

Participant Influences on the Success of Critical Path Method Planning in Construction Project Environments

Neil M. Pickavance MSc, MCIOB and Andrew D. Ross BSc (Hons), MSc, PhD, MRICS
and Damian J. Fearon BSc, MSc, PhD, MRICS.
Liverpool John Moores University
Liverpool, UK

Critical Path Method (CPM) planning as a logic-based and deterministic programming method operates in construction contracting environments characterised by excessive trade sub-letting, work package fragmentation, transient low-loyalty sub-contract labour, poor trade integration, and dislocated project teams. Despite some advances, newer methods adhering to a social-based collaborative approach, such as Lean Construction and Last Planner® System, have not yet positioned themselves as primary use methods of planning and project control. A reconsideration of CPM literature across construction programme management has been undertaken and several approaches to CPM planning are identified. However, there appears to be an absence of work on its practical application within construction contracting environments. Exploratory qualitative data was collected through a purposive sample of six semi-structured interviews with UK construction management personnel on a case-study project. Results were used to identify emerging key themes and guide back into the literature. CPM planning seems to operate in unstructured environments characterised by poor application, understanding, and ad hoc engagement by participants. It is concluded that problems with CPM may be rooted in people-based, and not process-based, issues.

Key Words: Critical Path Method, Last Planner® System, programme, subcontractor, integration

Introduction

Research Problem

This paper is part of an ongoing research project to investigate and understand the influences that project participants exert on the adoption and application of traditional Critical Path Method (CPM) planning at contracting organisations in the UK construction industry. CPM remains the most commonly used project planning technique in UK construction, possibly due to being a standardised method, familiarity, and being specified widely by construction clients. UK construction dispute resolution uses CPM extensively to demonstrate time entitlements. Despite this widespread use CPM is criticised as a construction planning tool (Tommelein et al, 1999), particularly from proponents of Lean Construction, Last Planner® System, and other similar social-based methodologies.

On the whole, complex construction projects in the UK are likely to be finished more than six months late (CIOB, 2008). From practical observations within construction project environments there appears considerable evidence that main and sub-contracting teams are failing to adopt and apply CPM in a structured manner. Further, reviews of literature on and around construction planning returned limited evidence of the understanding, adoption, and application of CPM within complex project environments. These environments, characterised by excessive sub-letting, work package fragmentation, transient low-loyalty sub-contract labour, and poor trade integration create dislocated relationships between teams within projects that are not well-suited to traditional CPM planning.

This paper further progresses a preceding critical investigation into the adoption and application of CPM within a construction project case-study environment. The categories and emerging concepts from the results of six qualitative semi-structured interviews with experienced personnel form a basis to guide back into the literature around construction management, supply chain integration and management, collaboration, partnering, and organisational cultures. This focuses the investigation on the wider context of project teams and an understanding of their impacts on the success of CPM planning within construction environments, and not just the system limitations.

Literature Review

Project Network Analysis

Project planning, management, and control of construction projects has traditionally been undertaken via network analysis. Originating from industrial, military, and production environments the transposition of CPM into construction was recorded in “A non-computer approach to the critical path method for construction” (Fondahl, 1962). With similarities to Program Management and Review Technique (PERT), CPM is based on mathematical and algorithmic models of logic networks applied to construction scheduling (Aquilano & Smith, 1980). Activities, milestones, and critical trades are mapped within a logical network, with programme management via this deterministic approach remaining a significant method of planning and project control (Agyei, 2015).

Educational Texts

Many subjects are successfully conveyed, and learned, from textbook format but characteristics and nuances of construction project planning is difficult to convey. Operating within a diverse, fragmented, multi-cultured temporary organisation delivering a complex, bespoke product with a transient, low-loyalty, sub-contracted workforce the creation, management, and execution of project planning goes beyond network diagrams and resource schedules. Application of CPM in contracting environments is not addressed in construction texts (Lester, 2006) and (Pierce, 2013).

Construction Industry Reports

UK government has commissioned numerous construction industry reports with the intention of providing best-practice strategies on key issues. Many focus on project delivery improvements such as partnering and collaborative working (Latham, 1994), performance and efficiency (Egan, 1998), reports to check and measure the success of previous reports (Wolstenholme, 2009), and production improvements (Construction 2025, 2013). Addressing high-level industry issues most reports do not consider the serious impact supply chain fragmentation has on projects.

Codes of Practice

Official codes of practice provide operating frameworks for project management and delivery. However, these appear to lean towards being largely administrative (British Standards Institution, 2010). The Project Management Body of Knowledge (Association of Project Management, 2012) similarly fails to address the complex nature of planning in fragmented contracting environments. The Code of Practice for Programme Management in the Built Environment (Chartered Institute of Building, 2016) also fails to adequately address real-world planning challenges.

The Planning Role

Responsibility for undertaking the project planning role at main contractors varies within the UK construction industry, from a dedicated planning position or by another project management team member. Depending on project size, company culture, and culture within a building sector there may be no formal responsibility for the project planning role. Poorly allocated and unsupported planning staff appears to foment a questioning of integrity of the planner role, coupled with limitations of formal deterministic planning (CPM) becoming more widely recognised (Winch & Kelsey, 2005). Similar querying on whether construction project planning was doing its job (Laufer & Tucker, 1987) demonstrates some misunderstanding of the fundamental nature of the execution of the planning role.

Collaborative Planning

Alternative planning methodologies (imported from automotive and production industries) from the 1990s onwards suggest alternatives to CPM’s hard-logic ‘push planning’ approach. Categorised as Collaborative Planning these comprise modern methods such as Lean Construction (Koskela, 1992) and Last Planner® System (Ballard, 2000). Similar variants are Agile Project Management, AgiLean Project Management, Six Sigma, and Lean Six Sigma. While characterised by improvement process, reduction of ‘waste’, and collaborative working via work-crew inclusivity there is little evidence that these approaches significantly address the root of supply chain fragmentation.

Method

Sample Description

The research design builds upon a qualitative case-study to collect and interpret data to discover concepts and relationships within a live construction project environment. The collation of the original data was by interviews, with the research position interpretivist in nature. This qualitative strategy emphasised social reality research over quantification of data (Bryman, 2016). The case study was undertaken at a new-build construction development in the UK Midlands area that had entered into its contract phase. The final account is projected to be circa £300.0M and the main contractor is a large construction organisation who operate predominantly on the UK mainland but also continental Europe. In addition, two sub-contract companies engaged on the same project were included in the study. Both sub-contract organisations were major UK supply chain contractors, one operating in the steel frame erection sector and the other operating in the mechanical and electrical building services sector.

Interviewees were selected as a cross-section sample of construction management personnel within the case-study organisations. Four construction staff from the main contractor, and one member of staff each from the sub-contractors were interviewed. Each participant was employed full-time in either a project manager role or project planner role and possessed between fifteen and thirty two years' experience in the UK construction industry. The mean years of experience of the sample was 26.2.

Instrumentation

The original eleven questions posed in the interviews were open and exploratory, designed to elicit rich data for further analysis. The questions spanned common topics in project planning and were developed from extensive observations and experience within a practitioner environment. The interviews used a semi-structured approach on a personal face-to-face basis with key topics derived from the literature. To focus the investigation the approach within this paper has been to utilise the questions (and responses) from six of the original eleven questions posed that concentrated on CPM challenges, supply chain integration, and co-ordination. The six questions were:

Q1. What do you perceive are the main challenges for contractors planning with Critical Path Method?

Q2. How much do attitudes and cultures within a company influence the successful development and co-ordination of an integrated construction programme?

Q4. How do you feel the programme development and co-ordination process could be improved?

Q5. What are the methods, techniques and protocols that construction organisations use to develop, co-ordinate and integrate critical path programmes?

Q7. What processes do you follow to establish and integrate the various sub-contract trade sections of the construction programme?

Q11. How do you feel a process similar to the RIBA's Plan of Work would be of use for developing a co-ordinated and integrated programme?

The data from the six interviews has been previously transcribed into written text and an open-coding analytical process undertaken. NVivo 11 qualitative data analysis computer software package was used to code the transcripts at the sentence level to identify categories and concepts. This analysis was to provide an initial exploratory investigation into the subject matter. Open-coding allowed the text to be opened up and expose the thoughts, ideas, and meanings contained therein, to uncover, name, and develop concepts (Strauss and Corbin, 1990).

This paper has built upon the initial investigation by utilising the categories and emerging key themes from the qualitative data analysis to guide back into the literature. This direction is intended to support the development of a conceptual framework for further positioning the research in the wider context of the subject areas via existing theories, methods, methodologies, and practice.

Results

Analysis of Data

Tables 1 to 6 summarise the questions, responses, categories, emerging key themes, and emerging literature.

Table 1

Q1. What do you perceive are the main challenges for contractors planning with Critical Path Method?

Response Data		
People understanding CPM and buying into it.		
Understanding CPM usage and outputs.		
Understanding the critical 'spine' through the CPM programme.		
Early supply chain involvement so they understand programme aspirations.		
Supply chain nominating their correct person so they understand it.		
Communicating the critical 'spine' to the supply chain.		
Better identification of critical and non-critical activities.		
Resourcing to suit the master programme constraints.		
Identifying the correct commissioning period.		
Preserving the commissioning period [from being compressed by delayed installation].		
Categories	Emerging Key Themes	Emerging Literature
Understanding CPM and Benefits.	Understanding of Programmes.	Training and Development.
Supply Chain Understanding.	Resourcing of Programmes.	Communication.
Understanding Critical Items.	Stages of Programmes.	Supply Chain Management.
Understanding and Focusing on the Critical Path.		Partnering.
Plant Resource to Support Programme.		
Programme - Commissioning Integration.		

Table 2

Q2. How much do attitudes and cultures within a company influence the successful development and co-ordination of an integrated construction programme?

Response Data		
Culture is a main influencer of successful programme development.		
Construction has a poorer planning culture than petrochemical or nuclear sectors.		
Cultures affect knowledge and understanding of programmes.		
The right attitude and culture is critical for programme development.		
Culture affects dissemination of supply chain strategy to their own leads.		
Company cultures critically influence the tender programme calibre.		
Poor cultures can allow programme provision to just be a 'tick-in-a-box'.		
Fragmented construction supply chains cause fragmented project cultures.		
Cultures have significant influence on approaches to programme development.		
Categories	Emerging Key Themes	Emerging Literature
Company Culture and CPM.	Operational Cultures.	Organisational Cultures.
Supply Chain Understanding.	Shared Understanding.	Collaboration.
Programme Reliability.	Trust in Programmes.	Partnering.
Collaborative Attitude to Programme.	Team Attitudes.	
Company Culture and CPM.		
Supply Chain Understanding.		

Table 3

Q4. How do you feel the programme development and co-ordination process could be improved?

Response Data		
Need to move from tender through to construction with the same sub-contractors.		
Once the critical 'spine' is established use programme co-ordination workshops.		
Supply chain need to understand what really makes an activity work.		
Full process understanding: design details, procurement, resourcing.		
Engage with supply chain, get heavily involved, make them understand programme.		
Get the outline of the programme, the critical path, major elements of work.		
Using resource schedules and histograms.		
Front-end engagement with the supply chain is invaluable.		
Early involvement [supply chain].		
Forming a clear, defined project programme strategy.		
Categories	Emerging Key Themes	Emerging Literature
Supply Chain - Consistency.	Programme Framework.	Supply Chain Management.
Supply Chain - Early Involvement.	Supply Chain Framework.	

Table 4

Q5. What are the methods, techniques and protocols that construction organisations use to develop, co-ordinate and integrate critical path programmes?

Response Data		
Programme creation by main contractor for supply chain to follow.		
Supply chain involvement to familiarise them with the project.		
Understanding your supply chain and control of the supply chain.		
Stability of the supply chain.		
Supply chain advice.		
Internal team input and co-ordination.		
Programme certainty at sub-contract pre-order stage.		
Steer them [the supply chain] as best we can.		
Programme creation by sub-contractor for their supply chain to follow.		
Early [programme] workshops need to happen.		
Categories	Emerging Key Themes	Emerging Literature
Programme - Evolution.	Supply Chain Led.	Supply Chain Management.
Supply Chain - Programme Resourcing.	Informal Processes.	Supply Chain Integration.
Programme - Development (Structured).		
Programme - Commissioning Integration.		
Team Collaboration.		
Supply Chain - Engagement.		

Table 5

Q7. What processes do you follow to establish and integrate the various sub-contract trade sections of the construction programme?

Response Data		
Workshops and analysis of each programme iteration.		
Team familiarisation and collaboration.		
Develop a programme critical ‘spine’ of the four or five main trades.		
Aligning the supply chain with a [our] pre-set construction programme.		
Iterative passes of the [developing] programme around the supply chain.		
Supply chain experience.		
Programme creation by sub-contractor for their supply chain to follow.		
Communication and meetings to understand programme dependencies.		
Programme creation by main contractor for supply chain to follow.		
[Work] scope and interfaces identification then programme integration.		
Categories	Emerging Key Themes	Emerging Literature
Team Collaboration.	Limited Processes.	Training and Development.
Communication with Supply Chain.	Lack of Framework.	Collaboration.
Programme - Site Co-ordination.		
Programme - Integration Framework.		
Programme - Development (Unstructured).		

Table 6

Q11. How do you feel a process similar to the RIBA’s Plan of Work would be of use for developing a co-ordinated and integrated programme?

Response Data		
Especially [needed] for integrating sub-contractor programmes.		
Very useful, a set structure [for] risk, output rate, schedule uncertainty.		
Would provide consistency to programmes over current ad hoc [development].		
Supply chain would understand it [programme development] better.		
Would we have time for that [process]? It would be a challenge.		
It would be hard [to do]; only if the client bought-in would it be a success.		
If we needed more time on pre-construction [to do this] clients wouldn’t be interested.		
Clients would need to buy-in, but they would [benefit from] receiving a ‘guarantee’.		
Work could be properly planned, a side-effect being a lot safer site as well.		
Stages [for programme development] might work, gets the whole team together.		
[Would provide] better integration and more in-depth programme development.		
Categories	Emerging Key Themes	Emerging Literature
Programme - Development (Structured).	Collaborative Strategy.	Collaboration.
Team Understanding.	Contingent on Client.	Partnering.
Programme - Integration Framework - Client Buy-In.		
Programme - Integration Framework.		
Programme - Strategy.		
Team Input to Programme.		

Discussion

Critical Path Method Planning in Construction Project Environments

Some challenges around the usage of traditional CPM planning appear not that it is a deterministic / logic-based method (as often) criticised by Collaborative Planning proponents, but fundamentally whether project participants have a basic understanding of CPM application and its benefits. Interviewee 3 (Contracts Manager): *“I think that the identification of the activities which are critical to the successful completion, that’s the main challenge...”*

Prevalent cultures at contracting organisations appear to directly impact and influence the adoption and application of CPM planning. Within a general construction contracting environment the participants seemed aware that they were maybe ‘stuck’ in the past. Interviewee 1 (Senior Planner): *“Different industries have different cultures...the petrochemical industry and the nuclear industry have got better cultures than the normal construction - as I call it - industry. I think they’re a bit behind the times, normal construction, they don’t like moving forward...”*

Early and consistent supply chain engagement and partnering was seen as crucial to CPM programme development and co-ordination, acknowledging the importance of trade programme contribution into the master programme. Interviewee 1 (Senior Planner): *“I think you should have a specialist set of contractors who do the tender, and they all know each other, get together, do the integrated programme together and that’s what you run with.”*

Formal protocols for CPM programme development seem poorly evident, and ad hoc approaches may be common. The informal ‘weighing-up’ of a project with the supply chain, alongside formal planning techniques, was stated. Interviewee 2 (Senior Project Manager): *“Yes, the supply of information, walking the course, making sure they understand the project itself, the logistical strategy on the project, what’s going on around the project in the area.”*

In a predominantly sub-contracting environment the approaches to trade programme integration had a major influence on quality and success of programme. Interviewee 2 (Senior Project Manager): *“We go through various workshops, we bring them together, we do analysis of the programmes at each iteration, we understand it, we get the buy-in from our teams, our supply chain.”* Significantly, the aforementioned events are not a formal protocol.

While a formal process framework (RIBA) exists for design development progression in the construction industry there is a notable lack of similar for programme development. Interviewee 1 (Senior Planner): *“I think there is a definite need for a structure for developing programmes, especially integrating the subcontractor programmes and how that links in to the main programmes.”* Lack of stage-gates in CPM programme development is evident here.

Conclusion

This study has undertaken a small number of interviews on a major UK construction project with full-time professional, experienced, and senior contracting personnel. The primary data collected rich, descriptive experiences from pre-arranged semi-structured interviews. From this data the use of CPM planning seemed to operate in an unstructured environment characterised by poor understanding and application of CPM and dislocated engagement by project participants into the programme management function. The results from this study may be fairly representative of contracting organisations in the UK due to the general nature of the project studied.

Emerging literature is directing further investigation into various themes such as training and development of project teams, communication, construction supply chain management, contractor partnering, organisational cultures, collaborative practices, and supply chain integration. The challenges with CPM planning relating to the logical and deterministic nature of CPM planning seem to be of only partial concern to the sample. Key inferences are that challenges with CPM planning may be rooted in behavioural and cultural issues over process-based issues.

A relatively small, albeit very experienced, research sample was used for the study. However, the paper has addressed a need evident from the literature search that the effects of behaviours, attitudes, and cultures within contracting organisations on the success of CPM planning doesn’t appear to be widely researched. Further investigation is necessary to be undertaken at UK contracting organisations to identify the adoption and application of CPM planning, with the aim of ascertaining the efficiencies of both the system itself and the operators of CPM.

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