Delay Analysis in
Construction Contracts
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Preface

Construction delay claims are a common occurrence in projects. When they arise they need to be evaluated quickly and managed efficiently. However, the whole topic of delay and the various analytical techniques available is one which provokes much debate and controversy due to the seemingly complex and sometimes conflicting guidance provided on these techniques. The purpose of this book is to serve as a practical guide to the process of delay evaluation and includes an in-depth review of the primary delay analysis methodologies available.

The chapters flow logically from an overview of construction programmes in Chapter 2 through to the identification and analysis of delays in Chapters 3 and 4. Due to the complexity of construction contracts and the varying levels of familiarity with programmes or delay analysis, problematic issues arise from time to time when preparing or reviewing claims for additional time. The more common problematic issues are reviewed in Chapter 5 followed by a commentary on some recommended presentation approaches and a case study in Chapter 6.

The views we express are based on combined experience of over fifty years working on a wide range of projects and dealing with programming and delay issues. In practice, most projects are delivered within acceptable time and cost parameters. However, when there is disagreement over the responsibility for unacceptable delays to project completion, major disputes can arise due to the failure to manage the impact of change, and claims for additional time, in a timely or effective manner during the course of the project. In these situations there is a requirement for reliable analysis and assessment of the delay impact which addresses qualitative, quantitative and entitlement perspectives to facilitate an agreement. Much of course turns on the selection and implementation of the most appropriate delay analysis technique. Currently there is little by way of formal instruction in the understanding and application of these techniques with many practitioners being self taught. Accordingly, one main purpose of this book is to assist those construction professionals responsible for assessing delays by way of explaining some of the underlying assumptions and difficulties that may be faced when using some of the more popular and widely used delay analysis techniques.

As we were trained and practised mainly in the UK and US construction industries respectively, we have sought to identify and include in this book best practice guidance from these countries. In addition, our experience gained
on major civil engineering, building and infrastructure projects around the world provided us with a broad perspective of the nature of delay analysis in practice, which in turn, we have reflected in the approaches and recommendations included in this text.

Delay analysis, which involves both the study and investigation of historic events, also entails assessing which of those events actually affected the completion of a project. This function is fundamental to the success of traditional construction management activity when potential delays must be identified and managed to prevent or reduce their impact on the project’s duration and out-turn cost. When carried out forensically, the process takes on a higher significance due to the accumulation of legal and consulting fees, interest on capital and other related costs as well as diversion of key management and operational staff. While forensic delay analysis may take on a higher relevance in the legal forum, it is important for construction and project management staff to familiarise themselves with the prevailing trends with regard to the use of critical path method (CPM) programming and project management software as well as recent case law relevant to delay claims and the recovery of time related damages. This should assist when attempting to settle negotiations over the impact of change, and unforeseen events, at the earliest opportunity.

Delay analysis is practised internationally, across multinational jurisdictions. We have refrained from including extensive commentary on case law or legal doctrines relevant to compensation for time related costs. With regard to project management and delay analysis terminology, we have tended, for consistency, to follow traditional UK terminology. For example, although ‘scheduling’ is the common term used in US CPM network analysis, the term scheduling traditionally has a different meaning in the UK. Although the term ‘scheduling’ is being used more widely for CPM applications in the UK, we have elected to use the terms ‘planning’ or ‘programming’ for consistency with prevailing UK guidance, texts, terminology and case law.

It is important to note that forensic delay analysis, like many technical fields requiring analysis, is a combination of science and art and requires many subjective decisions and assumptions by the analyst along the way. The methods described in this book do not represent every possible application of the techniques described nor does the book attempt to address every available technique. The appropriate method, and the appropriate application of that method, will depend largely on the circumstances and facts relevant to the case or project at hand. For example, deducing an as-built critical path cannot be computed using computer based CPM software alone and requires a diligent and objective analysis of the body of information available to the analyst. Any method of delay analysis used should be transparent, forward looking and, most importantly, consistent with and based on, a reliable body of factual evidence.

We are indebted to friends and colleagues in the fields of construction and law who through discussion, argument and general banter have contributed
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in the preparation of this work. We are also grateful to Julia Burden and her team at Wiley-Blackwell for their encouragement and guidance. Finally, last but not least, we thank our families who have patiently endured our absence and supported us most during the writing of this book.

John Keane
Tony Caletka
Chapter 1

Introduction

1.1 General

Construction represents a tenth of the UK Gross Domestic Product (GDP). Construction is a unique industry due to it being a fast moving, complex and dynamic process which depends on the successful coordination of multiple discrete business entities – including professionals, tradesmen, manufacturers, trade unions, investors, local authorities, specialist trade contractors, etc. to ensure the delivery of a project on time, within budget and of the required quality. This coordination is dependent upon the application of sound planning, programming and project controls, allied to the implementation of tried and tested management techniques. Much of this work is carried out using increasingly sophisticated computer applications that are continually advancing by offering more and more capabilities to the end user.

A survey\textsuperscript{1} carried out amongst UK contractors just over a decade ago found that 49\% of contractors did not use computers on construction site locations. Now not only are computers commonplace, but also the use of specialist planning software is common as is computer-aided delay analysis.

Risk is an inherent feature of construction and it is well known that ‘no construction project is risk free. Risk can be managed, minimised, shared, transferred, or accepted. It cannot be ignored.\textsuperscript{2} If it is accepted that risk is inherent in construction, then it must also be accepted that delays are also inherent in the process and should therefore be anticipated and managed and treated in a similar fashion as risk. When delays are experienced, this is not necessarily an indication that the process or management team is breaking down. Delays are often simply the result of an event which must be managed by a systematic process so as to anticipate the impact of that event on the programme, and to minimise the risk of further delay. Systematic management of delay during the course of the project also ensures that the cause of that delay is identified, and documented, at the earliest opportunity. When there is a requirement to identify the cause and effect of delay to establish entitlement to additional time or money, the results of any relevant analysis should be capable of being presented in a clear and unambiguous way.

\textsuperscript{1}P.J. Keane, 1994. \textit{Survey on Computer Usage in Construction Claims Management}.

\textsuperscript{2}Sir Michael Latham, 1994.
The most significant unanticipated cost in most construction projects is the financial impact associated with delay and disruption to the works. Assessing the impact of delay and disruption, and establishing a direct causal link from a delay event to effect, liability and the resulting damages, can be difficult and complex. Contractors and subcontractors require these skills for successful evaluation and presentation of time delay claims; the employer’s professional team require similar skills and techniques when analysing and evaluating extension of time entitlements under a construction contract. Where these delay issues are not resolved by the contract administrator and contractor in the normal commercial way, then such issues are often left to be decided by third parties in arbitration or adjudication, before dispute review boards or, ultimately, in litigation. All these steps along the dispute resolution hierarchy have different timetables and expectations regarding the evidence required to demonstrate cause and effect. In selecting the most appropriate technique to suit the project, the relevant facts, the timetable, the nature and number of delay events, as well as size of the potential dispute to ensure proportionality is maintained, must all be considered.

1.1.1 Purpose of this book

The purpose of this book is to provide a practical guide to the process of delay analysis for programmers and delay analysts, and to inform non-programmers of the nuances of delay analysis techniques available, the assumptions which underlie the precise calculations of a quantitative delay analysis, to level the playing field for non-programmers and experts alike. This entails an in-depth review of the primary methods of delay analysis in use today, along with some familiar secondary methods. The timing and purpose of delay analysis is also discussed together with a review of the fundamentals of critical path method (CPM) programming. The ‘project control cycle’ is also described in detail. Contemporaneous programming evidence, flawed or not, will usually be preferred to retrospectively created programme data, so the emphasis should be on establishing and maintaining an accurate and effective CPM programme throughout the performance of the works.

This book is intended for project and construction management practitioners, contract and legal advisors, and programming consultants alike, who not only seek an understanding of the principles, techniques and methodologies involved in the process of delay analysis, but also want to understand the techniques and underlying processes in some detail. Such individuals include those employed by project owners (employers), contractors/subcontractors, legal experts and consultants who often find the need to manage extension of time or delay claims.

The techniques discussed in the book can be used on projects under all forms of construction contract, both domestic and international. Disputes involving delay entitlement and quantification which have to be resolved by the inter-
vention of a third party trier of fact, are a frequent occurrence in the construction industry. Over the years, judicial decisions on several key aspects of delay dispute have been handed down by the courts, which have assisted, to some extent, in shaping the way in which delay analysis is undertaken in certain aspects. However, while the implications of these decisions clearly have a great bearing on the work of a delay analyst, it must be remembered that most, if not all, decisions regarding delay analysis are made not necessarily on the method of analysis, but rather on the underlying facts presented and relied upon.

The courts are only presented with delay issues after the event, and therefore decisions handed down mainly provide guidance on retrospective delay analysis techniques which demand, and rely upon, a high level of accuracy and detail with regard to the as-built programme. Notwithstanding the influence of the courts on the process of developing claims for delay and disruption, in order to accord with the ethos of this book, and the actual circumstances and facts many construction professionals find themselves managing, the authors have restricted the use of case law references to a minimum; for instance, where a principle has clearly been established and is commonly referred to in delay claims. Where cases have been referred to this has not been restricted to English case law but also includes a small number of significant US cases which are relevant to topics addressed. The US courts have accepted the concept of CPM programming and computer generated delay analysis submissions since the early 1970s. The English courts appear to lean in the direction of ‘common sense’, whereby the method of analysis is secondary, whether CPM programming techniques were relied upon or not.

It is important that a delay analyst should not become blinkered or be constrained by past judicial decisions in devising and applying delay analysis techniques prospectively in a live project environment. If a delay analyst adopts an unorthodox approach which is acceptable by both parties and resolves a time entitlement claim, then that is to be commended. In the same vein it is important not to get too hung up on ‘named’ approaches; this is largely another spin-off from judicial involvement in the development of delay analysis. Such named approaches include ‘time impact analysis’, ‘as-planned versus as-built’ and ‘collapsed as-built’. These names really only start to have any significance when used as expert evidence to provide a general indication of the approach being adopted by the delay analyst. Even so, there has been little guidance, until recently, as to how each method should be carried out. The primary named methods are often misused in court proceedings, arbitrations and adjudications.

Court decisions and arbitral awards sometimes indicate either a lack of willingness to come to grips with the issues and terminology or a difficulty in fully grasping the intricacies of sophisticated delay analyses. This is entirely understandable as judges are not usually presented with easy issues. The complexity of even the simplest of construction processes often proves to be extremely difficult to convey. Also courts, along with parties’ legal advisers,
are not always assisted by delay analysts who misdescribe or misapply these techniques and opposing experts who do not take one another’s approach ‘head on’. When two opposing party appointed experts refuse to engage the other’s method of analysis, this leaves a void where agreed programming evidence should be. These cases often conclude by the tribunal making an assessment based on the facts.

In summary, it is somewhat arbitrary to ‘badge’ and thereby restrict a piece of analysis, and while reference is made in this book to the primary delay analysis approaches, the authors urge caution in becoming too prescriptive because even these primary methods have secondary derivatives and many variations as to how they can be carried out. Also for this reason the authors have restricted the use of case law references to a minimum, to allow the site-based practitioner to make informed judgement calls when developing a delay claim rather than simply discounting one method of delay analysis over another, based on his or her understanding of the latest judicial decision mentioning a method of delay analysis being applied by either party.

This book discusses delay analysis techniques and approaches, with their appropriateness under given circumstances, and demonstrates how a combined, or hybrid, approach can be applied, complete with worked examples and case studies. Delay analysis is becoming an increasingly complex activity and there is continual debate and commentary on the primary approaches available. This book brings together the main techniques available in comprehensive primary and secondary categories. The particular techniques described in this book have been successfully tried and tested by the authors in both the commercial environment and in dispute resolution proceedings: adjudication, arbitration, dispute review boards and litigation. This book will serve as a resource guide for those practitioners, advisors, clients or contractors preparing or responding to construction delay claims.

1.1.2 Guidance

Two major guides have been produced on both sides of the Atlantic to assist those dealing with time extension claims and delay analysis. The first was the Society of Construction Law’s Delay and Disruption Protocol, published by the Society in October 2002 (SCL Protocol). The stated aim of the SCL Protocol is to provide useful guidance on some of the common issues that arise on construction contracts, where one party wishes to recover from another an extension of time and/or compensation for the additional time spent and the resources used to complete the project. The second more recent guide was published by the Association for the Advancement of Cost Engineering International (AACEI) in the form of its ‘Recommended Practice No. 29R-03

3 The SCL protocol can be downloaded from www.eotprotocol.com.
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Forensic Schedule Analysis (RP-FSA). This document, issued on 1 July 2007 was officially launched on 15 July 2007. The RP-FSA is primarily focused on the terminology and the application of forensic analysis and is a much more technical document than the SCL Protocol, although it does not address as broad a spectrum as the Protocol. The stated purpose of the RP-FSA is to provide a unifying technical reference for the forensic application of CPM scheduling and to reduce the degree of subjectivity involved in the current ‘state of the art’ concept while the state of the art in the US differs from the state of the art in England. Both of these documents are discussed and contrasted in Chapter 4.

1.1.3 Construction planning and programming

Most construction projects will benefit from CPM programming. Only the most basic of projects can and should be planned and managed intuitively. The rest require systematic planning and control. Over the past 30 years planning and programming have been fundamental building blocks in any project management and control system and, in some organisations, are given equal weight and importance as the budget and cost management.

CPM is the planning technique most commonly used in the construction industry today, and is based on the same critical path analysis principles established in the 1950s. In Chapter 2 the principles of construction planning and programming are explained. These techniques are fundamental in enabling a project to be successfully managed. CPM programming is a tried and tested method and is today essentially unchanged from the earliest applications almost 50 years ago. The chapter describes the essential elements of a successful project through the planning and programming phase and identifies the pre-construction tasks which are not only prerequisites to effectively planning a project but conversely in the case of insufficient pre-construction planning can result in programmes being developed which contain inherent delays.

The stages and lifecycle of a construction project are described in detail. The project planning stage is the most important to the development of an effective baseline programme. During the planning stage, the project definition is established. Executing a successful project requires a significant pre-construction effort which questions the underlying assumptions and business case for the project. During this stage the professional team considers such issues as whether a project is feasible and buildable, whether any new or novel method of construction will be required, and whether there are technical, geographical, time and/or financial constraints which would prevent the success of the project.

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4 Association for the Advancement of Cost Engineering International – Recommended Practice No. 29R-03 Forensic Schedule Analysis.
The chapter also discusses the process of preparing a construction programme, the creation of a work breakdown structure, and the fundamentals of CPM programming.

A significant aspect of delay analysis is the interrogation of records upon which reliance will be placed in analysis output. Accordingly, the need for good records and the various categories of required record keeping are explained. Finally, there is a cautionary note on predatory programming practices which should be avoided, along with advice as to how to detect and defend against each.

1.2 Construction delays

1.2.1 Identifying delays

The identification and assessment of delay entitlement can be difficult and time consuming. When any degree of complexity is introduced to the mix it can become particularly difficult for project staff who are over-worked while dealing with site issues and other project pressures, and who may be untrained in forensic analysis or programming skills. This often manifests itself as a poor strike rate in achieving extensions of time entitlements by contractors, or, when the employer’s team lacks these skills and awareness, a record of granting excessive extensions of time to contractors. To be successful, a time extension claim should adequately establish causation and liability and assist in demonstrating the extent of time-related damages or disruption costs experienced as a direct result of the delay events relied upon. The purpose of delay analysis is to satisfy the causation requirement in such a way that it can be used to assess the resulting damages.

Establishing a basis for identifying delay is the first topic dealt with in Chapter 3, which also deals with the construction phase of a project that is generally where the bulk of a project budget is dedicated. The construction phase is also the phase in which design delays, or lack of sufficient pre-construction planning, will often culminate into critical delays to completion, as measured by delays to site activities.

Delays may be categorised as excusable, non-excusable, compensable and non-compensable. When demonstrating that a delay is both excusable and compensable, the delay must be shown to be critical, by reference to a reliable critical path analysis. The tests which must be satisfied for a delay to be considered excusable and compensable are described and discussed in Chapter 3.

The carrying out of a successful delay analysis requires the preparation of a reliable as-planned programme and an accurate as-built programme. The effectiveness of delay analysis techniques can be greatly increased when it can be demonstrated that the as-planned programme was reasonable. Further discussion on as-planned programmes is also to be found in Chapter 2. The as-planned or baseline programme is useful contemporaneous evidence of a contractor’s original intentions, and should serve as the starting point when
identifying delays. Unfortunately there are many ways in which as-planned and progress programmes can be manipulated. Chapter 3 highlights checks that should be made to validate the reliability of such a programme before it should be used for any method of delay analysis.

One of the main objectives of delay analysis is the establishment of a factual matrix and a chronology of the events which actually delayed the work’s completion date. One important use of this data is to assist in the preparation and/or validation of an as-built programme. In the ideal situation, an as-built programme will have been prepared and maintained during the course of the works. The data required to periodically maintain and update a project programme can also be relied upon when forensically constructing an as-built programme. The primary sources of raw data required for the compilation of an as-built programme are discussed in Chapter 3, together with a cautionary note about the use of lazy scheduling practices, such as the overuse of constraints, negative lags, and ‘auto update’ functions which can be found in commercially available planning software.

The process of identifying delay events is a fundamental aspect of delay analysis and can be undertaken in two primary ways: either an ‘effect-based’ approach or a ‘cause-based’ one. Both of these are explained in Chapter 3, along with a discussion on contractor and employer risk events.

While this book is principally concerned with delay analysis, it is inevitable that the issue of disruption will have to be dealt with to some extent. Chapter 3 is confined to a general overview of disruption, particularly its interface with delay analysis. In the construction industry, delay and disruption are two terms that are often used in the same breath. This is understandable as delay and disruption often result from the same events. However, disruption, unlike delay, always has a direct consequence on financial loss. The main differences between delay and disruption are discussed, together with a review of the many causes of disruption, and factors that affect productivity. An example of calculating disruption is illustrated.

If there is no agreed model or method for quantifying the effects of disruption factors in advance, the establishment of the magnitude of the disruption or loss incurred will likely require the preparation of expert evidence. Accordingly a number of approaches have been developed which include, the measured mile, measured productivity method, work sampling, modified total cost approach, and site sampling (time and motion studies). These are discussed along with brief practical examples which are provided to assist in demonstrating the process of each type of analysis.

1.2.2 Analysing construction delays

The effect of delay and disruption can be identified and assessed using several dissimilar techniques. There is much discussion about the various approaches to delay analysis along with explanations as to why it should not be surprising when two opposing programming experts can apply the same technique
and produce widely varying and inconsistent conclusions. Delay analysis techniques are known by many generic titles and each method can be applied in several ways. The most widely known methods of delay analysis are subject to frequent misuse; but the name applied to a technique is not as important as the application of the chosen method. All commonly applied forensic delay analysis techniques generally fit within one of the following primary categories: impacted as-planned, collapsed as-built, as-planned versus as-built, and time impact analysis.

The ‘windows’ method is also described in detail, using several of the primary methods listed above. The term ‘windows’ simply refers to the period of time being analysed. When key milestones are relied on, the same approach is sometimes referred to as ‘watershed’ analysis. Each of these primary delay analysis techniques has secondary derivative methods of application, which may be used in prospective or retrospective settings. All of these named techniques are fully explained in Chapter 4, which also not only explains how to carry out and present several secondary derivative methods, but also contrasts the strengths and weaknesses of each method and considers the underlying assumptions the analyst must make when using any of these techniques. The four primary methods of delay analysis are also reviewed in detail in Chapter 4, complete with a step-by-step guide to their usage and an indication of some secondary approaches which can be derived from each of these primary approaches.

The chapter also explores the use of CPM and total float management techniques relative to delay analysis. CPM programming is essential when attempting to identify which activities are either critical or non-critical. The CPM programme is therefore the key to demonstrating those events which actually contributed to the critical delay to completion and those which may be deemed merely concurrent ‘events’. The concept of ‘pacing’ is also explained in detail. In the US courts the use of CPM programmes to demonstrate delay has been a requirement for some years, to the point where delay analysis in US courts almost exclusively rely on delay analyses which used CPM methods of proving entitlement.

There are many names used in the construction industry for the ‘time impact analysis’ (TIA) approach, probably because there are as many ways to apply the technique. A summary of the perceived strengths and weaknesses of the TIA technique are summarised in Chapter 4, along with many of the variations and options available to the analyst when carrying out this technique.

The ‘collapsed as-built’ (CAB) approach is a modelling technique which is traditionally carried out on a single-base programme, e.g. the as-built programme. The other side of the spectrum of the basic methods of analysis include as-built based analytical techniques which do not rely on calculated CPM models. In its simplest form, an as-built versus as-planned analysis compares the planned duration with the actual duration of a project and asserts the difference as being both excusable and compensable. These are referred to as ‘Observational’ in the AACEI RP-FSA.
On projects where the effects of acceleration (or attempted acceleration) or early completion programmes are at issue, it advisable to apply both a deterministic technique and an analytical technique, which is explained in Chapter 4. This provides a tribunal with a range of opinions, based on different assumptions.

The contemporaneous windows analysis is a technique which relies on the analysis of contemporaneous progress information and is considered to be dynamic because it considers the dynamic nature of the critical path. The as-built critical path of a programme shifts from time to time for many reasons as explained in Chapter 4.

A similar method to the contemporaneous windows analysis is the ‘month-to-month update’ analysis, whereby the progress achieved in one month, is superimposed on a previous month’s programme update. This is a method which discretely determines the loss/gain experienced due to both progress achieved/not achieved, and programming revisions made by the contractor. This is a form of ‘what if’ analysis, which identifies and isolates delays caused purely by progress, from delays (or gains) which resulted from changed logic, constraints or durations. This method of analysis is very effective when a contractor is seeking to demonstrate acceleration and needs to demonstrate what the ‘likely’ effect of a delay event would have been, as opposed to the ‘actual’ effect. The case study in Chapter 6 applies this technique in a worked example.

Determining which technique is the most appropriate to use under given circumstances is a subjective decision, guided by experience, the available information, and other relevant factors. Even when agreement is reached between the parties, often the application of the same ‘technique’ varies to such an extent that neither party is willing to accept the other’s conclusions. These issues have been addressed in both the SCL Protocol and the RP-FSA. Chapter 4 provides detail of the SCL Protocol and the 21 core principles. The approach to event analysis and delay quantification must be both systematic and pragmatic. Notwithstanding the importance of this activity, it is also essential to keep a sense of balance with regard to what is a proportionate cost to benefit ratio and to avoid overly complex analyses. These may be accurate, or precise, but may not be intuitive, at the risk of conflicting with a tribunal’s view of ‘common sense’. While courts have judicial latitude, contractors and contract administrators cannot be seen to base extensions of time on impressionistic assessments. The methods set out in Chapter 4 will assist parties in arriving at an approach that is pragmatic, systematic, and appropriate for the circumstances of their project.

1.2.3 Delay claim life cycle

Each and every delay claim has its own life cycle. The various stages may be summarised as follows:
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• Baseline programme is established
• Project commences
• Deviation from baseline programme is identified (or projected)
• Delay occurrence/discovery
• Delay analysis
• Delay claim submission and presentation
• Delay claim response
• Negotiations (and award of appropriate extension of time)
• Revised baseline programme is established and agreed
• Dispute resolution procedures (if award is not agreed)
• Delay claim resolution

Delay claims are a very effective way to spend money and divert management resource from running a business. Resolution by way of a mutually acceptable extension of time should be sought at the earliest opportunity to avoid the dispute stepping up to the next, more formal process. There are many pitfalls on the path to a successful delay claim resolution as well as steps that can be taken to improve the outcome; for example, the agreeing of delay impacts contemporaneously (i.e. as they arise during the course of the project works) rather than adopting a ‘wait and see’ approach. Chapter 5 considers a number of problematic issues which arise in connection with both programming and delay analysis. These include problematic issues related to the ownership of float in construction programmes, concurrency, programme submission and approvals, acceleration, disruption and mitigation of delay.

Effective communication of sophisticated delay analysis requires quality in the presentation. There are many ways to present similar facts with different conclusions. The benefits of visual aids with worked examples are explained in Chapter 6, together with methods of graphical presentation that are described and critiqued. In addition, a number of worked examples are included and case studies explained.

1.3 Burning issues in delay analysis

Chapter 5 discusses a number of problematic issues which have arisen in connection with both programming and delay analysis. These include:

• issues related to the ownership of float in construction programmes;
• concurrency;
• programme approvals;
• mitigation;
• acceleration;
• pacing;
• contractors’ entitlement to early completion; and
• the assessment of disruption damages.
Float is an integral part of CPM programming and delay analysis. The concept of float, which has given rise to much debate, is introduced in Chapter 2 and further explained in Chapter 4. In Chapter 5, float is discussed in detail, relative to its usage, measurement and ownership. Float loss can reduce a contractor’s contingency time cushion and increases the probability of critical delay to the project. Even where it doesn’t result in critical delay, float loss can cause financial loss to discrete task related resources. Chapter 5 discusses float loss measurement and also ways in which both employers and contractors can seek to influence a programme, and ways in which planners can manipulate float using various float suppression techniques. An issue of much debate for many years is ‘who owns the float in a construction programme?’; the implication being that the owner of the float has exclusive use of it. Chapter 5 reviews the various viewpoints on this matter.

Another common problematic issue which arises in the delay analysis is that of dealing with, and defining, concurrent events and concurrent delay. The uncertainty as to how concurrent delay should be managed or defined continues to cause difficulty to contract administrators, in particular in their task of assessing extensions of time and compensation events during the course of a project.

These issues impact both on the level of extension of time that might or might not be granted, and also on the amount of compensation, for example loss and/or expense, that might be due. Chapter 5 reviews definitions of concurrency, and considers alternative approaches for dealing with concurrent delay, including: ‘first-in-line’, the dominant cause approach, and the apportionment approach. When concurrent culpable delays are identified by the employer, contractors often argue that it was simply ‘pacing the work.’ This concept is discussed, including how it might apply equally to the employer’s professional team as well as to contractors.

Another area of potential difficulty is that of programme approvals and onerous specifications. Many of the major building and civil engineering forms of contract require the contractor to prepare and submit a construction programme. The content and standard of construction programming data that employers have required to be submitted by contractors in the past has varied quite considerably. However, in more recent times, with the advances in computer generated output and a growing awareness of the nature of construction planning, employers have been requesting ever increasing detailed and sophisticated programmes from contractors. In the US, particularly on government forms of contract, it is a more common practice to require quite detailed and sophisticated programme requirements. These issues together with approval or acceptance of construction programmes are discussed in Chapter 5.

The final issues reviewed under this chapter are those of delay mitigation, acceleration and contractors’ rights to early completion. The latter topic is when a contractor submits a programme which indicates an intention to finish a project earlier than the agreed contract completion date.
1.4 Presentation and case study

Effective communication of sophisticated delay analysis requires quality and sufficient level of detail in the presentation. It has been established that people usually understand and retain information at a much higher rate when it is presented to them visually. Studies in the US have shown that jurors, for example, retain as little as 10% to 20% of the material presented to them orally yet retain as much as 65% to 80% of material presented to them visually or with visual supplements. The effect of using high-impact, demonstrative evidence assists greatly in the success of a case which includes complex technical issues. There are many ways to present similar facts with different conclusions. The benefits of visual aids with worked examples are explained in Chapter 6 together with methods of graphical presentation which are described and critiqued.

In addition in Chapter 6, various methods of delay analysis are demonstrated using a case study, largely based on actual assignments. The information available on the case study project is listed and the method of identifying the as-built critical path is described in detail. The purpose of this chapter is to show how these methods of delay analysis may be carried out. It is important to note that the methodology demonstrated in this case study is not the only method, nor the only variant on the method demonstrated, for carrying out this type of delay analysis.
Chapter 2
Construction Programmes

2.1 Introduction

2.1.1 Planning, programming and project controls

In this chapter the principles of construction planning and programming are explained with a review of the merits of the main planning techniques currently in use in the industry. All but the smallest of projects require systematic planning, particularly due to the nature of construction projects. These are often one-off productions, on a site where few if any production facilities exist, with an array of trade contractors marshalled together and to be coordinated with material, plant and services providers. Each project effectively brings the factory to the job and each is different; from the location, to the design, to the participants. Each project requires customised, systematic coordination to avoid delays and cost over-runs.

Planning as a systematic function is a principle cornerstone of effective construction management. In the past, construction planning was something of a Cinderella activity, not entirely recognised as an important discipline in its own right. This all changed with the development of economically available personal computing power in the mid 1980s. Prior to this, construction planning was a time consuming and limited manual process, often most recognisable in the form of bar charts (or Gantt charts) posted like wallpaper in site conference rooms. Due to the effort required to edit, update or re-plan the works manually, these often remained posted, yellowed and faded, without an updated programme or as-built record of progress in sight.

It is difficult to envisage a project involving design, engineering, procurement, and/or construction which would not benefit from some form of critical path method programming or scheduling. Whilst few relatively simple projects may still be planned and managed intuitively, the rest require systematic planning and control. Construction planning and programming have come to the foreground of project management and control systems. In some organisations construction planning effort is treated on par with the financial elements of the project control cycle. Historically, planning was considered to be primarily a supporting activity, usually most relevant in the tender phase of a project. Little attention was paid to the project planner (if there was a dedicated planner) and the programmes, updated or not, were referred to very little (if at all) during the remaining life cycle of a project.
Delay Analysis in Construction Contracts

It is widely accepted among design and construction professionals that critical path analysis is the most appropriate tool for the management of complex construction projects and is at the heart of any functional project control system. The most commonly used planning technique based on critical path analysis principles is the critical path method or CPM. Many derivatives of the CPM approach have been developed, and it is still an evolving standard with some advances made in software and management theories, such as the application of the theory of constraints (TOC), the critical chain method (CCM), the use of probabilistic branching, the enhanced precedence diagramming method (EPDM) and Last Planner programming techniques. All of these derivative applications have their foundation in the basic principals of CPM which were developed some 50 years ago.

This chapter describes the tools required to enable a project to be successfully planned, programmed and controlled using CPM philosophies. These are tried and tested methods that have worked for the past 50 years and are today essentially unchanged from the earliest applications. The advancement in the development of computer hardware and processing speeds, together with the availability of low cost, easy, user-friendly software, have encouraged the widespread adoption of CPM based project control systems. These systems track and correlate cost and resource information with the planned and actual progress of work. Control systems and critical path programming, when developed hand-in-hand, assist project executives to decide what progress information is important to decision making during the course of a project. Where required they also assist courts in allocating damages to parties involved in construction related litigation.

Other forms of planning are also reviewed, from the traditional and still widely used bar chart to the more specialist applications such as line of balance charts and mass haul diagrams. The project control cycle (PCC) entails the entire effort involved in creating, monitoring and managing change to both the cost and time elements of a project. The main functions which make up the PCC include planning, programming and control, as follows:

**Planning:** define project, determine scope, set overall duration, budget, contingencies, identify risks and overall project goals.

**Project programming or scheduling:** identify individual tasks, assign resources and budgets to each, create a baseline which determines the earliest and latest allowable start and finish times for each activity, the available float to each activity, and the critical path through the project.

**Project control:** update project programme, monitor progress against the baseline for both cost and schedule performance, measure and manage the effects of progress, delays or changes (re-assigning resources and re-scheduling tasks as required to maintain progress).

The nuances between the terms ‘planning’, ‘programming’, and ‘controlling’ a project are clear once the process of project management and the stages of a project’s life cycle are clearly defined. Project management is not simply the
process of managing a project on site but much more. In a code of practice produced by the Chartered Institute of Building\(^1\) the project management function is defined as:

‘the overall planning, coordination and control of a project from inception to completion aimed at meeting a Client’s requirements in order to produce a functionally and financially viable project that will be completed on time within authorised cost and to the required quality standards.’

Project managers require a skill-set gained through education, training, experience and, where relevant, professional certification. In addition, a maturity of expertise is required to lead a team by guidance, mentoring and, most of all, by example. These skills ensure that a rational, systematic process of decision making is established to achieve the delivery of a defined project on time, within budget and to the specification or defined use intended. Each stage of a project requires the commitment and dedication of the professional team as all parties are essential to the successful outcome of a construction project.

The tasks described as ‘planning’, ‘programming’ and ‘control’ should not be confused with the traditional project life-cycle stages, as follows:

- Concept
- Feasibility
- Realisation
- Operation
- Termination

The task of planning a project takes place during the conception and feasibility phases, while programming and control are undertaken during the realisation phase. Realisation typically includes several individual phases, including design, procurement, construction, commissioning and hand-over. Factors for a successful project usually include an effective and well coordinated effort during the concept and feasibility phases which in turn result in realistic estimates, contingencies and time scales for completing all of the above phases. Likewise, projects that fail can often be linked to a failure to understand potential risks during the concept and feasibility phases, when the contractor is creating its baseline estimates and programmes.

### 2.1.2 Elements of a successful project

Simply put, for a project to be capable of being managed, it must have a beginning, a middle and an end. If there are no clearly defined aspirations, along with a clear definition of the project and completion criteria, uncertainty will

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prevail and the likelihood of arriving at an intended completion date on time will be reduced.

For a project to be capable of being planned, programmed and controlled, it must have the following elements:

- a clear definition of project;
- an appropriate staff level and experience;
- a pre-estimate of cost and time;
- identified risk contingencies (cost and time);
- each phase broken into manageable tasks;
- a formal change procedure established; and
- clear completion criteria agreed.

It is essential that all these elements are addressed prior to, or during, the planning stage, which is described in the following section.

2.2 Planning and programming

Before the planning process can commence, various pre-planning tasks should be carried out. These comprise setting the goals, objectives, constraints and aspirations which will define failure or success upon completion. Establishing a project owner or employer’s requirements and testing the business case for a desired project are all part of the ‘pre-planning’ phase. Any changes made to the project definition, once these goals are set and communicated through the employer’s requirements or contract documents, are disproportionately more expensive than changes made during the planning and programming phase. The pre-planning tasks which are prerequisites to effectively planning a project include:

- defining the purpose and goal of the project;
- defining all project stakeholders and their competing aspirations;
- identifying funding sources;
- identifying means for project delivery;
- establishing conceptual estimates and cost/benefit analyses;
- establishing conceptual summary programmes (milestones);
- defining risks and go/no-go criteria;
- selection of site;
- definition of professional team roles;
- development of schematic and preliminary design;
- preparation of contract documentation (including drawings and specifications);
- preparation of project management plan; and
- definition of project scope, milestones, duration and budget.
These tasks are not often coordinated and programmed to the same extent that construction tasks are but they are just as important, if not more so, to the successful outcome of the project. When project management principles are used to manage the above tasks pre-construction services are more efficient and transparent. A properly managed pre-construction phase can substantially reduce the risk of any unforeseen or unallocated scope emerging which was not clearly assigned to a work package or a member of the employer’s professional team.

While traditional delay analysis approaches tend to focus on the design and construction phase, delays and inefficiencies can often result due to circumstances which occur long before the first drawing is produced. Although these early factors are more difficult to identify as delay ‘events’, typical factors which can result in programmes containing inherent delays before the first delay event culminates on-site include:

- poor project definition;
- use of an inappropriate form of contract;
- inappropriate contract packaging strategy;
- ambiguities present in specifications, contract drawings, bills, employer’s requirements;
- the appointment of inexperienced managers and supervisors;
- insufficient budget allowances or contingencies (e.g. cost and time) for unforeseen events and design development;
- poor plant selection;
- failure to communicate plans/intentions to local authorities;
- ineffective site logistics planning; and/or
- incorrect assumptions regarding neighbouring sites, land-owners or other interested stakeholders.

Any of these risks can add unnecessary hurdles while contributing to a breakdown in project execution. Examples of the above factors can be identified, but pin-pointing the impact of each, or any combination of one or more, often proves difficult.

2.2.1 Project planning

The project planning stage is the most important aspect of defining and executing a successful project. In order to adequately plan the work, the input and coordination of the employer’s professional team is necessary. In addition planning often also requires the input of specialist trade contractors who must be engaged early in the planning stage to assist in the completion of design elements or specification of products, materials and any novel means (or methods) of construction which are being considered by the professional team. Commercial decisions and financial commitments have to be made by the