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What do construction project planners do?

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Abstract

Construction project planning is receiving growing attention as the limitations of formal deterministic planning are becoming more widely recognised. In particular, the last planner and critical chain approaches are diffusing rapidly. However, little of this debate has been informed by empirical examination of what construction project planners actually do. The research reported here draws on three different research projects. One on the overall context of construction project planning, and two focused on requirements capture for the virtual construction site system. For the later project, 18 construction planners were interviewed on their daily practice. The results show that construction planning for principal contractors is more about negotiation with other interested parties and rapid decision-making based on heuristics than detailed analysis.

Keywords: Construction project planning: Critical path analysis: Tendering

1. Introduction

There has been considerable debate over the last decade or so on the effectiveness of construction project planning. However, there is remarkably little research into what construction project planners actually do. The research reported here was undertaken as part of the requirements capture process for the development of the VIRCON system (VCS) as a strategic decision support tool for construction project planners. This larger research project is reported elsewhere [1]. This paper will explore the evidence on the role and practice of project planners that underpinned the development of the VCS. In so doing, it will address what Laufer and his colleagues [2] identify as the operation/systems analysis level of construction scheduling. The paper will first review some of the recent debates on construction project planning. It will then report the results from our interviews with 18 construction planners from five leading UK firms before some conclusions are drawn.

2. Recent debates in construction project planning

In an early paper, Laufer and Tucker [3] provide a critique of (US) construction planning. They argue that:

- The planning and evaluation of planning processes are non-existent.
- There is over-emphasis on critical path methods.
- Planners lack construction experience.
- Planners have poor information gathering methods.
- Planning is control-oriented instead of action-oriented.
- Plans are poorly presented with overly-complex information.

In a subsequent paper, Laufer and his colleagues [4] look at the definition and allocation of planning work.

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They found that there was no clear system used, and planning was done in a multiplicity of ways. Laufer and Tucker [5] discuss the problem of who should do construction planning and when they should do it. The specialist planner has the time to do the work but incomplete practical knowledge. The line manager has the practical knowledge but does not have the quality time to carry out the task. The specialist planner has better strategic decision-making skills than the short-term decision-making focus of the line manager. Line managers see the delegation of key decision-making to another as a threat to their position. These problems are also confirmed in a wider project management study [6] and can result in:

- The planner preparing a plan which has incomplete information and inadequate decision-making authority.
- The line manager treating such plans as merely an irrelevant forecast prepared by another.

For the whole project process, the ability to influence cost diminishes rapidly over time, the greatest influence being at the design phase. However the greater the time between plan and implementation, the greater is the variance of actual schedule and budget against plan. Detailed planning of activities planned to be executed far into the future – say more than three months – is futile. This is because:

- there are uncertainties which cannot be quantified;
- stochastic modelling does not identify the cause of variation;
- forecasting models extrapolate from past trends which may not be valid for the future.

Theoretically, the binomial theorem [7,8] supports this claim. The probability of an event occurring in repeated trials – where the event may be, for instance, a task running 10% over its planned duration – is given by the binomial distribution. This shows that the percentage error of the estimate of the mean performance on the task as a ratio of the percentage error for the mean durations of all tasks in the work breakdown structure (WBS) is inversely proportional to the square root of the number of tasks, for a discrete sequence of tasks. Thus for a 52 week project to be estimated at ±10% accuracy for handover date, a task with a duration of 2 weeks should only be planned with a ±50% accuracy, because some tasks will exceed their planned duration and others will not require it. This calculation, therefore, defines the lowest planning unit for the WBS. The larger the number of tasks in the WBS, the less point there is in planning each task accurately, because positive and negative variances will even themselves out at the level of the project as a whole. This argument, of course, does not apply where there are systematic biases in estimating.

3. Responses to the critiques of construction project planning

These critiques have stimulated a number of different responses. Goldratt [9] argued that there has been nothing new in project management in 40 years, and advocates the critical chain method (CCM). This addresses two of the key problems of CPM – the inherent uncertainty of task durations and the associated opportunistic behaviour in establishing the true duration of tasks, and the resourcing of tasks. In CCM, the *critical chain* is the *longest* resource constrained path through the network, theorised as a constraint to be elevated. Thus a critical chain looks like a critical path, but it includes resourcing in the dependencies.

The conceptual shift from critical path to critical chain by including resourcing issues in the latter might be considered simply a technical development, moving on from the resource levelling approaches which are well established. However, the elevation of the constraint introduces a much more radical aspect. This elevation starts from two observations:

- That actual duration for any planned task is unknown, but can be assumed to be distributed as a gamma distribution with the median task duration greater than the mode.
- Existing estimates of expected task durations are padded because they include *safety time*, greatly extending the length of the critical path.

In a situation where actual task duration is uncertain, and managers are held accountable for meeting stated durations (deadlines), then task duration estimates are going to be at the worst case end of the distribution, otherwise managers risk overrunning their deadlines. CCM instead proposes that the average estimated duration should be used. An inevitable result of this is that managers will overrun their planned durations half the time. This problem is solved by removing from managers the absolute responsibility to meet task-level duration deadlines, providing incentives for early completion instead. This approach was tried on the A13 road project in east London with great success [10].

As a result of these considerations, something of a consensus is emerging that construction planning has to be a much more decentralised activity in order to cope with the inherently uncertain nature of task duration. This issue is addressed directly by the developers of the "last planner" approach [11] who argue that construction planners should make only "quality assignments" where tasks:

- are sufficiently well defined,
  – to be co-ordinated with other work and
  – for the inputs to be identified and assembled,
- are ready to start because,
  – all materials are available,
  – design is complete,
  – precedent works are complete,
- have priority in the critical path for delivery to the customer,
- are commensurate in scale with the available labour for the coming week,
- are carried out within a system where the causes of incomplete or poor quality assignments are investigated and identified.

They argue that tasks not meeting these criteria should be deferred (even if this means a short-term loss of output against schedule) and analyse the benefits from following this course of action which they term as 'shielding' production.

Despite the fundamental important of these debates for construction project management, most recent research has gone into the refinement of existing planning tools, rather than research into exploring the organisational context of construction planning. Exceptions to this generalisation include the A13 and study [10] and Laufer [6] who investigated involvement in the planning process, and found that it is an essentially collaborative process involving line managers, designers, and planners at various stages of the process. Faniran and his colleagues [12] investigated the optimum allocation of resources to the planning process, concluding that both too little planning and too much planning were factors leading to poor project performance.

The aim of this paper, is to contribute to this limited empirical literature on planning practice. It will do this in two stages. First, the overall context of construction project planning will be explored through a single project case study which shows how the planner's work is located within a hierarchy of plans on the project. Second, data from interviews with 18 experienced planners will be reported in order to deepen our understanding of contemporary planning practice in the UK construction industry. The research reported in this paper will, therefore, help us to fill in some of these gaps in our current knowledge on construction planning practice.

4. The context of construction project planning

Fig. 1 is developed from a case study of a major hospital project in west London using a construction management procurement route, and shows the overall construction planning process. Italicized boxes represent contractually binding schedules. The research was financed by the (then) Science and Engineering Research Council. The client's project manager develops the *client's strategic programme*, which drives the *tender programme* for the procurement of the resource bases such as design consultants and construction manager, and also the *architect's design programme*. The contractually binding agreement between the client and construction manager is the *master programme*. The construction manager's project managers then prepare the *target construction programme* which guides the procurement of trade packages, and the *parcel documents programme* which drives the production of drawings by the architect. This last schedule is non-contractual,

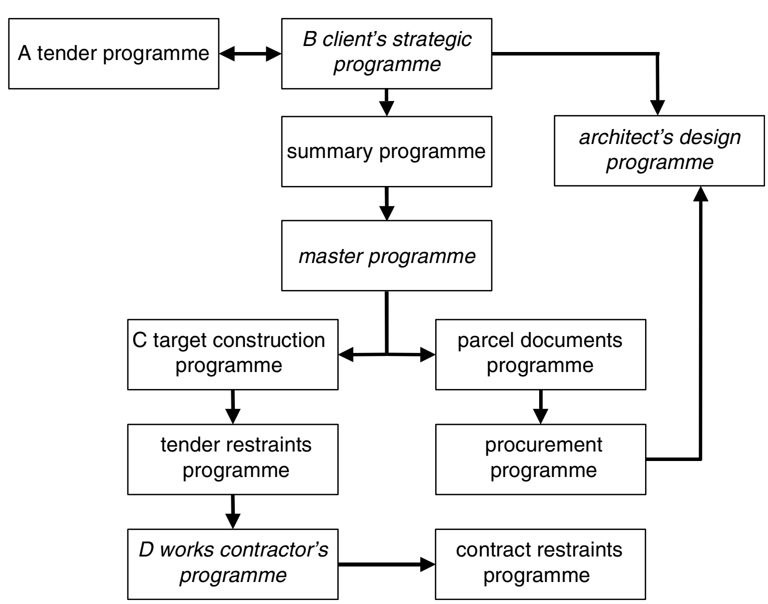

Fig. 1. The construction project planning hierarchy. Source: Developed from: [8] Figure 11.3.

but can be used in claims for delays against the client caused by the non-delivery of drawings. Within the target programme, trade contractors are given "windows" for the execution of their responsibilities on site in the *tender restraints programme*, and these are formally agreed in the *works contractors' programmes*. Within those, the trade contractors then schedule task execution at the level of work breakdown structure (WBS) that suits them which is communicated to the construction manager in the *contract restraints programme*. In order to gain more bargaining power, construction managers may not reveal the *master programme* to the trade contractors, and provide a *target construction programme* that is significantly tighter than the *master programme*, so as to buffer the completion date to ensure a satisfied client even if the works contractors programme slips (interviews 22/05/89; 30/09/89).

5. What do planners do? current practice in construction project planning

In order to explore further the reality of construction project planning semi-structured interviews were conducted between July and December 2000 with 18 experienced planners from five leading UK construction firms. Interviews came from the principal contracting and trade contracting divisions of those companies. The two packages covered by the trade contracting subsidiaries were piling and mechanical and electrical services. The research was funded by two EPSRC awards – GR/N/02917 and GR/R/51452 – and is more fully reported in [13].

Most of the planners interviewed were currently involved in planning at the pre-tender stage including assembly and presentation of the tender documentation – in other words, activity A in Fig. 1. About half of those were also involved at the post-tender pre-construction stage – in other words, activity C in Fig. 1. Only a few were further involved during the site works. Generally, although a number of the interviewed planners had on-site experience the typical pattern is that a planner works either at the pre-tender, pre-execution stages or on site but not simultaneously. The exceptions tend to be where planners work for some time on a single large project. In such cases it may make sense (from the employer's point of view) for their work to carry on to the execution stage.

For traditional contracting by single stage tendering the period for the preparation of the construction plan was around 4–6 weeks for larger contracts and 3–4 weeks for smaller ones. The post-tender to start on site period showed somewhat greater variation from 2 to 13 weeks. For two stage tendering, the first stage was similar to the single stage tender period but it was only at the subsequent stage that a price had to be presented. However, for the *planners* the time frame was similar to the traditional method. Those involved in two-stage planning reported that the plan was a significant factor in progressing beyond the first stage as a demonstration of competence was the paramount selection criterion at this stage.

Under construction management procurement, planners tended to be brought in earlier in the process. The principal contractors were also involved in partnered contracts and PFI schemes where the tender periods were considerably longer (3–6 months and more). On large civil engineering projects, the tender periods were also longer, averaging around three months. However, planners often work simultaneously on several tenders, and so the actual working time which is available to them for preparing each tender submission is substantially less than the average tender period.

Planners tended to be overwhelmed with information. They received large amounts of information that was not relevant to their role, and spent considerable amounts of time sifting through it. As might be expected, this problem particularly affected the planners working for trade contractors. On the other hand, the quality of much of the information received was poor. For instance, M & E drawings sometimes did not allow for any secondary steel support work, or installation space for pipework. Similarly, some designs showed a lack of understanding of the space required by piling plant, the most common problem being the siting of works too near confined boundaries making it impossible for plant to access the working area with sufficient working room.

The methods for dealing with the uncertainty caused by design information deficiencies were:

- Guess the missing information based on experience and past job records.
- Qualify the submitted tender.
- Assess the risk posed by the missing information and adjust the risk premium accordingly.
- Take a strict contractual stance on site with regards to negotiating the cost of variations to the tender drawings/specifications/scope of works.

Table 1 presents the documents produced by the planner as part of the tender team. The first four items were specifically mentioned by the interviewer, while the others were spontaneously mentioned by the informant. Those items only mentioned by one planner have been omitted as being specific to that planner's type of work. One informant reported that for *partnered* contracts, he was prepared to list all the risk items in the tender with prices attached – a sort of risk 'shopping list'. It was then up to the client to decide which risk items it wanted to take on board.

Table 1
Construction planners' deliverable outputs

	Number of mentions		
	Internal only	External partnered only	External
Non-financial information produced at tender stagementioned by more than one planner			
Items mentioned by the interviewer			
Method statement			18
Programme bar chart			18
Critical path analysis	3		8
Risk assessment	7	1	3
Additional items mentioned by the planners			
Preliminaries scheme/resources			5
Site mobilisation/layout drawings			5
Design programme (for D & B)			6
Design information requirement dates			5
Procurement programme			6
Team details/cv's/organigrammes			7
Record/references of previous experience			3
Buildability/programme/value eng. options	1		3
Quality assurance plans and procedure			6
Health and safety plans and procedure			7
Environmental protection procedures			3
Phased work location drawings	8		4
Overall resource schedules			3

Table 2
Domain- specific knowledge acquired

Type of learning mentioned by more than one planner	No
Better understanding of site processes and works contractors	7
Better understanding of M & E services and co-ordination with other trades	6
Development of better communication skills (including listening)	4
Experience through working on a wide range of projects	3
Better understanding of contracts and tender processes	3
Development of the ability to anticipate problems	2
Better understanding of the 3D/spatial aspects of the work (piling planners)	2
Development of a feel for task outputs and durations	2
Better understanding of supply chain management	2

Table 2 reports the domain specific knowledge planners believe that they have acquired which enables them to solve planning problems better than inexperienced planners. Older planners were critical of (some) younger planners. One felt that two generations of planners (taking a generation at 15 years) had now appeared who had little site experience. The first generation of 'unsited' planners was now teaching the second. Another felt that the younger planners were too technology driven instead of concentrating on developing a basic understanding of construction problems.

Fig. 2 shows the preferred planning software related to the value of recent contracts handled by each planner. It is clear that Primavera is preferred for larger value contracts and Power Project for smaller ones. A thorough review of the capabilities of these and other Critical Path Analysis software packages can be found in [14].

The Primavera users particularly praised its rigorous and disciplined task logic. The Power Project users criticised it for the same reason! The problem is that Primavera requires a substantial set-up time and considerable effort in maintenance and amendment. Amending one task in Primavera may force detailed adjustments of other tasks dependent on the amended task. Power Project will allow the last minute input of an 'illogical' task sequence which the planner believes will actually work but for which they do not have the time to re-input a new set of task dependencies. This is vital due to the very short tender periods identified above. According to our informants who use it, Power Project is easy to learn and easy to use with excellent presentation facilities. Users of both packages agreed that Primavera does require a significant learning period. The informants who preferred Primavera software to Power Project also tended to make intensive use of

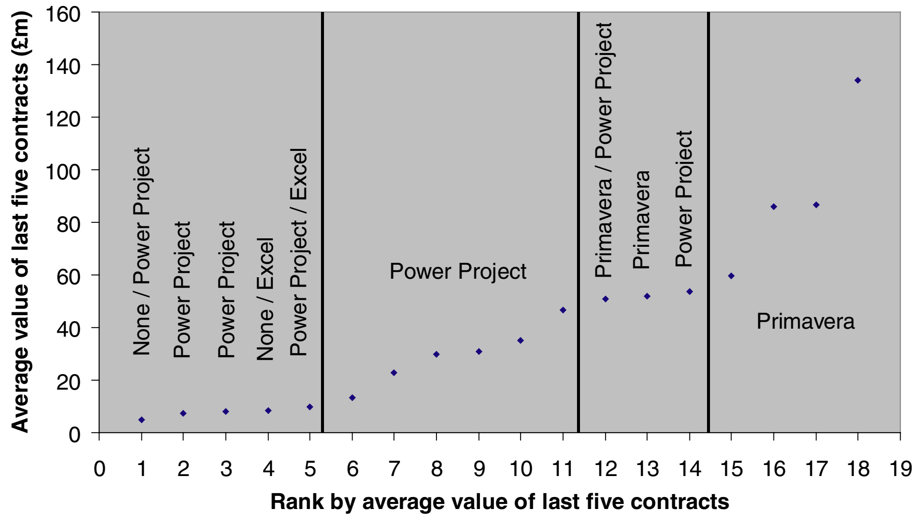

Fig. 2. Decision support tools used by construction planners. Source: [13].

critical path analysis, as opposed to restricting themselves to Gantt charts.

6. The construction planning process

The approach to process mapping deployed for this research is a ''business'' one derived from the work of Rummler and Brache [15], rather than an ''engineering'' one deploying IDEF0 (see [16] for this distinction). Table 3 categorises the four types of actor in the construction planning process. Clearly the client and consultants initiate the process through the invitation to tender. The suppliers and constrainers determine the ability of the principal contractor to deliver the client's requirements, the former through their capacity and the latter by the extent of their agreement to allow the contractor to use the most efficient construction processes where these impinge on their particular domain. The principal contractor's planning team mediates between these other actors to form a viable plan. The interaction with these actors also reveals a potential conflict between short and long-term goals for planners. While they have to negotiate 'robustly' with these actors on each contract, they also have to maintain a longer working relationship which may serve to moderate their negotiating behaviour.

The key difference between the situation for principal contractors and works contractors lies in those actors in the 'constrainer' category, because they include other works contractors carrying out works precedent or concurrent in time or space. Whereas for the principal contractor, constrainers are known, for the works contractor these may be unknown at the time of tendering (depending on the construction procurement method) and therefore no negotiation with them is possible. This makes it all the more important that the principal contractor's planner allows a sufficient distribution of space and other site resources to allow each works contractor to do their work unhindered.

Fig. 3 shows the overall pre-contract construction planning process for a principal contractor highlighting:

- The interdependency between construction site programme planning and design/procurement programme planning.

Table 3
Principal contractors' pre-tender construction planning process actors

Role	Description	Actors
Customer	Ordering built product, representing client's interests and supplying design information not controlled by the contractor	Client, project manager, architect, principal quantity surveyor, structural and M&E engineers
Performer	Planning construction as part of tender offer to supply built product	Principal contractor's planning team responsible to senior management
Supplier	Providing contractor with information on supply chain delivery capabilities	Trusted works contractors and specialist material suppliers
Constrainer	Controllers of the site and its environment who have the power to block or restrict construction operations	Client and/or client's landlord utilities, adjoining owners, police, regulatory/highway authorities

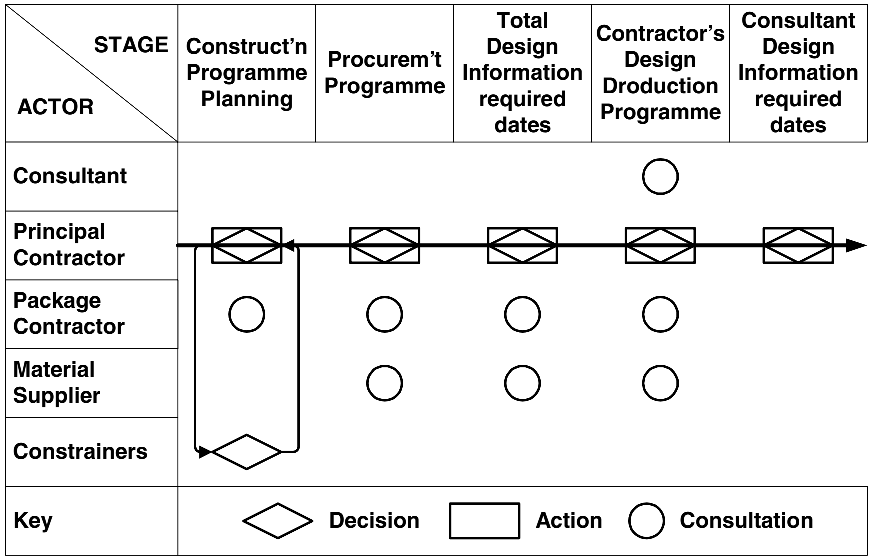

Fig. 3. The principal contractor's pre-contract construction planning process. *Source*: [13].

- The general sequence for determining the dates when design information is required from actors outside the principal contractor's supply chain.
- The substantial involvement of supply chain actors.
- The important decision role of constrainer actors.

The sequence of *action* which is being planned is clearly of the general form

Design → Procure → Construct

However the actual *programme planning* process has to be in reverse – or "backtimed" – due to the driving role in planning of the client's strategic programme, box B in Fig. 1 as follows:

Construct → Procure → Design

In a very important sense, from a planning perspective, design and procurement are merely inputs into the execution process on site which delivers the asset to the client ready for exploitation.

This can be illustrated by the following sequence of programme planning, as identified in the horizontal axis of Fig. 3.

Stage 1 – identification of the overall site construction programme

1.1 Breakdown of identified construction processes into packages according to supply chain capacities.
1.2 Planning of sequential logic of processes/packages in time and space.
1.3 Assessment of common site resources and temporary/enabling works required to service direct construction processes.
1.4 Negotiation with constrainers (as defined in Table 3) to allow certain construction operations.
1.5 Informal negotiation with supply chain representatives (and/or experienced in-house operations manager) to confirm or amend steps 1.1–1.4

Stage 2 – identification of the overall procurement programme

2.1 Identification of all key supply chain actors including those excluded from on-site construction processes.
2.2 Identification of lead times for key supply items and works contractor tendering.
2.3 Planning of sequential logic of procurement to support construction programme.
2.4 Informal negotiation with supply chain representatives to confirm or amend steps 2.1–2.3.

Stage 3 – identification of design information delivery dates required for procurement and construction

3.1 Identify all detailed design requirement dates (from all sources) to support construction and procurement processes

Stage 4 – identification of the contractor's design programme

4.1 Identification of temporary works design requirements.
4.2 Identification of supply chain design responsibilities.
4.3 Identification of supply chain information requirements to carry out design activities.

4.4 Identification of client's consultants' lead times required to approve design data for which the contractor is responsible.
4.5 Planning of sequential logic of contractor's design activities to support Stage 3 above.

Stage 5 – identification of the detailed design data requirement dates from client's consultants

5.1 From Stages 3 and 4 above computation of all outline/detailed design requirement dates in order to support contractor's design, procurement and construction programmes (the output of which may require repetition of Stages 1–4 above)

The output from stages 1.2, 2.3, 4.5 and 5.1 will form part of the tender submission. As indicated under Stage 5, this is an iterative process and may require several passes before a viable integrated programme can be produced.

Up to detailed design stage the client and the consultants negotiate both with each other and also with the local planning authority to arrive at an acceptable design. In this activity local regulatory authorities have to take note of objections by their own officers, the public and adjoining property owners at both outline and detailed construction permit application stage.

At the construction planning stage there is a number of decision actors. This makes the planner's negotiating skills all-important. Although works contractors do not decide whether or not to tender for part of the works at the *principal contractor's* pre-tender stage, if principal contractor planners do not have the tacit support of their supply chain at this stage (or confidence that such support will be forthcoming) then they are running a considerable risk.

There are further problems in negotiating with the 'constrainer' category of actors. If construction permit applications have been passed against the advice of local authority officers or against strong objections from neighbouring property owners then, subsequent negotiations with these actors at the construction programme planning stage may be all the more difficult.

7. Review of construction project planning practice

It was clear from the interviews that a systematic review of project planning (and project review in general) was either rare or non-existent. A significant number of informants said that they did not tend to refer to past job records as these were either non-existent or inadequate. Project feedback does, of course, occur (negative feedback in particular). However, without systematic feedback it is not clear how learning and improvement of the planning process can take place at an organisational level. Total project review is necessary to establish the reasons for project execution shortcomings. However, the actors most able to contribute to this process are those with the least motivation to expose their own errors.

Informants from the principal contractors were almost united in their approach to trade package identification. This view was that the packages should be split according to the known trade capacities of individual contractors. Principal contractors' planners can only realistically plan down to the works package level (broken down further into the main package components) in the *target construction programme* shown at C in Fig. 1. It is the trade contractors' planners in the works contractors programme shown in D in Fig. 1 who have to turn these packages into a WBS to yield a sequence of individual tasks through time. This practice vitiates against the recommendations of those arguing for the "clustering" of trades into technologically defined subsystems – see Winch [8] chapter 7 for a review.

Nearly all informants reported that, having selected the construction method, they disregard the construction period stated in the tender and work out what time they think it ought to take to carry out the works. That is their 'optimal' period in the sense that it allows for the minimum but robust time buffers to cope with risks attached to critical packages. In nearly all cases this tends to be longer than the stated contract period in the tender documents. They then see what time they can trim off the 'optimal' period. This exercise helps them to evaluate the risks associated with attempting to construct the building within the time preferred by the client/consultant. They often discuss this with estimators who have a knowledge of trade output rates. Although they will take note of this, many are sceptical about relying on such data. They prefer to use their own 'feel' for package times gained by experience.

Principal contractor planners do use critical path methods but their work is more in the nature of planning co-ordinators. They use critical path methods in a broad brush approach since they recognise that the people best placed to plan work in detail are the works contractors. What is clear is that those informants who plan larger more complex projects over several months attach greater importance to their use of critical path methods. One of those was a works contractor so he has to plan in detail. The remainder recognise the limitations of the methods but point out that they have to allocate fairly the contract time between different works contractors and they have enough experience and understanding of task dependencies to develop a workable network model. This assists them in negotiating with the works contractors. It also helps them to understand where the greatest time-risk areas might lie.

Virtually all planners said that they were not attempting to optimise the construction time but rather to get a realistic time which allowed a reasonable time buffer to take account of known risk areas. Most said that they would be prepared to 'walk away' from a contract if the construction period stated in the tender were wholly unreasonable by the submission of a non-conforming bid. Most were prepared to submit a non-conforming bid if they felt that they could offer a lower price. A few would be prepared to submit a non-conforming bid at a *higher* price and a *shorter* construction period where they believed that time was of the essence to the client.

8. Conclusions

Construction project planners add value for the contracting organisation by ensuring that estimating and tendering are based on a robust understanding of the methods, time and space required to carry out the tasks for each building contract and the corresponding risks involved. Their output can be influential in winning tenders not based on purely financial criteria. They have to perform both planning and other work in a time- and information-constrained environment which requires considerable use of heuristics based on judgement and experience-based learning. Negotiation and communication are important in their work and for this reason many of the processes and task interdependencies in their work are iterative. Their longer-term objectives have to take account of potential long-term relationships with operational management colleagues and representatives of other organisations with whom they have to negotiate.

Pre-tender construction planning has to be understood within the broader context shown in Fig. 1 that includes design and procurement planning. It is a high-level planning activity, which has to incorporate the many lower level plans of works contractors. It involves as much co-ordination of planning as direct planning although re-examination of the lower-level schedule may be required to confirm the robustness of the higher-level plan. It is this process that sets the framework for the more detailed level of activity as advocated by the last planner approach and critical chain which are most appropriate for the development of the works contractors' programmes shown as D in Fig. 1.

The benefits of planning are seen by mid-level managers as producing beneficial future states that would not have occurred and by top managers as preventing adverse future states that would otherwise have occurred. Accordingly the view of the benefits of planning varies within the organisation. The 'prevented' states can be difficult to identify and measure in economic terms. It is clear that planning has a crucial role to play in delivering construction projects consummately [3,12]. It is also clear that detailed planning needs to be decentralised to the level responsible for the execution of the works [10–12]. This paper, has focused on the pre-tender planning process which forms the basis of the negotiation and contractual agreement of the master programme, and also sets the strategic context for the more detailed decentralised planning to post-contract. We have shown that planners work in a complex network of relationships spreading within and without the contracting organisation, they work to pressing deadlines which preclude detailed analysis, and under significant levels of uncertainty. We encourage others to pursue this line of enquiry – planning remains central to construction project management, and its practice deserves more research attention than it currently receives.

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