Routledge
Taylor & Francis Group

Construction Management and Economics

ISSN: 0144-6193 (Print) 1466-433X (Online) Journal homepage: https://www.tandfonline.com/loi/rcme20

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To cite this article: Alexander Laufer , Richard L. Tucker , Aviad Shapira & Aaron J. Shenhar (1994) The multiplicity concept in construction project planning, Construction Management and Economics, 12:1, 53-65, DOI: 10.1080/01446199400000007

To link to this article: https://doi.org/10.1080/01446199400000007

Construction Management and Economics (1994) **11**, 53–65

The multiplicity concept in construction project planning

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22 December 1992; revised 2 August 1993

Why plan? Who should plan? What and when should one plan? These fundamental issues of construction planning raised by the authors 5 years ago, are revisited in this paper in the light of studies conducted recently within the construction industry. In the focus of this research program stood mature companies, advanced projects and competent and experienced practitioners of construction planning and management. The findings show that there is no one single answer to any of these basic questions and that in fact a state of multiplicity – of roles and users, plans and formats, timings and time horizons, planning parties and modes of preparation – prevail, calling upon the willing practitioner to resort systematically to situational analysis if effective planning is to be accomplished.

Keywords: Construction planning, formats of plans, planning modes, planning roles, timing of planning.

Introduction

In a previous work, reported a few years ago (Laufer and Tucker, 1987, 1988), several fundamental problems regarding the construction planning process were identified and described. Partial solutions were suggested as well, based to some extent on a few limited studies, but primarily on secondary information, inferred from many related studies, from both within and without the construction industry.

Since then the authors have been conducting an elaborate research programme in the construction industry, with the purpose of better understanding those problems and addressing them directly. Even more importantly, the studies made it possible to learn how mature construction companies have managed these problems in practice and found solutions for them. Thus, we purport in this paper to revisit these problems, to present the major relevant findings of our recent studies, and to introduce the concept emerging from them.

The problems are best articulated by the following questions.

1. Why plan?
2. What should one plan?
3. When should one plan?
4. Who should do the planning?

Each of these questions and mainly two of them which contain major dilemmas – timing (when) and competence (who) – are first presented the way they were raised at the time (and both followed by suggested solutions). They are highlighted on the basis of field data accumulated since, followed by the main report on each problem: the practice in mature companies. Finally, implications – mostly for practitioners – are offered in the light of the main conclusions.

The term 'mature companies' as used in this paper refers to companies that have:

1. established a well-developed management philosophy;

0144–6193

2. employed advanced management systems and tools;
3. accumulated vast relevant experience, including that learned by failures.

As a result, they have, in fact, succeeded in demonstrating effective performance.

Background

The following studies served as major sources for data and findings presented in this paper.

1. A Construction Industry Institute (CII) research project, which included interviews with 37 project managers from 11 owner companies, all members of the CII (Laufer, 1989).
2. A systematic review of 33 project management procedure manuals of large US firms (again members of the Construction Industry Institute): 20 from owner companies and 13 from general contractors (Howell, 1990).
3. In-depth interviews of 3–4 h with 18 managers from eight leading Western US construction companies, all conducted on-site and each pertaining to a specific project. Project costs ranged from $10 to 195 million, contracts were seven lump sum and 11 cost reimbursable and the facilities built were 15 commercial/industrial and three R & D. That study (Laufer *et al.*, 1992a) is the central source of empirical information for this paper.
4. A comparative analysis of various modes for detailed, short-term planning, based on observations and documented experience on construction sites in Israel and in the USA over a period of 10 years, 1980–1990 (Laufer *et al.*, 1992b).
5. A survey of 93 executives and project managers, affiliated with US owner companies (approximately two-thirds of the sample) and contractors. The data were collected in several workshops which took place during 1990–1991 (Howell *et al.*, 1993).
6. A case study research on 26 projects in Israel. These projects were executed in various industries, and they involved various levels of technological uncertainty. Overall 115 people were interviewed for this study. The research involved a framework for project classification and contingency analysis among various kinds of projects (Shenhar, 1992).

In addition, the authors have been continuously involved in consulting for and experimentation with US construction firms, through which the issues concerned were validated and clarified. Many of the proposed solutions have meanwhile been implemented.

This paper is a synthesis of the aforementioned studies. On the basis of their empirical results, fundamental key principles for planning are formulated and amalgamated into one coherent concept.

Definition of planning

This paper attempts to address planning in its wider, comprehensive sense. We therefore find it appropriate to adhere to the definition of planning that guided us, resorting to an analysis done in the framework of a previous study (Laufer, 1989).

From an extensive survey of the general literature, it is clear that the term planning is still widely debated (e.g. Wildavsky, 1973; Mintzberg, 1981; Snyder, 1982). Some equate planning with management. In the project environment it is perceived to cover all activities necessary to launch a project, while those that follow the launch are defined as project control. This division is inaccurate and possibly misleading. Others claim planning to be a decision-making process (conscious and deliberate selection among alternatives). But planning is in reality much more than just decision-making.

It was proposed that construction planning is a process composed of several elements. The more of these elements that are present, the more readily the process is recognized as planning.

Planning elements comprise the following.

1. A decision-making process.
2. A process of anticipatory decision-making – to decide what and/or how to perform actions due at some point in the future.
3. A process of integrating interdependent decisions into a system of decisions.
4. A hierarchical process evolving from general guidelines to objectives, to the elaboration of means and constraints that lead to a detailed course of action.
5. A process that includes part or all of a chain of activities comprising information search and analysis, development and design of alternatives, analysis and evaluation of alternatives and choice making.
6. The systematic employment of procedures (standardized and formal to varying degrees).
7. Documented presentation, in the form of plans.

In this paper, only processes accommodating most of these seven elements were referred to as planning.

The multiplicity principles

It is maintained here, on the basis of the accumulative findings and their analysis, that effective construction planning

1. addresses numerous purposes and various users;
2. requires numerous plans and various formats;
3. requires numerous timings and various time horizons;
4. requires numerous participants and various modes of preparation.

In the following, supporting data are provided showing how these multiplicity principles are practised in mature companies and how, in fact, they constitute the answers to the very questions and dilemmas raised by Laufer and Tucker (1987, 1988).

The 'why' question: multiple purposes and users

The 'purpose' issue

Laufer and Tucker (1987) concluded that construction planning plays five distinct roles:

1. execution (action planning);
2. coordination;
3. control;
4. forecasting;
5. optimization.

Using a theoretical model they analysed the actual pursuit of planning objectives as affected by the users' planning needs and their relative political power. They showed that, contrary to the normative role of planning, where formal action plans should receive very high priority, the actual role of planning in most construction companies is forecasting and control. Execution planning, which is in essence the *raison d'etre* for any planning, receives only low priority.

The practice in mature companies

The 'purpose' issue was addressed in two recent studies (Laufer, 1989; Laufer *et al.*, 1992a). The central conclusive finding was that in mature companies construction planning indeed played multiple roles, most of them being pursued quite extensively. Other important findings were

1. the extent to which the various roles are pursued is contingent upon the situation, e.g. owner's requirements, project characteristics, project stage, uncertainty level, etc.;
2. control is still the most widely pursued role, especially with regard to formal plans, nevertheless, action planning emerges as a high-priority role as well, both in formal and semi-formal planning.

The purposes of planning are strongly correlated with the users of the plans. Common users are

1. the owner (identifiable in at least three distinct different bodies: sponsor, client and user);
2. the various design engineers;
3. the home office (including various functional departments);
4. site management (line: project manager, general superintendent, foremen; staff: project/field engineer, scheduling engineer, cost engineer);
5. various subcontractors and suppliers.

As to the purposes of construction planning, 13 different roles were identified, most of which are formally and significantly pursued throughout the project life. The purposes indeed follow the evolution of project life, from the setting of objectives, through to planning of construction means at the various levels and control of the performance during construction, to drawing of lessons after project completion. They are summarized in the following (each illustrating – in parentheses – a typical user).

1. Setting the objectives, their priorities and trade-offs, and determining project constraints (a typical user: the estimator at the home office).
2. Providing a basis for contractual commitments between owner and contractor, as well as between contractor and subcontractors (e.g. project manager).
3. Obtaining a better understanding of the objectives, clarifying them and maximizing the probability of attaining them (e.g. project manager).
4. Defining and breaking down all required work (setting clear boundaries between work packages) to enable each project participant to identify and plan their share in it (e.g. project engineer).
5. Preparing a preliminary model and general guidelines for future plans, to allow sufficient lead time and to maintain continuity and global perspective (e.g. general superintendent).
6. Preparing action plan (process-oriented decisions), articulating direct work assignments for implementation (e.g. foremen).
7. Improving communication, coordination and integration of the multilevel (vertical integration of the various managerial echelons), multifunctional (horizontal integration of the various disciplines) and multistage (consistency of planning done at different times throughout project life) inputs and decisions (e.g. subcontractors).
8. Providing a yardstick for monitoring, reviewing and controlling project execution (e.g. manager at the home office).
9. Preparing a forecast of performance (product-oriented plans) for ongoing project control and as premises for owner's future planning (e.g. representative of the owner).

10. Improving optimization by considering and analysing more alternatives (e.g. general superintendent).
11. Avoiding wrong decisions by probing the future implications of current decisions (making decisions on what to refrain from doing).
12. Speeding up ability of response (flexibility) to future changes.
13. Utilizing the experience and the records accumulated from previous projects in a systematic learning process (e.g. estimator at the home office).

It should be noted that though roles 11 and 12 – concerning prevention and enhancement of responsiveness – are not covered by documented plans, their outcome is reflected in the whole process of planning. Also note that role 10 is only infrequently pursued, while roles 5 and 6 – although very central and always cultivated in mature companies – are often not fully articulated in formal, written plans.

To summarize the 'purpose' issue, the first multiplicity principle – the hierarchy principle – as practised by mature companies is 'effective planning addresses numerous purposes for various users'.

The 'what' question: multiple plans and formats

The 'focus' issue

The major flaw of the planning focus as identified by Laufer and Tucker (1987) was that scheduling (time planning) is over-emphasized while methods planning (how to carry out the work) is neglected.

The explanation provided for this state lies within three dominant factors: the influence of the owner, the goals of construction projects and the training of construction planners. It was maintained that two factors are reflected in the greater attention given to the planning of the schedule and the lesser attention given to construction resources and work methods. These factors are management's perceived ability to affect the time goal more than the cost or quality goals and the owner's power to accord the highest priority to the schedule (and, in particular, to the date of completion). This is particularly evident in cost-plus projects, which inherently place greater emphasis on scheduling. As to the second factor, Laufer and Tucker (1987) pointed to the weight given by most university programmes on construction engineering and management to scheduling techniques at the expense of construction methods, a trend further enhanced in the typical formal training with the progress made in computers.

This state of affairs is reflected in the existing literature on construction planning and is supported by recent studies. A thorough examination (Howell, 1990) of the project manuals of major US companies found that although some attention is given to several planning areas, the main focus is still scheduling and cost estimating.

Thus, the 'focus' issue should be portrayed less as over-emphasis on time and cost planning and more as an underestimation of most other functional construction plans, reflected both in attributed importance and in invested effort.

The practice in mature companies

Laufer *et al.* (1992a) have recently examined the focus of planning and resulting plans through three measures.

1. The relative effort invested in the preparation of various construction plans.
2. The rate of issuance of written/drawn-up documents for the various plans.
3. The use of different types of formats as representation media for the various plans.

For that purpose planning was classified into functional areas or construction plans, under the following headings: engineering and method (main construction technology), organization and contract, schedule, cost and cash flow, major equipment, site layout and logistics, work methods, manpower allocation and materials allocation.

The relative planning effort was evaluated at three separate planning stages throughout project life: pre-bid, pre-construction (from bid award to full mobilization) and during-construction. Results are presented later in the section on the dilemma of planning timing. The conclusive finding, though, was that the progressive companies studied in the sample had invested considerable efforts in multiple planning areas other than schedule and cost and cash flow at all planning stages.

The major findings of the two other measures, plan issuance and types of formats – evaluated at the pre-construction stage where commonly the greater part of formal planning takes place – are given in Table 1. With respect to functional plans issued in the form of a document, the results (second column from left) clearly indicate that schedule is far from being the only 'game in town'. Planning in most other areas was found to be expressed in issued plans in 70–90% of the sampled projects, with work methods and layout and logistics heading the list and not far from schedule. The explanation for the issuance proportion of cost and cash flow – lower than what might have been expected – is that this plan (as well as schedule, for that matter) has already been prepared prior to submission of proposal and in 22% of the sampled projects there was no need for a new cost plan after bid award (except, perhaps, minor revisions). Indeed, at the pre-bid stage, both plans – schedule and

Table 1 Plans and formats in pre-construction planning

Plan	Proportion of plans issuance (%)	Proportion of format use by type of format (%)					
		Textual	Technical diagrams	Organizational diagrams	Time charts	Tables	Total
Engineering and method	56	55	9	–	36	–	100
Organization and contract	67	59	–	35	–	6	100
Schedule	94	8	12.5	12.5	67	–	100
Cost and cash flow	78	20	–	–	30	50	100
Major equipment	72	47	20	–	13	20	100
Layout and logistics	89	30	60	–	5	5	100
Work methods	89	50	27	4	15	4	100
Manpower allocation	83	24	5	9.5	52	9.5	100
Materials allocation	78	45	5	–	25	25	100
Weighted mean	–	36	16	7	28	13	100

cost and cash flow – were reported to have been formally issued in 100% of the projects.

Formats used for issuance of plans were classified and grouped into five families.

1. Textual (lists and checklists, meeting protocols, verbal instructions).
2. Technical diagrams (including drawings).
3. Organizational diagrams (work breakdown structures, organizational structures).
4. Time charts (Gantt, CPM, time/resource diagrams).
5. Tables (including other kinds of standard forms).

Table 1 shows the rates of format employment observed for each functional plan and the weighted means for all plans. Two major findings emerge: the variety of employed formats and the high proportion of types of format not commonly identified with construction planning. Note, for instance, the high rate of textual formats used – with a weighted mean of 36% the most frequent type. Even in schedule, a third of the formats found to be used were types other than Gantt or CPM. Other noteworthy observations are the following.

1. All plans, except one, used textual formats at a rate of 20% and above. In five of these plans the rate was 45% and above.
2. The three technology plans – major equipment, layout and logistics and work methods – were the main plans which used technical diagrams, especially layout and logistics at a rate of 60%.
3. Time charts were mostly used by the two resource plans, manpower and material allocation, by the two control plans, schedule and cost and cash flow and by engineering and method. The highest proportions were reported in schedule (67%) and in manpower allocation (52%).
4. Cost and cash flow employed mainly tables (50%). Other main plans which used this format were materials allocation and major equipment.

When the formats are analysed and classified by their main emphasis and by their formality (e.g. CPM is a typical formal – well-defined, recognized standard – medium, while protocols of meetings are inherently informal), three families of formats can be identified. The textual, very informal formats are action- and planning process-oriented and are seldom used for control. The technical and organizational diagrams are employed mainly in the design and configuration of objects (rather than the planning of processes); they are semi-formal and partly used for control. The main focus of the third family – charts and tables – is time and money. These formats, extensively used for control purposes, are also the most formal mediums. They are mainly concerned with results and achievements, milestones and deadlines. They are employed for the planning of outcomes rather than for the planning of processes. It is evident therefore that, in spite of the variety and multiplicity, certain types of format fit specific requirements.

To summarize the 'focus' issue, the second multiplicity principle – the comprehensiveness principle – as practised by mature companies is 'effective planning requires numerous plans and various formats'.

The 'when' question: multiple timings and time horizons

The timing dilemma

The timing dilemma was described and elaborated by Laufer and Tucker (1988). It can be summarized by the following premises, which focus on the inherent uncertainty underlying the planning of construction projects.

1. Uncertainty is not an exceptional state in the otherwise predictable process of construction work. In fact it is a permanent feature in the realm of construction, obviously resulting from condi-

tions prevailing at the construction site and its environment during construction. But in fact recent studies have shown that uncertainty originates at much higher hierarchy levels and is rooted in a much earlier stage of the project life. Laufer (1989, 1991) and Howell *et al.* (1993) found that in many projects construction starts at a high level of uncertainty, due to the incompleteness and instability of project objectives emanating from the owner, which are to serve as directives for design engineering and for construction.

2. The longer the time interval between planning and implementation, the higher the uncertainty concerning the planned activity.
3. The higher the uncertainty in a project, the more difficult it is to plan and the less effective the planning will be in accurately articulating actions and outcomes.
4. Sophisticated models for planning are inadequate for coping with highly uncertain situations.
5. The earlier in the life of a project the planner comes to grips with all the relevant functional areas, the greater their influence on the project.

These premises highlight the difficulty of determining the timing of planning: should one plan well ahead of implementation and benefit from wielding greater influence or should planning be postponed until implementation is closer at hand in order to secure higher planning accuracy?

The solution suggested at the time

The major components of the solution suggested by Laufer and Tucker (1988) were as follows.

1. The degree of detail should vary inversely with the planning horizon, i.e. the closer the time of implementation, the greater the detail.
2. When uncertainty is high, the degree of detail for the near term should be lowered and its decrease accelerated across the planning horizon, i.e. a uniform degree of planning accuracy – and not of detail – should be aimed for across time.
3. As the planning horizon expands, the list of activities should become smaller and the specification for each activity more compact, more attention is to be paid to the examination of ideas than to the analysis of precise facts and numbers and more emphasis should be placed on assessing the futurity of current decisions.
4. The higher the uncertainty, the higher the frequency of planning revisions.
5. Planning horizon, degree of detail and revision interval, vary with management level. Top management prepares long-term plans with a low level of detail and infrequently updated, while the low level echelon prepares detailed short-term plans more frequently.

The suggested solution did not advocate delaying the start of planning. On the contrary, when partial solutions (i.e. initial planning with a low degree of detail) are given their rightful place, early planning becomes meaningful. This style provides for planning in greater detail at the appropriate stage of the project. Thus, the answer given to the question, 'When should one plan – early or late?' was 'Both – early and late'.

The practice in mature companies

We have found (Laufer *et al.*, 1992a) that in mature companies planning is done not only both early and late, but at numerous timings and, indeed, continually throughout project life. That planning is done at both pre-bid and pre-construction stages – and mostly at the latter – is not news. What is enlightening is that much planning is done during construction, assuming both formal and informal patterns. This is reflected in the relative effort invested in planning, in the involvement of the participating parties in planning and in the characteristics of planning meetings. Findings of the first two measures are depicted in Table 2. Here we dwell on the relative planning effort. The involvement of participants in planning is discussed in the next section.

Planning effort, measured by the relative time invested in the preparation of each functional plan, was evaluated on the basis of the plan reported to have been the one with the most time invested (designated as 100%). The bracketed figures appearing in Table 2 were obtained as follows: in each planning stage a mean rating of the relative planning effort of all projects was computed for each plan. The plan that scored the highest mean percentage in any given stage was then defined as requiring a relative planning effort of 100% and the results of all other plans in that stage were proportionally adjusted. For example, the bracketed figure in the upper left corner in Table 2 means that the planning effort invested in engineering and method at pre-bid planning was evaluated as 41% of that invested in cost and cash flow. This evaluation was done separately for each of the three planning stages, thus, the results are relative to each other only within a planning stage. As the results appearing in Table 2 show, time is, in fact, invested in the preparation of the various plans throughout the project life. Other than schedule and cost and cash flow, plans such as manpower allocation, work methods and layout and logistics, each entailed a third and more of the time invested in schedule for their preparation during construction. At all planning stages the cumulative effort invested in all plans other than schedule and cost and cash flow exceeded that invested in these two control plans.

Table 2 Key participants and relative planning effort

Plan	Pre-bid planning	Pre-construction planning	During-construction planning
Engineering and method	PM	GS, DE	PM, GS, PE, DE, SC
	(41)	(33)	(30)
Organization and contract	PM, HO	PM	PM, HO, GS, PE
	(52)	(43)	(18)
Schedule	PM, HO, SC	GS, SC, PM, PE	GS, PE, PM, SC, CL
	(82)	(100)	(100)
Cost and cash flow	PM, HO	PM, SC, GS, HO, CL	PM, PE, GS, HO
	(100)	(52)	(68)
Major equipment	PM, HO	GS	GS, PM, PE
	(34)	(47)	(27)
Layout and logistics	PM	GS, PM	GS, PM
	(39)	(61)	(33)
Work methods	HO	GS, PM	GS, PM, SC, PE
	(47)	(55)	(38)
Manpower allocation	–	SC, GS	GS, PE, PM, SC
	(22)	(37)	(43)
Materials allocation	–	GS, PM, SC	GS, PE, SC, PM
	(21)	(33)	(25)

PM, project manager; SC, subcontractors; GS, general superintendent; CL, client/owner; PE, project engineer; DE, design engineers; HO, home office.
Participants are listed in descending order of their degree of involvement.
Bracketed figures denote per cents of relative planning effort.

Planning – and in particular during construction – was found to be often conducted at various kinds of meetings. In most cases these meetings mainly served planning and not just coordination, even if quite naturally planning as such was normally diminishing as construction advanced, with uncertainty levels falling and a gradual transition to control mode. In some cases, however, a moderate to high degree of uncertainty was sustained almost throughout construction. Nahapiet and Nahapiet (1985), who documented many case studies in the US and UK, found that meetings were indeed a mode used extensively in planning – of both design and construction. They also reported that in the US it was even more pronounced than in the UK.

What about project control? In its classical meaning control comprises

1. setting standards;
2. measuring performance;
3. making comparisons and taking corrective actions (Koontz and O'Donnell, 1968; Ackoff, 1970).

We have found that, particularly at the overall project level, control of project-related outcomes was in general formally and systematically carried out. At the same time, control of resource utilization was performed less formally, typically entwined with planning issues during site meetings. An extensive and detailed treatment of this issue is given by Laufer and Koskela (1992).

The timing issue is correlated with that of time horizons: multiple planning timings use multiple planning horizons. At the pre-bid and pre-construction stages the planning horizon extends to the full duration of construction. There is, however, a difference in accents: prior to bid submission, feasibility studies are made (mainly concerning the construction method and other central technological issues) and their implications are considered, mostly in terms of cost and schedule. That also includes the checking of various issues with subcontractors. The emerging plan sets the project objectives, its main use – apart from the preparation of the proposal – being forecasting. The plan is also uniform in that it addresses all project stages, through to completion, at the same principal, undetailed level. Following bid award and in the initial stage of construction, overall long-term planning is affected by the commitment already in hand (including that of subcontractors, themselves doing part of the planning). The planning is thus more affirmative. It deals with solutions (although it still serves mainly for forecasting and control) and is no longer uniform: planning for the immediate stages is much more detailed than for later ones, particularly in the areas of organization and technology, where execution follows immediately.

During construction, the planning horizon varies as follows: formal planning – concerning mainly schedule, cost, manpower and materials – is done typically for three time horizons.

1. Through project completion – master/control plan (typically updated/revised on a monthly–

quarterly basis), mainly for the use of upper echelons: owner, home office, project manager.
2. Sixty/ninety days look-ahead – guidelines/ coordination (typically prepared on a monthly basis). Main users: project manager, general superintendent, subcontractors.
3. Two to three weeks – action planning (prepared every 1 or 2 weeks), for the use of the general superintendent, subcontractors and foremen (Laufer *et al.*, 1992b).

In addition, a less formal type of planning is taking place, mainly in the mode of weekly meetings (usually with textual formats as direct output), addressing all planning areas and in particular scheduling and those pertaining to technology (open questions, site layout, production array and always work methods) and resources. Although the main concern of these meetings is planning (anticipatory decision-making), they are also engaged in current issues, such as lack of drawings, solving conflicts (organizational and technical) and short-term coordination and control. To a small extent these meetings serve as follow-ups of the more formal 60/90 days look-ahead (only in a few companies is this done more extensively) and to a larger extent for the review and implementation of the short-term, 2–3 weeks' plan. There are mainly three kinds of meetings.

1. Owner meetings – project goals are addressed, timetable is reviewed and revised, and missing design information is identified.
2. Subcontractors meetings – process-oriented decisions are made, field activities are coordinated, shared resources (e.g. cranes, space) are regulated and focus is on methods planning.
3. Foremen meetings – focus is on coordination and planning of methods at the work station, tasks are directly assigned and shared resources are coordinated. All that pertains in particular to cases in which the constructor directly employs his/her own labour force.

To summarize the timing dilemma, the third multiplicity principle – the continuity principle – as practised by mature companies is 'effective planning requires numerous timings and various time horizons'.

The 'who' question: multiple participants and preparation modes

The competence dilemma

The competence dilemma – also referred to by Laufer and Tucker (1988) as the planner (staff specialist)–manager dilemma – is presented concisely in the following postulations, which describe the strengths and weaknesses of the manager (e.g. project manager, general superintendent) and staff specialist (e.g. project engineer, scheduling engineer) when required to carry out construction planning.

1. Planning is a mentally demanding and complicated process. Construction planning is particularly difficult, having to be done under constantly changing conditions, much of it being carried out during project execution, without complete information being always available.
2. Planning (i.e. integrating many interdependent decisions) requires not only much time, but much quality time. It is and should be carried out in large blocks of uninterrupted time.
3. Much time is required not only for planning *per se* (decision-making), but for documentation and the preparation of plans, as well as their dissemination and communication. The representation of decisions in plans requires special training and experience in the use of tools and techniques that are frequently updated.
4. A manager's activity is routinely diverse, brief and fragmented (his/her main problem is scarcity of attention). This makes planning by the manager alone very difficult, leading to the conclusion that he/she must be supported by a trained assistant with enough time to help in the planning process.
5. Part of the information needed for planning is unstructured and transmitted verbally and only to the manager. Imparting this knowledge regularly and systematically to a staff specialist is difficult. Moreover, with uncertainty being high (particularly in the early stages of construction), the information needed for planning is held by many functionaries (owner, designers, subcontractors, etc.), all very busy and in a constant state of time shortage. This difficulty is further aggravated by the fact that the information – required to be up-to-date and often given at short notice – is only partially structured and documented.
6. It is impossible to review and approve hundreds of interrelated decisions if one has not been involved in their preparation. It is thus a fallacy to assume that a manager can give meaningful approval to plans prepared by a staff specialist.
7. The greater the involvement of the implementor in the decision-making process, the greater the prospect for the successful implementation of the plan. The staff specialist has neither the authority to make decisions nor the power to implement them. Moreover, being often remote from the bustle of daily implementation, his/her plans may not be realizable.

It was concluded in summary that both the manager and the staff specialist possess only part of the necessary

competence and that neither can do the planning without the other. Thus, in order to perform effective planning, close cooperation between them is needed.

The solution suggested at the time

Given the lack of a reliable and accepted cognitive model of the planning process to demonstrate how cooperation between manager and planner/staff specialist takes place and based on solutions offered in the general literature (e.g. Hekimian and Mintzberg, 1968; Camillus, 1986), Laufer and Tucker (1988) suggested only a general outline of a recommended division of labour between the planner and manager, as follows.

1. Planning coordination should mainly be the responsibility of the staff specialist. It includes securing horizontal and vertical planning integration, decisions concerning the planning process itself (e.g. planning horizons, level of detail, updating frequency) and the management of the entire planning process and its implementation (e.g. distribution of information). The manager is to provide political backing and a supportive environment and at times to make decisions concerning the process of planning proper.
2. Data gathering should be almost exclusively handled by the staff specialist, including the employment of formal and informal data collection methods of both internal and external origin. The manager, on his/her part, should share the information of which he/she is the exclusive source.
3. Analytical activities, such as diagnosis, development of alternatives and evaluation of alternatives, are those in which the interaction between the staff specialist and the manager must be at its peak, calling for the utmost cooperation between them (which is also the most difficult to realize).
4. Choice-making is solely up to the manager. He/she can accomplish it effectively only if he/she was actively involved in the analytical phase.

Thus, the essence of the answer to the question, 'Who should plan – the planner or the manager?' was: 'Both'.

The practice in mature companies

Our findings, based on a sample of progressive and high planning-culture companies in the US (Laufer *et al.*, 1992a), show that there is not a planner, with whom a manager should cooperate in planning and that the problem is not confined merely to the distribution of the work-load between these two functionaries. Rather, many parties actively participate in the planning process.

This is clearly visible from Table 2, which presents the major participants according to the different functional plans and at the different stages of planning throughout the project life. Appearing in the table (in descending order) are parties reported to have been highly involved (the three upper levels on a six-level scale of degrees of involvement) in more than 50% of the sample projects. For that matter, some of the participants even represent more than just one individual (e.g. home office, design engineers, subcontractors).

Apart from the multiplicity of participating parties, several other major findings were observed and are also reflected in Table 2.

1. The project manager is involved in more planning areas throughout project life than any other functionary.
2. The general superintendent enters the planning arena strongly in pre-construction planning and continues to show extensive involvement, interchangeably with the project manager, during construction. At both stages he/she is remarkably involved in schedule and in the technology and resource plans.
3. The project engineer, almost invisible in the first two stages, becomes highly visible in nearly all plans during construction.
4. The home office is strongly involved in pre-bid planning and very little thereafter, when the site takes over as the major planning arena.
5. Subcontractors are highly involved in pre-construction planning and in planning during construction.

How is planning done? Though study of this issue has only recently begun, it is already possible to identify – on the basis of observations in progressive companies – a number of basic dimensions and blocks (still unclassified or interrelated).

It is obvious that in most cases planning does not convey the image most of us may have had: a single planner sitting at his/her desk, with all or most of the data at hand, preparing a complete plan – using management science/analytical tools and a computer. In fact, various modes of plan preparation are employed in construction companies. Some of the parameters of the planning mode, in its wider sense, are as follows.

1. Planning is done by a single planner or by a group – small or large – of participants, either in a face to face meeting or via a communication medium. As can be seen in Table 2, the number of dominant participating parties increases, on the average, throughout project life: one or two participants in preparation of most plans at the pre-bid stage, two or three in pre-construction planning and approximately four during construction. The leading planning area –

scheduling – demonstrates this trend in even larger numbers: three, four and five, respectively.

2. Planning can be formal, performed mainly by quantitative analysis and yielding rigorous, data-based solutions, on the one hand or it can be informal, heuristic planning, using qualitative considerations and heavily based on intuition and experience, on the other. A wide spectrum of various modes ranges between these two ends. The findings show that in every stage of the project, planning is carried out both in a formal and in an informal mode. Yet, in the pre-bid and pre-construction planning stages the formal mode is the dominant one, while during construction the informal mode predominates.
3. Planning is carried out either in a slow process, spread over several periods of time or in a rapid-solution mode. The slow mode fits strategic/conceptual planning, with its strong sense of divergency, while the second is more of an operational/tactical, convergent nature, leading to commitments. Various modes exist other than the two extremes.

Selecting the 'right' mode is a distinct situational analysis problem, inseparably connected with the three other multiplicity principles and strongly affected by their context. It depends more than anything on the emphasis of planning in progress at the time: clarification of issues, definition of the problem, information gathering/sharing, coordination, negotiation/bargaining and choice making.

To summarize the competence dilemma, the fourth multiplicity principle – the cooperation principle – as practised by mature companies is 'effective planning requires numerous participants and various modes of preparation'.

Implications

The findings presented above make it possible, already in the current state of the research, to offer several initial suggestions for implementation by practitioners with a view to improving the effectiveness of planning. The implications mainly concern the more difficult stage of planning, namely planning during construction.

Site management organization and roles

The multiplicity of the planning parameters – the numerous timings, the various plans in varying formats, the numerous parties planning in various modes – call for a single functionary who will take upon himself/herself the 'ownership' for the planning process, acting as the planning coordinator. He/she will be the one to initiate that process and to plan it, to propel and facilitate it. He/she will set and be responsible for the planning pace and progress and will serve as the moderator and integrator of all parties involved and all decisions made. He/she need not himself/herself be involved in the act of planning and its contents.

At the pre-bid stage, this planning coordinator is commonly the estimator or a similar functionary at the home office. In pre-construction planning, this role is normally assumed by the project manager, although less distinctly (to the point that in certain cases it is difficult to tell who 'owns' the process). To some extent there is a division of labour between the project manager and the general superintendent, due to the former's intensive engagement in organization, staffing, contracting and mobilization. Should the scheduling engineer be appointed as the planning coordinator, he/she may turn out not to be dominant enough.

The situation is in particular problematic, cumbersome and sometimes even unmanageable during construction, when the required integration of information is at its peak and all potential contributors of information are concurrently engaged in actually carrying out the construction. That is why the company should put its mind to the 'ownership' of the planning process during construction. Since the project manager is mostly occupied with planning and monitoring the attainment of project outcomes (effectiveness of the project) and the general superintendent is busy with planning processes, tasks and resource utilization (efficiency of the project), the project engineer seems to be the most appropriate figure – provided he/she has accumulated a certain field experience – for coordinating the planning, with special emphasis on the coordination of information flow.

Communication

It was established here that information gathering and distribution – timely, reliable and clear – is a central issue in planning during construction. Some ideas and ways to improve this process, as suggested by construction managers in mature companies, were as follows.

1. Install photocopy and facsimile machines for larger pages on site, use the telephone for conference calls, equip cars with cellular phones and run electronic mail with main office and owner's team.
2. For complex projects or part of them make a 'prototype room' on site, in which all problems (particularly interdependency/subcontractors' problems) are analysed (sometimes even resulting in the revision of a design) before going into 'real production'.
3. Prepare a simple and concise manual of procedures on the project.

We think efforts should be directed towards the

implementation of Groupware (Johansen, 1988; Groupware User's Project, 1990) to enhance the quality communication among all involved parties. Among other things, this medium needs to:

1. permit immediate mail transfer and reading;
2. support advanced graphics and be able to receive and transmit various kinds of formats;
3. be able to assist in sorting and processing information and in the evaluation of alternatives;
4. be able to operate in a single/multiuser environment and to talk to other systems (in particular be connected to the formal master and mid-term plans);
5. assure other features typically expected from management information systems, such as timeliness, accuracy, exhaustiveness, relevance, clarity and friendliness.

Of no less importance is the constant improvement of teamwork and training for less formal communication (verbal and textual).

Mid-term planning during construction

The detachment between the formal mid- and long-term plans on the one hand and the informal short-term planning and plans on the other, lessens the effectiveness of both. This deficiency should be redressed. In the very few companies that had managed to overcome this gap by employing a mode of semi-formal intermediate meetings, the integration and effectiveness of the whole process of planning were significantly improved. The more systematic and structured these intermediate meetings are, the less does the following stage of weekly short-term planning suffer from uncertainty and the smaller the 'chaos'.

Construction companies are well advised to adopt this planning mode. Issues to be handled at intermediate meetings typically:

1. are complicated and complex;
2. have no early and stable information about them while being addressed in the master plan;
3. need more lead-time than do issues typically handled through weekly action planning;
4. have no accumulated experience about them;
5. require feedback from lower levels;
6. necessitate strong involvement of and/or approval by many parties, including external ones.

Planning matrix

Site functionaries – project manager, general superintendent, project engineer, etc. – are subject to a chronic shortness of time. Given this situation, simple procedures and tools must be prepared to assist in applying the multiplicity principles.

Construction companies would do well to prepare clear procedures suitable for the firm's context and its personnel (e.g. size, geographic dispersal, managerial climate, sophistication of management systems and competence and experience of home and site managements) and for its typical project. These procedures can be efficiently summarized in a matrix which demonstrates the implementation of the multiplicity principles, as shown in Fig. 1. Note that while the examples provided in Fig. 1 pertain to three different timings, in reality each matrix should address only one specific timing.

Situational analysis

Throughout project life, effective planning calls for multiplicity – of purposes, plans, participants, users, etc. At a specific instant in the life of the project, specific features need to be selected and concentrated on, according to the situation. Thus, in order to effectively implement the multiplicity principles, situational analysis must be systematically resorted to. Using the planning matrix, three distinct layers of situational analysis can be identified.

1. At company level, by preparing a typical planning matrix (a long-enduring, one-time analysis). In firms with a rich variety of projects, more than one typical matrix should be prepared (e.g. for residential/commercial/industrial projects, for small/medium/large projects). However, due to the state of the art in this area on the one hand and the vast number of possible combinations, on the other, it is advisable to prepare only a limited number of typical matrices.
2. At the project level in pre-bid planning, the impact of the unique characteristics of the project (e.g. size, type of contract, objectives, innovation level, construction type, uncertainty level, per cent of work subcontracted, availability of managerial and planning resources) is imposed on the typical planning matrix in order to create the specific planning matrix (an *ad hoc* one-time analysis). This matrix is indeed the major product of the planning-of-the-planning process before construction starts.
3. At the project level during construction. The planning coordinator, assisted by the project manager, should adjust the specific project matrix to fit the changing situations (e.g. decreasing uncertainty levels, changes in the priorities of project objectives), thus creating the current planning matrix (a continuous activity, throughout the project life). This matrix is the product of the planning-of-the-planning process during construction. The factors affecting the increase in the

Figure 1 Proposed structure of planning matrix with examples
Timing[1]: — Pre-bid
— Pre-construction
— During-construction[1] — Master
— Mid-term
— Short-term

Plans	Engineering and method	Organization and contract	Schedule	Cost and cash flow	Major equipment	Layout and logistics	Work methods	Manpower allocation	Materials allocation	Other[5]
Purposes			Coordination, action plan[2]			Coordination, action plan[3]		Forecasting, control[4]		
Users			GS, SC, FM			GS, SC		PM, GS, SC		
Time horizons			3 weeks			6 months		18 months		
Revision intervals			1 week			2 months		1 month		
Planning participants			GS, SC, PE, FM			GS, PE		GS, SC, PM, PE		
Modes of preparation			Proposal: SC+PE, approval: meeting			Proposal: GS, processing, PE		Proposal: GS+SC, processing: PE		
Formats			Gantt, meeting protocols			Drawings, meeting protocols		CPM, tables		

[1] Select one.
[2] During-construction, Short-term.
[3] Pre-construction.
[4] During-construction, Master.
[5] e.g. safety, quality control, labour relations.
PM: project manager; GS: general superintendent; PE: project engineer; SC: subcontractors; FM: foremen.

frequency of project planning updating (e.g. uncertainty, level of interdependence) are normally those that will also affect the increase of the current-matrix updating frequency. Yet, the current planning matrix will be updated at a much lower frequency (e.g. every 6 months for the current planning matrix vs every month for the project master plan).

The preparation of these matrices entails an internal field study of situational analysis by the construction firm. An elaborate illustration of such a contextual approach is given by Pettigrew (1985), while a tangible product of pertinent studies, useful for field operations, can be an expert system (Meszaros, 1987; Landman, 1991).

The two central dilemmas addressed by the situational analysis during construction are the timing of planning and the extent of planning formality. Site management should continuously ask itself these two questions:

1. Has the solution of the problem been attempted too early or burdened with too many details while information is still incomplete and/or unstable or is the decision delayed to such an extent that it can have no influence whatsoever on site activities (and can no longer fall under the definition of planning)?
2. Are the mode of planning and/or the format of the plan too formal in the light of the available information, available time and role of planning or have we already arrived at a state of such informal planning and plan (e.g. random/split-up meetings, decisions written on back of envelope), that the quality of the decisions and/or their representation are deficient (and it can again no longer be defined as planning)?

Summary

March, the Stanford scholar whose monumental work was devoted for the most part to a study of organizational decision-making, summarized the role of the researcher as follows (March, 1981): 'Work on theories of organizational decision-making is an effort to develop an interpretation of organizational life that is theoretical, yet consistent with pragmatic knowledge'. This paper has attempted to provide an interpretation of the planning done in mature construction companies. That interpretation, in the form of the four multiplicity principles introduced – hierarchy, comprehensiveness, continuity and cooperation – may be viewed as the beginning of a foundation for a theory of construction planning.

The four principles – adjusted to the prevailing circumstances through explicit situational analysis – amount to a holistic approach to construction planning, which calls for profound changes in commonly practised approaches and procedures, for the readjustment of research topics and methods and for a broader formal education and training of civil and construction engineers, encompassing multiple areas other than the traditional ones and more fields of knowledge.

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