred and not the time its effect is felt.

The argument in *Motherwell Bridge Construction* is that since the contract period represents the time the contractor ought fairly and reasonably have to complete the works within, then it seems sensible that any extension should be on the same basis; i.e. a forecast of likely effect. This is the nature of prospective delay analysis. The NEC's concept of forecasting the effect prospectively seems most akin to putting the contractor back into the position he would be in without the delaying event.

Indeed, it may be considered that the obligation to provide a prospective extension of time is an essential interpretation of the clauses in a construction contract to maintain business efficacy. A contractor enters a construction contract on the basis that the construction period is available to complete the works within, and only failure to deliver the works within that period would result in the imposition of delay damages. In the case of an employer-delay event occurring, it appears to be business common sense that the contractor needs to know, in advance of completing the works, the new time for completion. Without this the contractor cannot decide whether he ought to accelerate (at a cost) the subsequent works or not. As the US doctrine on 'constructive acceleration'(i.e. recovery of acceleration costs in the absence of a decision on time) is not a feature of English Law, then the obligation on the employer to grant a prospective extension of time award is arguably stronger.

If an analysis is not undertaken prospectively but is undertaken retrospectively, the idea of reviewing actual durations is however, appealing as it is difficult (if not impossible) to not reflect on the actual duration of the works. As Barry (2009) asks, 'why 'guess' when the facts are available?' However, it is possible to review the actual duration without predetermining the result of the analysis by incorporating the actual effect. Construction is a real-time industry and decisions are made based on the best information available at the time. The benefit of hindsight is not available to the contractor and therefore should likely be excluded from an analysis if the aim of that analysis is to put the contractor in the position he would have been in save for the relevant event.

This is aptly demonstrated by taking an example to demonstrate the position of only relying on actual delay effects:

> *In a situation where an employer has a building in mind, which his advisors estimate will take 12 months to complete, he also has in mind an annex, which, if added at contract stage would (according to his advisors) increase the time for completion to 18 months. By adding the annex as a variation, and taking an as-built view to an EOT, the contractor may only be entitled to an EOT to the extent that one is actually needed. This may account for delays the contractor was having in constructing the building or the benefit of the contractor increasing resources to reduce the duration required for building the annex.*

The above example seems inequitable to the contractor on the basis that he ought to have the time fairly and reasonably required to complete the annex. This type of example may have been in Lord Carloway's mind in *City Inn* (discussed below) when opining that the contract administrator ought not to take into account any contractor delays in the assessment of a claim for extension of time based on a 'relevant event' – specifically if it is one relating to additional scope.

The concept of not applying hindsight also appears to align with thinking that delay to completion is delay on the then critical path (meaning the critical path at the time of the delay event). As the critical path can change over time, it may be that what was assessed as likely to have delayed completion at one stage of the project may not ultimately delay completion at the end of the project, perhaps due to actions implemented by the contractor in real time. Indeed the SCL Protocol (2002) states:

> *The Protocol recommends that, in deciding entitlement to EOT, the adjudicator, judge or arbitrator should so far as is practicable put him/herself in the position of the CA [Contract Administrator] at the time the Employer Risk Event occurred. He/she should use the Updated Programme to establish the status of the works at the time. He/she should then determine what (if any) EOT entitlement could or should have been recognised by the CA at the time. The results may not match the as-built programme, because the Contractor's actual performance may well have been influenced by the effects of accepted acceleration, re-sequencing, redeployment of resources or other Employer and Contractor Risk Events, in order to try to avoid liability for LDs. That does not necessarily mean than an EOT will not be due.*[39]

This is on the stated SCL Protocol principle that:

> *…The goal of the EOT procedure is the ascertainment of the appropriate contractual entitlement to an EOT; the procedure is not to be based on whether or not the Contractor needs an EOT in order not to be liable for liquidated damages…*[40]

> *…[it] is a matter of entitlement, not need…*[41]

39 Guidance Section 4.19

40 Guidance Section 1.2.9

By 2002 the position being recommended was that an EOT analysis ought to be prospective, using CPM methodology and resulting in entitlement programmes. This resultant programme need not accord to actual delay, which is the difference between ‘entitlement’ and ‘need’.

5.4 Decline in Reliance on Critical Path Analysis Case Law (2004 onwards)

In the Hong Kong case of *Leighton Contractors (Asia) Ltd v Stelux Holdings Ltd* (2004), HCHK, Leighton argued that the contract made it clear that both “delay” and “likely delay” gave proper grounds for an extension of time. Leighton contended that by standing in the architect’s shoes at the time of the delay events, if the arbitrator thought that an event was likely to cause delay, she should have granted an extension of time and it was irrelevant that, with hindsight, the event did not actually delay completion, whereas the Arbitrator had rejected Leighton’s expert’s use of the Time Impact Analysis. The court rejected those contentions and upheld the decision of the arbitrator:

> *…In particular, Leighton alleged that Stelux caused critical delay by releasing tender information for MVAC and electrical sub-contract works late. The Arbitrator found that the information was indeed provided later than it should have been according to the original programme. But she held that such lateness could not have delayed the completion of works.*
>
> *The information was required for the award of the superstructure MVAC and electrical sub-contracts. On the date when it originally ought to have been provided, Leighton was still involved in substructure works. Even by the time that the information had been provided and the MVAC and electrical subcontracts awarded, Leighton was only just ready to start (and had not yet commenced) construction of the basement slab.*

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[41] Guidance Section 4.19

> *It accordingly seems to me that the Arbitrator reasonably concluded that the late information could not have caused actual delay…*

The court confirmed that the actual status of works "at the time" of an event is more relevant than simply comparing actual dates with planned dates. The court noted though a time slice approach to examining extension of time entitlement may be appropriate, an overly theoretical or artificial result which has no regard to the "as-built" situation will be rejected if the analysis:

> *…focused on the prospect of delay resulting from an event at a given time, regardless of whether the event had actually caused delay…*

In *Skanska Construction UK Ltd v Egger (Barony) Ltd* (2004) EWHC 1748 (TCC), Skanska was engaged by Egger for the construction of a sophisticated wood chipping plant in Scotland. The project's guaranteed maximum price was £12m. The disputes concerned claims made by Skanska in the order of a further £12 million relating to what it argued were due to delays, extensions of time and loss and expense. There was also a counterclaim from Egger for more than £4 million. Each party adduced programming expert evidence. The experts used very different methods to analyse the evidence relating to delays. HHJ Wilcox criticised Skanska's expert for errors made in reconstructing the initial contract programme in CPM, which he found not reliable to use as a baseline for the analysis. Instead he preferred Egger's expert, whose analysis he found:

> *…objective, meticulous as to detail, and not hide bound by theory when demonstrable fact collided with computer program logic…*

In criticising *Skanska's* expert, HHJ Wilcox stated:

> *...Mr Pickavance produced a report of some hundreds of pages supported by 240 charts. It was a work of great industry incorporating the efforts of a team of assistants in his practice. It was evident that the report… was largely based upon factual matters digested for Mr Pickavance by his assistants …There were times when the impression was created that Mr Pickavance was not entirely familiar with the details of the report, which he signed and presented…There were pressures of time upon him. This and the extent of reliance upon the untested judgment of others in selecting and characterising the data for input into the computer programme, however impeccable the logic of that programme, adversely affects the authority of the opinion based upon such an exercise.*
>
> *… It is evident that the reliability of Mr Pickavance's sophisticated impact analysis is only as good as the data put in. The court cannot have confidence as to the completeness and quality of the input into this complex and rushed computer project. I preferred the evidence of Mr Simpson as to programming and planning matters to that of Mr Pickavance…*

The case of *Great Eastern Hotel Company Ltd v John Laing Construction Company Ltd* (2005) EWHC 181 (TCC) at 184, concerned the refurbishment and extension of the Great Eastern Hotel in London. Laing was construction manager of the project, engaging trade contractors to complete the works. The dispute involved claims raised by Great Eastern in respect of project delay of about 44 calendar weeks. By way of defence, Laing made a counterclaim based upon alleged material misrepresentation and also denied culpability of the delay by pointing finger at both other parties and other concurrent causes of delay. In relation to the case on delay, the expert witnesses of the parties approached their analyses of the delay using two different approaches. The Judge rejected the prospective analysis by Laing's expert because it ignored:

> *…the actual events which occurred ... and gives rise to an hypothetical answer…*

He said (emphasis added):

> *…I reject Mr Celetka's evidence that the late design information either caused or contributed to the critical delay in the Project. His analysis was self-confessedly incomplete. He did not have the time to approach the research of this aspect of the case in the complete and systematic way, furthermore, <u>the impacted as planned analysis delay takes no account of the actual events which occurred on the Project</u> and gives rise to an hypothetical answer when the timing of design release is compared against the original construction programme. Thus it would take no account of the fact that the design team would have been aware of significant construction delays to the original master programme, and would have been able to prioritise design and construction to fit this. Furthermore, Mr Celetka in his report compares the timing of the actual design releases against an original programme which was superseded by later versions of the procurement programme on which Laing showed later dates for the provision of the information required...*

Whereas, in regard to the claimant's expert witness:

> *…I accept Mr France's careful evidence as to the impact of the flow of design information throughout the Project. It was based on thorough research and objective analysis. Whilst there was some delay in relation to the provision of design information, it was not critical delay. It was the delay endemic in a large and complex Project when it is anticipated that the design would evolve and some information was provided "just in time"…*
>
> *…Mr France took account of the actual events in his researches and exhibited in his researches and conclusions the clear-sighted objectivity that informs the whole of his report…*

This focus on what actual events and actual effect was highlighted in the Australian decision in *Kane Constructions Pty Ltd v Sopov* (2005) VSC (30 June 2005), Para 673, where Warren CJ in the Victoria Supreme Court stated:

> *…More specifically, with EOT claims, the burden of proof is on the claimant to establish actual delay. Whilst theoretical calculations, particularly those contained in computer software programs, are useful tools in the building industry, generally further information will be required. Whilst there may be assumptions and calculations, it is necessarily a matter of the claimant proving in the proper way that there has been actual delay such as to substantiate claims for reimbursement…*

In *Mirant Asia-Pacific Construction (Hong Kong) Ltd v Ove Arup & Partners International Ltd* (2007) EWHC 918 (TCC), p564-574, Mirant claimed significant damages against Arup as damages for breach of contract and negligence in relation to a coal fired power station constructed at Sual on Luzon Island in the Philippines. The construction of the plant was carried out by a consortium of several companies and the client was the Philippines government power company. One of the consortium companies changed its name to Mirant Asia-Pacific Construction, and this company awarded a contract to Ove Arup for the design of the foundation slab for the power station's boilers. In April 1997 two of the main foundations of Boiler House Unit 1 failed which required extensive remedial works which Mirant claimed delayed the project.

There were many problems with the project including problems with the coal-yard and coal jetty, the cooling water system, the provision of the transmission lines and the failure of the Unit 1 generator itself. There were also changes in key personnel. Significantly there was no monthly critical path analysis undertaken during the project so that the parties were unable to determine how much time was available to deal with the boiler foundation problem before it affected the project as a whole. There was no accurate way to determine how urgent it was for a solution to be agreed and implemented. Judge

Toulmin held that the movement of the boiler foundations was not the dominant or even a dominant cause of the delay to the project, nor did it contribute materially to the loss arising out of delay to the project.

In reaching his decision Judge Toulmin made a number of comments on the difficulty of accurate analysis and particularly CPM. He advised that

> *…working with critical path analyses on complex projects is not an exact science and that the question of whether an event has delayed the project is always a question of fact…*

In apparent recognition of the possible inaccuracy of any analysis based as it is on uncertain data, HHJ Toulmin considered that it was important to look at activities at or near the critical path to understand their potential impact on the project. In relation to the critical path he said:

> *…As computers have become more sophisticated, the critical path analysis has been enabled to become more sophisticated. This has become an invaluable tool which enables a complex construction Project to be managed with better available information. The analysis will identify at a given date which important aspects of the Project are falling behind the programme, particularly if they are on or close to the critical path, what if any is the impact on other aspects of the programme and where additional resources need to be placed. It will also demonstrate where activities are ahead of what is planned and enable a decision to be taken on whether planned activities need to be rescheduled.*
>
> *It is also used as a tool for analysing, as at the given date, what has caused any delay that has occurred and what is the extent of that delay…*

However, without such analysis undertaken by suitably experienced experts, he commented that the parties may be mistaken as to what is on the critical path. He referred to time impact analysis as an excellent method of analysis, but he emphasised that the analysis will only be valid if it is comprehensive and takes account of all activities, saying:

> *…There may be more than one critical path.*
>
> *It is important to look at activities at or near the critical path to understand their potential impact on the Project. Windows analysis, reviewing the course of a Project month by month, provides an excellent form of analysis to inform those controlling the Project what action they need to take to prevent delay to the Project.*
>
> *Without such analysis those controlling the Project may think they know what activities are on the critical path but it may well appear after a critical path analysis that they were mistaken.*
>
> *A less reliable form of critical path analysis is the watershed analysis. This analyses the Project in terms of a few key events. It may be a sufficient check in the course of a Project to analyse what changes, if any, may need to be made in the Project at the time of a benchmark event…*
>
> *…It is, of course, obvious that the analysis is only valid if it is comprehensive and takes account of all activities.*
>
> *I add the proposition that if a retrospective delay analysis is being conducted on a Project, the analysis must include the time to the end of the Project, otherwise activities may occur which will take them on to the (or a) critical path after the date of the final window or watershed…*

This last proposition was a criticism of one of the experts in the case, and his analysis was held to be seriously flawed.

HHJ Toulmin noted the aim of a delay analysis:

> *…The analysis will identify at a given date which important aspects of the Project are falling behind the programme, particularly if they are on or close to the critical path, what if any is the impact on other aspects of the programme. It is also used as a tool for analysing, as at the given date, what has caused any delay that has occurred and what is the extent of that delay…*

Finally however, HHJ Toulmin held that the analysis was merely a tool to be considered with the other evidence. The question of the delay caused by the failure of the Boiler foundation was a question of fact and the evidence of programming experts might be of persuasive assistance in making that finding.

In *London Underground Ltd v Citylink Telecommunications Ltd* (2007) EWHC 1749 (TCC) the project involved the replacement of the entire communication systems throughout London's underground rail network, together with the continued operation of that new system. It was one of the most complex renewal projects ever undertaken on the network. CTL claimed an overall extension of time based on a large number of alleged breaches of contract by LUL which were alleged to have caused delay. It was a global claim. The dispute proceeded first to adjudication and then to arbitration. The Adjudicator rejected CTLs claim as a global claim because he did not consider that CTL had made good the claim in all but the most trivial respects. The Arbitrator also rejected CTLs global claim. The Arbitrator considered that even if the global claim failed, that was not the end of the matter. He examined the evidence and decided that it was possible to identify a link between a particular LUL breach of contract and 48 weeks of delay to progress.

LUL challenged the Arbitrator's Award and argued that it should have ended at the finding on the global claim. LUL submitted that what the Arbitrator did, was to deal with a case which was not before him. Ramsey, J. decided at paragraph 37 that:

> *…(4) In relation to findings of fact:*
>
> *(a) A tribunal should usually give the parties an opportunity to address them on proposed findings of major areas of material primary facts which have not been raised during the hearing or earlier in the arbitral proceedings.*
>
> *(b) A tribunal has an autonomous power to make findings of fact which may differ from the facts which either party contended for. This will often be related to inferences of fact which are to be drawn from the primary facts which are in issue. Such findings of fact will particularly occur where there are complex factual or expert issues where it may be impossible to anticipate what inferences of fact might be drawn. In such a case the tribunal does not have to give the parties an opportunity to address those findings of fact.*
>
> *(c) Where a tribunal has been appointed because of its professional legal, commercial or technical experience, the parties take the risk that, in spite of that expertise, errors of fact may be made or invalid inferences drawn without prior warning…*

In *LUL*, he quoted what Lord McFadyen said in relation to pleading of causation at paragraph 20 of *Laing v Doyle*:

> *…Causation is largely a matter of inference, and each side in practice will put forward its own contentions as to what the appropriate inferences are. In commercial cases, at least, it is normal for those contentions to be based on expert reports, which should be lodged in process at a relatively early stage in the action…What is not necessary is that averments of causation should be over-elaborate, covering every possible combination of contractual events that might exist and the loss or losses that might be said to follow from such events…*

At paragraph 144, Ramsey, J. said:

> *…As in this case, within the global claim there may remain pleaded events for which a party is responsible which, on the evidence, have caused delay. Necessarily there will be no specific pleaded case that the remaining pleaded events caused a particular element of the delay. As Lord McFadyen said at paragraph 20 of Laing v. Doyle the pleading of causation need not be over elaborate covering every possible combination of contractual events that might exist or, as applied to this case, covering the delay that might be said to flow from every possible combination of such events. Instead as the Lord Ordinary put it in paragraph 38:*
>
> *…there may be in the evidence a sufficient basis to find causal connections between individual losses and individual events, or to make a rational apportionment of part of the global loss to the causative events…*

And at paragraph 164-165 he said:

> *…Under clause 31.7 the obligation, upon LUL initially or upon the arbitrator in arbitration, is to "grant an interim extension of time as is fair and reasonable in the circumstances". The trigger for that provision is that a Delay Event which "will prevent or delay it from complying with its obligations in the timescale provided by this contract". <u>The question of what is fair and reasonable in the circumstances indicates that the remedy is not tied to a particular analysis nor is the arbitrator bound to follow the contentions of the parties</u>. The assessment is one which necessarily has a subjective element and is based on an assessment of the circumstances…*
>
> *…Secondly, whilst analysis of critical delay by one of a number of well-known methods is often relied on and can assist in arriving at a conclusion of what is fair and reasonable, that analysis should not be seen as determining the answer to the question. It is at most an area of expert evidence which may assist the arbitrator or the court in arriving at the answer of what is a fair and reasonable extension of time in the circumstances. As the Arbitrator found at paragraph*

> *310 of the Award: "I therefore regard CTL's submission that the Connect Project is not best suited to analysis by the Critical Path Method as being well-founded…*

In *Costain Ltd v Charles Haswell & Partners Ltd* (2009) EWHC 3140 (TCC) at 181, Costain engaged Haswell to advise them in relation to carrying out ground treatment preparatory work prior to the construction of suitable foundations on a project being undertaken by Costain, on the Lostock and Rivington Water Treatment Works near Bolton. Costain's Contract was under the GC/WORKS/1 (Edition 3) - Single Stage Design and Build Form of Contract. The Contract Sum was of the order of £23 Million.

Pre-tender, Haswell advised that conventional foundations could be used for the two relevant buildings provided the ground under them was pre-loaded in order to minimise any settlement. Post-tender, Haswell revised this design, recommending that piled foundations be used instead. By that time, soil had already been placed on the site to pre-load it in accordance with the Original Design. Costain claimed for the additional costs and delays arising from this design change

Costain alleged that the additional work and testing, together with the time for the design of the piles foundations and completion of the piled foundations, caused a critical delay of 12 working weeks and 4 working days (and as a result they had been on site for this additional period). The programming experts appointed by the parties (Mr Crane for the claimant and Mr Purbrick for the defendant) were directed to meet by the Court. During one of these meetings the experts:

> *…agreed that the appropriate methodology to assess delay in this was "time impact analysis" or the "windows slice analysis" which involves considering the state of progress of the project prior to the delaying event in question and then impacting the effect of that delaying event on the Contract Programme in order to establish the time effect of that event, in particular the delay to the Project Completion Date.*

The experts also agreed which Contract Programme to use as the Baseline Programme for their delay analysis and also agreed the as-built data showing when individual activities started and ended.

Crucially the experts have also agreed that, the delays to the construction of the foundations to the RGF and IW caused critical delays since the RGF was on the critical path of the project at the time. (In this regard it should be noted that the term "critical delay" as opposed to any other type of delay, connotes that the delay in question was to an activity which was on the critical path of the project so that a delay to that activity would, all other things being and remaining equal, inevitably lead to a similar delay to the project completion date)…

In relation to the expert planning evidence, Mr Fernyhough QC (Sitting as a Deputy High Court Judge) stated:

…Both experts have concentrated their attention on the four months from October 2002 to January 2003 during which the effects of the abandonment of the ground treatment works and the design and construction of piled foundations were taking place….They have also agreed that, at that time, those works were on the critical path of the project so that, all other things being equal, and if no later mitigation measures were taken, those delays would ultimately delay the completion of the project as a whole…

However, Mr Fernyhough QC went on to say at a paragraph 181 of his judgement:

…But the experts have not considered the effects of the delays to the foundation works on all the other activities taking place on site during the relevant period nor have they carried out any investigation, post-January 2003, to see whether the delays to the foundations… "locked in" to the programme as at the end of January 2003, were later mitigated, neutralised or even exacerbated by later events. The limited nature of the experts' investigations as described,

> *becomes highly material later when the Court has to assess the damages recoverable by Costain flowing from these delays…*

He distinguishes his concerns between a claim for an EOT (time) and a claim for damages (money) as follows (paragraph 183):

> *… it is necessary to draw a distinction between a claim for damages for delay and a claim for an extension of time of the completion date on account of delay. When an extension of time of the project completion date is claimed, the contractor needs to establish that a delay to an activity on the critical path has occurred of a certain number of days or weeks <u>and that that delay has in fact pushed out the completion date at the end of the project by a given number of days or weeks, after taking account of any mitigation or acceleration measures</u>. If the contractor establishes those facts, he is entitled to an extension of time for completion of the whole project including, of course all those activities which were not in fact delayed by the delaying events at all, i.e. they were not on the critical path…*

> *…But a claim for damages on account of delays to construction work is rather different. There, in order to recover substantial damages, the contractor needs to show what losses he has incurred as a result of the prolongation of the activity in question. Those losses will include the increased and additional costs of carrying out the delayed activity itself as well as the additional costs caused to other site activities as a result of the delaying event. But the contractor will not recover the general site overheads of carrying out all the activities on site as a matter of course unless he can establish that the delaying event to one activity in fact impacted on all the other site activities. Simply because the delaying event itself is on the critical path does not mean that in point of fact it impacted on any other site activity save for those immediately following and dependent upon the activities in question.*

…But 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…buildings…

He concludes that as:

…it has not been shown by Costain that the critical delay caused to the project by the late provision of piled foundations to the…buildings necessarily pushed out the contract completion date by that period or at all…..it is simply a matter of speculation…

This is perhaps odd when he found that:

…The experts have agreed that the delays to the RGF and IW 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….

He explains this anomaly as follows:

…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. Or the Contractor may apply additional resources to the delayed activities in order to accelerate them and thereby reduce the delay to those activities. Or, as in the present case, where the Employer was itself responsible for critical delays prior to the failure of the ground treatment works, it may be that extensions of time granted by the Employer cover part of the same period as delays under consideration. All of these are possibilities which need to be investigated in order to establish whether the assumption that a

critical delay locked into the project in January 2003 does in fact lead to a delay to the completion of the whole project some 16 months later…

…In the absence of any analysis of the interrelationship between all the operative delays from start to the finish, which is absent in this case, in my judgment it is simply not possible for the Court to be satisfied on the balance of probabilities that the assumption upon which this part of Costain's case depends, is correct…

…this finding is no criticism of the approach and calculations of the programming experts. They both considered, correctly in my view, that the period to be assessed was the period during which the delays occurred and that is what they did. Having done so, they both concluded that critical delays, to differing extents, had occurred as a result of the foundation works. But they were never asked to investigate and did not consider whether or not those critical delays in fact carried through and led to the project completion date being pushed out to the same extent. Thus there is no way of knowing whether that is the case or not. Costain has not sought to establish by evidence that this was the case notwithstanding that is the basis of its prolongation claim…

Presumably in the interests of proportionality, the experts focussed their investigation only on the period of delay in question, without having any regard for what happened after the design change, specifically on follow-on activities and other structures elsewhere within the project.

From the above judgement, the following key points can be distilled:

(i) The courts are prepared to accept CPM, however, generally not as evidence of delay to completion without a full analysis of the activities leading to completion; and

(ii) Notwithstanding CPM, a factual analysis is still required.

The extent of critical delay to a project cannot be determined prospectively. Even if considered critical, the initial delay ultimately: (i) may not have an overall delaying effect on the project as a whole; and (ii) may be subsequently mitigated or negated. All other delays to the project need to be considered.

In the 2010 case of *City Inn Limited v Shepherd Construction Limited*, the contractor, Shepherd, in 1998 entered into a JCT'80 contract with a schedule of amendments to construct a hotel in Bristol for City Inn Limited, a company registered in Scotland. The contractual completion date was 25 January 1999 and liquidated damages were set at £30,000 a week. Practical completion was certified in March 1999. In due course the architect granted a 4 week extension of time but ascertained a 5 week culpable delay enabling the employer to deduct £150,000 delay damages.

In a subsequent adjudication, Shepherd was awarded a further 5 weeks EOT and City Inn was ordered to repay the delay damages. City Inn (being a company registered in Scotland) disputed this decision in the Outer House of the Court of Session.

Matters in dispute included City Inn (the pursuer) stating Shepherd (the defendant) were not entitled to the contended 11 weeks' time extension nor the four-week extension granted by the architect. Both parties relied upon the expert evidence of their programming experts, who were described by the judge, Lord Drummond Young as:

> *…well qualified to speak about the issues that arose in the case…*

Shepherd's expert initially attempted to construct a critical path analysis of the project, but was concerned that any logic links he may presume could lead to an unreliable analysis. In a transparent change of approach, he undertook a form of As-planned v As-built analysis. This was criticised by City Inn for not being based on a critical path analysis. City Inn's expert did carry out a critical path analysis based on the As-Built programme: it was rejected by the judge as indicated in paragraph 29 of the judgement:

> *…In my opinion the pursuers clearly went too far in suggesting that an expert could only give a meaningful opinion on the basis of an as-built critical path analysis. For reasons discussed below (at paragraphs [36]-[37]) I am of opinion that such an approach has serious dangers of its own. I further conclude, as explained in those paragraphs, that Mr Lowe's own use of an as-built critical path analysis is flawed in a significant number of important respects. On that basis, I conclude that that approach to the issues in the present case is not helpful.*
>
> *The major difficulty, it seems to me, is that in the type of programme used to carry out a critical path analysis any significant error in the information that is fed into the programme is liable to invalidate the entire analysis. Moreover, for reasons explained by Mr Whitaker (paragraphs [36]-[37] below), I conclude that it is easy to make such errors. That seems to me to invalidate the use of an as-built critical path analysis to discover after the event where the critical path lay, at least in a case where full electronic records are not available from the contractor…*

In concluding, the judge expressed his preference to analysis based on factual evidence, sound practical experience and common sense despite that such analysis might not be based on critical path analysis and rejected the approach based on flawed as-built critical path analysis. He said:

> *…I think it necessary to revert to the methods that were in use before computer software came to be used extensively in the programming of complex construction contracts. That is essentially what [Shepherd's expert] did in his evidence. Those older methods are still plainly valid, and if computer-based techniques cannot be used accurately there is no alternative to using older, non-computer-based techniques…*

In preferring Shepherd's expert, Lord Drummond Young found in favour of Shepherd and concluded that if there was no single dominant event causing delay, it was appropriate to apportion the overall delay between the causes.

City Inn took the matter to appeal in the Inner House of the Court of Sessions. City Inn's appeal was dismissed and the decision of Lord Drummond Young was upheld, but only by a two to one majority, highlighting the lack of agreement on delay analysis. Lord Osborne, in *City Inn*, summarised the majority common-sense position and five propositions were formulated. Of these (iv) and (v) are particularly noteworthy:

(i) For a claim for an extension of time to be successful, it must first be concluded that the matter under scrutiny is a Relevant Event which has, or is likely to delay the works.

(ii) The question of causation arising from the above is one of fact, to be determined by the application of common sense.

(iii) Although a critical path analysis may assist in the matter of causation, it is not obligatory.

(iv) If a dominant cause can be identified as the cause of some particular delay, effect will be given to that by leaving out of account cause(s) which are not material regardless of which is the Relevant Event.

(v) Where two causes are materially operative, one being a Relevant Event and the other not and neither is a dominant cause, it is open to the decision maker to apportion the delay between the events to be assessed in a fair and reasonable manner.

The majority judgment in the Scottish case of *City Inn* supported the "fair and reasonable" approach which they interpreted so as to enable the decision maker to:

- choose the dominant cause, regardless of whether it is a Relevant Event competing with contractor's culpable delay (in other words the dominant cause trumps the Relevant Event); and
- where two causes are materially operative (one being a Relevant Event and the other not) with neither being a dominant cause, it is open to the decision maker to apportion delay

The first of these views accords with what is classified as a Windows based analysis, where the Relevant Event is considered in the circumstances known at the time, including the then known progress.

However, it is of note that even where the majority of the judges agreed, there was a dissenting view to this approach. The dissenting judge, Lord Carloway, rejected the proposition that delay caused by the contractor should also be considered in assessing the effect of a Relevant Event, relying on a narrow interpretation of the JCT wording:

> *…Clause 25.3.1 provides that it is in the power of the architect to form an opinion on whether a matter complained of is a Relevant Event and whether the completion of the Works is likely to be delayed thereby beyond the Completion Date…*

His view of this provision was expressed as follows:

> *…This provision is designed to allow the contractor sufficient time to complete the Works, having regard to matters which are not his fault. This does not… involve any analysis of competing causes of delay or an assessment of how far other events have, or might have, caused delay beyond the completion date…*

So if bad weather occurs the contractor would expect an extension:

> *…It is of no moment that there was a contractor delay before, during or after the weather conditions…*

The dissenting judge therefore disagreed with the reasoning of the first instance decision and the majority on appeal in *City Inn* over their view that where there was concurrency between a Relevant Event and a contractor default, in the sense that both existed simultaneously regardless of which started first, it may be appropriate to apportion responsibility for the delay between the two causes. He said that this was wrong:

> *...That is not an exercise warranted by any term of the contract… What the architect must do is concentrate solely on the effect of the Relevant Event… It is not in short, an apportionment exercise… The words "fair and reasonable" in the clause are not related to the determination of whether a Relevant Event has caused the delay in the Completion Date, but to the exercise of fixing a new date once causation is already determined…*

According to Lord Carloway, Clause 25 required the contract administrator to assess the EOT to take each Relevant Event notified by the contractor in turn, and make the judgment as to whether progress of the works *"is being or is likely to be delayed"* by it. This did not, in his view, involve any consideration of competing causes and therefore any notion of apportionment. Lord Carloway said:

> *106. ....delay caused by the contractor.....is irrelevant so far as the contractual exercise is concerned. That exercise does not involve an analysis of competing causes. It involves a prediction of a Completion Date, taking into account that originally stated in the contract and adding the extra time which a Relevant Event would have instructed, all other things being equal.*
>
> *110. ...the exercise remains one of looking at the Relevant Event and the effect it would have had on the original (or already altered) Completion Date. If a Relevant Event occurs (no matter when), the fact that the Works would have been delayed, in any event, because of a contractor default remains irrelevant."*

Lord Carloway's dissenting view is interesting as in 2012 he was appointed Lord Justice Clerk (the second most senior judge in Scotland) and he appears to be suggesting an "entitlement" view of EOT akin to the principle set out in the SCL Protocol (Society of Construction Law, 2002) that followed the logical application of the contractual machinery, rather than the otherwise generally accepted pragmatic position that the delay event should be considered at the time of the event.

This judgment demonstrates that senior judges have conflicting views on how to assess the effect of delay events on the completion date. However, the decision in *Adyard Abu Dhabi v SD Marine Services* (2011) EWHC 848 (Comm), page 286 noted:

> *…in so far as Lord Carloway was suggesting in his judgment that it is not necessary to show that the relevant event is an operative cause of delay to the progress of the works, it does not reflect English law. As set out above, the English law authorities in relation to extensions of time under the JCT form and similar contracts are clear that it must be established that the relevant event is at least a concurrent cause of <u>actual delay</u> to the progress of the works…*

In *Adyard*, Lord Carloway's view was therefore not accepted. Instead, the position in English Law, that a delay analysis ought to establish that the delay event is the cause of actual delay, was explained and at page 287 concluded:

> *…The majority in the City Inn case accepted that the issue of whether a relevant event causes delay is to be assessed by reference to the progress of the works as a whole. They clearly recognised the relevance of considering and establishing causation in fact...*

Although this is a Scottish case and therefore not of direct effect in English Law, it is included here as it may be of persuasive value and was a landmark case considering the proposition of delay analysis in recent times.

The 2011 case of *Adyard Abu Dhabi v SD Marine Services* (2011) EWHC 848 (Comm) was concerning the construction of two ships. Adyard, a small to medium-sized shipyard, contracted under two separate shipbuilding contracts with SD Marine, a commercial supplier of services to the public sector, for the construction of two sea vessels which were to be ready for sea trials by contractually agreed dates. Both contracts gave SD Marine the right to rescind in the event that the vessels were not ready. Inevitably works were delayed, the contracts were not completed within the time stated in each contract and SD Marine purported to exercise its right to rescind.

SD Marine purported to rescind the shipbuilding contract because of the Adyard's failure to have the vessels ready for sea trials by the date stated in the contract. Adyard relied on the prevention principle. Adyard's case was that SD Marine was not entitled to rescind because it had ordered variations to the contract which delayed the work.

There were three stages to the Adyard's argument:

- First, the Adyard said that SD Marine had ordered variations;
- Second, Adyard said that the contract did not entitle the shipyard to an extension of time for any delay caused by the variations; and
- Third, Adyard said that the variations had caused delay.

In the event, Adyard failed at all three stages of the argument. Mr Justice Hamblen said in regard to concurrency, at paragraph 279, that HHJ Seymour QC:[42]

> *…makes it clear that there is only concurrency if both events in fact cause delay to the progress of the works and the delaying effect of the two events is felt at the same time. In HHJ Seymour QC's first example, the relevant event did not in fact cause any delay to the progress*

[42] In Royal Brompton Hospital NHS Trust v Hammond (No 7) (2001) 76 Con LR 148

> *of the works. His first example is consistent with Colman J's comments as to the situation in which a variation is instructed during a period of culpable delay at pages 30 – 31 of the report in Balfour Beatty…*

HHJ Seymour stated that *Adyard* was required to show that the variations were likely to or did cause actual delay to the progress of the works. He suggested that apportioning of delay as in *City Inn v Shepherd* did not reflect English law. That the project was in critical delay at the time of the variations meant that no actual delay had occurred as a result of any changes made by SD Marine and so Adyard's case was rejected.

In the 2012 case of *Walter Lilly,*[43] Akenhead J said:

> *…I am clearly of the view that, where there is an extension of time clause such as that agreed upon in this case and where delay is caused by two or more effective causes, one of which entitles the Contractor to an extension of time as being a Relevant Event, the Contractor is entitled to a full extension of time. Part of the logic of this is that many of the Relevant Events would otherwise amount to acts of prevention and that it would be wrong in principle to construe Clause 25 on the basis that the Contractor should be denied a full extension of time in those circumstances. More importantly however, there is a straight contractual interpretation of Clause 25 which points very strongly in favour of the view that, provided that the Relevant Events can be shown to have delayed the Works, the Contractor is entitled to an extension of time for the whole period of delay caused by the Relevant Events in question. There is nothing in the wording of Clause 25 which expressly suggests that there is any sort of proviso to the effect that an extension should be reduced if the causation criterion is established. The fact that the Architect has to award a 'fair and reasonable' extension does not imply that there should be some apportionment in the case of concurrent delays…*

[43] Walter Lilly & Company Ltd v Giles Patrick Cyril Mackay and another (2012) EWHC 1773 (TCC)

This decision by Akenhead J is more akin to Lord Calloway's dissenting judgement in *City Inn*. However, the 659-paragraph judgement turns on what are very unusual facts and circumstances, therefore its wider application has to be treated with care.

CHAPTER 6

6 CASE STUDIES

6.1 Introduction

The approach of using case studies was required in this thesis as most disputes in the UK are dealt with by arbitration and adjudication, so the details of the dispute and how the cases are presented are unreported. Even where cases do go to court, little comment is made on the nature of delay analysis and the validity of the method used (Gorse, Bates, & Hudson-Tyreman, 2006). As explained in **Chapter 2.5.4**, the situation of the researcher allowed access to programming expert reports that had been submitted as part of the expert witness evidence in national and international disputes.

Where delays do occur on construction projects, experts are often employed to analyse delays based on project records and report their findings to a tribunal and the quality of the expert report is likely to influence the success of the claim (Gibbs, Emmitt, Ruikar, & Lord, 2012). An expert is often appointed by both parties to the dispute. The Claimant is the party who refers the dispute to arbitration and submits the claim. The Respondent is the party with whom the Claimant is in dispute with and who responds to the claim (and often submits a counter-claim).

Twenty-seven (27) expert reports covering 16 different projects where delay issues have been referred to arbitration have been examined as part of the case study review. To ensure as balanced a view as possible, 11 of the cases have an expert report for both the Claimant and Respondent.

The expert reports for each case study is tabulated below:

Project No.	Claimant Expert Report	Respondent Expert Report	Both Expert Reports
1	Y	Y	Y

Project No.	**Claimant Expert Report**	**Respondent Expert Report**	**Both Expert Reports**
2	**Y**	**Y**	**Y**
3	**Y**	**N**	**N**
4	**Y**	**Y**	**Y**
5	**Y**	**Y**	**Y**
6	**Y**	**N**	**N**
7	**N**	**Y**	**Y**
8	**Y**	**Y**	**Y**
9	**Y**	**Y**	**Y**
10	**Y**	**Y**	**Y**
11	**Y**	**Y**	**Y**
12	**Y**	**Y**	**Y**
13	**Y**	**N**	**N**
14	**Y**	**N**	**N**
15	**Y**	**Y**	**Y**
16	**Y**	**N**	**N**

Figure 16 – Tabulation of Case Studies (Author's illustration)

Due to the confidential nature of the projects and the associated disputes, the research does not identify any particulars that could identify the project name or the parties to the dispute. Some basic information has been provided to provide context to the disputes. Generic language, where necessary, has been used to replace terms or phraseology that may have identified the project.

Sample bias was apparent, as the projects were all over £50 Million (although the disputed sums were for a lot less) and all reports were submitted for arbitration, although there was a spread between international and UK based arbitrations. This bias will have an effect on the results as it is usual on large projects to have programmes prepared using CPM. This contrasts to smaller projects, which generally do not have programmes either partially or fully logic linked (CIOB., 2008).

Each expert report was between 50 and over 300 pages in length. Thus, it was not practicable to summarise each of the reports. As such, a matrix of questions was produced. This matrix evolved over time, but had four main constituent parts:

- Method of Delay Analysis employed;
- Detailed Methodology;
- Reasons for the Methodology; and
- Additional Reasons for Methodology.

Each of the above four categories are explained below:

(i) Method of Delay Analysis employed:

From the review of delay analysis methodologies described in **Chapter 4**, the common delay analysis methodologies have been identified:

Methodology
Window Analysis
Time Impact
As-Planned v As-Built
Impacted As-Planned
Collapsed As-Built

So as not to stretch interpretation of the methodologies employed, space remained available for any other methodology. From this, two additional types of methodology were identified within the case studies:

Methodology
Other: As-Built
Other: Production Analysis

(ii) Detailed Methodology

In addition to the identification of the delay analysis methodology, the AACE (2007) note variants to the various models used and how they are used. As such the following questions were identified based on (a) the AACE (2007) taxonomical classifications; and (b) the information provided in the expert reports. The detailed methodological categories were as follows:

Detailed Methodology
Uses Original Baseline
Uses Modified Baseline
Solely uses Baseline
Solely uses As-built
Uses contemporaneous updates
Creates updates
Dynamic Modelling
Static Modelling
Forward Looking

(iii) Reasons for the Methodology

This identified the reasons why the experts had selected their methodology. In some instances this was not explicitly provided but could be inferred from the explanation provided within the reports. The Reasons for the Methodology were obtained from the findings of the survey undertaken by Braimah and Ndekugri (2008). This was an appropriate listing as it was identified in the PhD thesis of Braimah (2008) that areas worthy of further research included:

> *Like DAMs, the selection of appropriate DSAMs is also dictated by a number of factors. This has contributed in part to the long standing debate surrounding the appropriateness of using these methodologies, particularly the use of the global method. Consequently, a research into these factors towards the development of appropriate guidelines or decision tools for selecting the most appropriate methodology would go a long way to assist practitioners and help reduce the likelihood of disputes*

The reasons for the selection of the methodology were as follows, listed in order of the relative importance of delay analysis selection factors described by Braimah and Ndekugri (2008):

Reasons for Methodology
Records availability
Baseline programme availability
The amount in dispute
Nature of baseline programme
Updated programme availability
The number of delaying events
Complexity of the project
Skills of the analyst
Nature of the delaying events
Reason for the delay analysis

Reasons for Methodology
Type of contract
Cost of using the technique
Dispute resolution forum
Time of the delay
Size of project
Duration of the project
The other party to the claim
Applicable legislation

(iv) Additional Reasons for Methodology

In addition to the factors identified by Braimah and Ndekugri (2008), research into the case studies identified further reasons why delay analysis methodologies were selected or why the detailed methodical decisions were made. These were not predetermined but identified as part of the study:

Additional Reasons for Methodology
Baseline programme was not dynamic
High number of constraints in Baseline (BL)
Analysis of work-streams rather than activities
Contract required actual delay
Updates were not agreed and optimistic
Missing evidence to Remaining Duration (RD) therefore used % complete
Programmes updated to suit revised logic

Each of the case studies is briefly explained below, with a short background to the project followed by a summary of the Claimant's and Respondent's expert report analysis.

6.2 Case Study 1

The project was an international infrastructure project in excess of £100M. The contract was a bespoke set of conditions with bespoke terms for the assessment of EOTs. The clause provided entitlement to an EOT where the delay fairly entitled the contractor to an EOT and was a determination by the Engineer after due consultation with the employer and contractor. The claimed delay was a period exceeding 10 months. The delay issues are confidential, however for context there were three main delay related issues: (i) lack of access; (ii) errors on drawings increasing actual quantities; and (iii) lack of instructions.

The experts agreed that both the TIA and Windows Analyses methods are reasonable provided that (a) the baseline is properly modelled, (b) account is taken of changed working sequences, and (c) progress data is as accurate as possible.

6.2.1 Case Study 1 –Claimant

The methodology applied by the Claimant's expert was a time impact analysis. The analysis noted that the agreed programme included changes post contract. The analysis was therefore based on the tender programme. Increased quantities caused the "impact".

6.2.2 Case Study 1 - Respondent

The methodology applied by the Respondent's expert was a windows critical path analysis with progress updates at key points in time. There was an approved baseline programme, however no contemporaneous updates were available, so these were recreated using contemporaneous as-built data. The analysis considered events at (or near) the time they occurred.

Selection of the methodology was said to be dependent on:

(i) The available contemporaneous records regarding the agreed plan and the actual progress;

(ii) The nature of the works; and

(iii) The time the analysis is carried out.

It was noted that the more reliable the contemporaneous documents the more robust the delay analysis.

6.3 Case Study 2

The project was an international process plant project in excess of £200M. The contract was a bespoke set of conditions with bespoke terms for the assessment of EOTs. The claimed delay was a period exceeding 12 months. The issues are confidential, however for context there were five main issues: (i) lack of access; (ii) lack material and equipment; (iii) design changes; (iv) low productivity; and (v) insufficient cranage.

6.3.1 Case Study 2 – Claimant

The Claimant's expert favoured a time impact analysis methodology. However, the expert considered the baseline was not suitable for dynamic use in the analysis without major modification and to make considerable changes to the baseline would make analysis lacking in contemporaneous foundation and highly theoretical. As such, the Claimant's expert selected an as-planned **-**v**-** as-built analysis. The determination of the as-built critical path was assisted by a review of level of resource. The analysis also considered the near critical paths.

6.3.2 Case Study 2 – Respondent

The Respondent's expert employed a windows critical path analysis. The methodology used the contemporaneous updates produced by the contractor. The methodology quantified the delay between updates to the baseline programme. It began with the identification of the critical path from the update at the beginning of each period and then quantified the delay during that period by comparing progress at the end of the period to that forecast at the beginning of the period. The results were contrasted to the contemporaneous facts of the project.

The Respondent's expert adjusted the baseline programme and explained the adjustments made and the reasons for those adjustments. The stated benefits of the analysis were:

- The analysis was based on contemporaneous updates and therefore was familiar to the parties;
- The analysis identified the changes to the critical path in each window; and
- It was a forward-looking analysis but considered what actually happened.

6.4 Case Study 3

The project was an international process plant project in excess of £200M. The claimed delay was a period exceeding 9 months. The issues are confidential, however for context there were two main issues: (i) change in sub-contractor; and (ii) lack of resources.

6.4.1 Case Study 3 - Claimant

The methodology applied by the Claimant's expert was a windows critical path analysis with progress updates at key points in time. There was an approved baseline programme, however no contemporaneous updates were available, so these were recreated using contemporaneous as-built data.

The Claimant's expert adjusted the baseline programme and explained the adjustments made and the reasons for those adjustments.

The analysis was contrasted to contemporaneous data.

6.4.2 Case Study 3 - Respondent

No Respondent expert report was available.

6.5 Case Study 4

The project was an international sports stadium for a sum in excess of £100M. The delay was 13 months. Issues included: (i) delay in receipt of permits; (ii) utility delays; and (iii) lack of access to parts of the Site.

6.5.1 Case Study 4 – Claimant

The Claimant's expert adopted a windows analysis methodology. The expert modified the baseline programme and recreated updates from as-built data (but maintaining the baseline logic). The factors considered in the selection of the methodology included:

- The detail and reliability of the contemporaneous progress information;
- The availability of appropriate programmes; and
- The nature of the delaying events.

6.5.2 Case Study 4 - Respondent

The Respondent's expert also adopted a windows analysis methodology. The expert used the original baseline programme and relied upon the contemporaneous updates, including changes to logic.

6.6 Case Study 5

The project was an international building project in excess of £500M. The Contract was bespoke but the EOT clause permitted an EOT on the grounds of a delay event being likely to cause a delay.

6.6.1 Case Study 5 - Claimant

The Claimant's expert adopted the windows methodology and used the contemporaneous baseline and the contemporaneous updates. The analysis was contrasted to contemporaneous data.

6.6.2 Case Study 5 - Respondent

The Respondent's expert employed a windows critical path analysis (which the expert termed 'Time Slice Methodology'). The expert considered the choice of methodology was based on:

(i) Whether the contract requires likely or actual delay;

(ii) The detail and reliability of the contemporaneous progress information;

(iii) The availability of appropriate programmes; and

(iv) The nature of the delaying events.

The Respondent's expert used the baseline programme. However, due to the absence of what the expert considered reliable updates, the Respondent's expert recreated these at three-monthly intervals, using the baseline as the model.

The Respondent's expert noted there are usually considered to be five methods of delay analysis as follows

(i) A comparison of As-Planned with As-Built;

(ii) An Impacted As-Planned analysis;

(iii) A Collapsed As-Built method;

(iv) Time impact analysis; and

(v) Time slice analysis.

The analysis was contrasted to contemporaneous data.

6.7 Case Study 6

The Project was an international power project in excess of £300M. The delay was 10 months. The Contract was based on the FIDIC form.

The issues are also confidential, however for context there were four main issues: (i) lack of access; (ii) late receipt of drawings; (iii) additional works; and (iv) co-ordination with other Contractors.

6.7.1 Case Study 6 - Claimant

The methodology applied by the Claimant's expert was a windows critical path analysis with progress updates at key points in time. There was an approved baseline programme, however the contemporaneous updates were not provided regularly, so these were recreated using contemporaneous as-built data. Causation was identified from contemporaneous records. Windows were chosen based on major milestone events.

6.7.2 Case Study 6 - Respondent

No Respondent expert report was available.

6.8 Case Study 7

The Project was an international power project in excess of £200M. The contract was bespoke as was the EOT clause. The delay exceeded four months. The main issue was a newly imposed restriction on employing a second shift. The analysis was to assess the effect of the reduced production on the programme.

6.8.1 Case Study 8 – Claimant

The Claimant's expert used an impacted as-planned prospective analysis. He modified the baseline and adopted two impact periods.

6.8.2 Case Study 8 – Respondent

The Respondent's expert utilised the windows analysis methodology, relying on the original baseline and producing contemporaneous updates from as-built data.

6.9 Case Study 8

The project was a UK electrical project in excess of £200M. The Contract was bespoke as was the EOT clause. The delay exceeded 16 months.

6.9.1 Case Study 8 – Claimant

The methodology employed was a combination of an observational as-planned v as-built and a production based analysis as it was considered the complexity of the project did not suit a traditional critical path methodology due to the high number of constraints within the programme.

6.9.2 Case Study 8 –Respondent

The methodology used was a windows critical path analysis using contemporaneous updates. The windows based time slicing analysis was described as the best way of assessing how progress according to the current plan was being achieved and what held up that achievement. It was considered that the as-built critical path did not reflect the changing critical path known contemporaneously and the baseline programme was quickly out-of date due to the lack of strict sequence to complete the project.

Validation of the as-built dates for critical and near critical activities was undertaken. A sensitivity analysis was also prepared.

The analysis was contrasted to contemporaneous data.

6.10 Case Study 9

The project was an international process plant in excess of £200M. The project was delayed by 19 months. The contract was bespoke but the EOT clause permitted an EOT on the grounds of a delay event being likely to cause a delay.

The issues causing the delay were: (i) site layout; (ii) changes to design; and (iii) design approval delays.

6.10.1 Case Study 9 - Claimant

The Claimant's expert used the windows critical path analysis method and the contemporaneous updates. Minor modifications were undertaken to the baseline programme.

Validation of the as-built dates for critical and near critical activities was undertaken. The analysis was contrasted to contemporaneous data.

6.10.2 Case Study 9 – Respondent

The Respondent's expert used the windows critical path analysis method and the contemporaneous updates. Minor modifications were undertaken to the baseline programme which was agreed between the experts. The Respondent's expert supplemented the analysis with a "what-if" update on the basis of an alleged relationship not reflected in the contemporaneous updates.

6.11 Case Study 10

This was an international marine project, in excess of £100M. The contract was based on FIDIC and provided for likely as well as actual delay. The delay was seven months. The issues were (i) changed survey data; (ii) additional works; and (iii) unforeseen conditions.

6.11.1 Case Study 10 – Claimant

The Claimant's expert used an as-planned v as-built analysis. The analysis considered the following steps:

- Establish the original planned intent for carrying out the works from the baseline programme;
- Establish the actual sequence of the works progress, or an "as-built" programme; and
- Analytically compare the two and establish what actually caused delay to the progress and completion of the works.

6.11.2 Case Study 10 –Respondent

The Respondent's expert used a time impact analysis. The expert used a modified baseline programme. Contemporaneous updates were available, but unreliable and were therefore reproduced.

6.12 Case Study 11

The project was an international road project, in excess of £50M. The contract was bespoke and allowed for an EOT where the delay fairly entitled the contractor to an EOT and was a determination by the Engineer after due consultation with the employer and contractor. The delay was thirteen months. The issues were (i) error in survey data; (ii) changes in quantities; (iii) testing deficiencies; (iv) lack of access; and (v) lack of progress.

6.12.1 Case Study 11 – Claimant

The Claimant's expert used a windows analysis using the original baseline programme and recreated updates (although it is noted the expert called this a time impact analysis). The method chosen was explained as follows:

> *At the start of each window the as-planned programme that is applicable at the end of the previous window, after impacting the events applicable to the previous window, is updated to take account of progress and thus identifying any delaying inefficiencies that are the contractor's risk. Also imposed on the programme are any necessary logic or duration revisions due to mitigating measure, to reflect the contractor's intentions.*

This comparison between actual delay and forecast delay differentiates time impact analysis from windows analysis.

6.12.2 Case Study 11 –Respondent

The Respondent's expert used a windows analysis using a modified baseline programme and recreated updates based on contemporaneous progress data. The choice of methodology was said to be dependent upon:

- The nature of the Works;
- The time in the lifespan of the Works at which the analysis is carried out; and
- The available contemporaneous records regarding both the agreed plan for the works and actual progress.

The expert noted three common methodologies:

(i) Time Impact Analysis;

(ii) Windows Analysis; and

(iii) As-Built analysis.

6.13 Case Study 12

This was a UK based building project, in excess of £100M. The contract was bespoke. The EOT clause allowed for the consideration of any delay event in a manner that is fair and reasonable. The delay was three months. The issues were (i) late handover; (ii) additional works; and (iii) late design information.

6.13.1 Case Study 12 – Claimant

The Claimant's expert used a windows analysis with time impacting for causation.

There was a baseline programme, which was modified. Contemporaneous updates were provided but did not revise the logic to suit the contractor's revised intentions. Updates were therefore recreated.

6.13.2 Case Study 12 –Respondent

The Respondent's expert used a windows analysis using the baseline programme and the contemporaneous updates.

6.14 Case Study 13

The Project was an international roads project for an amount exceeding £50M.

The issues included: (i) unforeseen ground conditions; (ii) adverse weather conditions; and (iii) lack of access.

6.14.1 Case Study 13 – Claimant

The Claimant's expert utilised a windows analysis methodology. The original baseline programme was used, but although contemporaneous updates were available, the data was considered inaccurate and therefore were updated with as-built data.

6.14.2 Case Study 13 – Respondent

No Respondent expert report was available.

6.15 Case Study 14

The project was an international power cable project for an amount exceeding £50M. The issues included (i) late approval of drawings; and (ii) changes in specification.

6.15.1 Case Study 14 – Claimant

No report available.

6.15.2 Case Study 14 – Respondent

The Respondent's expert used a time impact analysis (which was on the planned programme but only because no progress had been achieved at the date of the delay event).

6.16 Case Study 15

The project was an international power plant for an amount exceeding £200M. The contract was bespoke. The EOT clause allowed for the equitable adjustment of the completion date in the event of owner's risks materialising. The delay was 11 months. The issues were (i) late handover; (ii) additional works; and (iii) late design information.

6.16.1 Case Study 15 – Claimant

The Claimant's expert modified the baseline programme and recreated updates. The expert used a windows analysis methodology producing a forward looking dynamic analysis. Some events were impacted into the programme for a prospective–type assessment.

6.16.2 Case Study 15 – Respondent

The Respondent's expert utilised an as-built critical path due to the nature of the delay events. The aim was to ascertain that each activity commenced as a result of a preceding activity. The as-built logic was determined by asking the following questions

(i) Why did this activity commence at this date?

(ii) Why not earlier?

(iii) What was preventing it from being commenced?

In many cases it was stated the predecessor was straightforward. Where less clear, an examination of the facts was needed to ascertain which predecessor was the last to be completed.

Issues to consider when selecting the methodology included:

- The terms of the contract;
- The substance and quality of the programming and planning information; and
- The availability of records.

6.17 Case Study 16

The project was an international power plant for an amount exceeding £200M. The contract was bespoke. The EOT clause allowed for a fair and reasonable assessment of the EOT due. The delay was seven months. The issues were (i) change in sequence; (ii) unforeseen conditions; and (iii) design changes.

6.17.1 Case Study 16 Claimant

The Claimant's expert utilised a windows analysis methodology, with a modified baseline programme and recreated updates.

6.17.2 Case Study 16 Respondent

No report available.

6.18 Analysis of Case Studies

The analysis of the case studies is contained in **Chapter 7.4** below and concluded in **Chapter 8.6**.

PART III - ANALYSIS, CONCLUSIONS AND RECOMMENDATIONS

CHAPTER SEVEN

7 ANALYSIS OF DOCUMENTARY DATA

7.1 Status of Time Management in the UK

The following analysis is based on the CIOB survey data contained in **Chapter 3**.

The use of programmes within the construction industry is very high, with 88% of respondents having occasion to write, read or consider construction programmes. Despite this, there were obvious deficiencies in: (i) the production of a logic-linked programme; (ii) the production of regular programme updates; and (iii) producing update programmes with proper progress.

There was a strong correlation between the number of EOT claims being accompanied with compensation claims, with 83% of respondents being awarded recovery on both. Using the Spearman rank correlation coefficient, it was found that the success of recovery of EOT is not associated with the success of recovery of compensation and *vice versa*. However, where respondents were awarded both EOT and compensation, there was a relatively greater recovery of EOT than compensation in proportion to that claimed.

From an analysis of the average EOT award scores, the respondents improved the award of the EOT (by at least 25%) through:

(i) Using complex planning tools;

(ii) Having the baseline programme independently validated;

(iii) Regularly updating the programme; and

(iv) Providing accurate updating.

Overall, the CIOB noted that, in more than a third of building projects and four-fifths of engineering projects, it was perceived that the contractor was predominantly held to be to blame for any delay to completion, however 86% of all respondents answering this part of the survey did not have the facilities to, and were thus unable to, identify promptly the likely effect upon the completion date of slippage or imposed changes in the works. Thus the majority of respondents were unable to manage the effects of delay to progress, other than intuitively, and would have difficulties in preparing a reliable delay analysis to prove their entitlement to an EOT in a formal dispute arena.

7.2 Common Delay Analysis Methodologies

The following analysis is based on the data contained in **Chapter 4**.

According to Ndekugri *et al* (2008) there is a need for more empirical research to complement and extend existing knowledge, understanding and use of the most common delay analysis methodologies. In addition, they suggested the extent of usage of a delay analysis methodology generally corresponded to the degree of awareness of the techniques (even though there were known concerns about the methods being adopted).

Identification of the common delay analysis methodologies avoids taxonomical confusion and improves familiarity. Numerous publications in the US and the UK have focused on describing delay analysis methodologies. Based on a review of these publications, as well as academic literature, case law and case studies, it can be concluded that there are five common delay analysis methodologies. From the perceived benefits and criticisms of each, these delay analysis methodologies can be ranked in order of reliability (with (i) being less reliable and (v) being most reliable) as follows:

(i) Impacted As-Planned Analysis;

(ii) Collapsed As-Built Analysis;

(iii) As-Planned v As-Built Analysis;

(iv) Time Impact Analysis; and

(v) Windows Analysis.

This ranking is based on the theoretical nature of the Impacted As-Planned Analysis and the Collapsed As-Built Analysis being criticised in case law; *Great Eastern Hotel v John Laing* and *City Inn Limited v Shepherd Construction Limited* respectively (as discussed in **Chapter 5**).

That Windows Analysis is the most accurate method is supported by Lovejoy (2004) who suggests that four of the above five common delay analysis methodologies can be categorised as follows:

Method Selected	Data Required	Effort Required	Accuracy Expected
Planned v As-Built	Extensive	Average	Fair
Impacted As-Planned	Moderate	Average	Good
Collapsed As-Built	Extensive	Significant	Very Good
Windows	Extensive	Major	Excellent

Figure 17 – Tabulation of Delay Analysis Method Assessment (Lovejoy, 2004)

This ranking is in conflict with the awareness of the methodologies in the UK, which were ranked as follows (Braimah, 2013): [44]

Approaches	Contractor Awareness Rank	Consultants Awareness Rank	Overall Awareness Rank
As-Planned v As-Built	1	1	1

[44] Braimah identified 8 methodologies, hence the ranking from 1 to 8. However, the five common methodologies have been extracted in the table.

Approaches	Contractor Awareness Rank	Consultants Awareness Rank	Overall Awareness Rank
Impacted As-Planned	3	3	2
Collapsed As-Built	5	6	5
Time Impact Analysis	6	2	6
Windows Analysis	8	8	8

Figure 18 – Tabulation of Delay Analysis Method Ranking (Braimah, 2013)

Therefore, although the Windows Analysis, based on this research, is the most accurate and reliable method, it is also the least known, when ranked against alternative methodologies for both contractors and consultants.

The Windows Analysis method brings in the key attributes of Time Impact Analysis in terms of assessing the delay event at (or near) the time of the event, but relies on actual retrospective analysis rather than prospective forecasting. It has been suggested by Cummins (2003) that a combination of these two methods may be appropriate:

> *…In fact, both a prospective and retrospective analysis is probably required for a proper after the event investigation into delay on a project. An assessment of likely delay at the time the delaying event occurs is helpful to demonstrate the reasonableness of acceleration or mitigation measures undertaken by the Contractor (for which the Contractor may be seeking compensation) after the delaying event in order to reduce the actual delay to the contract. However, as stated above, for the purpose of post completion analysis (by court or arbitrator) a retrospective analysis is also required to show actual delay to completion and it will be this analysis that should form the basis of an after the event EoT claim. An analysis of actual delay is also required if a claim for prolongation is to be made in respect of the event which led to actual delay to completion…*

Although Time Impact Analysis is an accurate method, it is accepted that it does not assess actual delay, which is needed for a retrospective analysis of delays and required for a cost claim for prolongation costs.

From a review of the various methodologies available and the previous research into their reliability, it is concluded that the most favourable methodologies are: (i) the Time Impact Analysis methodology; and (ii) the Windows Analysis methodology, although these two methodologies are the least understood (as explained in **Chapter 4**). This is perhaps surprising as the SCL recommend the Time Impact Analysis methodology (as explained in **Chapter 1.9** above), so it could perhaps be expected that the construction industry would be more familiar with this methodology.

Familiarity with methodologies is important; since if the analyst is unfamiliar with the methodology then they are less likely to choose that methodology even though it may be more appropriate. The corollary of this is, if the analyst is familiar with a certain methodology, then the analyst may be more likely to select that one, despite its weaknesses.

Grefen (2000) noted that familiarity is a precondition for trust which, in general, is an important factor in many social and economic inter-actions involving uncertainty and dependency especially those concerning important decisions and new technology:

(i) Familiarity is an understanding, often based on previous interactions, experiences, and learning of what, why, where and when for example a delay analysis method can be employed.

(ii) In the same example, trust deals with beliefs about the most appropriate method (and this is often based on familiarity).

True statements are more likely to be repeated than false ones, therefore it is to be expected (or assumed) that a statement repeated by many people or heard a number of times is more likely to be accurate than a statement that is never repeated. Familiarity can however lead to illogical validation. In a study undertaken by Arekes et al (1989), it was found that increased familiarity increased the perceived validity of the decisions being made. They noted the truism in Joseph Goebbels statement (1942):

> *…Propaganda must therefore always be simple and repetitious. In the long run only he will achieve basic results in influencing public opinion who is able to reduce problems to the simplest terms and who has the courage to keep forever repeating them…*

The listing of the most common methodologies in publications and journals may be leading to confusion over the most appropriate delay analysis methodologies, as analysts become familiar with the terms and approaches without necessarily recalling their strengths and weaknesses. This familiarity may lead to analysts choosing the wrong or inappropriate methodology.

An alternative approach to making industry aware of the most appropriate methodology is by adopting a 'Take the Best' approach. This approach was explained by Newell et al (2003) in relation to predicting the winner of a horse race as follows:

> *Take, for example, predicting the winner of a horse race. We can gather information concerning the jockey, the trainer, the course, and the recent performance of the horse. We might then choose to integrate all this information, perhaps weighting some pieces, such as the identity of the trainer, as more important than others to reach a conclusion about the likelihood of the horse winning the race. An alternative to this integrative process is to single out a piece of information, such as the identity of the jockey, that we believe to be the best predictor of winning and base our decision solely on this information.*

Gigerenzer and Goldstein (1996) have shown persuasively that such a simple "take-the-best" (TTB) heuristic can, under certain circumstances, prove to be as effective and sometimes better than integrating across a variety of sources of information. They recommend, as an approach, to “take the best and ignore the rest”.

It may be the case that the single piece of information in decision making on delay analysis methodology is “which method is recommended as the best”. This was perhaps the idea behind the SCL Protocol providing a singular recommendation on a type of methodology. Conceptually, providing a single recommendation would have a number of benefits, including:

(i) Industry has clear and unambiguous direction on the best method to use;

(ii) Analysts become most familiar with the best method, rather than relying on other methods they may otherwise be more familiar with;

(iii) Certainty exists among analysts thereby reducing arguments on methodology; and

(iv) Industry can work towards producing the documentation required to implement the methodology.

The Time Impact Analysis or Windows Analysis are identified in **Chapter 4** and this study as the most appropriate methodologies, however, alternative methodologies are necessary in circumstances where insufficient information is available to undertake these types of analysis, for example:

- If no as-built data is available then the only available analysis would be an impacted as-planned methodology;
- If no baseline programme is available then the only available analysis would be a collapsed as-built methodology; and
- If no CPM logic is available then the only available analysis would be the As-Planned v As-Built methodology.

However, the analyst must appreciate that the absence of actual data or a baseline from which to measure change may seriously affect the likelihood of demonstrating the cause of delay to the completion date.

This can be seen from a review of guidance from case law provided by Judges when parties have been required to demonstrate causes of delay and their effect on completion.

7.3 Common Law Direction for Delay Analysis

The following analysis is based on the data contained in **Chapter 5**.

7.3.1 Pre-1992

The use of computers in construction was limited prior to late 1980s. Although CPM was developed in 1960, its use in UK construction was not extensive. Projects relied upon hand-drawn bar charts to co-ordinate and manage the works. The key issue of how to carry out the work did not receive due attention and a survey of small construction companies in early 1980s showed only 10% attempted to use CPM (Laufer & Tucker, 1987). However, by the late 1980s there was resurgence in the use of CPM mainly due to the introduction of the personal computer and developments in user friendly project planning software (Reece, 1989), with Primavera, the popular scheduling tool, being founded in May 1983.

Prior to 1992 the courts applied a common sense approach of what actually happened rather than what might have happened as in *Yorkshire Dale Steamship v Minister of War Transport* (1942) A.C. 691, where Viscount Simon LC stated:

> *…It seems to me that there is no abstract proposition, the application of which will provide the answer in every case, except this: one has to ask oneself what was the effective and predominant cause of the accident that happened, whatever the nature of that accident may be…*

> *… This choice of the real or efficient cause from out of the complex of facts must be made by applying common sense standards. Causation is to be understood as the man in the street, and not as either the scientist or the metaphysician, would understand it…*

However, what is common sense to one person is not to another. Too broad an analysis may result in intuitive assessments: an approach also rejected by the courts.

7.3.2 1992 to 2002

From an analysis of relevant common law decisions between 1992 and 2002 it would appear that the courts were requiring CPM or at least promoting the use of CPM. The focus within the decisions was on demonstrating that delay exceeded available float and was on the critical path. It was an accepted concept that the critical path could and was likely to change, thus implying that a delay analysis would identify the delay on a changing critical path and therefore had to be modelled at the time of each delaying event.

There is a view among commentators that *John Barker Construction Limited v. Portman Hotel Limited* (1996) 83 BLR was the first case in the UK in which CPM techniques were approved.

7.3.3 2002

The Protocol (Society of Construction Law, 2002) was issued in 2002. This specifically supports a theoretical and entitlement based approach to the assessment of an EOT:

> *…The Protocol recommends that, in deciding entitlement to EOT, the adjudicator, judge or arbitrator should…determine what (if any) EOT entitlement could or should have been recognised by the CA at the time. The results may not match the as-built programme, because the Contractor's actual performance may well have been influenced by the effects of accepted*

> *acceleration, re-sequencing, redeployment of resources or other Employer and Contractor Risk Events, in order to try to avoid liability for LDs….*[45]

The Protocol recommended a Time Impact Analysis for 'after the event' delay analysis:

> *The Protocol recommends that, in deciding entitlement to EOT, the adjudicator, judge or arbitrator should as far as is practicable put him/herself in the position of the CA at the time the Employer Risk Event occurred.*[46]

That the results of the analysis may not match the as-built is not contradictory to the state of the common law at the time.

7.3.4 2003 onwards

The approach recommended by the Protocol (Society of Construction Law, 2002) was soon after tested in the Hong Kong case of *Leighton Contractors (Asia) Ltd v Stelux Holdings Ltd* (2004), HCHK.

Leighton argued that the contract made it clear that both "delay" and "likely delay" gave proper grounds for an extension of and it was irrelevant that, with hindsight, the event did not actually delay completion. The Arbitrator rejected Leighton's expert's use of the Time Impact Analysis. The court upheld the decision of the arbitrator on the basis that the event did not cause actual delay.

According to Burr and Palles-Clark (2005) case law leads to a number of interesting points:

- The first is that it is far from clear that a critical path analysis is always required or merited if it is so plainly obvious that a delaying event has affected the critical path. He suggests it may well be

[45] Guidance Section 4.19

[46] Core Principle 12

valid for the contract administrator to form an impression of the critical path and the effect of a delay on that path without undertaking his own critical path analysis. However, if the contract administrator's decision is not accepted, then a third-party tribunal, who has no prior knowledge of the project, would have to be persuaded of the merits of the contractor's claim. This is generally through some sort of delay analysis.

- The second point is that there are various techniques for the analysis and presentation of delay claims and it is essential to recognise that these various methods can produce different results. As mentioned in *Royal Brompton v Hammond*, the programming expert:

  > *…frankly accepted that the various different methods of making an assessment of the impact of unforeseen occurrences upon the progress of construction works are likely to produce different results, perhaps dramatically different results. He also accepted that the accuracy of any of the methods in common use critically depends upon the quality of the information upon which the assessment exercise was based…*

- Finally, critical path analysis is a calculated approach to determining entitlement with reference to a logic linked model of the operations, their sequence and interrelationships and questions whether such a calculated model can ever truly determine the subjective question of what is fair and reasonable.

The courts decided that a theoretical or entitlement based analysis was not reliable. Instead the court needs to assess what actually delayed the works.

This requirement, for the programme model to represent the facts of the case was also discussed in the Final Report on Construction Industry Arbitration published by the Commission on International Arbitration of the International Chamber of Commerce in Paris (ICC, 2001), which stated:

> *…It quite frequently happens that many of the number of assumptions that have been made in the construction of such a retrospective network are in the end so controversial that the network cannot be accepted by the Tribunal for the purposes for which it was created…*

Arbitrators and Judges therefore prefer not to rely on a theoretical programming analysis. The use of a CPM programme is accepted as the main way to forecast the effect of the delay events at the time of the event, essential when assessing delays on a changing critical path; however it is essential that the analysis also considers and explains what actually happened.

Despite indicating that the time for completion (and therefore the extended time for completion) ought to be the time available to the contractor in which to perform the works, the courts do not accept "entitlement" programmes that 'total-up' to prospective assessments of EOT. Instead, the courts will be looking at whether the delay event actually delayed completion, preferring 'need' over 'entitlement'.

7.4 Analysis of Case Studies

The following analysis is based on the case study data contained in **Chapter 6**.

The results from the case studies were collated in a matrix, contained in **Appendix B**, and provided here in the main text as an extract (for the first 5 case studies) in *Figure 19 - Matrix of Case Study Results* below:

Case Study	1	1	2	2	3	4	4	5	5	Total
	Claimant	Respondent	Claimant	Respondent	Claimant	Claimant	Respondent	Claimant	Respondent	15
Methodology										12
Window / Period Analysis	N	Y	N	Y	Y	Y	Y	Y	Y	19
Time Impact	Y	N	N	N	N	N	N	N	N	3
As-Planned v As-Built	N	N	Y	N	N	N	N	N	N	2
Impacted As-Planned	N	N	N	N	N	N	N	N	N	1
Collapsed As-Built	N	N	N	N	N	N	N	N	N	0
Other: As-Built	N	N	N	N	N	N	N	N	N	1
Other: Production Analysis	N	N	N	N	N	N	N	N	N	1
Detailed Methodology										
Uses Original Baseline	Y	Y	N	Y	N	N	Y	Y	Y	13
Uses Modified Baseline	N	N	N	N	Y	Y	N	N	N	12
Solely uses Baseline	N	N	N	N	N	N	N	N	N	2
Solely uses As-built	N	N	Y	N	N	N	N	N	N	2
Uses contemporaneous updates	N	N	N	Y	N	N	Y	Y	N	7
Creates updates	Y	Y	N	N	Y	Y	N	N	Y	14
Dynamic Modelling	Y	Y	N	N	Y	N	N	N	Y	15
Static Modelling	N	N	Y	Y	N	Y	Y	Y	N	12
Forward Looking	Y	Y	N	Y	Y	Y	Y	Y	Y	23
Reasons for Methodology										
Complexity of the project	Y	Y	Y	N	N	N	N	N	N	5
The amount in dispute	N	N	N	N	N	N	N	N	N	0
Size of project	N	N	N	N	N	N	N	N	N	0
Duration of the project	N	N	N	N	N	N	N	N	N	0
Nature of the delaying events	Y	N	N	N	N	Y	N	N	Y	13
The number of delaying events	N	N	N	N	N	N	N	N	N	2
The other party to the claim	N	N	N	N	N	N	N	N	N	0
Updated programme availability	Y	Y	N	Y	Y	Y	Y	Y	Y	22
Applicable legislation	N	N	N	N	N	N	N	N	N	0
Type of contract	N	N	N	Y	Y	Y	Y	Y	Y	23
Dispute resolution forum	N	N	N	N	N	N	N	N	N	0
Nature of baseline programme	Y	Y	Y	Y	Y	Y	Y	Y	Y	26
Baseline programme availability	Y	Y	N	Y	Y	Y	Y	Y	Y	25
Cost of using the technique	N	N	N	N	N	N	N	N	Y	1
Skills of the analyst	N	N	N	N	N	N	N	N	N	0
Reason for the delay analysis	N	N	N	N	N	N	N	N	N	0
Time of the delay	Y	Y	N	N	N	N	N	N	N	2
Records availability	Y	Y	N	N	Y	Y	Y	N	Y	15
Additional Reasons for Methodology										
Baseline programme was not dynamic	N	N	Y	Y	N	N	N	N	N	3
High number of constraints in BL	N	N	N	N	N	N	N	N	N	2
Analysis of work-streams rather than	N	N	N	N	N	N	N	N	N	1
Contract required actual delay	Y	Y	N	N	N	N	N	N	N	3
Updates were not agreed and optimistic	N	N	N	N	N	Y	N	N	Y	6
Missing evidence to RD therefore used %	N	N	N	N	Y	Y	N	N	N	3
Programmes updated to suit revised logic	N	N	N	N	Y	N	Y	N	N	4

Figure 19 - Matrix of Case Study Results (Extract)

To each of the categories a Y(es) or N(o) was included. The "Total" column at the right of the table counts the number of Y(es) across each case study shown at the top, which has been divided into Claimant and Respondent.

7.4.1 Delay Analysis Methodology

From an analysis of the 27 expert reports, the following results emerged:

- 19 expert reports used the Windows Analysis methodology;
- 3 expert reports used Time Impact Analysis methodology;
- 2 expert reports used the As-Planned v As-Built methodology;
- 1 expert report used the Impacted As-Planned methodology;
- The Collapsed As-Built methodology was not used;
- There were two instances where the experts used different methodologies:
    - 1 used the As-built methodology; and
    - 1 used a Production Analysis methodology.

The overwhelming choice of the experts was the use of the Windows Analysis methodology, which was used in more than two-thirds of the expert reports analysed (as shown in **Appendix B**). This is illustrated in *Figure 20 – Analysis of Expert Use of Delay Analysis Methodologies* below:

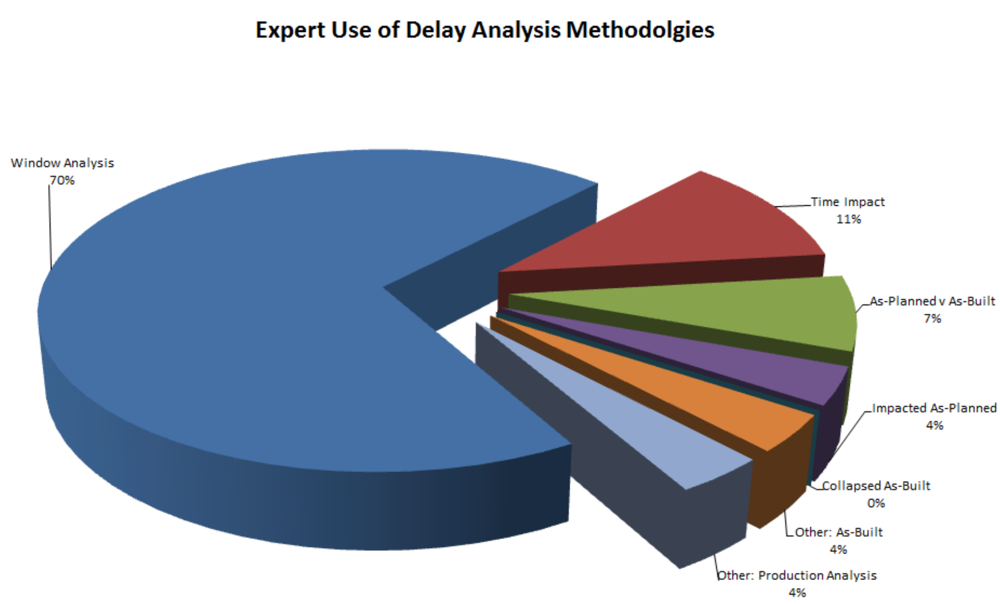

Figure 20 – Analysis of Expert Use of Delay Analysis Methodologies

In addition to identifying the most used delay analysis methodology, it was noticeable that none of the experts used the Collapsed As-Built Analysis methodology. Although the Impacted as-Planned was used on one occasion, this appeared to be due to the nature of the event which was alleged to affect the essence of the planned approach to the works. This does not seem to represent a general endorsement of the methodology.

The research demonstrates the unreliability of the following two methodologies for retrospective analysis:

(i) Collapsed As-Built methodology; and

(ii) Impacted As-Planned methodology.

Where the case study provided both a Claimant and Respondent expert report, the level of agreement over the use of the Windows Analysis methodology is tabulated as follows:

Agreement on the use of Windows Analysis methodology		
One Expert used Windows Analysis	5	50%
Both Experts used Windows Analysis	5	50%
Total	**10**	

In 10 case studies where there was both a Claimant and Respondent expert report, in half the projects, the experts agreed that Windows Analysis was the appropriate methodology. Where there was no agreement on the use of the Windows Analysis methodology:

- It was the Claimant who, in 80% of the cases, adopted an alternative approach; and
- In the 5 instances of adopting an alternative approach, each alternative approach was unique, in that each alternative approach was not repeated in any of the other 4 instances.

7.4.2 Detailed Methodology

Of the 19 expert reports that used a Window Analysis methodology:

- 9 used the original baseline; whereas
- 10 modified the original baseline.

Where the Claimant and Respondent expert reports used the Windows Analysis methodology, an analysis of the level of agreement over the use of the original baseline programme demonstrated there was 67% disagreement (i.e. where one expert used it and one did not) over whether the original programme was appropriate for a Windows Analysis methodology. This is tabulated below:

Agreement on use of original baseline programme		
One Expert used Original Baseline	4	67%
Both Experts used Original Baseline	2	33%
Total	**6**	

Where the Claimant and Respondent expert reports used the Windows Analysis methodology, an analysis of the level of agreement between whether there was agreement over to modify the original baseline programme demonstrated there was 60% disagreement over whether to modify the original programme to ensure it was appropriate for a Windows Analysis methodology:

Agreement on use of modified baseline programme		
One Expert used Modified Baseline	3	60%
Both Experts used Modified Baseline	2	40%
Total	**5**	

The decision to modify the original programme or use it unmodified is a matter of the expert's view on the nature and suitability of the baseline programme. In the case studies, there was almost a 50% instance of the expert modifying the baseline, although generally the opposing expert disagreed that such a modification was justified or necessary.

Of the 19 experts that used a Window Analysis methodology:

- 7 used the contemporaneous updates; whereas
- 12 created the updates.

Where the Claimant and Respondent expert reports used the Windows Analysis methodology, an analysis of the level of agreement between whether there was agreement over to use the contemporaneous updates demonstrated there was 75% disagreement over whether the contemporaneous updates were appropriate for a Windows Analysis methodology. This is tabulated below:

Agreement on use of contemporaneous updates		
One Expert used contemporaneous updates	3	75%
Both Experts used contemporaneous updates	1	25%
Total	**4**	

Where the Claimant and Respondent expert reports used the Windows Analysis methodology, an analysis of the level of agreement between whether there was agreement over to create updates demonstrated there was 75% disagreement over whether to create updates appropriate for a Windows Analysis methodology:

Agreement on creating updates		
One Expert created updates	3	75%
Both Experts created updates	1	25%
Total	**4**	

The decision to use contemporaneous updates or create updates is a matter of the expert's view on the nature and suitability of the updates. In each of the case studies, contemporaneous updates were available. In the case studies, there was a 63% instance of the expert creating the updates, although generally the opposing expert disagreed that the creation of the updates was justified or necessary.

The factors that lead the experts to create updates were explained as:

(i) The contemporaneous updates were not agreed and optimistic in their reporting;

(ii) Evidence of the 'remaining duration' was missing, therefore the updates were validated based on 'percentage complete'; and

(iii) The contemporaneous updates were not updated with logic changes, therefore adjustments were needed.

Of the 19 expert reports that used a Window Analysis methodology:

- 11 used the programmes dynamically;
- 8 used the programmes statically; and
- All considered the analysis as a forward looking analysis.

Where both Claimant and Respondent expert reports used the Windows Analysis methodology, an analysis of the level of agreement between whether there was agreement to use the programmes dynamically demonstrated there was 60% disagreement over whether to use the programmes dynamically in the Windows Analysis methodology:

Agreement on using the programmes dynamically		
One Expert used the programme dynamically	3	60%

Both Experts used the programme dynamically	2	40%
Total	**5**	

The decision to use the programmes dynamically (i.e. by using the calculate function in the programme to assess the effect of events) as opposed to using the programmes statically (i.e. by taking readings from the programmes without introducing delay activities) is a matter of the expert's view on the nature and suitability of the updates. In the case studies, there was 57% instance of the expert using the programmes dynamically, although generally the opposing expert disagreed with using the programmes being used dynamically.

In situations where the programme was used statically, this was still considered a forward-looking analysis, with the new plan superseding the old plan at each window.

7.4.3 Reasons for Selecting a Particular Methodology

The categories of reasons for selecting the methodology were those identified by Braimah and Ndekugri (2008) who ranked them in order of importance. Based on the analysis of case studies, an alternative ranking of importance, based on the number of '(Y)es' returns against each reason is provided below.

Reasons for Methodology	Case Study Results	Case Study Rank
Nature of baseline programme	26	1
Baseline programme availability	25	2
Type of contract	23	3
Updated programme availability	22	4
Records availability	15	5
Nature of the delaying events	13	6
Complexity of the project	5	7

Reasons for Methodology	Case Study Results	Case Study Rank
The number of delaying events	2	8.5
Time of the delay	2	8.5
Cost of using the technique	1	10
The amount in dispute	0	14.5
Skills of the analyst	0	14.5
Reason for the delay analysis	0	14.5
Dispute resolution forum	0	14.5
Size of project	0	14.5
Duration of the project	0	14.5
The other party to the claim	0	14.5
Applicable legislation	0	14.5

The top five most important factors affecting the delay analysis methodology based on the 'Case Study Rank' are:

- Nature of baseline programme;
- Baseline programme availability;
- Type of contract;
- Updated programme availability; and
- Records availability.

The ranking from the case study is contrasted to the ranking by Braimah et al (2008) in the table below:

Reasons for Methodology	Case Study Rank	Braimah et al (2008) (B&N) Rank	Overall Rank
Baseline programme availability	2	2	1

Reasons for Methodology	Case Study Rank	Braimah et al (2008) (B&N) Rank	Overall Rank
Nature of baseline programme	1	4	2
Records availability	5	1	3
Updated programme availability	4	5	4
Type of contract	3	11	5.5
Complexity of the project	7	7	5.5
The number of delaying events	8.5	6	7
Nature of the delaying events	6	9	8
The amount in dispute	14.5	3	9
Cost of using the technique	10	12	10
Skills of the analyst	14.5	8	11
Time of the delay	8.5	14	12
Reason for the delay analysis	14.5	10	13
Dispute resolution forum	14.5	13	14
Size of project	14.5	15	15
Duration of the project	14.5	16	16
The other party to the claim	14.5	17	17
Applicable legislation	14.5	18	18

The top five most important factors to the analyst based on the B&N Rank are:

- Records availability;
- Baseline programme availability;
- The amount in dispute;
- Nature of baseline programme; and

- Updated programme availability.

A comparison between the ranking of the factors affecting the selection of delay analysis methodologies shows three main points:

(i) The top five factors are similar in both studies, with the following notable differences:

- The experts in the case studies considered the most important factor affecting the methodology was the availability and nature of the baseline programme. This is understandable, as without a plan, the analyst is left with an as-built only method;
- The experts in the case studies did not consider the amount in dispute to be a factor. The presence of the amount in dispute was a surprising result in the Braimah study (2008) who noted the possible reason for this is the fact that analysing delay claims can be costly and time-consuming process particularly when using methods such as Time Impact Analysis and Window Analysis. This is less of a factor for the expert who has an over-riding duty to the Tribunal and therefore will not be overly constrained by cost and time, although should always avoid any disproportionate analysis; and
- The experts considered the type of contract to be a significant issue, as the analysis must first comply with any specific contract requirements. However, this was found to be a less important factor in the Braimah study (2008).

(ii) The variation from the expert reports is that eight of the factors identified in the Braimah study (2008) were not identified as issues to the Experts, although the following four issues would not be an issue to the expert:

- The skill of the analyst;
- The reason for the delay analysis;
- The time of the delay; or
- The amount in dispute (which has already been discussed above).

(iii) After accounting for the above, the remaining factors are all the lowest relative importance factors identified in the Braimah study (2008).

In overview, there is a strong level of agreement between the results from the case studies and the Braimah study (2008) of the top five factors to consider when selecting the delay analysis methodology.

Based on a combined ranking, the top five factors to consider when selecting the delay analysis methodology are:

- Baseline programme availability;
- Nature of baseline programme;
- Records availability;
- Updated programme availability; and
- Type of contract.

CHAPTER EIGHT

8 CONCLUSIONS

8.1 Introduction

There are two contrasting philosophical stances on how delay analysis (and subsequent delay claims) should be approached. The first is that any delay analysis ought to be a **prospective** analysis of the effect of a delay event at the time the delay event occurred. The second is that a delay analysis ought to be a **retrospective** analysis of the actual delay caused. From a logical perspective the former is supported, at least, by (i) the law of restitution; (ii) the nature of the construction industry being a time critical one; (iii) the need for the contract to be construed in such a way as to provide business efficacy (as a contractor needs to know when he is required to finish the works); and (iv) the fact that the nature of the original completion dates and the ascertainment of liquidated damages are prospective.

Taken at face value and in isolation therefore, delay analysis should be prospective. Although it is not explicitly stated in their reasoning, this may have been what prompted the SCL to recommend a Time Impact Analysis methodology for prospectively assessing delays in construction contracts in their Delay and Disruption Protocol. Indeed, some forms of contract promote this approach, such as the NEC.

However, claims for extensions of time are invariably accompanied with claims for associated costs; as there is an inevitable time-related cost incurred due to the increased time of being involved in a project. Cost claims are considered differently; they are based on actual loss. By combining these two elements (i.e. time and cost) in a single dispute, the common law, in trying to come to terms with that dichotomy, has developed to an extent that a prospective assessment of time is unlikely to be acceptable. Instead, an assessment of what actually happened and that the event caused actual delay is what is required. This is a more naturally acceptable approach in a jurisprudential sense.

This approach by the courts may change if the contract tackles this dichotomy by imposing an associated prospective assessment of costs (as with the NEC), although no English law judgements were found on this issue.

In any event, and likely due to their complexity, delays tend to be assessed after the event. At this stage it is less likely a prospective analysis would be undertaken (even with the NEC), when a retrospective analysis can (and likely should) take into account what actually happened: the question being ‘why guess when you can rely on the facts?’ In examining the circumstances of a dispute, the third-party resolver tends to assess the delays against the contemporaneous facts. In doing so, if the delay analysis is done on a prospective (sometimes called an entitlement) basis, then the greater the number of delays being impacted, the further away from the facts the delay analysis becomes.

There have been some significant previous investigations into the delay analysis methodologies that are available. There is general agreement on the five most common methods. The strengths and weaknesses of each have been addressed by commentators and this has allowed the ranking of the most appropriate methodologies in terms of acceptability to the courts.

There has also been investigation into the factors affecting the selection of appropriate methodologies, as this was considered necessary to avoid perceived bias on choosing methods to provide a desired outcome. A suggestion was to provide a formula for the selection of the methodology, and by inputting various criteria, calculate an answer as to the most appropriate methodology.

Case studies were analysed as part of this research. These were based on 27 expert programming reports submitted as evidence in arbitrations. The purpose of this part of the study was two-fold: (i) to examine whether the factors established as key to the selection of delay analysis methodologies were influential in practice; and (ii) to discover the actual occurrence of the different methods of delay analysis that were selected by the experts engaged in these cases. The results demonstrated that many of the key factors for selecting a method were not considered by the experts, however there was strong indication of the methodologies favoured by the experts and corroboration for some factors that influence these choices. When combined the top ranked factors were:

- Baseline programme availability;
- Nature of baseline programme;
- Records availability;
- Updated programme availability; and
- Type of contract.

The results also demonstrated that the experts overwhelmingly supported the use of the Windows Analysis methodology and that alternatives were only chosen if the data required for this approach to be performed properly was considered to be unavailable.

In identifying whether it was appropriate ‘to select any particular methodology over another’, a review of decision making criteria was undertaken. This established that there was a ‘familiarity bias’ that resulted, in some cases, to an apparently unconsidered selection of methodology.

An improvement to decision making related to selection of methodology is to adopt the ‘take the best and ignore the rest’ approach. This decision making approach was supported by the Society of Construction Law in the 2002 Protocol, where a single methodology was recommended: the Time Impact Analysis. However, this study also identifies that the method recommended by the 2002 SCL Protocol is in reality not the approach that has been deemed the most acceptable method for demonstrating delay under English Law.

This conclusions section considers:

- The need for the research;
- The status of time management in the UK Construction Industry;

- Common law guidance on delay analysis;
- Case study results;
- Methodology selection criteria; and
- Conclusion on objectives of the research

Each of these is addressed below.

8.2 The need for the research

The need for research in the field of delay analysis has been argued, and this has been evidenced by: (i) the lack of readily available information regarding all delay analysis techniques (Bordoli & Baldwin, 1998); (ii) that parties in the UK have little guidance in the proper assessment and resolution of delay claims (Scott, Harris, & Greenwood, 2004); (iii) that many projects still end up in disputes regarding extensions of time claims and this situation is unlikely to change in the future (Carmichael & Murray, 2006); and (iv) there is a need for more empirical research to complement and extend existing knowledge, understanding and use of the most common delay analysis methodologies (Ndekugri, Braimah, & Gameson, 2008).

From a survey undertaken in 2008, it was identified that between 30 to 67% of projects undertaken were delayed by up to three-months beyond the completion date and yet 86% of all respondents did not have the facilities to (and were thus unable to) identify promptly the likely effect upon the completion date of slippage or imposed changes in the work. Therefore these respondents were unable to manage the effects of delay to progress, other than intuitively.

8.3 Status of Time Management in the UK

The status of time management in the UK was discerned from a 2008 survey by the CIOB. This was the most relevant and best available source of information related to time management due to (i) the confidential nature of disputes in the industry; and (ii) the perceived unwillingness of firms to provide reliable information to industry professionals.

Findings from the survey were:

- The absence of programmes was the most significant issue that would affect the choice of delay analysis methodology. This was to such an extent that the CIOB stated delays were unable to be managed in construction, despite it being more likely than not that delay would materialise.

- The absence of independent reviews of programmes, the production of regular updates and the accurate updating of programmes affects the level of EOT recovery.

The CIOB survey has demonstrated that lack of awareness of (i) the importance of programmes to demonstrating delay; and (ii) the knowledge of planners, are key factors that affect the management of time in the UK construction industry.

8.4 Common Law Guidance

Before the wide usage of computerised delay analysis methodologies, the courts applied a common sense approach to causation. However, with the advent of computerised methods, and the resulting ability (in theory at least) to access, retrieve and present large amounts of data, a 'common-sense' only approach has come under increasing pressure. What is common-sense to one person is different to what is common sense to another, and this gives a somewhat arbitrary appearance to the resulting decisions, especially when contrasted with decisions that could be potentially based on standard technical approaches to hard evidence.

Following the start of widespread use of computerised CPM, the first case to approve of CPM analysis was decided in 1992. From researching relevant common law decisions between 1992 and 2002 it was found that the courts were requiring CPM, or at least, promoting the use of CPM. The focus within the decisions within this period was on (i) demonstrating that a delay to an activity was not one that simply used up the float to that activity but was one that would affect the completion date, i.e., identifying critical delay; and (ii) understanding related issues such as "who owns the float". A concept within these legal decisions was that in the analysis of delays on a project the critical path could (and was likely to) change. This implied that a delay analysis would identify the delay on a changing critical path and therefore had to be modelled at the time of each delaying event.

In 2002 the SCL produced a protocol that set out the idea of assessing EOTs at the time of the event, even when undertaking a retrospective analysis. The Protocol recommended the use of a Time Impact Analysis: a method which impacts the effect of events on the programme updated with progress at the time of the event, to determine whether, at that stage, the event affected the completion date. It is widely accepted that this methodology is good practice when undertaking prospective analysis. The question addressed by the courts was 'whether this was good practice for a retrospective view?'

The answer, based on a review of decisions since 2002, is an overwhelming 'no'. While the courts have accepted the Time Impact Analysis methodology as a sound method, they are nevertheless unlikely to accept its results without considering what actually happened. This does not mean the courts favoured an as-built analysis, as that has been criticised as unhelpful. They have been keen to recognise that delay to completion can only be demonstrated by delays to the critical path. They have also identified that the critical path is likely to change over time and consequently demonstrate a preference for a 'time impact analysis'. However, the courts have rejected the notion of 'stopping' the analysis after the impact of the event has occurred, insisting that the analysis must continue to completion of the project to demonstrate the actual effect of delays to completion. In doing so, the forecast effect ought to be assessed against what actually happened. This, in essence, is the Windows Analysis methodology. This approach by the courts is likely due to the dichotomy of having to assess the outcome of time claims and cost claims within one dispute.

8.5 Common Delay Analysis Methodologies

Consistency and accuracy in the terminology used in the description of delay analysis methodologies is important. Different authors have historically used different descriptions. In this study, efforts have been made to unify taxonomy. While such precision was felt to be beneficial, any such change in terminology may create greater confusion within wider industry by moving away from common names. The identification and explanation of the common methodologies is therefore favourable.

Based on a detailed literature review and following on from previous research, five common methodologies have been identified and are explained in **Chapter 4**. These are ranked in order of reliability, from least reliable to most reliable, as follows:

- As-Planned v As-Built Analysis;
- Collapsed As-built Analysis;
- Impacted As-Planned Analysis;
- Time Impact Analysis; and
- Windows Analysis.

This ranking is based on the theoretical nature of the Impacted As-Planned Analysis and the Collapsed As-Built Analysis being heavily criticised in case law, specifically *Great Eastern Hotel v John Laing* and *City Inn Limited v Shepherd Construction Limited*.

The ranking of reliability is in direct conflict with the awareness of the methodologies in the UK. Awareness and usage of these methodologies appears to be largely based on their familiarity rather than their reliability. Additionally, confusion, in the industry at large, between the Time Impact Analysis and Windows Analysis methodologies is unhelpful.

There are advantages to "taking the best and ignoring the rest" with respect to providing recommendations on the appropriate delay analysis methodology. It may be that greater familiarity with less reliable methodologies is accounting for their continued usage.

8.6 Case Study Results

From a review of 27 expert programming reports, it was found that the overwhelming choice of the experts was the use of the Windows Analysis methodology, which was used in more than two-thirds of the expert reports analysed.

When using the Windows Analysis methodology the following steps were identified as a matter of expert view (which must depend on the specifics of each particular case):

(i) Whether to use the existing baseline programme without modification;

(ii) Whether to modify the existing baseline programme;

(iii) Whether to rely on contemporaneous update programmes; or

(iv) Whether to recreate update programmes based on as-built data.

There was no consensus within the case studies to suggest which of the above are more requisite to the Windows Analysis method, although it has been recommended in one judgement that it is more appropriate to recreate the update programmes based on as-built data than rely on contemporaneous updates.

Based on a combined ranking between the case studies and the survey results from the Braimah study (2008), the top five factors to consider when selecting the delay analysis methodology are:

- Baseline programme availability;
- Nature of baseline programme;
- Records availability;
- Updated programme availability; and
- Type of Contract.

The case studies show that the factors identified in the Braimah study (2008) as proposed criteria for selecting the delay analysis methodology are not in practice considered by the experts in selecting a method, but some of the criteria were used as reasons for not being able to select the Windows Analysis method, which was the favoured method.

Analysis of 27 expert reports showed that:

- 19 expert reports used the Windows Analysis methodology;
- 3 expert reports used Time Impact Analysis methodology;
- 2 expert reports used the As-Planned v As-Built methodology;
- 1 expert report used the Impacted As-Planned methodology;
- The Collapsed As-Built methodology was not used;
- There were two instances where the experts used different methodologies:
    - 1 expert report used the As-built methodology; and
    - 1 expert report used a Production Analysis methodology.

The overwhelming choice of the experts was the use of the Windows Analysis methodology which was used in more than two-thirds of the expert reports analysed. Of the 19 expert reports that used a Window Analysis methodology:

- 9 expert reports used the original baseline; whereas
- 10 expert reports modified the original baseline.
- 7 expert reports used the contemporaneous updates;
- 12 expert reports created the updates.
- 11 expert reports used the programmes dynamically;
- 8 expert reports used the programmes statically; and

All of the expert reports considered the analysis as a forward-looking analysis.

8.7 Methodology Selection Criteria

Based on the analysis of the common delay analysis methodologies, it is clear that logically, there is in fact no “choice” regarding selection and that what is widely accepted as the “best” methodology for a delay analysis is the so-called ‘Windows Analysis’. What we are left with is a series of variants of this method. These are:

(i) The “As-is” method - this uses the contemporaneous programmes and compares the different programmes in their unaltered state;

(i) The “Split” method - this separates the comparison between different contemporaneous programmes into (a) the effect of progress and (b) the effect of revisions such as logic changes;

(ii) The “Modified” or “Recreated” method - this is used where extensive modification or recreation of the contemporaneous updates is undertaken; and

(iii) A “Single Base” or “Multi Base” approach – this depends upon whether delay events are added and removed from a single programme or a series of programmes.

This approach requires a programme and either contemporaneous updates (progress and logic changes), or as-built data to allow updates to be created.

The only circumstances for not doing Windows Analysis in one of the forms above are where the essential documentation is not available. Then, necessarily, the methodology cannot be chosen and an alternative method is needed.

8.8 Conclusion on Objectives

In summary, the conclusions, based on evaluation of the various data collected against the objectives that were stated in **Chapter 1.11** above are:

Objective	Conclusion	Reference
Identify the current state of time management in the UK.	The majority of projects in the UK finish at least 3 months later than the planned completion, however most contractors are unable to effectively manage delays or demonstrate the effect of delays.	Chapter 3.1
Identify whether there are any common methodologies available for retrospective delay analysis.	There are five common delay analysis methodologies. These are: • As-Planned v As-Built Analysis; • Collapsed As-built Analysis; • Impacted As-Planned Analysis; • Time Impact Analysis; and • Windows Analysis.	Chapter 4.9
Assess whether it is appropriate to have a selection criterion for the selection of a delay analysis methodology.	It is appropriate to have a selection criterion. However, rather than adopt a formulistic approach, a “take the best and ignore the rest” approach is recommended.	Chapter 4.10

Objective	Conclusion	Reference
Assess whether the selection of methodologies is influenced by common law.	The selection of the appropriate delay analysis methodology is influenced by common law. In particular English common law supports the Windows Analysis methodology.	Chapter 5.6
Based on case studies identify (a) the method of delay analysis actually used in resolving disputes; and (b) the reasons for that selection.	The choice of methodology is overwhelmingly in support of the Windows Analysis methodology. This is because it identifies delays on the critical path at the time and assesses actual delay to completion.	Chapter 6.18
Contrast the findings from the above five aims with the recommendation from the SCL Protocol (2002)	The recommendations from the SCL Protocol **(2002)** are for analysts and dispute resolvers to use the Time Impacted Method for retrospective delay analysis. This has support from commentators but is not supported by the guidance from English common law.	Chapter 8.7

Each of these is discussed below.

(i) **The current state of time management in the UK**

As explained in **Chapter 8.3** above, time management in the UK construction industry has not improved significantly since the wider introduction of computers in the late 1980s. Recent industry and research surveys have revealed the lack of proper use of CPM programmes and the inability of contractors to effectively manage delays in a clear and transparent way. There is a need to educate and train contractors and employers on the benefits of good programming and time management.

Training and education should also extend to the methodologies to be employed in the analysis of delays and the awarding of EOTs on projects. This is seen to be a specialist area and divorced from contract administration, yet although different skill sets are needed for a forensic analysis from forward planning, these are an essential set of skills, seeing that most projects will incur delay of up to 3 months and some considerably greater.

(ii) Common methodologies available for retrospective delay analysis

There are five common delay analysis methodologies as explained in **Chapter 8.5**. It is preferable to continue the usage of these descriptions as there has been, and continues to be, confusion over the naming of the methodologies. This has prevented familiarity with the main available methodologies.

There was consensus from previous research that the Time Impact Analysis and the Windows Analysis were the most reliable methodologies.

Although seeking an EOT and seeking recovery of associated prolongation costs are dealt with separately under most standard forms of contract, research has shown that claims for time are nearly always accompanied with claims for cost. While conceptually the two issues may be separated based on their inherent purpose, these are, on a more practical basis, linked. However, from the point of view of claims evaluation, in particular whether the assessment of time and money claims should be prospective or retrospective, there is a major difference in terms of the application of the proper forensic logic to be adopted.

With an extension of time, although it is up to the contractor to initiate an EOT process, [47] it is nevertheless imperative for the employer to ensure it is available, as it secures the constraint of the completion date (instead of the requirement to complete the project within a reasonable time) and secures the imposition of liquidated damages. With this process, it may be considered appropriate to employ a prospective approach of delay analysis to forecast the effect of employer delays, as this is akin to: (i) the way the completion date was established in the first instance; (ii) that the damages being imposed by the employer for failure to complete by the completion date are a forecast; and (iii) that the contract period is the time the contractor has to complete the works within and not necessarily the time needed. As each of

[47] Joseph Constantine Steamship Line Ltd v Imperial Smelting Corp (1942) AC 154 (HL)

these is a theoretical forecast, a more theoretical approach to assessing the potential impact may be reasonable. Indeed, when assessing an extension of time alone, this may be sufficient.

With a claim for prolongation costs, however, the onus is on the contractor to establish that the delay event to one activity in fact impacted other site activities and caused the project to be late. This requires the analysis to consider the actual effect of delays to the completion date and demonstrate that the additional actual cost was incurred due to the delay.

Clearly from the standpoint of forensic logic, there is a distinction between a claim for damages for delay and a claim for an extension of time of the completion date on account of delay. However, it would seem an odd method of analysis that considered the treatment of the analysis of delays and costs differently. Indeed, this may even seem nonsensical, as a contractor could be alleging one set of delay events caused the delay to the critical path at the time of the event and he is therefore due an EOT on an ‘entitlement’ basis, whereas alleging a different set of delay events caused actual delay to completion providing him with entitlement to a recovery of costs.

The method of analysis that would overcome these anomalies and be suitable for both purposes is a Windows Analysis, which can consider the impact of events, but then looks at what actually happened. This may change if the contract required a prospective approach to cost claims, such as the NEC.

(iii) **Is it appropriate to have selection criteria for delay analysis methodology?**

Previous research based on survey data has identified the criteria for making a selection of a delay analysis methodology. It was considered appropriate to weight each of these criteria and provide formulae to be used in the selection of the delay analysis methodology. It was considered that this would be less controversial that selecting a model without process (Braimah, 2008).

These findings were tested through case studies, where the criteria obtained from surveys was used in a matrix. This matrix was completed based on an abductive analysis from case studies.

From case studies, the previously identified main criteria are supported as generally sound. Combining ranking from previous research and this research, the main criteria for the selection of delay analysis methodology are:

- Baseline programme availability;
- Nature of baseline programme;
- Records availability;
- Updated programme availability; and
- Type of Contract.

The case study research has demonstrated that the selection of the most appropriate method cannot be described as a "choice". There is overwhelming support for the Windows Analysis methodology. This should be deviated from generally only where the information was not available to produce it or the contract specified an alternative approach.

(iv) **Whether the selection of methodologies is influenced by common law?**

Although there seemed little to no guidance on what the courts have favoured in terms of delay analysis methodology, a trend was discerned from a review of case law related to delay related issues.

A review of case law and reported decisions demonstrated a sea-change in direction from the courts. From the late 1980s to 2002, the courts promoted the use of CPM to demonstrate delay, with no particular focus on methodologies. There was consensus that the critical path of a project can change and that the effect of delays ought to be considered at the time of the event against the critical path at the time.

From 2002 there was a move away from any theoretical answer that was being presented and a greater focus on what actually happened. The courts specifically questioned the use of Time Impact Analysis for retrospective application and promoted the use of Windows Analysis.

(v) **Based on case studies identify (a) the method of delay analysis actually used in resolving disputes; and (b) the reasons for that selection**

A clear majority (19 out of 27) of the case studies showed a preference for Windows Analysis methodology. In particular, divergence from this approach was not due to an alternative preferred method but a result of the facts of that particular case not supporting the use of Windows Analysis: generally this related to the non-availability of suitable programmes.

There was difference of opinion over whether the baseline programme ought to be modified and whether the contemporaneous programme updates ought to be relied upon or reproduced using as-built data. It is noted that in one dispute, the presiding judge expressed a preference for recreated progress updates based on validated as-built data due; his reason being its inherent accuracy as being produced specifically for its intended purpose.

Conclusions on the reasons for selecting the various methods have been discussed against item iii) above.

(vi) **Contrast the findings from the above five aims with the recommendation from the SCL Protocol** (2002)

The main conclusions of the SCL Protocol (2002) were firstly, that there was a specific preferred delay analysis methodology, and secondly to recommend the Time Impact Analysis methodology as the preferred approach for prospective and retrospective analysis.

There are clear advantages to recommending a single analysis methodology. The question is which methodology should be recommended? Use of less reliable methodologies has been increased due to lack of knowledge or experience with more reliable methods. This research has demonstrated the Time Impact Analysis method is not suitable as a retrospective delay analysis methodology in that it does not take account of what actually delayed the works. The most appropriate retrospective delay analysis methodology is the Windows Analysis methodology. The method can also, to a certain extent, be applied prospectively. This is supported by the three main sources of data in this study, namely: the review of the literature, of common law, and of the arguments presented and results of 27 case studies.

The recommendation of the Windows Analysis methodology applies to all projects with a CPM programme and as-built records. While the absence of these is prevalent in many construction projects in the UK, promotion and understanding of the methodology may improve Industry awareness of their need. If the successful conclusion of a party’s claim could be prejudiced due to lack of a CPM programme and as-built records, it is likely that the party will take steps to remedy this in future projects. This will be an improvement not only to delay analysis, but to time management generally in construction.

CHAPTER NINE

9 RECOMMENDATIONS

9.1 Main Recommendations

The recommendations following this study are:

(i) Education is needed within the UK Construction Industry on the common delay analysis methodologies and the selection of an appropriate delay analysis methodology.

(ii) The movement towards a formulaic approach to delay analysis methodology selection may be inappropriate as it suggests that "choice" is based on familiarity with all the methodologies of equal probative value.

(iii) Familiarity with methodologies may be confusing the perceived reliability of the methods. It is an improvement to make a recommendation on the most suitable retrospective delay analysis methodology based on "take the best" method of decision-making.

(iv) The only existing UK guidance on the selection of an appropriate delay analysis methodology is within the SCL Protocol. The recommendation by the SCL of the Time Impact Analysis should be reconsidered, as it is not supported by evidence, in particular, by recent common law decisions.

(v) Based on the case studies of Industry expert programming reports, the recommended retrospective delay analysis methodology is the Windows Analysis methodology. This is also supported by a detailed literature review.

(vi) It is an improvement to promote the Windows Analysis methodology and identify what this requires, as it avoids the use of less reliable methodologies. Once clearly understood, this may lead to greater adoption by Industry of the documentary requirements of the particular methodology, namely: a CPM baseline programme; regular programme updates are preferred; and reliable as-built information.

(vii) Windows Analysis can be improved by: (i) selecting sub-windows in the event the critical path changes between main windows; and (ii) separating delay measures caused by logic from delays caused by progress.

(viii) A flow chart for the selection of methodology would be an improvement on a formula as it would demonstrate the reliability hierarchy of methodologies.

The flow chart below shows the ‘take the best’ decision is to utilise a Windows Analysis methodology. This explains the process involved in a Windows Analysis and includes additional steps, including:

(i) Impacting additional work scope as events into the programme at the time the event was known;

(ii) Separating the effect of progress from the effect of logic;

(iii) Providing the alternatives of using an “as-is” or a “modified” method (the decision depends on the specifics of each case, although using re-created update programmes have greater support in case law); and

(iv) Creating sub-windows if there is a change in the critical path between the programme at the start of the window and the programme at the end of the window.

It is recommended that other methodologies should only be considered if the documentary data is not available for a reliable Windows Analysis. In such instances, an As-Planned v As-Built methodology is recommended. Use of an Impacted As-Planned should only be used in the absence of as-built data, although this will compromise the reliability of the result. In a similar vein, the Collapsed As-built should only be used in the absence of a suitable plan, but again, its reliability may be questioned in a formal dispute arena.

The flow chart is as follows:

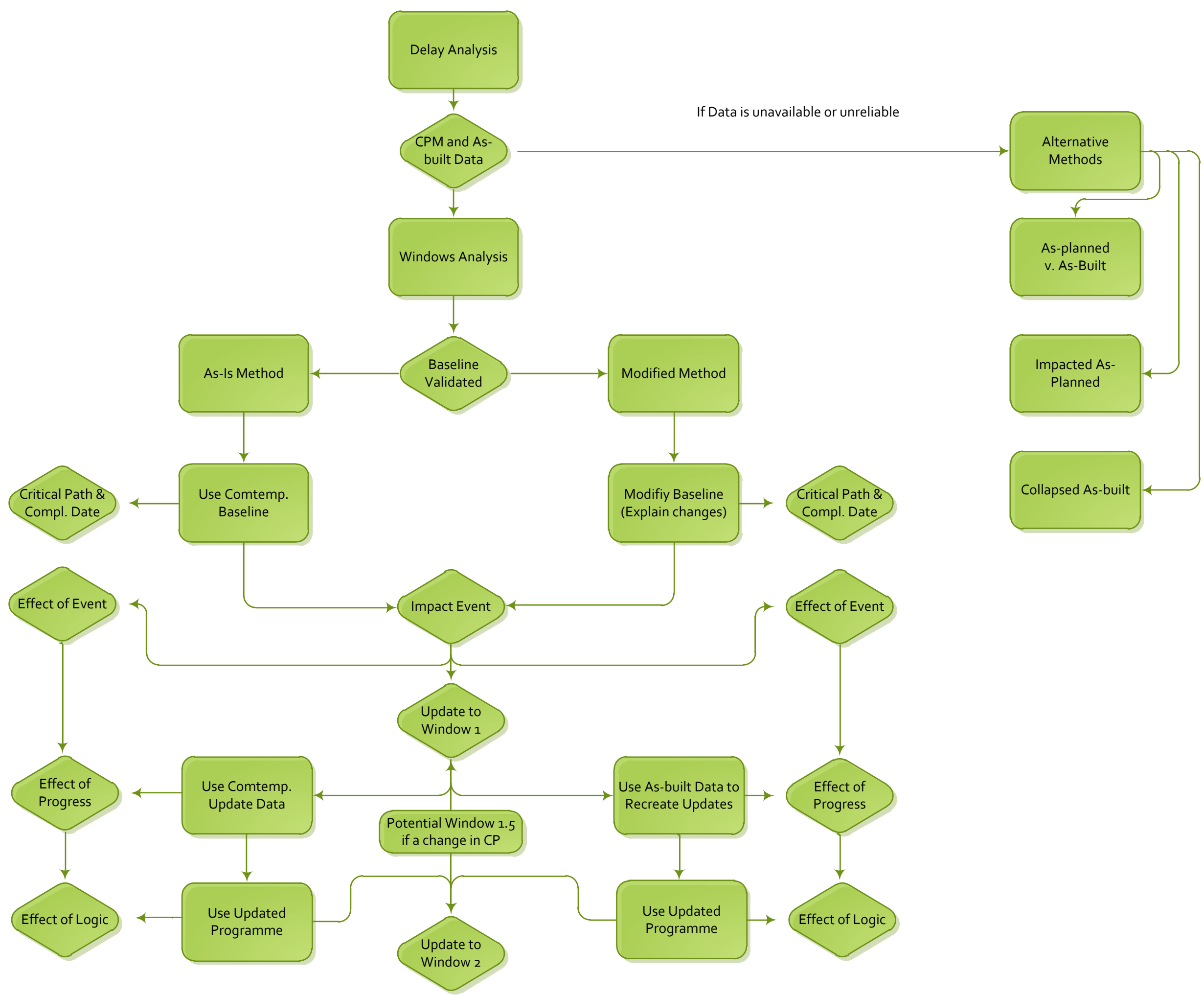

Figure 21 – Flow Chart of Recommended Delay Analysis (Author's Illustration)

9.2 Main Achievements and Contribution to Knowledge

The contribution of the research is two-fold.

For practitioners, it will increase their understanding of methods of delay analysis and their appropriateness. This is important, as the study shows that the choice of method is often dictated by lack of understanding of alternatives, or by ignorance of good practice regarding the collection of suitable data for the most appropriate method. From a review of the published data on this issue, five common methodologies exist for delay analysis:

- As-Planned v As-Built Analysis;
- Collapsed As-built Analysis;
- Time Impact Analysis;
- Impacted As-Planned Analysis; and
- Windows Analysis.

These are explained and discussed at **Chapter 4.3 to 4.7** above. Only three of the methods are capable of establishing actual (i.e. *retrospective*) delay as opposed to *prospective* delay. Of the above methods, these are:

- As-Planned v As-Built Analysis;
- Time Impact Analysis; and
- Windows Analysis.

Based on a review of case law related to delay analysis over the last 20 years, there has been a relatively recent shift in what is acceptable to the courts. This shift appears to have occurred between 2000 and 2002 and clearly shows the preference for methods that can best identify delays retrospectively.

It is unfortunate that the SCL Protocol was issued precisely at this time and that two of the four approaches that it identified (Impacted As-Planned Analysis and Time Impact Analysis) were *prospective* techniques. Despite findings by Ndekugri et al (2008) that Impacted As-Planned methodology, for example, was used successfully in practice, the present study has revealed that from 2002 onwards the courts have criticised such prospective techniques for being theoretical and not reflecting actual delay. In fact, since 2002, the courts have tended towards an analysis methodology that demonstrates actual delay, namely, Windows Analysis. Support, in the Protocol, for the two other methodologies may actually have increased confusion within the industry.

From an analysis of dispute related case studies, it was found that, of the various methodologies relied upon by delay analysis practitioners; the most selected methodology employed was a Windows Analysis methodology. Any variation from this methodology, once adopted, was in whether the analyst utilised contemporaneous updates or created updates based on contemporaneous progress data. This variation was driven by the availability or the perceived accuracy of the contemporaneous updates.

A more academic (albeit practically significant) contribution of this work is crystalized by the views of Judge Toulmin Q.C. CMG in Motherwell Bridge Construction (see above at **Chapter 5.3**) and the dissenting judgements in City Inn (see above at **Chapter 5.4**). It concerns the philosophical and jurisprudential basis of the EOT clause.

Although the main purpose of an EOT is to protect the employer's right to exercise liquidated damages, it does so by protecting the contractor from the levy of damages for delay caused by any client act of prevention. Other justifications for EOT may be present in the contract, for example, for pragmatic or economic reasons. When a delay event occurs, the act of prevention should be assessed in such a way as to put a party into the position he would have been but for the prevention. As the completion date itself is a forecast and liquidated damages is a pre-estimate, it seems sensible and right that the assessment of delay due to an event should also be a forecast. This suggests that purely in matters of delay, a prospective approach to the assessment of EOT is the correct one. While disputes concern only time, the superior logic of assessing EOT prospectively might well prevail. However, as identified earlier (**Chapter 7.1**), evidence from the 2008 CIOB review shows that the majority of delay claims include money as well as time. It appears that the courts cannot bring themselves to assess financial claims on the same prospective basis when a retrospective analysis can take into account what actually happened: the question being 'why guess when you can rely on the facts?'

9.3 Recommendations for Further Research

During the research period for this study a number of initiatives were announced that may have a further bearing on the issues under examination. Prompted by the findings of the CIOB study, (that the majority of respondents are unable to manage the effects of delay to progress, other than intuitively, and would have difficulties in preparing a reliable delay analysis to prove their entitlement to an EOT in a formal dispute arena) the new CIOB Contract (CIOB, 2013) places a heavy emphasis on the management of time within the project. This is further supported by publications aimed at improving the management of time on complex construction projects (CIOB., 2010). Study of the effect of this new contract once it has been implemented on multiple contracts may show an improvement in the frequency in the use of more reliable delay analysis techniques.

It has also been announced that the SCL are proposing an update to their Protocol. The findings of this research have been communicated to the authoring panel and this may expose some of the issues raised within it.

Finally, the case studies used in this research were for large value projects. A similar analysis based on smaller value projects may be appropriate, although proportionality, albeit an issue in delay analysis, is not the main obligation on a delay analysis expert, which is reliability in their overriding duty to the court.

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Yorkshire Dale Steamship v Minister of War Transport (1942) A.C. 691

APPENDIX A

E-Mail Exchange between Author and Society of Construction Law

From: Andrew Parry

To: SCL

Sent: 15 April 2015 15:55

Dear SCL,

As part of my doctoral studies into delay analysis methodologies, I have also been considering the guidance provided by the Protocol and contrasted that to research papers / case law / case studies. Based on my research I have identified the following points which you may wish to consider (and I am happy to explain these in greater detail if you consider it worthwhile):

1. Common Delay Analysis methodologies

The title of delay analysis methodologies is important, as it dictates Industry familiarity with the method. From my research it is widely understood that there are five common methodologies:

- *As-Planned v As-Built Analysis;*
- *Collapsed As-built Analysis;*
- *Time Impact Analysis;*
- *Impacted As-Planned Analysis; and*
- *Windows Analysis.*

It has been identified that Industry is not as aware of Time Impact Analysis and Windows Analysis as it is of IAP and AP v AB. Familiarity with the methods drives their use. Unless there is a strong need to revise the naming of the Windows Analysis methodology to "Time Slice Windows Analysis" then this should be avoided (also it seems redundant to have the term "Time Slice" and "Window").

I do not agree the Longest Path is a methodology in itself but is more likely considered a variant to the AP v AB.

2. Change in Common Law

My research also identified that the courts, since around 2004, have favoured actual delay over prospective delay. This supports the need to change the conceptual position that there can be an "entitlement" programme which may be divorced from reality. This will align with (i) the change in legal landscape; and (ii) the fact that *time claims are almost always accompanied with cost claims and there are clear disadvantages to having two potentially varying delay analysis: one for time and one for cost.*

This is a methodological issue. The recommended methodology should allow for assessment of the actual extent of delay, but its effect on completion can still be forecast at/near the time of the delay event (see Recommended Methodology below).

Removal of "considering the delay at the time of the delay event" does not affect this and therefore I do not support changing it. This guidance in the original protocol was generally sound (although going too far to make it only suitable for prospective analysis), as it reflected (i) the likelihood of the critical path changing and therefore assessing the delay against the critical path at the time; (ii) the need in Industry to provide a prospective analysis; (iii) the concept that the purpose of an EOT is to extend the time in which to complete the works within, rather than the actual time needed at the end of the Project; and (iv) the nature of programmes being a forecast tool and (at present) the best tool available to the contractor and employer.

It would assist Industry to know that it was acceptable to assess delays on a changing critical path, rather than solely the as-built path.

3. Guidelines on delay analysis time distant from the delay event

Conceptually it appears odd that a CA assessing delay contemporaneously is being encouraged to use a different approach than that which would be employed retrospectively. This may increase the incidence of disputes, as, by changing the method a different outcome is the implicit result.

4. Recommended Methodology

I think it key that the SCL provide a recommendation on the most reliable methodology (subject to the facts supporting the methodology). It is inappropriate, based on my review, to suggest there are options available for the parties to "choose a method" (see wording of Section 4.3). The reasoning in the first edition in this regard was sound: that it is better to have a standard and move Industry towards that standard. However I also agree that the TIA is not the appropriate method for a retrospective delay analysis. There are many advantages to supporting a standard (as understood in the first edition). The issue is which standard. From my research it seems a widely held view that Windows Analysis is the most appropriate method for retrospective analysis and by combining this with impacting, it is also suitable for prospective analysis.

In my view, the SCL should reconsider their position of not recommending a methodology as by making a recommendation it would likely increase the level of agreement on methodology (as aimed for in Section 4.13).

I agree on the explicit language of using common sense. This could be contextualised by stating "…and not wholly theoretical."

I hope this helps.

From: SCL

To: Andrew Parry

Sent: 30 June 2015 16:32

Dear Andrew

A belated thank you for providing feedback on the consultation draft of the rider to the SCL Delay & Disruption Protocol. The review committee has considered your helpful comments and those of all others who kindly provided feedback. As a result, some further amendments were made to the rider and the final version will be published on the SCL website shortly.

As you can appreciate, in producing the rider, it has been necessary to balance comments and viewpoints from numerous individuals. As a result, it may be that not all of your comments were incorporated into the final document (although, of course, they were considered and debated by the review committee).

We anticipate convening a seminar later in the year to discuss the amendments to the Protocol and, at that point, we can explain the rationale for including / not including certain comments from SCL members.

Thanks once again

APPENDIX B

Matrix of Case Study Results

Case Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
Project	1	1	2	2	3	4	4	5	5	6	7	7	8	8	9	9	10	10	11	11	12	12	13	14	18	18	23	**Total**
Expert	C	R	C	R	C	C	R	C	R	C	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	R	C	**0**
Methodology																												**0**
Window / Period Analysis	N	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N	Y	N	Y	**19**
Time Impact	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	**3**
As-Planned v As-Built	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	**2**
Impacted As-Planned	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**1**
Collapsed As-Built	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Other: As-Built	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	**1**
Other: Production Analysis	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**1**
Detailed Methodology																												
Uses Original Baseline	Y	Y	N	Y	N	N	Y	Y	Y	Y	N	N	Y	N	N	N	Y	N	Y	N	N	Y	Y	Y	N	N	N	**13**
Uses Modified Baseline	N	N	N	N	Y	Y	N	N	N	N	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	N	N	N	Y	N	Y	**12**
Solely uses Baseline	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**2**
Solely uses As-built	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	**2**
Uses contemporaneous updates	N	N	N	Y	N	N	Y	Y	N	N	N	N	N	Y	Y	Y	N	N	N	N	N	Y	N	N	N	N	N	**7**
Creates updates	Y	Y	N	N	Y	Y	N	N	Y	Y	N	Y	N	N	N	N	N	Y	Y	Y	Y	N	Y	N	Y	N	Y	**14**
Dynamic Modelling	Y	Y	N	N	Y	N	N	N	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	N	**15**
Static Modelling	N	N	Y	Y	N	Y	Y	Y	N	N	N	N	Y	Y	Y	N	Y	N	N	N	N	Y	N	N	N	Y	Y	**12**
Forward Looking	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	**23**
Reasons for Methodology																												
Complexity of the project	Y	Y	Y	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	**5**
The amount in dispute	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Size of project	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Duration of the project	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Nature of the delaying events	Y	N	N	N	N	Y	N	N	Y	N	Y	N	Y	N	N	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	**13**
The number of delaying events	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	**2**
The other party to the claim	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Updated programme availability	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y	**22**
Applicable legislation	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Type of contract	N	N	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**23**
Dispute resolution forum	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Nature of baseline programme	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**26**
Baseline programme availability	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**25**
Cost of using the technique	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**1**
Skills of the analyst	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Reason for the delay analysis	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**0**
Time of the delay	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**2**
Records availability	Y	Y	N	N	Y	Y	Y	N	Y	Y	Y	Y	N	N	N	N	Y	Y	N	N	Y	Y	Y	N	N	Y	N	**15**
Additional Reasons for Methodology																												
Baseline programme was not dynamic	N	N	Y	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**3**
High number of constraints in BL	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	**2**
Analysis of work-streams rather than	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	**1**
Contract required actual delay	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	**3**
Updates were not agreed and optimistic	N	N	N	N	N	Y	N	N	Y	Y	N	N	N	N	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	**6**
Missing evidence to RD therefore used %	N	N	N	N	Y	Y	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	**3**
Programmes updated to suit revised logic	N	N	N	N	Y	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N	N	N	N	N	**4**