Understanding construction delay analysis – the role of pre-construction programming

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Abstract

Modern construction projects commonly suffer from delay in their completions. The resolution of time and cost claims consequently flowing from such delays continues to remain a difficult undertaking for all project parties. A common approach often relied on by contractors and their employers (or their representatives) to resolve this matter involves applying various delay analysis techniques, which are all based on construction programmes originally developed for managing the project. However, evidence from literature suggests that the reliability of these techniques in ensuring successful claims resolution are often undermined by the nature and quality of the underlying programme used. As part of a wider research carried out on delay and disruption analysis in practice, this paper reports on an aspect of the study aimed at exploring pre-construction stage programming issues that affect delay claims resolutions. This aspect is based on an in-depth interview with experienced construction planning engineers in the UK, conducted after an initial large-scale survey on delay and disruption techniques usage. Summary of key findings and conclusions include: (1) Most contractors prefer to use linked bar chart format for their baseline programmes over conventional CPM networks. (2) Baseline programmes are developed using planning software packages, with the most popular software being *CS Project*, followed by *Power Project* and then *MS Project*. The latter pose difficulties when employed for most delay analysis techniques, except for simpler ones. (3) Manpower loading graphs are not commonly developed as part of the main deliverables during pre-construction stage planning. As a result, most programmes are not subjected to resource loading and leveling for them to accurately reflect planned resource usage on site. This practice has detrimental

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effects on the reliability of baseline programmes in their use for resolving delay claims; (4) Baseline programme development involves many different experts within construction organisations as expected, but with very little involvement of the employer or its representative. Active client involvement is however quite important as it would facilitate quick programme approval/acceptance before construction, a necessary requirement for early delay claims settlement, which otherwise are often left unresolved long after the delaying events with the potential of generating into expensive disputes. The study results provide a better understanding of the key issues that need attention if improvements are to be made in delay claim resolutions. Additional research focusing on the testing of these results using a much larger sample and rigorous statistical analysis for generalization purposes would be helpful in advancing the limited knowledge of this subject matter.

Keywords: Claims, delay and disruption, planning and programming, extensions of time, delay damages, scheduling.

Introduction

Delay in the completion of projects has become an endemic feature of the construction industry as highlighted consistently over the years in various studies (Harris and Scott, 2001; Scott and Harris, 2004; Arditi and Pattanakitchamroon, 2006). The traditional approach to dealing with the risk of delays involves making provisions in construction contracts as to how delay issues are to be resolved amicably among contracting parties. Such provisions enable the contractor to recover from the employer, in the event of delays arising from events over which the latter is responsible, an extension of time and/or compensation for the resulting additional time and cost expended. Conversely, there are also liquidated or actual damages provisions by which contractors are to compensate employers in the event of delays from events over which the former bears the risks involved. Weather a delay qualifies as a basis for an extension of time, compensation or liquidated damages is a matter of risk allocation between the contractor and the employer, as defined in the contract (Zack, 1995; Pickavance, 2010).

In spite of the contractual provisions for dealing with delays, contracting parties often run into difficulties in unravelling what constitutes the real cause (s) of the delay and how much of it is attributable to each party, for purposes of deciding on the right time and/or cost compensations accordingly. Review of the literature suggests that the significant factors responsible for this difficulty can be narrowed down into two main issues. First, there is the issue of contractual related problems in the form of incomplete or ambiguous contract documents (Thomas, et al., 1994; Al-Najjar, 1995, Yates and Hardcastle, 2003) and unfair risk allocation in contracts (Jannadia et al. 2000; Pickavance, 2005, p.16). These issues have however continued to remain quite challenging to resolve effectively (Al-Najjar, 1995; Bajari et al., 2007), partly due to employers' inability to fully and adequately address all possible uncertainties within their contract documents (Ibbs and Ashley, 1987; Thomas, et al., 1994; Walker and Pryke, 2010). The second issue relates to inadequate or lack of necessary information to support the entitlement and quantification of claims made (Jergeas and Hartman, 1994; Kangari, 1995; Vidogah and Ndekugri, 1998). This latter issue is relatively less difficult to deal with than the former, through for example embarking on improvements in information management systems of construction organisations. An important source of the information required is the development and maintenance of construction programmes. In particular, the critical path method (CPM) form of programme, which is now a key requirement for the analysis of delay claims (Wickwire et al, 1989; Kallo, 1996, Wickwire and Groff, 2004). Advances in computers and the rapid development of powerful programming software over the years have made it practicable for far more rigorous analysis to be undertaken than hitherto was the case. However, whilst the ease of running the analysis has increased as a result, so has the accuracy of programmes decrease (Sreet, 2000; Korman and Daniel, 2003; Lucas, 2009). Many practitioners have thus expressed misgivings about contractors' programmes (Mace 1990; Revay, 2000; Owens, 2003; Kursave, 2003; Carmichael and Murray, 2006; Lucas, 2009), criticizing them of often being poorly prepared and also not managed effectively during the project. Programmes with such deficiencies do not constitute a valid basis for delay claims assessment and would produce results that are deceivingly inaccurate, which is a major source of the disputes surrounding claims settlement (Pickavance, 2005; Carmichael and Murray, 2006).

Consequently, the need to address relevant programming issues has long been recognized as being pivotal to both delay claims dispute prevention and dispute resolution (Pinnell, 1992; SCL, 2002; Pickavance, 2005). Yet, very little research has been done on programming matters to help establish better understanding of the key issues and their influence on delay claims resolutions. The vast majority of past research studies have rather focused on the methodologies for analyzing delays - see for example, the work of Bordoli and Baldwin (1998), Finke (1999), Williams, et al.(2003), Hegazy and Zhang (2005), Al-Gahtani and Mohan (2005) and Ibbs and Nguyen (2007). As a contribution towards building such understanding, this paper reports on aspects of a study conducted to shed lights on construction programming practice within UK construction industry with the view to identifying the key issues that influence delay claims assessment. The issues investigated and reported in this paper include:

- what tools (and in which formats) are used for developing baseline programme during preconstruction stage of a project?
- what are the main deliverables produced during pre-construction programming stage of projects?
- who are the experts involved in programme development and what are their extents of involvement?
- to what extent are baseline programmes resource-loaded and/or leveled?

The remainder of the paper is structured as follows. The next section presents a brief overview of delay analysis techniques and their relationship with construction programmes, as a way of setting out the theoretical basis of the role programming practice plays in delay analysis. The section that follows describes the research methodology used in conducting the study, followed by analysis and discussions of the study results. The final section presents a summary of the study findings and conclusions.

Influence of programming on delay analysis techniques

The resolution of delay claims involves the claimant or the defendant identifying and quantifying the effects of one or more occurrences that caused (Pickavance, 2005):

- delay to progress that resulted in delay to one or more completion dates;
- prolongation of contractor's and/or subcontractor's time-related costs;
- delay to progress that caused loss and/or expense to be suffered by contractors or subcontractors; and

- reduction in productivity (or disruption) that caused loss and/or expense to be suffered by contractors and/or subcontractors.

Dealing with each of these scenarios or a combination of them involves the claimant assessing how the delays experienced by various project activities affect others and the project completion date, and then determining how much of the overall project delay is attributable to any party involved. To carry out this undertaking, employers and contractors often resort to various delay analysis techniques available in practice. The most common techniques, as reported in the literature (for example, Finke, 1999; Alkass *et al*., 1996; Zack, 2001; SLC, 2002; Pickavance, 2005) are: *As-planned vs. As-built*, *Impacted As-planned, Collapsed As-built, Window Analysis* and *Time Impact Analysis*. Not only are each of these techniques known by different terminologies among practitioners, they also have their own variant forms of unique application procedures (Alkass *et al*., 1996; Pickavance, 2005). The various techniques therefore produce different results at different levels of accuracies when applied to the same delay claims scenario, as established in various studies (Alkass *et al*., 1996; Bubshait and Cunningham, 1998; Stumpf, 2000). In addition, disputing parties tend to employ the techniques in such a way as to satisfy their individual interest of casting their cases in the best light. All these characteristics go to compound the problems associated with delay claims resolutions. As detailed descriptions of the techniques abound in the literature, only programming requirements affecting their application will be focused on in the sections following.

In terms of construction programme usage, the techniques differ from each other based on three elements: the type of programming format required, the sort of programme used as the analysis baseline reference and the mode of application employed. On these bases, the technique can be classified as shown in Figure 1 (Braimah, 2008).

[Insert Figure 1 about here]

On programme format requirements, the techniques are grouped under CPM-based techniques and non CPM-based techniques. The former are more popular because they allow for the determination of critical path(s) and also are able to show the interrelationships among multiple causes of delay (Wickwire *et al*., 1989; Fruchtman, 2000; SLC, 2002; Pickavance, 2005; Arditi and Pattanakitchamroon, 2006). Among the non CPM-based techniques, bar chart forms are more popular than those based on S-Curve and linear scheduling techniques (e.g. the Line of Balance). These latter techniques were not within the scope of this research and so all the further discussions on non-CPM techniques in this paper refer to those based on bar charts only. A major limitation of the bar chart techniques is their inability to show the true effects of delays on project completion (Alkass *et al*., 1996; Fruchtman, 2000; Wickwire 2004). However, they can be used successfully to analyze some types of delay claims especially those involving fewer activities and simple relationships (Pickavance, 2005).

According to Wickwire *et al*. (1989), the baseline or reference point used in delay analysis varies for the various techniques depending on the choice between the following three options:

(i) *Forward pricing* – valuing the delay at its inception by impacting the contractor's baseline programme with the delaying events. Techniques suitable for such analysis include the Impacted As-planned and the As-planned But-for methods;

(ii) *Contemporaneous pricing* – valuing the delay as it is occurring or immediately after it has occurred and the techniques for performing this analysis include the Time Impact Analysis (also known as 'Contemporaneous Period Analysis').

(iii) *Hindsight pricing* – determining and valuing the delay after the project is completed. This is performed using methodologies such as Collapsed as-built, As-planned vr as-built and the Window analysis.

These analysis options are highly influenced by timing of the analysis. The forward pricing (commonly termed as 'Prospective Analysis') is usually carried out when the project is in progress and the Contractor and/or the Employer representative (Engineer/Architect) needs to forecast the impact of known events on the future completion date for purposes of estimating an extension of time, for example. This analysis is thus often branded theoretical (Pickavance, 2005), in the sense that it does not consider the actual delays that occurred but seeks to demonstrate what might have been the delay arising from particular events. On the other hand, the Hindsight analysis (commonly termed 'Retrospective Analysis') is performed after the project is completed (i.e. after-the-fact), when analysts would have the full benefit of hindsight. Such analysis is considered to be 'actual' and therefore more reliable as it focuses on identifying the actual delays experienced, their time of occurrence and the events or circumstances that gave rise to them (Pickavance, 2005).

The mode of application of the techniques methodologies varies based on three different modes of operations: direct analysis, subtractive simulation and additive simulation.

Direct analysis

This involves the analyst examining the construction programmes available (the baseline programme, its updates or the as-built programme) as it is, without carrying out any major adjustments or evaluations on them (Trauner, 1990; Alkass et al., 1996; Lovejoy 2004). The techniques that use this type of analysis are therefore relatively easy, simple and less expensive to implement. Examples include the As-planned vrs As-built, Net Impact and Global Impact technique (Zack, 2001; Alkass et al. 1996; Arditi and Pattanakitchamroon, 2006).

Subtractive simulation

This mode entails removing the delays of each party from the as-built programme to establish their effects on the project completion date (SCL, 2002; Lovejoy 2004). There are two main ways by which the delays can be removed (Trauner, 1990): removing all the delays at a go from a single as-built schedule (i.e. single stage simulation) or removing the delays in stages from multiple schedules (multistage simulation). The technique based on this mode of simulation is the Collapsed As-built (Alkass et al. 1996; Zack, 2001).

Additive simulation

Under this mode, the analyst formulates the delay events as activities and then adds them to the programme (baseline programme or its updates) to establish their effects on the project completion date. As with the subtractive simulation, the additions can also be done in a single stage or multi-stages. Techniques that fall under this type of analysis are the Impacted As-planned, As-planned But-for, Window Analysis and Time Impact Analysis (Finke, 1999; Pickavance, 2005; Hegazy and Zhang, 2005).

The level of analysis detail required for each technique varies in accordance with the different modes of operations highlighted above. Techniques that use direct analysis approach are thus often termed “simplistic methods”, while those involving extensive modifications of the schedules, as in the additive and subtractive simulations, are termed “sophisticated methods” (Alkass *et al.*, 1996). The latter groups tend to give more accurate results than the former but they require more expense, time, skills, resources and project records to operate (SLC, 2002; Pickavance, 2005). The characteristics of the techniques based on these factors and their relative reliability as discussed in various text (SCL (2002, Arditi and Pattanakitchamroon, 2006; AACE 2007) can be summarized in Figure 2 (Braimah, 2008).

[Insert Figure 2 about here]

The accuracy and reliability of delay analysis performed by existing techniques are thus highly influenced by the availability of adequate project information, most of which are programme related. A major source of the information is also generated by contractors on a periodic basis in the form of statused/updated and revised programmes (Fruchtman, 2000, SCL, 2002; Arditi and Pattanakitchamroon, 2006). The timely keeping of these information in an accurate, well-organised manner throughout the life cycle of the project is a key task in preparing, analysing and resolving delay claims (Pinnell, 1992; Pickavance, 2005). Therefore much of the issues affecting the proper analysis of delay claims and their settlement relate to how construction programmes are developed and maintained in the course of construction.

Research Design and Strategy

The research strategy adopted was carefully selected based on the research questions to be addressed and the best strategy that offers the right framework for answering them. As a result of the multiplicity of the questions and diversity in types and sources of data required, it became apparent early in the study that the best methodology to use would involve a combination of qualitative and quantitative research methods. Therefore, a mixed method research design as described typically by Bryman (1992) and Creswell (2003), was adopted, where the two research approaches were integrated in a sequential two-stage data collection process. The first stage used a quantitative method based on a cross-sectional postal questionnaire survey to investigate the 'structural' features of social aspects of delay analysis. This survey was designed to tap, at large scale level, the awareness of existing delay analysis techniques, their use in practice, obstacles affecting their use, etc. (see results in Ndekugri, *et al.* 2007; Braimah and Ndekugri, 2009). The second stage of the data collection process employed a qualitative method based on cross-sectional in-depth interviews to investigate planning and programming factors (i.e. the 'processual' aspects) that influence the use of delay analysis techniques. Interviews were considered appropriate due to a number of reasons, including fragmentation of the functional roles of the potential participants, their geographical dispersion and commercial confidentiality. It is worth mentioning that the first stage questionnaire survey was designed to facilitate the second stage data collection. For instance, results of the survey were used to confirm and narrow down the programming issues that require further investigation at the second stage. The survey was also used to identify suitable respondents by asking them to indicate their willingness to participate in the second stage interviews. The key advantage of this approach is that respondents' prior involvement in the survey makes them highly suitable for the interview because of their awareness of the framework of the whole research study.

Design of Interview Guide

Although there are various strategies for administering interviews, the most pervasive one in qualitative studies is personal or face-face interviews, which was the approach adopted due to its appropriateness to addressing the research questions. This approach also allows for observations to be made and also for the researcher to interact with the natural settings (Creswell, 2003). The format of the questions asked in interviews can be classified into four groups (Patton, 1990; Bogdan, and Biklen, 1992; Gill and Johnson, 2002): totally structured; structured questions with open responses (semi-structured); open questions with structured answers; and totally unstructured. The nature and scope of the issues investigated in the study suggested semi-structured as the most appropriate option for designing the interview questionnaire. This format has the advantages of both opened and closed–ended interviews (Patton, 1990; Creswell, 2003). Using this format, an interview guide was carefully formulated following recommended guide in the literature (Patton, 1990; Creswell, 2003). The guide listed out the relevant questions on construction programming under two main sections: preconstruction stage programming and construction stage programming.

Sampling and data collection procedure

The sampling procedure followed involved first accessing the Kompass Register (company search engine at *gb.kompass.com*), The New Civil Engineer (NCE) Consultants File and the Royal Institute of Chartered Surveyors (RICS) Directory, which together contain in excess of 5000 providers of products and services in the UK construction industry. From these databases, a list of 2000 contracting and consulting firms of different sizes and operating in areas relevant to the subject matter of the research were then compiled as the study population. The selection ensured that a representative number of organizations from each of the six geographical regions of the UK (namely, North East, North West, South East, South West, Midlands and Scotland) are reflected in the population.

Non-probability sampling techniques were then employed to obtain the sample frame for the study, as no such frame exists on construction organizations with relevant experience on programming and delay analysis. The sampling techniques involved using a combination of quota and purposive sampling, as described typically by Patton (1990) and Bogdan and Biklen (1992), to select 600 construction organizations (300 contractors and 300 consultants), based on the need to ensure that the outcomes are nationally applicable and cover the experiences and attitudes of contractors as well as consultants, especially engineers and architects in their roles as contract administrators. The first stage of the data collection process involved mailing postal questionnaires to the selected organizations, which had 130 responses (63 from Contractors and 67 from consultants), representing a response rate of 21%. Out of the construction firms who took part in the survey, 15 agreed to participate in the later interviews and did so enthusiastically. These respondents were experienced practitioners who occupied key positions in construction firms. Also, they were all planning engineers with considerable experience in planning and programming, totaling 150 years, as Table 1 shows.

After identifying the potential interviewees, they were all contacted via telephone or email to arrange for appropriate date, time and place for the interview. Closer to the interviews, copies of the interview guide were emailed to them with an accompanying cover letter, reminding them of the interview. In addition to these arrangements, respondents' consent on the interview process to be used was also sought prior to commencing each interview, in line with research ethics standards. Each interview began with a brief introduction on the purpose of the interview, what the results will be used for, means for recording conversations and how all information received will be kept strictly confidential. In the course of each interview a number of steps were also taken, to ensure its proper conduct and to avoid any possible biases from creeping into, by observing the following advice (Patton, 1990): (i) asking one question at a time; (ii) remaining neutral as far possible by trying not to show strong emotional reactions to responses, for instance; and (iii) taking control of the interview by sticking closely to questions of interest. Generally, each interview took between 1-2 hours to complete, where information was recorded by both note-taking and tape-recording. The data obtained, which were largely qualitative in nature, was later transcribed and analysed.

[Insert Table 1 about here]

Analysis and discussions of results

The method of analysis adopted involved the following. First, all interview responses were recorded successively for each of the questions to form a database, which were carefully examined to identify emerging themes and then collated using frequency analysis into summary results. The sections following present and discuss the results obtained under the key issues investigated in the interviews.

Baseline programme development

As noted previously, construction programmes in the form of CPM are now invaluable tools for analysing the effects of delays on progress project completion date. The tool has also been endorsed by the courts as evidenced by a number of court cases. For instance, in the UK case of *Balfour Beatty Construction Limited v The Mayor and Burgess of the London Borough of Lambeth (2002) 1 BLR 288,* wherein the claimant sought to enforce an adjudicator's decision in relation to an extension of time and loss and expense claim, the Judge stated that: *"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)".* Although most construction contracts require the contractor to provide a programme at the commencement of the works, evidence from literature (for example, Neale and Neale 1989; Owens, 2003) raises questions as to the availability and suitability of such programmes for delays claims resolutions. To ascertain the full extent of this perceived problem, interviewees were first asked to rate the frequency by which their organisations prepare and submit baseline programmes to their employers or its representatives for purposes of checking and subsequent approval or acceptance, as required by most contracts. Their responses were captured on a five-point Likert scale from "never" (=1) to "always" (=5), which gave an average value of 4.07. This high ranking suggests that baseline programmes are often submitted to project employers for checking and acceptance.

Respondents were also asked to mention the programming technique they often use in preparing their baseline programmes. All respondents mentioned linked bar charts as the format they usually employ for most of their projects. They went on further to provide their reasons behind this preference. Summarized in Table 2 are the lists of the reasons they gave. With this finding, a further question was posed to the respondents as to how they perceive the use of traditional CPM network (i.e. arrow or precedence diagramming methods). Majority replied that the linked bar chart is a form of a network diagram that is able to show the critical path and at the same time offer an easy-to-read appearance like the Gantt chart and therefore concluded that they do not see why traditional CPM network should be used. One respondent noted: "*I would not say most contractors and clients will struggle with network diagrams, but is not the norm these days. I can't remember the last time we used a network diagram"*. Another commented: *"Company culture is programming using linked bar chart. It is the technique we have been using over the years and is able to do the job without problems."*

[Insert Table 2 about here]

Although the linked bar chart tries to incorporate the good qualities of bar charts such as being simple to understand with the logic relationships of CPM, its main weakness is that it can generate "link maze" (i.e. activity links criss-crossing over each other in a complex fashion). This can create difficulties in identifying the relationships between individual activities and links to an activity that does not start at its earliest time, especially for projects involving complex sequence of activities.

Software use for planning and programming

Existing CPM software packages do not only have different functionalities and capabilities (Conlin and Retik, 1997; Winch and Kelsey, 2005), but are also known to lack transparency on certain scheduling operations (Sanders, 2005 and Winter, 2006). For instance, the packages have different settings and ways of dealing with issues such as calendars, rescheduling activities with lags, handling of stautus updates (progress override or retain logic settings), resource allocation, to mention but a few (Maroto and Tormos, 1994; Kastor and Sirakoulis, 2009; Winter, 2009; Winter, 2011). With these characteristics, different software are likely to produce different results when used to analyze a particular delay claims (Planning Planet Forum, 2009), further exacerbating the difficulties often surrounding the amicable resolution of disagreements between the claimant and the defendant. Converting a programme from one software package into another does not offer a viable solution either as the process is affected by conversion difficulties and information distortions (Planning Planet Forum, 2009). A notable recommendation for dealing with these software problems is for the disputing parties to agree on a common software for undertaking the delay claims assessment (SCL, 2002), unless the contract specifies otherwise.

It was thus important to investigate the type of software packages that are currently used to develope programmes. In response to a question on this, all respondents indicated that they use computer planning software packages and went further to mentioned specific packages they commonly use (see Table 3). Despite the popularity of these packages, they have been criticized for their indiscipline task logic (Hegazy and El-Zamzamy, 1998; Winch and Kelsey, 2005), which has the potential of not facilitating smooth retrospective reconstruction of programmes when undertaking delay analysis. Amongst the list, *MS Project* is relatively less expensive and easy to use (Winch and Kelsey, 2005; Winter, 2011), yet it appeared as the 3rd most popular software. The reason behind its less popularity could probably be due to the difficulties it poses to schedulers when used to maintain a programme and perform delay analysis (Planning Planet Forum, 2009; Winter, 2011). Specifically, Winter (2011) identified

MS project weaknesses as including the difficulty of using it to note uncompleted work before data date and for identifying variances between a series of schedules, and hence concluded that it is hard to use it to run most types of delays analysis techniques (except for simpler techniques). On the other hand, *Primavera*, which is very popular in the USA and highly recognised as being very versatile both for project planning and delay analysis (Liberatore et al, 2001; Winch and Kelsey, 2005; Nosbisch and Winter, 2006; Winter, 2011), is not commonly used in the UK. Only one respondent claimed that they do occasionally use it (but very rarely), stating that this is only when their client specifically ask for it to be used. Although some respondents hailed this package as being in-depth and robust, yet they gave reasons for its low usage in practice as being relatively expensive to purchase, complex to use and requiring of a long set up time.

[Insert Table 3 about here]

All the commonly used CPM software are commercially available packages; none of the respondents mentioned any in-house software as an alternative tool they use for programming. This practice has the advantage of making it possible for the disputing parties to readily obtain access to a common software for the analysis, should they decide to agree on one as SCL recommends (SCL, 2002). Also, by using the same software, the trier-of-fact is able to compare the claim presentations from the disputing parties on a level-play field, thereby increasing transparency in the dispute resolution and also making it possible for key issues at the heart of the dispute to be identified and focused on.

Other planning deliverables generated

Delay analysis goes beyond the mere assessment of construction programme(s) as noted previously. The accuracy of the analysis very much depends on the underlying data used (Pickavance, 2005), making it mandatory for analysts to check and analyse the data sources, if credibility of the analysis is to be ensured. Data sources often relied on include progress reports, project correspondence, site dairies, minutes of meetings, supervision and inspection reports, method statement, resource allocation and costs, as noted by various authors (e.g. SLC, 2002; Pickavance, 2005; Kartam, 1999; Carmichael and Murray, 2006). A number of factors influence the reliability of these records, as evidential aspect of the analysis, including, documenting the records first-hand, at the time of the event or shortly afterwards (i.e., contemporaneously), and as part of formal and regular business process(Pickavance, 2005). Planning and programming procedures over the whole spectrum of the function should ideally ensure that records kept meet these requirements. Yet, many delay claims continue to be unsuccessful resolved due to lack of relevant contemporaneous records (Jergeas and Hartman, 1994; SCL, 2002), despite that proper record keeping has long been emphasized as a recommended good practice. Lack of contractual requirements in UK-based projects on documentation of project progress records is one of the key reasons attributable to this problem (Carmichael and Murray, 2006).

To understand the extent by which current contractors' programming practice support the upkeep of relevant data used for analyzing delay claims, respondents were thus asked to mention other planning deliverable they often produced in addition to the baseline programme. Table 4 lists out such deliverables, which are all relevant information sources for effective presentation and assessment of delay claims (Pinnell, 1992; Pickavance, 2005). Among the list, method statement appears to be the most popular deliverable, followed by cash flow chart/S curve. The high importance attached to method statement is commendable because of its crucial role in programme development. It is in line with this role that the SCL's protocol (SCL, 2002) strongly recommends contractors to develop method statements for purposes of cross-referencing them with the programme.

[Insert Table 4 about here]

The different percentage response rates for the various deliverables suggest that contractors attach different levels of importance to each of them. This pattern was not unexpected as the degree to which each is of relevance to managing projects and for supporting subsequent delay claims varies as well. However, the results show that manpower loading graph is among the least popular deliverables produced. This has the potential of making it difficult to resource-load the baseline programme, which has implications on progamme reliability for delay analysis, as discussed later on under the section on resource loading and leveling.

Experts involvement in baseline programme development

Credible delay claims presentation and assessment require, among others, that the baseline programme employed should be a realistic model, especially on the logical relationships, adequacy of project activities and sufficiency of the activity details shown (Pinnell, 1992; SCL, 2002; Street, 2000; Pickavnace, 2005). However, a common criticism of programmes has been that they often contain errors and tend to fall short of these requirements (Street 2000; Owens, 2003; Lucas, 2009). Such deficiencies would not only undermine programmes as a reliable tool for analyzing delay claims, but could also result in their rejection by the Client (Zafar and Rasmussen, 2001). The factors responsible for the deficiencies in programmes include: the level of planning knowledge and skills of the individuals or groups responsible for developing them; the amount of scheduling effort (and level of commitment) expended (Pinnell, 1992; Lukas, 2009;); and cooperation between the different personnels assigned to managed the project (Laufer and Tucker, 1988; Laufer *et al.*, 1993; Cohenca-Zall *et al.*, 1994).

As the involvement of different individuals is one of the key issues that affect the quality of programmes developed, respondents were asked to indicate the level of involvement of such individuals on a scale of 1-5 ("1 for lowest involvement" and "5 for highest involvement"). The results of the responses obtained are as indicated in Table 5.

[Insert Table 5 about here]

The results support the view in literature that programming process involves many different parties, most of which are staff within the construction company. Their degree of involvement varies, which is also consistent with the notion that programming efforts are discharged at different rate by different parties (Laufer and Tucker, 1988; Laufer *et al.*, 1993). Planning engineers and project managers appear to make significant inputs than the other participating parties, with the least involvement coming from the client, which suggests that programme generation is still much the responsibility of contractors. Although most contracts tend to follow this position, the little involvement of clients is probably one of the reasons responsible for the frequent rejection of contractors' programmes by clients (Zafar and Rassmussen, 2001). A programme rejection or any delay with its approval may put the contractor in a very difficult position when faced with the need to substantiate early delay claims and similar difficulties to the client's representative in assessing same. On the other hand, timely approval of programmes has the potential of facilitating quick resolution of delay claims and helps avoid all difficulties that go with resolving them long after the delaying events, as often recommended (SCL, 2002). Therefore to improve delay claims resolution process, it is important for clients to get more involved with programme development as this will help clarify issues with the programme quickly, thereby reducing the possibility of its rejection or delay in approving it.

Resource loading and levelling

The basic assumption underpinning traditional CPM programme is that resources required by activities are unlimited. This assumption is, however, not valid as resources tend to be limited in most practical situations (Woodworth and Shanahan, 1988; Pickavance, 2005). Therefore without detailed consideration of the reality of resource availability it is possible that activities will have been programmed to overlap or occur simultaneously when they should not have been. As a result, developing resource loaded programmes is critical to evaluating both reliable task duration and network logic, especially when many tasks require the same resources at the same time (Kuhn, 2007). Such programmes would hence show a more realistic float values in non-critical activities, which is highly crucial when analyzing delays to decide on contractual entitlement of time extensions claims. For these reasons, resource loading or leveling consideration in delay analyses is very important to ensuring accurate and trustworthy results (Pickavance, 2005; Nosbisch and Winter, 2006; Ibbs and Nguyen, 2007), save for the Collapse as-built technique as it does not rely on baseline programme.

To investigate the degree to which resource loading/leveling is carried out in practice, respondents were thus asked to rank the extent to which the programmes they produce are resource-loaded and leveled, using a scale of 1-5 (1 for "never" and 5 for "always"). The analyzed results gave an average rank value of 1.7 each for resource loading and leveling, meaning that programmes developed are rarely resource loaded or leveled. In fact, 80% of the respondents claimed they seldom resource-load their programmes. This is consistent with the low extent to which manpower loading graphs are produced, as one of the key planning deliverables (See Table 4). Only two interviewees claimed that they occasionally do carry out resource loading and that this is only done for some activities whose resource requirements can be determined easily. The rest gave reasons for not resource-loading their programmes as follows:

1. the process involved is quite difficult and time-consuming;
2. resource-loaded programmes are difficult to follow in practice making it unhelpful;
3. it is impracticable to resource-load many activities as managing resources is hard;
4. the process requires much inputs from many diverse sources, making it a very complex task to coordinate ; and
5. the exercise is often not part of clients' programming requirements to meet.

The low degree of resource-loading exercise carried out in practice suggests that most of the programmes developed in practice are unlikely to well reflect contractors' resource usage plan. Delay analysis based on such programmes would produce results that do not accurately reflect reality and thus may not be considered as a reliable basis for delay claims resolution. Reacting to this comment, few of the interviewees mentioned that the only instance resource-loading is sometimes carried out is when potential delay claim events such as variation orders have to be dealt with on prospective basis. They claimed that they often resource-load "fragnets" of variation task upfront before inserting them in the main programme to evaluate the time and cost impacts prior to their actual execution. Only one respondent mentioned that in the absence of resource-loaded programmes, they sometimes create one retrospectively using actual records, admitting that this can be a very laborious exercise to perform though.

When asked whether they do carry out resource leveling during pre-construction planning stage, over 80% answered that they seldom perform this. The reasons they gave were that, it is an exercise that is: (i) usually not considered crucial by clients; (ii) often not practical to undertake because resources are often difficult to manage and control; and (iii) time-consuming to undertake. One interviewee commented: "*In practice, resources are often dedicated to a number of activities belonging to different work packages or are shared across several projects, making it inflexible to redistribute resources in order to smoothen or level them".* Very few claimed that they sometimes carry out resource leveling and mentioned that they only do so for some works, particularly those in which resources, typically site operatives, can easily be moved around.

In spite of the numerous reasons operating against resource loading and leveling, it is increasingly vital for analysts to take resource allocations into account in their analyses (Carmichael and Murray, 2006; Ibbs and Nguyen, 2007), as this ensures reliable results that are necessary for successful claims resolution. For instance, resource consideration occupies a vital step in the thorough methodology developed and used by Kartam (1999) to successfully resolve many delay claims. From UK case law perspective, the case of *McAlpine Humberoak v McDermott International (1992) 58 BLR,* reinforces the need for contractors to account for resource allocations in their delay claim submissions. The judge in this case disapproved of the plaintiff's claims on the basis that no consideration was given to how resource usage was planned for and how they were actually utilized during construction. Wickwire (2002) also reviewed legal decisions in the US and noted that *'in any analysis of project delays, the contractor is required to take into account realistic resource leveling'*. However, none of the traditional delay analysis techniques deal with the impact of resource allocation in their procedures (Ibbs and Nguyen, 2007). There is also very little research on how this consideration can be incorporated in the existing techniques.

Although the incorporation of resource loading effects in delay analyses represents a more accurate and rigorous assessment of delay claims and recognized by many as such, there is little legal precedent on its acceptability or requirements of baseline programmes to be resource driven. There is therefore the need for further research into this aspect of programming and their incorporation into delay analysis to help enhance the resolution of delay claims in practice.

Summary and Conclusion

As part of a wider research carried out to investigate delay and disruption analysis in construction organisations, this paper reports on an aspect of the study conducted to throw light on the underlying programming issues affecting delay claims resolutions, as demonstrated by an initial large scale survey of the research. The aspect reported was based on an in-depth interviews carried out with experienced planning engineers within the UK construction industry. The key conclusions based on the study findings are summarised as follows.

Most contractors prefer to use the linked bar chart format for their contract programmes and gave reasons for this preference (over conventional CPM networks) as the format being relatively easy to prepare, use, maintain and more importantly, having the ability to show the critical path as well. Interestingly, the basis for using this format has nothing to do with the project contract with some contractors openly admitting that using linked bar chart format is a company culture. This format has no major limitations but its easy-to-read appearance feature could suffer when employed to programme projects with complex activity relationships. Baseline programmes are developed using computer software packages and the most popular planning software in use are *CS Project* and *Power Project*, followed by *MS Project* and then *Asta Teamplan* as the least popular. With the exception of *MS Project*, there are no major issues of concern reported in the literature regarding the use of these software packages for delay analysis. The *MS Project* is relatively less expensive and easy to use but it is difficult to use it to perform forensic delay analysis, except for simpler cases. Although this software is not the most popular, its use contributes (probably to a low extent) to the reasons behind the low rate of use of sophisticated delay analysis techniques, such as the *Time Impact Analysis*, in the UK. The *Primavera* software package is not commonly used in the UK because of reasons of its high purchase cost, long set-up time and high skills required, although this software is very popular in the USA and recognized also as being very versatile for both project planning and delay analysis. The suitability of any programming format employed for a project depends much on factors such as project complexity, cost, time available, etc. It would be useful for employers to thus specify in their contracts the best format and software package the contractor should use for programming the works or they should at least check to ensure that whatever format or software being used is appropriate for the project at hand.

In addition to the contract programme development, other planning deliverables contractors produce during pre-construction stage include method statement, cash flow chart/S-curve, phasing plans, design schedule, information required schedule, procurement programme and site layout programme. All these are useful information sources for resolving delay claims. However, an important deliverable that is essential but is often not produced is manpower loading graphs. The reasons given for this lapse include the concern that it is time-consuming and difficult exercise to perform; that it is not often part of clients' requirements and also not considered by parties as a crucial requirement. Not surprisingly, the study found that baseline programmes are hardly resource-loaded and leveled appropriately to accurately reflect the reality of how resources will be used on site. This practice has the tendency of affecting the reliability of baseline programmes used for resolving delay claims.

The development of baseline programme involves many different expertise most of whom are staff of construction firms. The Planning Engineer/Planning Manager appears to make the highest input, whilst the client and/or his agent make the lowest input. Due to the little involvement of the latter, issues of baseline programme reliability are unlikely to be picked up during early stages of the project. This would not facilitate programme approval or acceptance process that would have to be undertaken later on by the employer or its representatives. Depending on programme specifications, as stipulated in the contract, delays in programme approval could result in lack of an agreed workable programme until some period after construction has commenced. As a result, contractors might find it difficult to substantiate any delay claims resulting from risk events occurring within this period. Therefore, active involvement of clients would help with quick generation of acceptable baseline programmes, and hence facilitate prospective resolution of delay claims (i.e. close in time to when the delay risk event occurred), rather than on retrospective basis or long after the event, which has often been a recipe for disputes.

Whilst the interviews enabled an in-depth analysis of some construction programming issues, the relatively small sample size used (which is often the case for qualitative methods) limits the ability to generalize the results, but does increase correspondence to reality. The findings reflect construction schedulers' local practice and their knowledge, intuition and experience, which provide insights into the perceived theories of programming issues that influence delay analysis. Such insights provide better understanding of the key issues that need attention if improvements are to be made in delay claim resolutions. Additional research that focuses on the testing of the results and other theories using a much larger sample and rigorous statistical analysis for generalization purposes would be helpful in advancing the limited knowledge of this subject matter.

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List of Tables

Table 1 Details of respondents and their organisations

Type of construction organisation	**Percent**
Building contracting only	20.0
Building and Civil Engineering contracting	46.7
Civil Engineering contracting only	33.3
Organisations' Annual Turnover (£m)	
<5	3.1
5 – 25	22.4
26 – 100	31.8
>100	42.7
Respondents' years of programming experience	
5-10	13.3
11-20	53.3
21-30	26.7
>30	6.7

Table 2 Reasons for preferring Linked bar chart format

Reason	**Percentage response (%)**
Easy to prepare and use	80
Easy to read and maintain	77.3
Company policy	62.1
Clients' request	52
Ability to show critical path and activity relationships	55

Table 3 Planning software commonly use for programming

Planning software	Percentage response (%)
CS Project	31
Power Project	31
MS Project	23
Asta Teamplan	15

Table 4 Other preconstruction planning deliverables

Planning deliverable	No of respondents
Method statement	13
Cash flow Chart/ S Curve	11
Health and safety guidelines	7
Phasing plans	4
Design schedule	3
Information required schedule	6
Procurement programme	4
Site layout programme	7
Manpower loading graph	2
List of temporal works	1
Schedule on environmental issues	3
Area programme	4

Table 5 Involvement in pre-construction programming

Expertise	Level of involvement (in %)					Involvement
	1	2	3	4	5	index
Planning engineer	15.4	0.0	15.4	30.8	38.5	75.5
Project manager	23.1	15.4	38.5	15.4	7.7	53.9
Site manager/agent/engineer	30.8	38.5	23.1	7.7	0.0	41.6
Estimator	23.1	30.8	23.1	23.1	0.0	49.3
Contracts manager	46.2	15.4	30.8	7.7	0.0	40.0
Subcontractor/suppliers	38.5	38.5	30.8	0.0	0.0	41.6
Client/his agent	53.8	30.8	15.4	0.0	0.0	32.3