AN ANALYSIS OF FACTORS AFFECTING PROJECT PERFORMANCE IN INDUSTRIAL BUILDING

(with particular reference to Design Build contracts)

by

Stephen M. Rowlinson
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Preface

The research reported here commenced in July 1982 at the Construction Study Unit of the Department of Building Technology at Brunel University. The author was employed at that time through a research grant (No.GR/B/96575) provided by the Science and Engineering Research Council under their Specially Promoted Programme in Construction Management and to whom the author's gratitude is extended for their support.

The research model and methodology developed throughout 1982 and 1983 and the author was greatly assisted in this process by *Bob Newcombe, Richard Fellows and Dave Langford* (of the Construction Study Unit) whose encouragement and support is gratefully acknowledged. The comments and help provided by other research staff in the Construction Study Unit is also acknowledged and grateful thanks extended to the staff of the many cooperating organisations who provided an immense amount of data and access to confidential information without which the research project would not have been possible.

This thesis was originally submitted in December 1987 and has since been amended to its present form. The help provided by way of comments on the shortcomings of the original text by Professor V. Torrance is gratefully acknowledged.

Steve Rowlinson
Hong Kong , March 1988

Notes

Chapter 3 of this thesis, **Design Build: Perceptions and Status**, was published as Chartered Institute of Building (U.K.) Occassional Paper No. 36, *Design Build - Its Development and Present Status*, in May 1987.

Throughout this work *Building Team* refers to the whole team involved in the project from inception to completion and including the client, designers, constructors and all specialists. The term *Site Team* refers only to those members of the building team who are engaged in the actual production process, i.e. main contractor, domestic and nominated subcontractors, etc.. The pronoun *he* is used throughout the text to represent both sexes and is preferred to the alternative he/she for the sake of readability and does not imply that women are excluded from any of the roles described.

References in the text and figures to Newcombe (which do not have a specific citation) are based on private discussions with Bob Newcombe during the course of the research.

Synopsis

The problem of determining an appropriate procurement form for the management of a construction project has been surrounded by controversy and strongly held opinions. The work reported here attempts to indicate some rational basis for choice in this decision by identifying those factors which significantly affect project performance, with particular reference to the distinctions between design build and traditional procurement forms.

Two basic propositions are addressed by the work. The former is that design build forms perform better than traditional forms. This view is based on the conventional, construction industry view of the factors which affect performance. The latter is that contextual factors and the management and organisation of the construction process are the major determinants of project performance. This view stems from the application of management theory to the construction process and takes into account more and diverse variables than the conventional view.

The factors which affect construction project performance are identified by reviewing three basic areas which are fundamental to the research. The first is the construction process and the way it has been treated and analysed in the past, which has been based around the traditional form of organisation. The second is the perceptions held concerning the design build process and how this procurement form has developed over recent years. A taxonomy of design build organisations is presented. Finally, the literature concerning project management, in general and specifically applied to the construction process, is reviewed and those factors which have been identified as affecting project performance identified.

Following on is a review of performance measures which have previously been adopted. Based on this review a number of measures are chosen to compare performance (a mixture of objective and subjective measures). The foregoing leads to the situation where two research models are proposed and tested, by the formulation of related hypotheses, in two separate phases of the research process. A sample of 47 projects was used in the initial phase of the work and this was followed up by 27 detailed case studies in the subsequent phase. The data collected are analysed using partial correlation analysis as the principal analytic tool and the main results are reported below.

The primary conclusion to be drawn is that procurement form is not a good predictor of performance. In general, the management, organisation and contextual variables are found to be more strongly associated with performance. Specifically, increased client complexity and dependence are found to be associated with reduced performance, as are increased project complexity and uncertainty. Document certainty and completeness and the degree of competition in letting construction works are all factors found to affect performance. Familiarity and differentiation are organisational factors which are found to be strongly associated with performance. Finally, it is shown that different procurement forms can be located on a structure grid and that those organisations which are appropriately located are associated with higher levels of performance.

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Chapter 1

Introduction

INTRODUCTION

The Building Industry

The building industry is unique in its methods of working which allow the responsibility for design to be far removed from that for construction. This divison of responsibility between the professionals and the builder has cultivated a wide variety of procurement forms. The growth of these forms has been accelerated by a deflation of the building market which has been brought about by a steady reduction in new orders since 1979, coupled with an inexorable increase in the building cost index which has not been matched by a commensurate rise in the tender price index. Government policies have had the effect of reducing the amount of work undertaken by the public sector and so, in a highly competitive market, alternative procurement methods have flourished with clients taking advantage of the stagnant situation.

This growth in the use of alternative procurement forms has stemmed also from criticisms of the traditional system. In an unpublished report, Higgin (1964:24) criticised the building industry for its unwillingness to recognise the informal system that operated on most building contracts and which was seen as a necessity due to the unsuitability of the formal system.

> 'problems will remain as long as building has a formal system that insists on applying independent responsibilities to a task all parts of which are interdependent.'

> 'the informal procedures only exist because the formal system intrinsically has characteristics which are incapable of handling effectively the system of operations required for the building process. Far from the informal system being a lazy man's way out, it can be seen to be a quite essential means of adaptation for the inappropriate formal system to work at all.'

It is not surprising that this document remains unpublished, it was deemed at the time to be too strong for the construction industry to be able to accept and that state of affairs has probably changed little in the intervening decades. The research on which the report was based dealt almost exclusively with traditionally organised contracts but at a later point in the report Higgin suggests that design build methods, or package deals, and management methods might achieve a wider co-ordination of control and that such methods have arisen spontaneously, as if to meet the need for more control. The debate that Higgin sets in motion in his paper continues in the trade press to this day despite numerous reports and research projects into the problem of which method is best, if any. Design build may be seen to cope explicitly with the interdependence of the building tasks; management methods may adapt the building process and roles played by its participants to account for this interdependence; traditional methods do not formally recognise the interdependence but evolve a social system to deal with it.

Procurement Forms

Previously, in periods of buoyant demand such as that when the Tavistiock Institute studied the building industry, the traditional approach has dominated the industry. This approach is characterised by the appointment of a principal adviser, normally an architect, who leads the design team which is assembled at his recommendation. The building project is designed and detailed up to a point where the various elements of the design can be taken off and worked up into a bill of quantities. At this stage the builder is invited to bid for the construction work and, if successful, is expected to start on site within a few days with very little knowledge or understanding of the building he is to construct and probably having made no acquaintance with the client for whom the building is to be produced. The traditional method has been criticised for its slowness, due to the sequential nature of the work, and the incidence of time and cost overruns, attributed in part to the lack of input by the builder during the design phase. Its advocates point to its flexibility in allowing a wide choice of consultants and builders and the fact that it has flourished for most of this century.

The alternatives to this approach fall into two main categories, the design build approach and the management (or consultant builder) approach. Design build methods offer single point responsibility for the client with one organisation, generally a building company, contracting to fulfill all the design and construction responsibilities for the project. This approach has been criticised on two counts: firstly, private architects have denigrated the architectural quality of buildings produced thus; secondly, the quantity surveying profession has cast doubts on the value for money obtained by entering into such contracts which are commonly assumed to be let by negotiation. These criticisms are countered by design builders claiming to build more quickly and more efficiently. Management approaches allow the builder to have an input into the design phase without disturbing the principle of divided responsibility. They are believed to lead to rapid and efficient construction but may reduce price competition or add an extra consultant to the team, and so fee, to the bill.

Objectives

The objective of the research is to study the differing performance of two procurement methods in particular - design build and traditional. The proposition 'procurement form determines project performance' is investigated and then an alternative proposition, 'the context of the project determines the most appropriate form for best performance', becomes the subject of investigation. The aim of such an approach is to attempt to reconcile the conflicting views which, on the one hand, indicate that procurement form is a major determinant of performance (NEDO, 1983; Sidwell, 1982) and those, on the other hand, which proclaim that the management of the building process (Ireland, 1984A) is the major determinant of project performance. Finally, a further proposition, 'each form has distinct procedures and characteristics associated with it', is investigated in an attempt to determine whether management procedures are wholly independent of,or attributes inherent in, different procurement forms.

The Research

The research reported here thus adopts a contingency view of the problem: in certain circumstances particular methods will be appropriate. The importance of the client, his background and experience, are examined; this is an area which has been neglected in many previous studies, the client being recognised implicitly, if at all. As a consequence, some time was spent initially attempting to define the priorities that a client has in mind when undertaking a building project and relate these to his background and experience in order to determine appropriate measures against which to assess performance. The characteristics of the project are seen as an important factor affecting performance and these are investigated in terms of complexity and uncertainty. The foregoing represent the context in which the building process takes place and an understanding of this process indicates that many managerial and organisational decisions may be independent of the procurement form chosen. Hence, the impact of managerial (controllable) and organisational variables on performance and the nature and size of this impact is explored and related to the context of the project.

Scope of the Research

The method adopted in the research was one of cross-sectional case studies conducted through structured interviews with project participants (based around questionnaire 3 in Appendix 1) and supplemented with data collected from mailed questionnaires. This approach facilitated the collection of data concerned with measurable phenomena within the scope of the research and some psychological and social aspects could be investigated during the interview sessions, although this was not the main thrust of the work.

Twenty seven projects were studied in detail out of an initial sample of forty seven. The number for detailed study was thought to be both manageable and large enough to allow conclusions to be drawn. The initial sample was randomly selected but the sample for detailed study was based on project cost, greater than £0.5M, and accessibility to data and personnel. In total, over ninety individuals (from building contractors, architectural and surveying practices and client organisations) were interviewed during the course of the study.

It was assumed during the research that all the organisations and personnel involved were competent within their own professional field; this does not imply any assumption concerning their managerial capability and roles.

Industrial Building

Industrial building was chosen as the market sector to investigate as it provided a reasonably homogeneous group of clients and projects to work with and effectively held a number of variables constant, such as the somewhat intangible concept of architectural quality, whilst performance in other areas was investigated. Design build has been used quite extensively in industrial construction for a number of years; in 1973 it was estimated that 24% of industrial buildings were constructed under design build methods (Wilson, 1974:41) and 21% in 1981 (Nedo, 1983:56-65). Thus, the method is well established in the industrial sector and a relatively large population exists from which to choose a sample. New construction orders in 1980 were £10,500M of which £1,800M (17%) was private industrial work. Total industrial output in 1980 was made up of sixty per cent private factory buildings, over twenty per cent warehousing and nearly ten per cent were public sector projects (which was made up of work for nationalised industries and advance units for development corporations). Capital allowances for factory building were still available during the period of the research, a factor which helped keep demand in this sector at a reasonably buoyant level.

Structure of Thesis

Three themes, the building process, the design build form and project performance, are treated in the introductory chapters in order to provide the necessary background for the presentation of the research model and methodology in Chapters 6 and 7. The results of data analysis and subsequent discussions follow these and the thesis closes with an examination of the conclusions

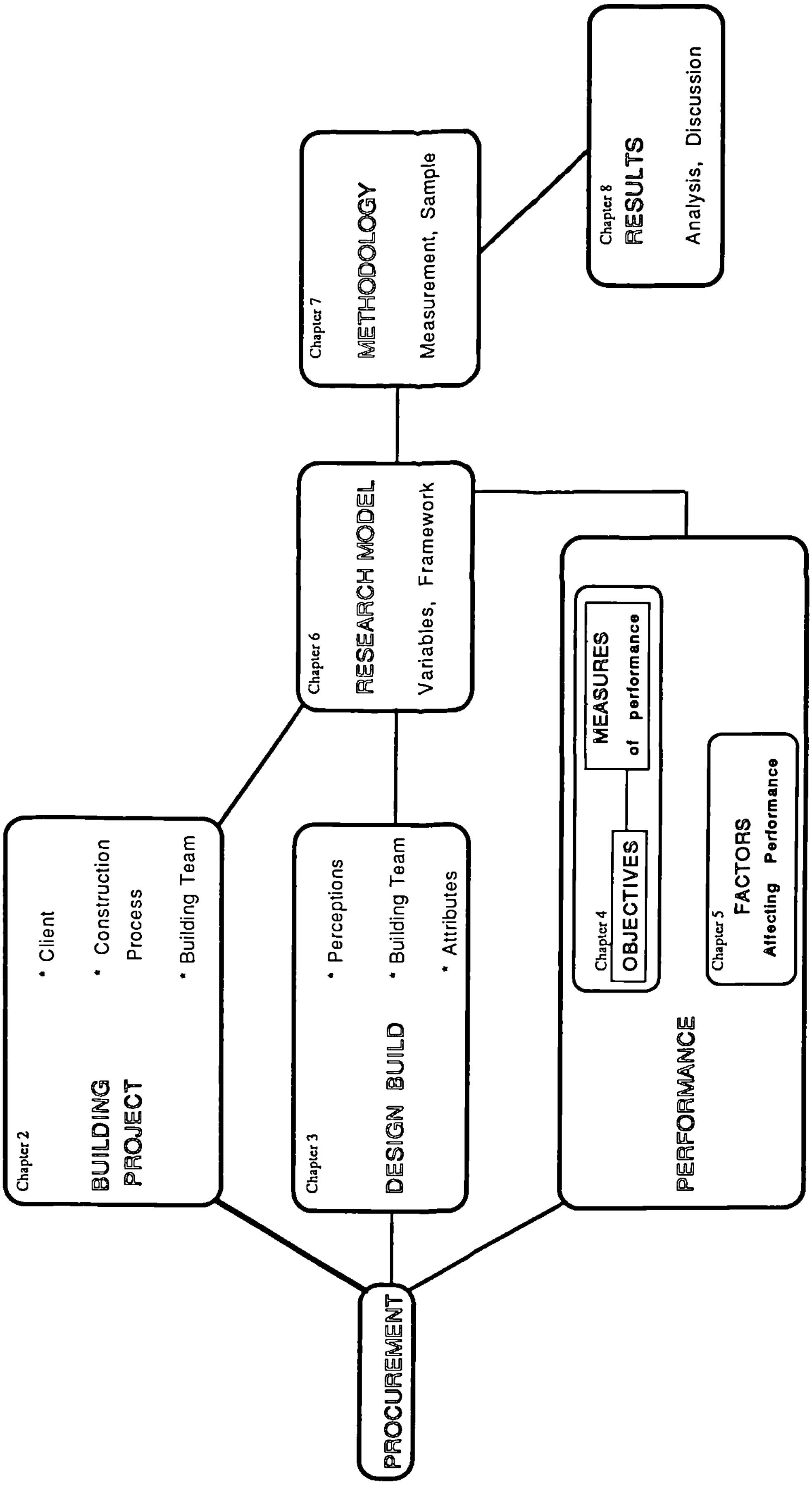

Figure 1.1: Thesis Map

drawn from the research. The structure is shown in Figure 1.1, the Thesis Map.

Chapter 2 is an examination of the building process, as exemplified by the traditional system in operation in the United Kingdom. The expectations of the client and the nature of the client body are discussed and the nature of the construction process is investigated; the stages view and systems view are presented. Attention is thence turned to the building team with a consideration of the roles of and relationships between the participants. Chapter 3 discusses the development and status of the design build method based on the perceptions of parties to the construction process. Commonly held views of performance are scrutinised, with reference to current trade literature and research, and the viewpoint of client, builder and professionals is taken into account. The design build process is discussed and the chapter concludes with a presentation of the characteristics attributed to the design build form.

A review of client objectives when commissioning a building project is undertaken, in Chapter 4, which leads to a critical discussion of performance measures adopted in previous research in order to provide a basis for choice of the measures of performance used in the research. Factors affecting performance, as identified from a literature review of construction and general project management, are presented in Chapter 5. The components representing procurement forms are treated first followed by the contextual factors of client and project. The project process itself is then addressed and the effects of the building team, its organisation and management, and project procedures adopted are highlighted. The domains of human factors and the environment are reviewed in order to complete the picture.

The review of previous published and unpublished research, and opinions expressed publicly and privately, lays the foundation for the presentation of the research model in Chapter 6. The components of the two models, the latter an extension of the former developed for the later phase of the research, are expounded and the propositions on which they are based are presented. The hypotheses tested during the research are a natural consequence of the model and propositions and are listed at the end of the chapter. Chapter 7 presents and discusses the research methodology adopted and covers the method of data collection, the statistical analyses used and the properties of the sample under consideration. More detailed case study information and data listings are included as Appendix 2.

The penultimate chapters present the data analysis and discussion of the resulting correlations and contingencies which have been found to exist. These chapters are quite extensive with a careful explanation of the relevance of particular statistical results and, of course, the results are related back to the hypotheses developed in Chapter 6 and the review of current thought in Chapters 2 to 4. The thesis culminates with a presentation of a critical review of the conclusions which can be drawn from the research and their relation to previous investigations.

Chapter 2

The Building Project: Traditional Views and Change

THE BUILDING PROJECT:
TRADITIONAL VIEWS AND CHANGE

Introduction

It is necessary at this stage to describe the participants in the building process, the process itself and the way in which the participants interact in the building team in order to develop a framework within which the research can be based.

The Client

It appears that over the past decade the client has been putting his views on the construction industry more and more forcefully. Slough Estates perhaps initiated this stridency in a public manner in 1976 with the publication of 'Industrial Investment' (Mobbs, 1976) which, inter alia, accused the U.K. construction industry of poor performance due to "the utilisation of out-dated building methods." The client was expressing a lack of confidence in the ability of all the participants in the building process to work together efficiently and effectively. Slough continued their offensive on the building industry through their M.D. (Mackenzie, 1979) who, when addressing the inaugural meeting of the East Anglian Building Study Centre, said: "I believe that if the industry's objective is to satisfy my needs, then it is failing to do so." In an interview in Building magazine John Carpenter (1981), director of building for John Lewis Partnership, pointed out that traditional procedures could not be followed in the real world and that: "It is a fallacy in most client organisations to assume the client can be one man."

This view is reflected in a paper by Cherns & Bryant (1984) which criticises construction industry researchers for oversimplifying the role of the client and suggests that a non-unitary view of the client demands that the client's history and the project's pre-history must be studied to understand fully the construction process. They imply that the poor performance compared with the U.S.A. (which Slough Estates noted) is a problem of the clients' organisational deficiencies as much as it is the shortcomings of the construction industry. This view has its genesis in the Tavistock report (Higgin, 1965) some twenty years earlier.

Lansley (1984), in discussing the classification, assessment and education of clients, reports that:

> 'research would focus on the way in which client needs are initially presented to the industry and the way in which clients' sophistication (i.e. the demand or need for professional skill) is complemented or ignored by the industry'

Thus he acknowledges that the client body is heterogeneous and has some varying level of input to make to the construction process. He goes on to say that the client can be an agent for change in the construction industry but too little information is available on options for the control of projects. This influence was also acknowledged by Andrews (1983) in his article entitled "The Age of the Client" where he discusses the clients' role in the building process and his satisfaction with the outcome. This influence has made its mark most recently in the launching of the British Property Federation Manual (1983) which provides a formula for building development. The client is making his presence felt in a powerful manner: so, what is the nature of the client body?

The Client Body

The Wood report (1975:25) discusses the "sponsor (committees)" of the building process when analysing the role of public clients and the Tavistock report (Higgin, 1965:89) refers to the "initiator" of the process. There is an implicit recognition in both that the sponsor is not necessarily the end-user of the building and that the initiator may be a group of interested, competing parties. To quote from the second Tavistock report (Crichton, 1966:39):

> ''The client' is a complex system of differing interests and 'the client's' relationship is seldom with a single member of the building industry.....These client systems.....are made up of both congruent and competing sets of understandings, values and objectives. Much design and even building work has proved to be abortive because unresolved or unrecognised conflicts of interests or objectives within the client system have only come to light after the building process has been initiated.'

A little further on the report notes that the building industry's reaction to this is an impatience of this complexity and that a lack of skills necessary to resolve the problems of interdependent decisions is a manifestation of this. Bryant returns to this theme in his paper with Cherns (1984:180):

> 'Each participant can be seen to be bringing to the table his own sense of what is at risk personally, as well as what is at stake professionally or departmentally, in the forthcoming project experience.....Many of the stakes are reputational....In considering the role of the client, then, we cannot treat the 'client' as unitary'

Thus the client may be viewed as complex, in that there are many facets to 'his' character and decision making process and the client is also dependent on other organisations, or parts of 'his' own organisation, for the inputs and constraints placed on the decision to build. The work of Pugh and the Aston Group may shed a little more light on this, in terms of ownership, control and authority structures and their effect on organisation. This complex client may also bring an element of uncertainty to the project if unresolved conflicts are allowed to continue. Although the client is likely to be non-unitary he may well be singular in the sense that, although he may be categorised as a member of a sub-set (such as a local authority), he is unique and has his own peculiar needs and ways of operating. A more detailed, operational view of the workings of the client organisation is provided by Bonoma (1982) who describes six decision centres which influence the progress of any project. This complex client is certainly a political animal and may appear schizophrenic if funding is coming from one body, functional requirements from another and detailed requirements from yet another e.g an institution-funded development by a property developer with pre-lets.

Legally, the client and his representative are normally well-defined in the contract documents but these only serve to provide the framework within which we can define the procurement system and the informal systems of authority developed may well have more influence on the course of a project than these formal authorities. This is reflected by Flanagan in an interview with Building magazine (1981) when he says:

> 'Building is about getting it right for the client....we class "client"...as one big amorphous thing. For some clients who only build once in their lives it is the most important decision they will make. So how can they understand JCT or the standard method.'

The question of client experience is brought to light here; those with little experience need help in both the formal and informal aspects of the building process and have to come to terms with the roles that they will play. Sidwell (1982) describes the client in terms of his sophistication, how often he has built, and his specialisation, i.e. the building of similar facilities previously. The Tavistock report (Higgin, 1965:16) recognises this client sophistication as a scale running from naive to experienced and, if one takes account of the facility of in-house building professionals, one can define a single concept, sophistication, which Lansley (1984) takes to be reflected in the clients reduced need for professional skills supplied by the building industry.

This raises the issue of where the client stands in relation to the building industry: he can be totally outside it; he can be partially within it e.g. Slough Estates and Local Authority Architect Departments with their own design professionals; he can even be within the system by employing a direct labour organisation.

No matter who the client is, it is often the case that members of the building team do not actually meet him first hand, the architect acts as a surrogate client in many traditional contracts (Wood, 1975:15) and designers and contractors know his requirements at second and third hand only. At the symposium "Buying Building Work-the pressure for change" Stuart Lipton pointed out that 90% of subcontractors had never met the client so "They don't know what his aims are" (*Building*, 1983B). This in effect returns to the theme of the Tavistock report from 20 years ago; communications in the construction industry.

The development of the U.K. client over the years from a naive individual to a sophisticated public and corporate body is neatly summarised in Newcombe's grid, Figure 2.1.

When studying industrial clients in particular, it is necessary to look to other research that focusses on industry and Woodward's research (1958) affords a useful classification system for industrial clients. Woodward found that technology is a major factor in shaping many organisational features and

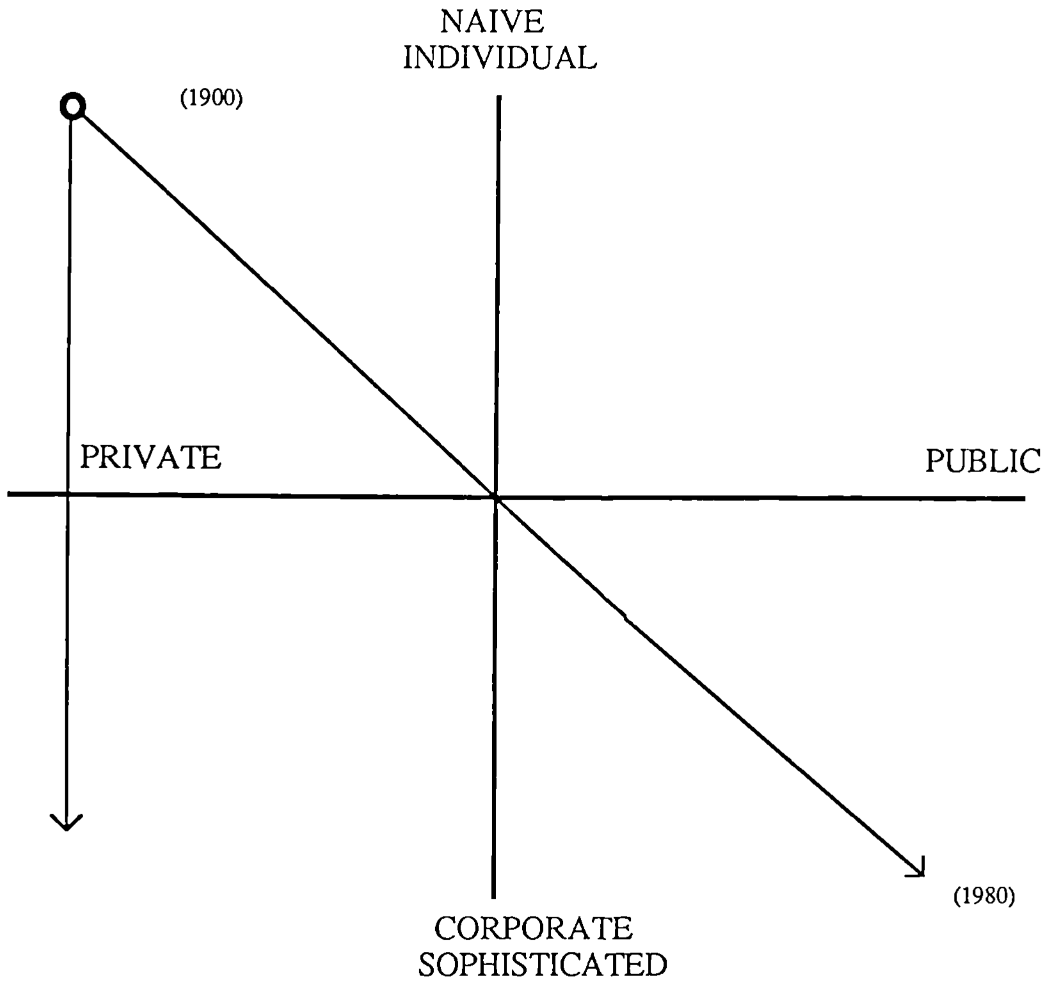

Figure 2.1: Evolution of the Client

classified companies as: unit and small batch producers; large batch and mass producers; process producers. This system, with the addition of distribution industries at the lower end of the scale and new, high technology industries at the top end of the scale, has been adopted here as a tool for categorising the industrial clients of the building industry. It has the merit of reflecting scale, human input to the production process and capital intensity of the particular client and so is a reflection of complexity of the production facility. Another advantage is that the categories are indicative of the structuring and authority structures of the client although one must add the caveat that the Aston programme qualified and limited the import of Woodward's conclusions.

Expectations

With this change in the client over time and the singularity of clients, is it possible to establish a set of objectives which are valid across the wide spectrum of building clients? A useful proposition to investigate is that some criteria are universal, others are likely to be industry or client specific. A reasonable set of expectations are as follows.

Without doubt the building client has to make some choice over the way the risks in the building process are to be shared. The client can influence the distribution of risk by his choice of payment method and his approach to selecting his design and construction organisations. Figures 2.2 and 2.3 are indicative

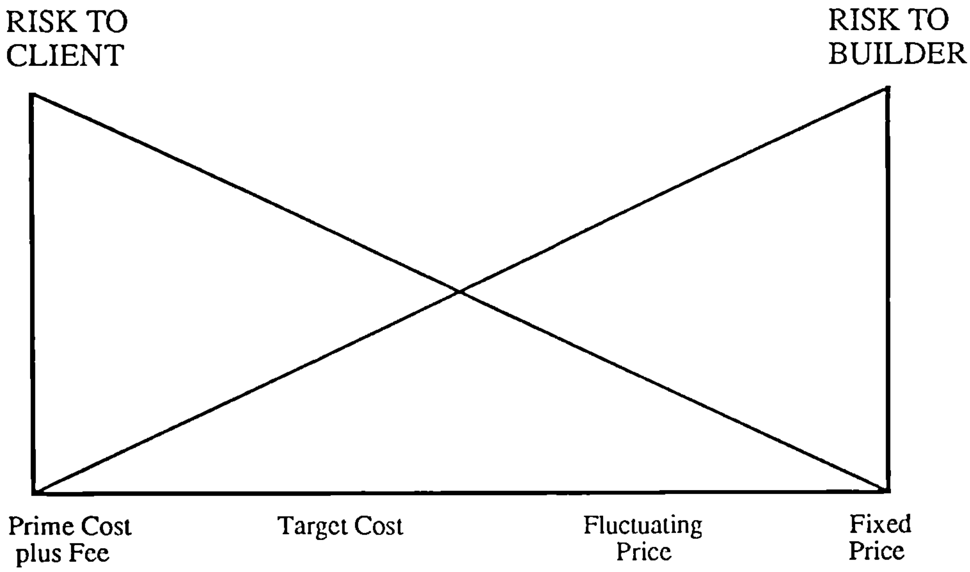

Figure 2.2: Risk and Payment Method

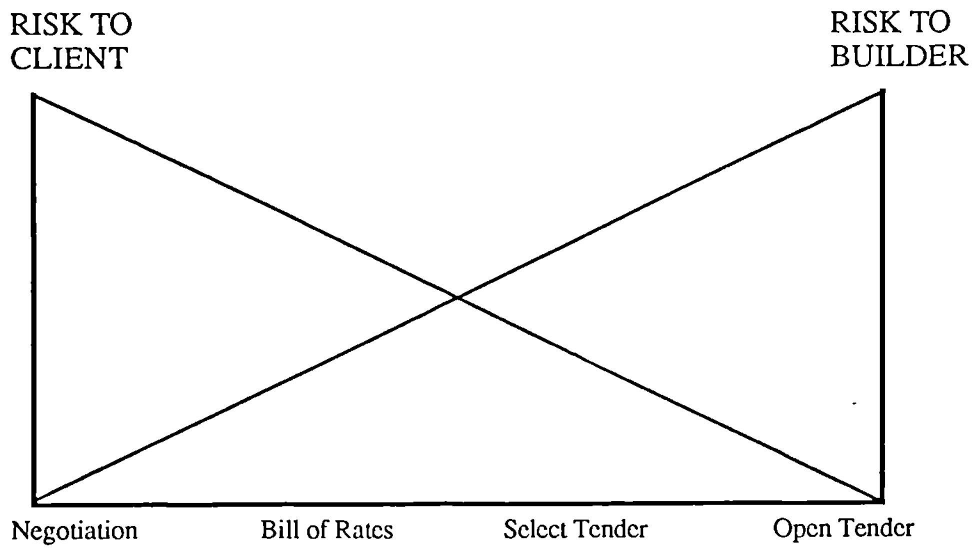

Figure 2.3: Risk and Selection Method

of the risk distributions associated with such choices in an ideal world. The fact that the industry experiences frequent time and cost overruns places the inexperienced client in a position of ignorance when making his choice, and the sophisticated client has a much more complex decision to make than inspection of the figures would indicate. Thus, although he has the opportunity to choose to some extent the amount of risk he is prepared to take in the building process, the client is faced with a very uncertain outcome no matter what his objective is.

The client may well wish to distribute the responsibility for design and construction processes according to the ability he has to deal with the building industry. Thus some clients will require single point responsibility whereas others will accept multi-point responsibility and some role in the co-ordination of design and construction processes. A clear definition of the liabilities of individual members of the building team is another requirement along with some form of guarantee, whether that be a trade association guarantee, such as NHBC operate, or a defects period written into the contract. Following from this the client will expect, and to a large extent has in the U.K., a well-established legal framework within which the building industry operates. The client will need some assurance that the organisations that he appoints have the physical resources and financial capacity to fulfill the building task.

The client has a right to expect unbiased advice, at least from the professionals in the building industry. One can debate whether a building contractor is obliged to offer the same, but one is always likely to come down on the side of professionalism rather than commercialism which puts the industry's reputation at risk if it overrides professional judgement.

These universal criteria mirror Maslow's hierarchy of needs (1943) and are as such low-order needs which must be satisfied before the client considers the high-order needs which are presented below. The low-order needs are concerned with confidence in the framework within which the project will take place and over which the client has limited control as an individual, whilst the high-order needs are those criteria pertinent to the individual project and which the client can influence substantively.

Flexibility to change one's mind is a requirement for many clients, particularly in those industries which experience rapid changes in technology and design. Clients must be made aware that a trade-off exists here between final cost certainty and flexibility. Paul Wilson, manager of IBM's building department says:

> 'The U.K. system seems to be built around the acceptance of change during the construction process. The system is probably over-flexible and while this is normally in the client's favour he probably does not realise how much he is paying for

it.' (Building, 1980)

The client will expect a minimum level of disruption to his main purpose whilst undertaking a building project; this level of disruption will vary according to the project and its context and can be controlled to some extent by the procurement path and appointment procedures that the client adopts.

Clients expect a certain level of performance from the industry and this performance is measured against a number of criteria which again are dependent on the client, the project and the context of the project. Most writers in this area emphasise time, cost and quality as the main criteria but little work has been done to assess the weightings attached to each. Banwell (1964), Wood (1975) and NEDO (1983) assumed that the trade off between time and cost, the time and cost as measured against yardsticks and fastest time respectively were the criteria to be assessed. Bromilow (1970,1974) investigated predictability of costs and time and the extent of variations, and the NEDO report (1976) "The Professions in the Construction Industry" considered that architects had the major interest in quality as far as the construction industry was concerned. Ireland (1983) makes the the most comprehensive approach to the problem to date by assessing cost per square metre, time per square metre, income per square metre and architectural quality.

These views, taken in isolation, cannot adequately account for the trade-offs which occur in setting criteria for performance:

cost can be variously defined as cost per square metre; predicted cost; life cycle cost; maintenance cost; running cost; etc.. Thus it would be helpful to draw up a list of possible criteria which individual clients might rank according to their preference. Table 2.1 indicates a list of possible criteria as reported by Rowlinson and Newcombe (1984) in a paper emanating from the initial research on which this thesis is based. This can be taken one stage further: based on the comments above regarding the technology and production processes of industrial clients, typical client criteria profiles can be produced for different sectors of industry. Such profiles are presented in Table 2.2 and more fully discussed in the papers of Rowlinson & Newcombe (1986A, 1986B, 1984).

Construction Industry Expectations

In 1975 the Wood report pointed out that "the client has important responsibilities to fulfil and that these cannot be delegated to the designer or contractor" (Wood, 1975:25). Whilst not advocating a reduction in the role played by the building industry in procurement Wood emphasised the strategic role of the client particularly in the areas of selection of designers and builders, setting key dates, brief development, monitoring at all phases and restriction of major alterations (1975:31). Although the client may well wish to delegate much of the authority for this role, perhaps to his principal advisor, he is well advised to heed the warning of Graves who points out that "the standard of service given by the building industry

* Functional building
* Client awareness of risks and uncertainties associated with project
* Accountability of design team
* "High Tech" or innovative design
* Maximisation of useable floor area
* Status, image and activity of building reflected in design
* Flexibility to change design at any time
* Taxation incentives
* Low maintenance and running costs
* Use of existing premises during construction
* High/low level of involvement in project
* Desire to be informed of progress at all stages
* Balance between capital and long term ownership costs

Table 2.1: Client Criteria
(from interview data)

PRODUCTION PROCESS	CLIENT EMPHASES
High Technology Industry	* Comprehensive brief development prior to construction * Involvement at all phases * Capacity to change works throughout project
Distribution Industries	* Accuracy of cost estimates * Speed of construction once decision to build is made * The "RIGHT BUILDING", one that aids the distribution process
Mass & Batch Production Industries	* Low running costs * Functional Buildings * Accurate time and cost estimates

Table 2.2: Client Criteria - by Industry

relates closely to the amount of effort expended by the client in establishing a good brief" (Graves, 1978:5) and "satisfaction at the construction stage is closely linked with the degree of control and supervision by the client himself" (1978:6). The delegation of this authority to control is made difficult for many clients for whom "alternative methods of acquiring buildings are not known" (1978:8). Hence, although the construction industry expects the client to make appropriate decisions it has not fulfilled its duty to inform him of his alternatives at an early stage. Thus, an increasing awareness of the importance of marketing has sprung up within the industry. Mowlem's chairman, Philip Beck, pointed out in 1983 that:

> 'at one time we were too dependent on the public sector and the tender which was posted through the letter box. We did not get out enough and talk to our customers...we have realised that we must be closer to our customer.' (Building, 1983A)

Thus the building industry is making much more use of marketing and, in the process of educating the client regarding the alternatives on offer to him, is learning more about the nature of the client and his political background. This can only be to the good of the industry, placing the industry ever nearer those involved in the decision to build. Wood sees advantages in the client having "a continuity of demand" (Wood, 1975:30) which aids the briefing process and benefits both the building industry and the client; a particularly good example of this is the collaboration between Marks & Spencer and Bovis (MPBW, 1970).

Whilst advocating client involvement Wood warns of the danger of interference by the client in areas which are not his responsibility (1975:26) and it is true to say that the client can be expected to provide certain services to the building industry; most importantly - prompt decisions, timely payments and an opportunity to generate a sensible profit.

Finally, the Wood report is critical of the way public clients develop their strategies for dealing with the construction industry. Newcombe interprets this as the public client's structure having an undue and rigid influence on his strategy and so project structure. This is seen as a cause of poor performance and is reflected in the inflexible, inappropriate system of standing orders leading to competitive tendering and consequent performance. The private sector client is relatively free to view each project individually and make choices concerning his strategy which lead to an appropriate project structure and, theoretically, a better level of performance. This improved performance certainly finds support from Sidwell (1982:66), although his analysis was not based on a detailed study of strategy.

The Construction Process

The central issue is; how does the construction process operate? An understanding of this is essential if the concept of procurement forms and their differences is to be tackled. The construction process is the framework within which the procurement form is situated and according to which the procurement form can be analysed.

The Stages

The construction process can be viewed as a set of distinct, technical activities, the most well-known example of this being the RIBA Plan of Work (RIBA, 1967). This consists of what appear to be twelve independent stages in a project which follow one another in a sequential manner. Wood "defines the construction process to include all activities involved in obtaining a building or civil engineering work" (Wood, 1975:3) and NEDO (1976:fig 2.1) refers to a flow diagram indicating tasks to be completed at various stages of the project in order to explain the roles of the participants in the building process. This representation is simplified in Morris's Project Life Cycle (1983:7), a conceptual model which incorporates the four broadly defined stages of feasibilty, design, production and start-up in a continuum, rather than discrete phases. A more detailed model in the publication 'A Client's Guide to Industrial Construction' (DoE, 1982) is used to illustrate five different procurement methods. This model details decisions at each phase of the process and shows logical links from one decision to another and indicates feedback loops. Interestingly, it is deemed necessary to include the people involved and tasks to be performed in order to fully explain the process. Thus, the view of the construction process as a set of discrete activities following end on end is implicitly challenged and the role of people in the process recognised.

The Systems Approach

Higgin and Jessop (1965:88) saw the building process as starting with "a clients need to build" and ending with the "satisfaction of this client need". A feature of the building process was the socio-technical system within which it operated: that is, technical resources of materials and equipment were transformed into the finished building through the resource controllers whose task was to form relationships between interdependent, autonomous organisations by patterns of communications which had more or less social content. In fact three main functions were distinguished in the building process: design, construction and co-ordination (1965:57).

This process then is seen as a series of interdependent parts which operates within a system comprising of people who manage and supervise it and have their own goals. The process is thus controlled by formal and informal procedures. Newcombe rationalises this model as shown in Figure 2.4 and points out that the design and construction phases are quite clearly defined but the pre-construction and post-construction phases are defined much more fuzzily.

Morris (1974:80) builds on the work of Tavistock and emphasises the reciprocal nature of design and construction work rather than it being seen as (again Tavistock provides) a "sequential

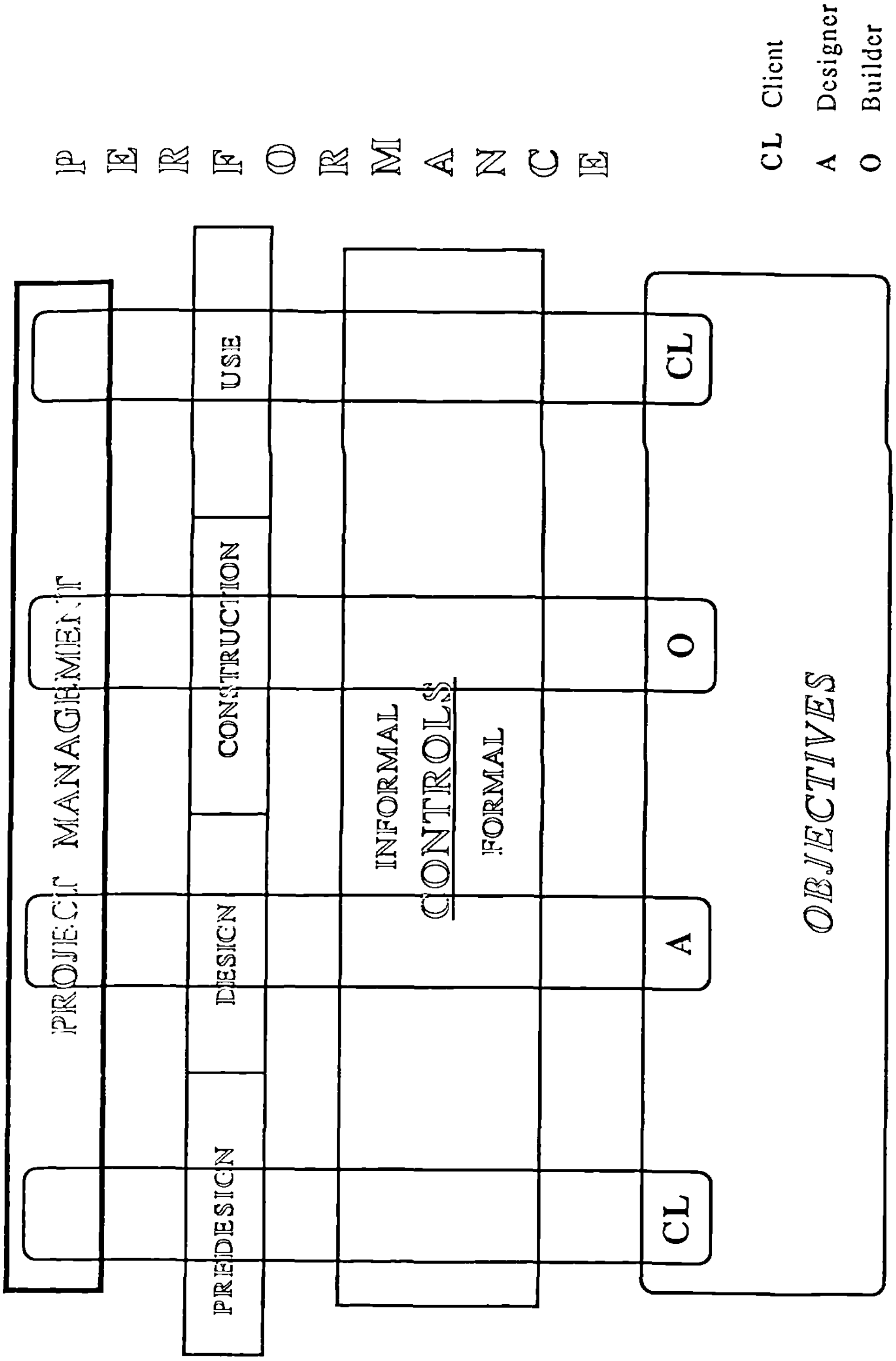

Figure 2.4: Newcombe's Model of the Construction Process

finality" . His Ph.D. thesis (1972) concentrates on investigating the differentiaion (based around Miller's Three T's (1959)) and integration necessary at each phase of the construction process and his explanations are aided by the use of a three stage model of the building process which divides each stage into appropriate subsystems, as illustrated in Figure 2.5.

Walker, in his book (1985) and Ph.D. thesis (1980), uses the technique of linear responsibility analysis to investigate decision making and appropriate organisation structures for construction project management. Again adopting a systems viewpoint, he sees the project management process as residing within a system of behavioural responses, techniques and technology, organisation structure and decision making with three main stages - project conception, inception and realisation. In recognising the *non-sequential nature of the construction process* he adds task discontinuity to Miller's three T's (1959).

Sidwell (1982) saw the principal variables present in the construction process as client and project characteristics, the building team and project procedures. Ireland (1983) adopted Kast and Rosenweig's model of the organisation (1974:19) and indicated that he had reversed their proposition of management and structure being dependent systems and conducted his research on the basis that "technology used, structure chosen, the psychosocial aspects and the way the project is managed will all have an effect on the achievement of objectives" (goals and

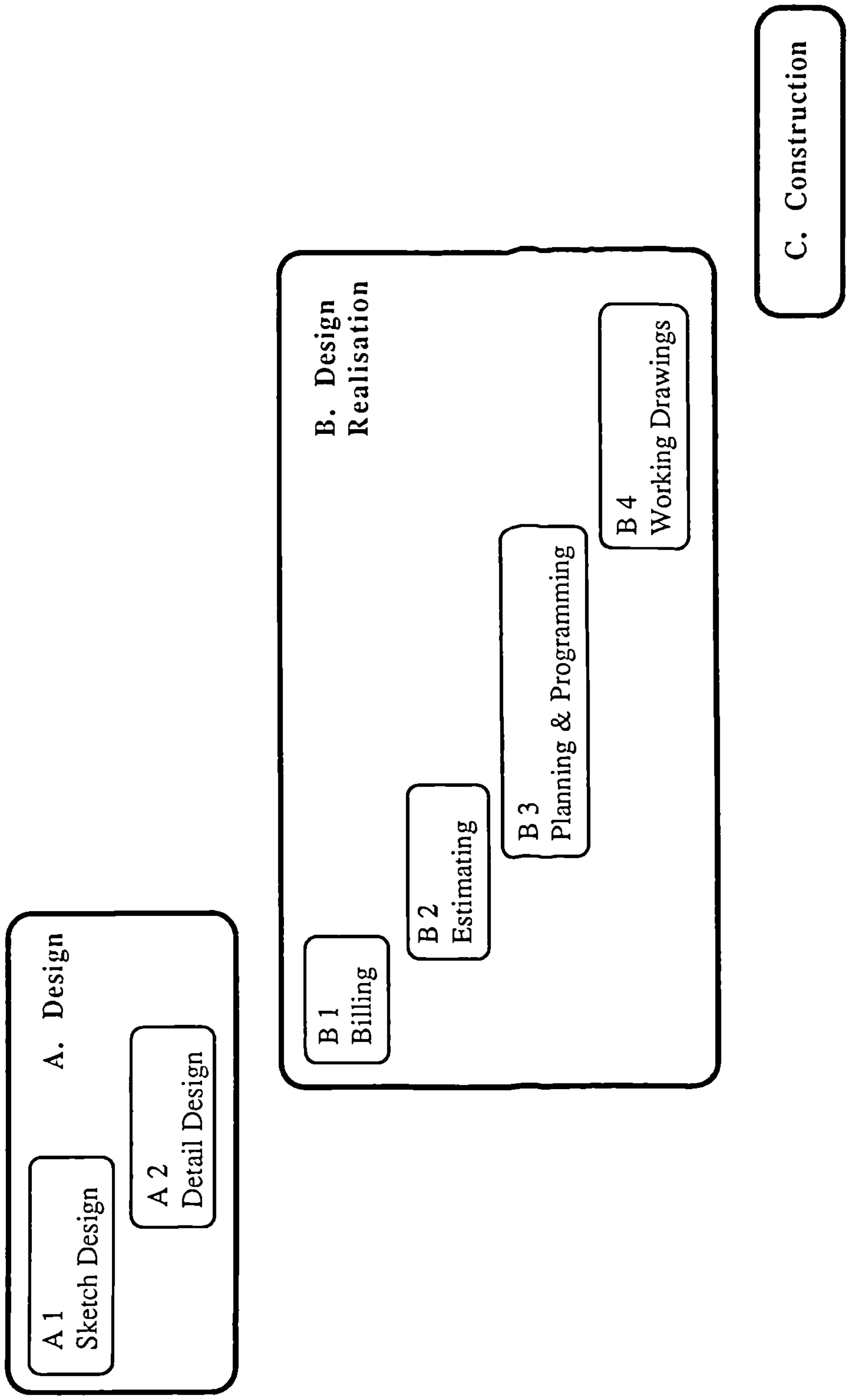

Figure 2.5: Morris's Model of the Building Process

values subsystem) (1984B:5). Ireland maps these sub-systems to form a model of strategic control of the building process but unfortunately omits any discussion of who should exercise this control.

A common strand in the systems views is the recognition of the uniqueness of projects and clients and the adoption of a contingency approach to selection of the procedures and people to mould an appropriate procurement form within the construction process.

Nature of the Stages

The sequential finality of the RIBA model imposes a set of frozen roles on the construction process which have only been released by the adoption of alternative procurement forms. However, if one reviews Newcombe's model, Figure 2.4, one can characterise the pre-construction stage as entrepreneurial in nature in that it requires the generation of ideas and alternatives along with the provision of finance against competing schemes. The design stage is the strategic stage at which the goals of the building team are properly defined and the construction phase is the operational end which provides the means of achieving these goals. The post-construction stage is the production phase which sees the operation of the facility and is the ultimate goal of the client. Morris (1983:6) characterises design and feasibility stages as 'evolutionary and organic in character' and the production phase as 'highly mechanistic'. These stages are, of course, all interdependent and are separated by fuzzily defined boundaries - 'dynamic project interfaces'.

Nature of the Process

The second report of the Tavistock Institute was entitled "Interdependence and Uncertainty" and reflected what the researchers felt to be the two most important characteristics to be incorporated in a model of the building process (Crichton, 1966). The overlapping of stages in the construction process and fuzzy boundaries between stages add to communications problems of interdependence already inherent as information has to be made available to more people and organisations more quickly, and this is hindered by parallel working of organisations and the discontinuity of operations that this causes. Uncertainty thus arising is compounded by the fact that during design many options may be presented for consideration and uncertainty also exists within the client body, the environment and labour resources. Due to this situation, the informal mechanisms of control in the construction process have a major integrative function but can lead to role ambiguity and poor performance as often as they can improve the process.

The view given above describes the construction process as a very complex system and it is now incumbent to review the role and structure of the building team in this process.

The Building Team

At some stage during the construction process the client will make a decision on the selection of the building team and, as this occurs, thought must be given to the roles of and relationships between members of the team and the actions needed to manage this team. Cherns and Bryant (1984) apply the concept of the temporary multi-organisation to the building team, 'an organisation of organisations' (Stocks, 1984). Elsewhere, the project is seen as having 'a limited objective and lifespan, and therefore with a built-in death wish' and is described as a 'weak system compared with the continuous and self-perpetuating drives of other contributing systems' (APM, 1984:28). Building a team from a 'wide variety of organisations and motives' is thus a difficult and complex task and this section addresses some of the issues involved.

The roles played and the formal and informal system of controls operating will determine the pattern of relationships that develop and so the nature of the team, which may well change over time. A team should be a group of people working together toward a common goal and their combined efforts are organised into a co-operative whole. The traditional method of procurement does not wholly support this view however, as Banwell (1964:1) pointed out:

> 'The most urgent problem which confronts the construction industry is the necessity of thinking and acting as a whole.'

On reviewing Newcombe's model it is apparent that the sub-system under scrutiny is that of the "people without the process". The main components of this system are the roles of the participants and the relationships between the resource controllers which shape the coalition.[1]

The Professional

The roles of the building team can be divided into the managerial and technical functions that they have to perform. The technical functions relate to the individual's profession, of which there are many in the building team. Each profession has its own norms, values, sense of identity and control over entry (Stocks, 1984:9) and, hence, the capacity to form sub-groups with their own goals within the larger organisation. Further, it has been argued that the relationship between an organisation and its professional employees must produce conflict as commercial and professional values are incompatible (Hall, 1967). With professionalism is likely to come specialisation. As research and education advances, and as organisations expand and undertake wider ranges of work, it becomes feasible to train new entrants into the profession in narrower domains of knowledge and expertise. The generalist makes way for the specialist, following Taylor's principles of specialisation and divison of labour, with a consequent, greater need than previously for an over-arching management role to direct and control the project team.

[1] See page 41 for further details on the coalition.

With the idea of this greater need for management in an environment of increasing professional specialisation Stocks's comment (1984:16) is most pertinent:

> 'Within the *traditional* approach...the client expects the architect to manage his contract unaware of the fact that the consultant has not received management training.'

Stocks goes on to discuss Mintzberg's view that the professional bureaucracy is inflexible and ill-suited to a changing environment (Mintzberg, 1979), such as that encountered in building design. He argues that the traditional *building design* team can be regarded as a professional bureaucracy and, whilst criticising some of Mintzberg's assumptions,indicates that such a structure is thus unlikely to be appropriate for the building process (Stocks, 1984:28).

<u>Roles</u>

With the foregoing views in mind it is now appropriate to discuss the concept of role and its relation to the building team. Kast and Rosenweig (1974:261) define the concept of role as:

> 'relating to the activities of an individual in a particular position. It describes the behaviour he/she is expected to exhibit when occupying a given position in the societal or organisational system.'

March and Simon (1958) argue that specialists (or professionals) operating in conjunction with other specialists from different domains are faced with role conflict, ambiguity and intergroup conflict. Klauss and Bass (1982:43), in a study of inter-personal communications, argue that the literature indicates that role clarity (lack of ambiguity) leads to organisation effectiveness. Katz and Kahn (1978) use the concept of role as the linking pin between the individual and the organisation (and others within the organisation).

The roles played by the actors in the building team have their origin and development in history and, until recently, had atrophied into the frozen roles of the traditional system. If one draws the analogy with the stage it is possible to identify how roles can change and so the process takes on a new nature. For many years Olivier's portrayals of Richard III and Henry V were accepted as the standard to follow. In 1984 this changed with the roles played by Branagh in Henry V and, more dramatically, by Sher in Richard III. These two actors adopted new roles and changed the way people looked at the plays, particularly with Sher's sinister portrayal of Richard as a cripple making violent use of his crutches. The audience saw new themes and nuances in the play and fellow actors were forced to adapt their roles to a lesser extent. So too with the building process, new interpretations of old lines (of demarcation) lead to new procurement forms ; a different view of the process, a paradigm shift. Each actor has certain expectations when playing his role and the formal and informal controls in the process allow them to fulfil these, but only if they are aware of how the director is interpreting the play.

Hersey and Blanchard (1972) discuss the process of change using the phases (unfreezing, change, refreezing) identified by Lewin (1947). Unfreezing is the breaking down of old ways of doing things so that an individual is ready to accept new alternatives; the driving forces for change are increased. In construction, the introduction of new methods of procurement, the push for change by clients, exposure to foreign competition and the downturn in workload can be seen as media bringing about unfreezing. Hersey and Blanchard argue that change occurs through learning new patterns of behaviour and this comes about through internalisation (new behaviours are persistently demanded of the individual) and identification (behaviour is learnt by identification with models presented to him).

If one attempts to extend this concept and relate it to building teams one might propose that individuals in specialist design build and construction management organisations change and adapt to their new roles by internalisation whilst those who work with such organisations on an irregular basis change by identification (fragmented design builders are an example of this, see Chapter 3, p 65). Schein (1961) contends that internalisation 'automatically facilitated refreezing' into the new role whereas identification 'persists only so long as the ... original influence model persists'. Thus, such propositions indicate that individuals and teams engaged in the same procurement form regularly (or who have an established relationship) are likely to have their new roles constantly reinforced and so refrozen.

Those organisations which move between forms constantly may well suffer inefficiencies due to role ambiguity among team members due to an absence of internalisation. Whilst admitting that it is difficult to translate the psychology of change directly from permanent to temporary organisations and from individual managers to organisations the foregoing does provide some basis for expecting better performance from building teams specialising in a procurement form and having established relationships with other team members from different organisations.

Relationships

A major factor in the smooth running of the building process is the relationships between the resource controllers in the various professions represented in the construction team. As the Tavistock report (Higgin, 1965:77) points out:

> 'The central problem arises from the fact that the basic relationship which exists among resource controllers has the character of interdependent autonomy. There is a lack of match between the technical interdependence of the resources and the organisational independence of those who control them.'

Thus Tavistock views the social system, the relationships between resource controllers, as a major problem. (At this point it must be pointed out that Tavistock did not investigate other than traditional procurement forms. One has no indication, from published work, whether they saw design build or management contracting as systems which could overcome these problems). Why is this social system a problem? The answer lies in the people involved, they have their own reasons for being involved in the project and a set of needs to be fulfilled from the project. These are almost certainly going to conflict with other team members and so the client's objective, a successful project, may not be top of anyone else's list of objectives. As Cyert & March (1963) point out: organisations do not have objectives, only people have objectives. Thus the client's objective of a successful project is subsumed into the social system which is characterised by:

> 'participants...excessively concerned with their roles vis a vis other participants and insufficiently responsive to the needs of the manufacturing industry.' (Graves, 1978:7)

The Coalition

It is clear that what is thought to be a team is really a coalition, "a temporary combination for special ends between parties that retain distinctive principles".

The characterstics of the coalition (Cyert, 1963) are as follows:

1 it has shifting and multiple goals
2 management time is spent more on controlling the coalition and so less on controlling the environment in which the coalition operates
3 its objectives vary between members and over time thus requiring a concensus to be reached by a satisficing technique
4 uncertainties will exist due to professional and organisational barriers which are manifested in communication problems
5 the worst scenario is for conflicting objectives to generate dissent and so the need for members to leave the coalition

The coalition needs to be managed so that dissenting views are avoided and roles are harmonised. This can be done by modifying the expectations of the participants to fit the particular process and by operating the coalition in a controlled environment - this implies using tested, well-known and understood methods and so is an inhibitor to innovation. Even so, claims, contingencies and crisis management are inevitable consequences of the coalition as described: the side payments referred to by Cyert (1963:30) which "represent the central process of goal specification ...policy commitments".

If the above view of the people and relationships in the building process is accepted, its implications for procurement methods is manifest. Any system which moves away from the conflicting goals of a coalition and towards the unified effort of a team is likely to be more efficient and effective. The problem of individuals having their own peculiar goals within any organisation will always exist but a system which allows organisations to co-operate with one another is obviously advantageous. The question must be asked though, what is the situation in a design build firm? The present chapter has discussed the building team mainly within the context of the traditional approach to procurement. The sequent chapter provides a counterpoint by investigating current perceptions concerning the design build form.

Chapter 3

Design Build: Perceptions and Status

DESIGN BUILD:
PERCEPTIONS AND STATUS

Responsibility

The use of design build methods is certainly not peculiar to the building industry, many modern industries have a tradition of design build work including sophisticated micro-electronics and pharmaceuticals, shipbuilding, the automotive industry and most capital goods. Emerson (1962:27) remarks

> 'In no other important industry is the responsibility for design so far removed from the responsibility for construction.'

The reasons for this division of responsibility in the construction industry are a complex interaction of historical precedent, professional distinctions, the prototypical nature of construction projects and other diverse forces. The intention of the author is not to investigate the underlying reasons for the present structure of the construction industry in Great Britain but to investigate the various attributes which distinguish design build organisations from the general contractor and the professional practice. A number of companies claim to have been first in the field; whoever truely won that race is now engaged in the much less conceptual pursuit of maintaining their position in an increasingly crowded and aggressive market place.

Recent Trends

Many major builders have introduced a design build capacity into their groups over the past decade in various ways as discussed in the following sections. Of the 900 entries in the Building and Civil Engineering section of the Kompass Register 1983, thirty four per cent offered a design build service of some description; this included all the major U.K. contractors. In a survey conducted by R. Moore (1983) it was found from a sample of 38 contractors that twenty four per cent of their turnover was in the design build field (on average for contractors with turnover greater than £5M). A similar survey of over one hundred industrial clients by the author and Newcombe (1984) revealed that industrial clients let twenty six per cent of their projects on a design build basis and over fifty per cent by the traditional method. These findings reflect the increased importance of the design build approach; the following section reports the building industry's perceptions of this form of procurement.

Perceptions of Design Build

The emergence of design build as a major method for procuring buildings has been surrounded by confusions of definition and a whole host of perceptions, and misconceptions, concerning its impact on the building process and building team. It is apparent that design build is satisfying an increasing number of clients and, along with the spectrum of management approaches, has threatened the predominance of the traditional approach to building. In so doing it:

> 'raises fundamental questions about the integration of skills within the construction industry, the quality of service provided for the industry's customers, and satisfactory standards of consumer protection' (Evans:1978)

The following section investigates commonly held perceptions concerning design build in order to provide a framework within which this procurement form can be investigated.

Performance

In 1976 Roger Harris stated that:

> 'package deal projects, because of improved communications, ought to be quicker to construct' .

This is certainly a commonly held belief; not only is there the opportunity in design build for improved communications but also the opportunity to overlap the design and construction phases and to incorporate the somewhat intangible concept of buildability into the design by the involvement of the contractor. This notion of speed is borne out in the Financial Times of June 30th 1982:

> 'It is the package deal that many clients turn to if they are looking for speed in building.' (Amery, 1982:iii)

Nahapiet (1983:13) believes that the method provides a high degree of flexibility and response to changes at all stages of a project which, along with phasing of design and construction, results in early completion of the project. He is silent, however, on the price paid for this flexibility. NEDO (1983:19) also confirm this view:

> 'Design-and -build contracts...produce buildings very quickly, particularly if the contract is a negotiated one.'

There is a commonly held belief, probably well-founded, that all design build contracts make use of the overlapping of design and construction phases i.e. parts of a building are still being designed whilst construction is underway. Although this may be untrue for those builders such as Yorkon and Conder who sell 'systems' more than buildings (and so greatly reduce the design phase by taking components off-the-shelf), it is valid for most other design build organisations and is one of their main marketing tactics. Thus it may be reasonable to expect that the overall project duration is shorter on design build projects but the design and construction phases separately could well be longer as site work is continuing based on only partially complete design work; the overall time saving accrues due to the overlap of the phases. Time is not the only factor however, NEDO (1983:18) records that:

> 'Time is one factor to be balanced with others. Most customers regard cost as their priority.'

Whether this is cost in the absolute sense of minimum possible or adherence to a budget agreed at a particular moment in time is not clear. Certainly these are two distinct concepts and the latter is more easily tested than the former. Sidwell (1984) contends that:

> 'Clients are often puzzled by the various terms used within the industry, there are cost plans, tenders, final accounts and fees. Essentially the client is interested in the early prediction of the total amount he will have to pay and the variance between this figure and the final sum....One reason for the success...of package deals...is that they are more positive about the final cost to the client....There is no guarantee that it (the predicted cost) was the right one.'

NEDO's view is that real cost savings can be made if the project is such that the builder's practical experience is of use (NEDO, 1983:19) On serial contracts or the production of standard facilities this may not be the case but one would expect it to be so in general. Along with this perceived cost advantage over other forms of contracting research interviews conducted during the course of the research have indicated that design build organisations have taken a leaf out of Bovis's open book policy and offered guaranteed maximum price contracts. A key selling point is that the builder undertakes to give the client a share of any savings if he completes the work below the agreed price; a method widely practised in the United States (Building, 1983E & 1983A). In this manner the client is assured both that the contractor is offering something very close to the lowest possible price and that he will not exceed his agreed budget. Close examination of the detail of such agreements often reveals a number of caveats concerning the latter assurance.

Nahapiet (1983:13) makes the point that value for money is difficult to assess with design build contracts because of the different systems and services offered and the limited information available at the award of contract. It is a fair point, which also applies to many other procurement forms, that with only partially complete designs one cannot be certain that one is comparing like with like. In competitive design build bids, with no outline designs for the bidders to work to, assessment is likely to be extremely difficult. Bearing this in mind the builder may well be wary of committing resources to a competition which may prove to be somewhat of a lottery. This is certainly the view of Owen Luder (1970) who considers that a builder's commercial instincts will lead him to make a design input which will be the minimum to get the job. The cost of tendering for design build work will be dealt with at another juncture.

As a past President of RIBA, Owen Luder would press a further charge against the design builder, that of poor quality. Design is the prerogative of the architect and, due to the articles of association of RIBA, none of their members are to be found at the commanding heights of design build organisations. In a leader on 4th November 1983 Building Magazine stated:

> 'Architects superciliously like to explain away design/build by arguing that clients adopt it as a means of procuring the cheapest possible building and inevitably end up with a shoddy product.'

Quality, in terms of design, is a difficult issue; it is both subjective and modish. Few designs can immediately be described as carbuncles and it may take many years before we can consider a building to be an old friend. Very little truly great architecture is produced but a large number of pleasant and acceptable buildings are built each year: few clients desire monuments to themselves, many require a building that reflects their image in some way. To back up the architects' view Franks (1982) (in a view which was echoed, in one of the case studies, by Roy Morcon, a project manager with Sony, U.K.) states:

> 'Package deals may have technological versatility but they are not usually associated with prestigious buildings.'

Nahapiet (1983:13) agrees, citing a lack of stimulus for innovation and Bennett and Flanagan (1983), in their series of articles entitled 'New Directions, Management Options',suggest that design build is only suitable for 'simple well defined or standard buildings'. Thus the *quality argument extends to the* building fulfilling its function as well as incorporating good design. Antoni and Bengtsson (1975:17) came to the conclusion that:

> 'The closed process which is the package deal....only be resorted to for projects in which function can be defined in fairly unequivocal terms.'

The argument continues, and design build organisations are well aware of the reputation which, until recently at least, has stuck to them. Michael Millwood of John Laing Construction says:

> 'It (design build) has in some eyes been equated with the worst of the 1930's speculative building and has been a form of contract studiously avoided by many eminent professional practices.' (Building,

1983A)

Bovis describe their SASH Sports Hall projects as "not just another package deal building cobbled together in the contractor's drawing office" (Davies, 1983A): the building was in fact designed by Nick Grimshaw and Ove Arup & Partners. Thus the design builder is attempting to overcome a poor reputation by employing a rather differentiated approach to the problem, namely working in some form of joint venture with established and renowned architects and consultants. Some design builders are making headway in changing perceptions of the quality of product without resorting to such methods. In a feature on design build as an alternative procurement form David Pearce (1978) wrote:

> 'The D/B process has not been notable for producing buildings of stunning visual quality, but that is just what JT (Design Build) have done.'

The battle appears to be an internecine struggle between the construction industry professions but the ultimate arbiter must be the client. It is for him that the design, details, materials and functional performance of a building actually work and the industry must take note of his perception of performance. NEDO, in the booklet 'Thinking About Building' (BDP, 1985), attempt to advise "successful business customers" on the procurement forms available to them and list nine factors to be accounted for in selecting an appropriate form (based on the findings of "Faster Building for Industry"). In general design build and management forms are reckoned to perform better on time and cost performance than the traditional approach but design build is not recommended for "prestige" projects whereas management and traditional are. Finally, to quote Sidwell's synopsis (1984:286) of the NEDO report:

> 'though traditional methods of contracting are good, alternative forms such as design build, management contracts and project management produce quicker results at competitive prices and with no resulting loss of quality."

With such a diverse set of opinions abroad, research is obviously needed to provide empirical evidence to add to this debate.

<u>The Building Team</u>

The question is now posed: how do the building team members perceive design build? Is it a threat to a comfortable status quo? Does it provide an opportunity to generate more work for individual organisations? Is it a worthwhile alternative to explore? The following is an investigation of such questions.

In 1978 Building Magazine saw design build as a threat to traditional forms of contracting. In undertaking design build work the initiative is taken from the architect and rests with the builder who determines the pattern of design construction integration. Ray Cecil (1983) points out that:

> 'Design Build implies major changes in roles, relationships and responsibilities, and for no one more radically than the architect'

The architect essentially loses the role of contract administrator and with it a portion of the fee that he could expect. The position is worse still if he is in competition with an organisation wholly dedicated to design build; an organisation which does not look to the profession for any of its workload. In this instance all design work, and fees, are lost to the builder. Thus the threat is both to the architects role in the building process and to the very existence of his practice. Colin Davies (1983B) believes that this shift has come about in part because:

> 'Architects are failing to establish an effective dialogue with clients. Design and builders and project managers have a better record in this respect.'

Male (1984:296) notes in his case study that 'there was considerable role ambiguity between participants' citing this as an underlying problem inhibiting good practice. Certainly, the architect who involves himself in a design build project must understand and adapt to his new role. As reported on a factory project in Dorset:

> 'The most important thing is that his contract is with Conder (the builder), not with the client,....The architect produces his design on the basis of a brief put together by Conder's technical staff whose main aim is to win the tender.' (Davies, 1983C)

The M.D. of design build Contractor A sees the architect's new role within its design group in terms of different priorities and relationships. In the traditional contract the architect has little interest in the ease of construction compared with his quest for quality of design. From research interviews and periods spent in design build offices it is apparent that, as part of the design build organisation, the architect is expected to seek buildable solutions and enhance the ease of construction; the proposition is that this will in fact improve the quality of construction at the end of the day. The architect is also subjected to a shorter and more informal communication channel to the site manager, this he may find disconcerting. This new role need not be intolerable however, particularly for the private architect involved in a joint-venture with a contractor, as Cecil (1983) points out:

> 'Essentially , he reverts to the role that most architects claim to be the one they enjoy most and are *best fitted for-leader of the design team.'*

Corroboration comes from the Farrell Partnership in their design build project for TV-am with Wiltshiers:

> 'For the Farrell partnership it was much closer to the designer architect ideal in the sense that...the practice could get on with its main interest-doing tasty designs, leaving most of the day-to-day contract administration to Wiltshiers-which is where the contractual responsibility lay.' (Lyall, 1983)

A threat is also posed to those general contractors who do not move into this growing market as inevitably they will be invited to tender less often for a smaller market share as design build work takes a more significant proportion. In a recession this is an almost irresistible force causing contractors to compete in this new market sector. Thus, at once it is both a threat and an opportunity.

Building contractors have been quick to respond to this opportunity but the market has proved difficult to break into. A supplementary analysis of Moore's research (1983) indicated that it took a general contractor an average of five years to break into the design build market from the point in time that he started to offer the service. A critical mass is probably required to convince a client that a general contractor has the capability to take on design build work. The large construction groups, such as Balfour Beatty and Trafalgar House, have the financial muscle to raise loans in the money market at preferential rates and so generate another opportunity, that of contractor finance. This is perhaps the builders' ideal method of winning a contract as he has total control over the building process and can also structure the financial arrangements to suit his own requirements as well as those of the client. Peter Howell, chairman of Trollope & Colls says:

> 'Finance can be treated no different from bricks, mortar or management, it can now become routine.' (Building, 1984B)

Design build need not be an opportunity solely open to the builder; the architect, as shown by Farrell and D Y Davies can make a move into this market and so "take on the design builders at their own game" (Building, 1983D). Davies offer a Cost Guarantee Contract, that is they guarantee that their designs generate a minimum possible price when on site, any overrun being absorbed by the practice (Building, 1983C). It must be said that such ventures by the architectural profession are fairly limited at the moment and most practices prefer to adopt Farrell's approach of working jointly with a contractor whom they know and feel comfortable with.

The Quantity Surveying profession appears to have decided jointly to concentrate on developing an expertise in the project management approach to procurement but many practices have siezed the opportunity to develop an expertise as client advisors on design build projects. The builders and the profession have developed a happy relationship in that design builders are quite willing to recommend that clients appoint a quantity surveyor to check that value for money and quality are being attained.

In 1978 Graves (p8) contended that "Alternative methods of acquiring buildings are not widely known" and in 1983 NEDO indicated that clients drift into the traditional approach unaware of alternative methods of managing their contracts. This position may well have altered since the publication of 'Construction for Industrial Recovery', especially since the publication of numerous client guides and the distribution recently of 'Thinking About Building'. Experienced clients are certainly more aware of what is now available even if they are unsure as to the merits of different procurement forms. In an interview with the author the M.D. of Client B[1] described the traditonal system as "the animals came in two by two" but thought the design build system was "proactive"; by this he meant that

[1] Information concerning clients and building teams is contained in Appendix 2. In this case, study No. 10 refers.

the builder asked him questions and forced decisions from him whereas he felt that the traditional system allowed him to put off decisions without warning him of the consequences until the architect or builder reacted to some incident. These are highly personal views but the point is made that alternative procurement forms exist and that a client has the opportunity to choose one system that suits his situation. Suhanic offers sixteen ways for a project manager to deliver his project without including Ted Nicklin's (1984) 'selective design allocation' method; this is obviously a very confused situation to be presented to any but the most experienced clients and NEDO's efforts in trying to explain, and to some extent simplify, the clients route through this maze are to be applauded. Time will eventually reveal how permanent the move away from traditional contracting is and answer Cecil's questions (1983):

> 'Are we witnessing a permanent and radical change of our role, a temporary economic expedient or just a widening of the divide in the profession between the gentlemen and the players?'

<u>The Process</u>

The selection of contractors is an issue that must be raised when discussing design build and NEDO (1983) states:

> 'The market based on simple price competition is likely to narrow if there is a continuing move away from the traditional methods of organising projects.'

The general view appears to be that design build contracts are more often negotiated than won in competition. This is certainly what design builders aim for and observation indicates that at present such organisations concentrate many more resources in marketing than do general contractors: Design Build Contractor C has employed a marketing director for four years on a turnover rising from £15M; General Contractor B, with over £300M turnover, has only recently employed a marketing director.[1] The presently depressed level of building output tends to suggest that a client is best advised to seek some form of competition however, and it is unlikely that new clients will negotiate directly, only those for whom the contractor has satisfactorily completed past works. Thus design build cannot be regarded as the key to negotiated contracts and better profit margins; marketing and past performance are more likely determinants of this.

One can however develop something of a "brand image" as identified in the Cranfield/Financial Times survey (1979):

> 'The people (clients) interviewed tended to classify building firms in various ways which influenced their selection. Thus some builders are readily seen as "design and build" contractors and others as "management fee" people.'

Bovis, with their A5 fee and management contracting contracts, are the most obvious example of this. This can be of great benefit if, as Carter (1970) points out, building owners perceive a lack of specialisation in the profession which they would like to see changed. NEDO (1983) pointed out that design build projects were less successful if the builder lacked specialist

[1] Refer to Appendix 2, case study No 10 for contractor C & case study No 9 for contractor B.

experience. It is not clear whether this was specialist experience of a project type or in the field of design build work but both points are surely applicable. Franks (1982) believes that specialisation in a particular building system confers the advantage of clients actually "sampling" a building and so visualising their requirements more tangibly.

Moving on to the bid preparation phase of a project, design build poses a serious problem for would-be contractors. Many more resources must be allocated to preparing a bid for a design build contract than a traditional one and the risk of not being awarded the contract is often as great. Select competition is the order of the day for many clients in both building and civil engineering, Table 3.1, below, illustrates the costs incurred.

TENDERERS	AVE TENDER COST	CONTRACT VALUE	SECTOR
4	£75K	£20M	Building i
5	£150K	£20+M	Civ Eng ii
5	£60K	£10M	Building iii
	Average = 2.75% of contract value		

[i Building, 1984A:17; ii McLaughlin, 1986; iii case study 48]

Table 3.1: Average Tender Costs

Thus it can be seen that substantial sums of money are put at risk and many design build organisations will wish to ascertain how many other bidders are involved in a competition before committing themselves. The problem of "gazzumping" by inexperienced organisations moving into this new market was seen as a problem by many long-established organisations and a source of bad publicity for the procurement form. Warszawski (1975) suggests that sound business practice would preclude bidding when the product of expected profit and probability of a successful bid equals or exceeds the preparation expense of a bid. For those contractors working with architects in joint ventures on a no-job, no-fee basis these costs are reduced considerably and John Laing plc feel that contractor input at the formative stages improves communications and information flow "at a time when it is needed by the contractor" (Building, 1983A)

Nahapiet (1983:13)points out in one of his case studies that:

> 'it eased communications between the various specialist groups who were all part of a single organisation. This clarity and simplicity was felt...to have been especially important in this very complex and tightly constrained job.'

Harris (1976:69) cited improved communications as a major factor in speeding up design build contracts although they must also have contingent effects on the quality and cost of the final product. One must add a caveat here, the proposition of improved communication is based on the supposition that the design build organisation is a team drawn from one organisation only; this is not always the case and, as A G Davies points out in a letter to Building (1984C:7), "The design is spread through various companies and parts of the country. Therefore communication/co-ordination or lack of it will take its toll." Thus communications improvement will be dependent on the organisation of the design builder and, in every case, the quality, motivation and attitude of the personnel involved. This is counterbalanced by the argument of John Lelliot that by not employing in-house design staff the client receives the benefit of design by *independent practices with* reputations for different specialisations (Building, 1984C)

During construction the thorny issue of variations or change orders arises. Antoni and Bengtsson (1975:18) warn against the use of design build if changes may be necessary to the design once the builder has been appointed. Bennett and Flanagan (1983) categorically state:

> 'it (design build) does not provide the solution where there is likely to be a need for design innovation, flexibility or change during the construction process.'

Bennett and Flanagan betray their professional backgrounds to the reader here as the basis for their argument must be that there is no bill of quantities to value such changes against. This reflects a less than full understanding of the operational aspects of many design builders who have formalised procedures for assessing, costing and implementing proposed changes within a specified timescale. Rates are normally based on subcontractors quotes for work packages and the systems give the impression of operating smoothly, more quickly and with no cost disadvantage to the client compared with the traditional method. Franks' assertion (1982) that "variations...are unusual because design decisions have been made before work commences" refers only to the ideal situation and not the real world. There is still a strong likelihood in design build contracts that variations will arise although interviews have revealed that design build organisations do attempt to discourage these and explain the disruptive effects on programme and budget that such changes engender.

The Client

There is considerable agreement on the main advantage of design build to the client, it is single point responsibility. The FT/Cranfield study (1979) states:

> 'the popularity of "design and build" seems to stem from the opportunity it affords some clients to simplify relationships with contractors and consultants.'

The idea of one organisation to deal with is attractive to many clients, especially when they compare this approach with the multiple contracts and agreements that the traditional approach offers. However, single point responsibility does not mean that the client will deal solely with one person, many different professionals will be involved and the client still has no control over how they are co-ordinated and how well they communicate. NEDO (1983:19) point out that the checks and balances provided by an independent professional are not automatically provided and Nahapiet (1983:13) also draws attention to the loss of control and importantly:

> 'potential benefits derived from working with a single organisation can in practice become a major problem should adverse relationships develop'

Other drawbacks occur in allocating design responsibility, particularly in joint venture design build, and are discussed by Cecil (1983), Sims (1983) and Crowther (1984) to name but a few.

The last word on the subject of perceptions is the view of a rather cynical director of a major construction company who stated during an interview with the author:

> 'Many companies offering a design build service are not big enough to be more interested in the service they offer than what the directors can take out of the company.'

It is the authors view that, based on numerous visits to sites, offices and clients of design build organisations, many of these builders offer a much more professional service than this comment implies and so are worthy of serious study.

The Design Build Context

At present in the U.K., design build organisations, from evidence collected during case studies of individual projects, can be categorised as follows. The categorisation is based on the differentiation which each mode brings about (in terms of spatial, temporal and sentient differentiation).

Pure Design Build

The pure design builder strives for holism, a complete and self-contained system. All necessary design and construction expertise resides within one organisation and this is sufficient to complete any task that arises. The company directors often sell their product with an evangelistic zeal and, because of the complexity of today's building industry environment, the organisation generally specialises in a particular region or, more likely, a number of discrete market sectors. All aspects of design and construction have the capacity to be highly integrated and much experience and site feed-back can be effectively harnessed. An example of this form is Design Build Contractor C who has specialised in commercial buildings in the South-West and more recently high-tech production facilities. As turnover has increased and staffing levels expanded the company has felt confident to move further afield. Design build Contractor A, a much larger organisation, have been operating both nationally and internationally for a number of years and have specialised in complex production processes. Such firms are firmly entrenched in the small to medium size range, rarely undertake other than design build contracts and are susceptible to aggressive predators once they become publicly owned companies.

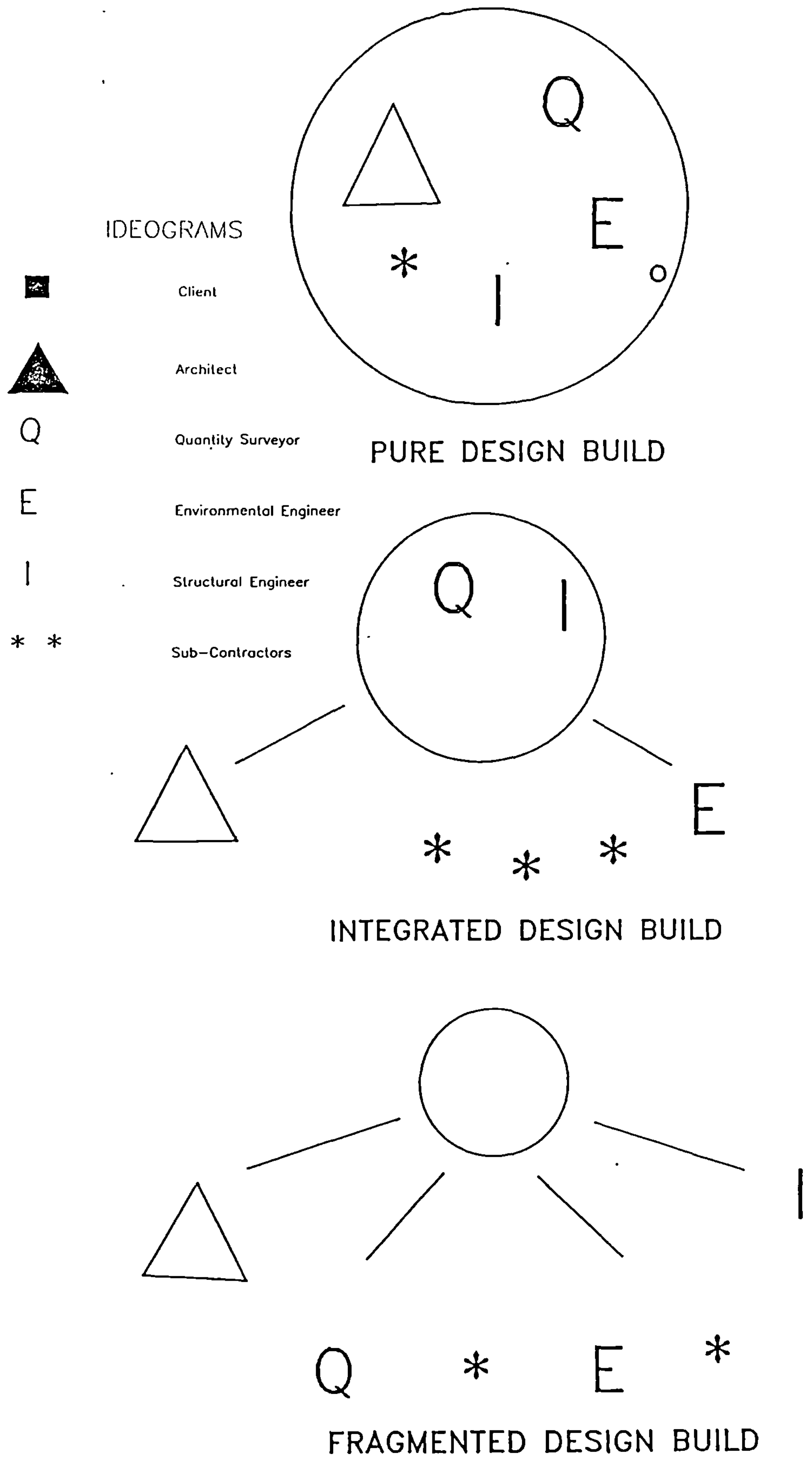

Figure 3.1: The Design Build Organisation

Integrated Design Build

The integrated design builder takes a less than holistic approach to the design and construction team and is prepared to buy in design expertise whenever necessary. This may take the form of architectural or other consultancy services but a core exists of designers, engineers and project managers who are experienced in their own specialism and the workings of the organisation. They provide the link pin between the internal and external organisations and so exert an integrative influence on the team. The design and construction teams may well be separate organisations within a group and both design build and traditional tendered work may be undertaken. This more general approach to construction tends to be a development from a general contracting background and so these organisations are more mature and are often medium-sized builders. More integrative effort is required on individual projects than with the pure design builders but specialist staff exist to provide this.

Fragmented Design Build

Many building organisations, large and small, and massive construction-based groups have taken an interest in design build over the past decade. Many of these builders tend to operate a fragmented approach to design build projects, perhaps in a manner that the integrated design builders did when first undertaking design build projects. The design group may be quite small, perhaps consisting solely of project managers whose task is to take client briefs and appoint consultants, on an appropriate basis, to develop designs. Major companies have the capacity to expand such units or subsidiary companies (for which the group has reduced liability) quite rapidly if required but, in the first instance, much effort must be made to integrate the work of the external consultants, as with a traditional contract, and to co-ordinate an appropriate input from the group's construction divison. Over a period of time a sense of identity and feedback from site may grow but, initially, many of the integration and co-ordination problems of the traditional approach will manifest themselves along with some role ambiguity amongst the professions as they come to terms with the builder as leader of the design and construction team. It is reasonable to suggest that general contractors and fragmented design builders take on projects within their overall capacity for work whereas pure design builders must constrain their efforts to work within their area of competence. Tender costs are likely to increase as one moves from fragmented design build through integrated to the pure form as less work can be subcontracted to other organisations, perhaps on a no-job, no-fee basis.

Site organisation is not regarded as a distinctive attribute of design build as, based on information from case studies, many traditional sites in England effectively run on a management basis at present. Design and manage is basically a design build option, the method by which the builder is paid changes, and so his role on site, but he is still the sole point of contact for the client; a little more of the risk involved in building is taken by the client. The topic of payment methods is dealt with in Chapter 5.

Attributes of Design Build

The following is a review of attributes which can be ascribed to design build organisations based on the arguments discussed above and in Chapter 2. The unique attribute of a design build contract is the single point responsibility taken on by the design build organisation. With this responsibility comes a number of other attributes *which are present in design build* contracts to a greater or lesser degree. Until 1981 the Joint Contracts Tribunal had no form of contract dealing specifically with design build contracts, the NFBTE and client's and contractor's own forms were widely used. The non-existence of an industry standard presented problems for many clients as there was no recognised document to judge the fairness of the others against.

It has become apparent from case studies conducted during this research that pure design builders are, in the main, medium-sized organisations who need to specialise in particular areas of the country or building types in order to maintain a competitive edge. The limiting factor on how much specialisation is required appears to be the size of design group that can be supported and so integrated and fragmented design builders appear to be less restricted by this need to specialise as they are able to make use of the of bought-in expertise on a commercial basis.

A major advantage of the design build approach is the opportunity it provides to overlap the design and construction processes by having one organisation responsible for both although the degree of overlap instigated can vary and is a strategic decision which can be made in the light of the needs of individual clients and projects.

Other concepts which have potential for improvement in design build projects are communications and buildability. One would expect the former to improve through familiarity of members of the organisation with one another and a reduction in differentiation and increase in shared objectives, but one must bear in mind the fact that more fragmented approaches to design build might well sacrifice some of these benefits. Improvements in the latter are expected to flow as a consequence of earlier contractor involvement in the building process but may be traded off against a lowering of quality or function due to expediency on the part of the builder.

Selection and payment procedures are not fixed with design build contracts anymore than they are with other procurement forms but, as argued in Chapter 5, particular forms are more appropriate than others. Linked to this however is the opportunity to reduce tender costs by direct negotiation with the client, so reducing the abortive tender preparation work of open or select tender methods. Competition may be introduced, if the client wishes, by letting packages of work to subcontractors on a select tender basis and, from case studies, this appears commercially attractive to both the client and the builder. CCMI (1986:13) indicate that 26% of design build contracts in the sample studied were negotiated whilst 60% were one stage bid contracts.

Finally, it was interesting to note during visits to pure design build organisations the heavy investment in integrated Computer Aided Design (CAD) systems which linked all the detail design phases to the document presentation and construction control phases. Such systems require heavy investment and can only be justified if they will be used intensively and if the barriers of professional vested interests can be overcome. Although these systems were only partially successful in achieving fully integrated project control it appears that to date only pure design builders have shown any inclination to incorporate CAD systems which span the full pre- and post-contract spectrum of functions; an example of such a system is given by Hunt in an article in Chartered Quantity Surveyor (1984).

	Unique Attribute
1	Single Point Responsibility
	Imperatives
2	Form of Contract Required
3	Need to Specialise
	Options
4	Opportunity to Improve Communications
5	Opportunity to Improve Buildability
6	Any Selection Procedure Feasible
7	Any Payment Procedure Feasible
8	Opportunity to Overlap Design and Construction
9	Opportunity to Buy-in Expertise
10	Opportunity to Reduce Tender Costs
11	Opportunity to Integrate CAD Technology

Table 3.2: Attributes of Design Build Methods

Chapter 4

Project Performance: Measures

PROJECT PERFORMANCE:

MEASURES

In order to compare the performance of building teams in completing different projects some measures of performance are required. These measures need to reflect the objectives determined by the client when engaging in the construction process and as such may vary from client body to client body. However, a review of feasible objectives postulated in the literature appears in Chapter 2 and performance measures adopted in previous research, reported below, will serve to indicate the scope of the topic and provide a basis for the choice of measures used in this work.

Client Objectives

It is important to restate that this research is based around the performance of the construction industry as perceived by the client. Taking this as a reference point the following review indicates feasible objectives of the client. The fact that other building team members have different objectives is accepted and it is acknowledged that these objectives will affect relationships within the team, or coalition (p41 refers), and so modify performance. Nevertheless, what is being presented here is a definition of the frame of reference within which the research has developed.

NEDO (1983:22) worked from the premise that the key objective of certain industrial clients was speed of construction. This formed the basis for the research undertaken but other objectives were identified and formulated as priority ratings in "Thinking About Building" (BDP, 1985:6) which was based on the 1983 research report. These objectives included:

early completion of the project
need to make variations during construction
level of quality in design and workmanship
price certainty before commitment to proceed
price competition in choice of building team
division of contractual and professional responsibility
risk avoidance

Wood (1975:105) notes that the criteria mentioned most consistently were: meeting the budget; low maintenance costs; time; cost; functionality. He adds that 'a relatively complex amalgam of these components goes into the concept of value for money', perhaps the most important criterion for publicly accountable clients. In discussing client's needs Ferry and Brandon (1986:13) relate the client's time and cost requirements to contractual arrangements. Time requirements range from no critical requirement and early completion unwelcome to shortest time (overall or for construction work) and earliest start. Reliable guaranteed completion dates and provision for phased completions are also included as needs. Cost requirements follow a similar format and also include low maintenance costs, balance between capital and maintenance costs, cash flow, share in the risk of development and minimum capital commitment. Thus predictability of cost/time, lowest cost and shortest time for sections or phases of the project are regarded as different objectives applicable to different clients and projects.

Ireland (1983:9) reviews a number of objectives found in the literature and lists over thirty different criteria. He points out (p13) that it is impossible to pay attention to all of these objectives and accepts for analysis the objectives of:

> 'reducing time
> reduced cost
> increasing quality.'

Bromilow (1974:58) *succinctly states that in his* opinion:

> 'The most significant overall objectives in building operations are to define the design and specifications, price and timing of the proposed building, and, once they have been agreed by the client, to meet them.'

This simplicity does not necessarily exist in practice however as Sidwell (1982:29) admits of the fact that, despite the definition by the client of his objectives, the matter is complicated by 'the degree of conformity between expectations, interpretation of the brief, and realization of the project' all of which are functions of the client's, designer's and builder's abilities and skills.

In research aimed at investigating construction firms' marketing methods Baker and Orsaah (1985) investigated how customers chose their contractor and found that low price, company financial standing, company reputation and early completion date were the major factors (in descending order of importance). They also noted that 'most customers compromise their objectives to achieve what is most important to them'.

In a study of both construction and other types of project Morris (1986:30) adopts three measures of success, two of which relate specifically to client objectives. These are 'Project Functionality - does the project perform financially, technically or otherwise in the way expected?' and 'Project Implementation - was the project implemented to budget, in schedule, to technical specification?'. Morris argues that both measures are important as success or failure in one is independent of the other; the former reflects long term objectives of the performance of the facility in use and the latter the short term objectives of provision of the facility as, when and how required. On the other hand Baker, Murphy and Fisher (1983A:684) concluded that adherance to budget, schedule and specification does not adequately define success and they developed a definition from their study of 650 projects for NASA which they termed "perceived success of a project". This definition included attainment of high levels of satisfaction from the parent, client, users and project team (also included by Morris) as well as meeting project technical specifications. They found that budget and schedule performance were not significantly related to perceived success or failure.

The problem of multiple objectives becomes more complicated as the impact of competing groups within a client body and the change of objectives with time are introduced (Cherns, 1984). The researcher is thus faced with the task of either assessing the changing objectives of each individual client body for every project studied, which effectively limits the size of his sample, or adopting universal criteria for every client and studying more projects. The adoption of universal criteria based on time, cost, quality and functional performance of building projects has the added advantage of allowing comparisons to be made with previous research (Sidwell, Ireland, Wood, Graves) and so such a mechanism was chosen for this research. The details of the actual measures adopted are discussed below and in Chapter 7.

Performance Measures

Taking the criteria of time, cost, quality and functional performance as the basis for consideration, as discussed above, a number of different measures can be identified in the literature. These measures reflect different objectives and have been developed for differing purposes. They are reviewed here in order to provide the background to the choice of measures adopted in this research.

In an extensive research programme spanning the 60's and 70's Bromilow led a team which investigated the performance of building projects in Australia. The work was painstaking, it took two years to collect the data in a consistent format (Bromilow, 1974:58), but in 1974 some 370 building projects had been studied. From this mass of data Bromilow developed models of the time, T, in working days elapsed during construction, number, N, and value, V, of variations and had begun work on a model to predict preconstruction time, P. These models were all a function of the cost, C, of the project. The relationships were expressed as follows:

$$T = 313\ C^{0.3}$$
$$N = 147\ C^{0.81}$$
$$V = 110\ C^{1.25} \qquad (1974:60)$$
$$P = 343\ C^{0.27}$$

Bromilow was seeking to develop a frame of reference within which to compare performance and produce a procedure whereby the timing of building projects could be planned more realistically (1977). His results showed that contracts overran on cost by five per cent on average but by forty seven per cent on time, a staggering figure. Only twelve per cent of all projects were completed on time. When assessing variations he found that the client had generated forty one per cent of all variations (1970). Thus Bromilow made use of mathematical models of the relationship between cost and i) time; ii) variations; iii) preconstruction time. These provided norms for the speed of the building process and the occurrence of variations. He also analysed overruns on time and cost which provided a measure of the accuracy of the industry's time and cost predictions.

Wood (1975) adopted a similar approach (to the latter) in the United Kingdom when analysing public sector contracts. A survey of 300 public sector clients was conducted which examined over 2000 projects in order to identify procedures leading to good and bad performance. Fifty in-depth case studies were conducted with 250 participants which certainly gave the data a richness in its reported form. Although the statistics given are all descriptive the commentary adds a prescriptive narrative for good practice, based, one assumes, on the detail of the case studies. Time and cost yardsticks (calculations of overruns) were adopted to measure performance and forty per cent of the sample were found to have cost variances greater than five per cent (p80). The average time overrun was over seventeen per cent with sixty per cent of projects overrunning by more than five per cent and more than thirty per cent by over twenty per cent (p79). Wood also investigated alterations (variations), final account and retentions as part of the survey.

Of direct relevance to this research is Graves' report (1978), "Construction for Industrial Recovery", which was designed to make known the views of manufacturing industry on the performance of the construction industry. Graves reported that eleven per cent of customers with recent construction experience were dissatisfied with the final cost of construction work and seventeen per cent were dissatisfied with the time taken from design to completion (p48). It is interesting to note here the use of subjective measures of time and cost performance compared with the objective measurements of Bromilow and Wood. Such measurements are less time consuming to collect but are opinions rather than factual data. Thus, although they may not reflect actual performance in physical terms, they do indicate compliance or otherwise with objectives that the client has set himself in dealing with the building industry. The report also investigated satisfaction with the service provided by the construction industry in design and planning, the construction process and defect rectification.

The Slough Estates report (Mobbs, 1976), which compared construction performance experienced by seven development companies associated with Slough Estates in Canada, Australia, Belgium, U.S.A., France, Germany and the U.K., may well have been the stimulus for Construction for Industrial Recovery. Among the findings reported were that: total time from inception to completion in the U.K. was at least seventy per cent longer than in any other country; preliminary design phases were more complex; prices in the U.K. were comparable to those in Europe but more than those in North America. This international comparison adopted the approach of comparing identical buildings, a very difficult point to determine, on the basis of actual times and costs of their production. Obviously, exchange and interest rates would have a significant influence on these comparisons of costs and a better approach may have been to consider labour, plant and material inputs to ascertain a surer comparison of costs. However, the report certainly stimulated debate concerning the performance of the construction industry in the U.K. no matter what reservations might be held about the data used.

From a study of 32 projects within the framework of his research model Sidwell (1982) noted that publicly funded projects were more costly and less timely than privately funded ones and that integrated teams were used for higher cost projects. Design and construct teams were associated with projects of short build times and short total times. In order to draw these conclusions Sidwell adopted "success" as a dependent variable. The success measures were subjective and objective, namely: client satisfaction on cost and on time; overrun on cost and on time as a percentage of the planned cost and time. Build rate (average turnover per month of the project) and design, construction and total times were also included in the analysis as project variables.

The most comprehensive report to date concerning procurement methods is the NEDO publication "Faster Building for Industry" which saw the culmination of five years research in June 1983 and was produced on behalf of the Building Economic Development Council. A massive survey of 5,000 industrial construction projects was undertaken in 1980-81 out of the 9,000 constructed each year - an impressive sample. These were used as the basis to analyse the time required to produce buildings within given cost ranges. Design build and management methods were picked out as providing projects up to fifty per cent faster than normal.

Study of a support document for the report,BRE Note 42/82 (unpublished) by Beamish (1982), brings up questions about some of the figures in the main report however. Much of the data was collected from contractors quarterly returns which record work in progress and output and which are, in reality, estimates rather than factual data: the report points out the discrepancy between output recorded and value of new orders for the sample year 1980. Although contract price increases and a low level of orders compared with previous years are contributory factors to this discrepancy it is likely that mis-reporting could also be a contributory factor. All later conclusions on speed appear to be based on regression equations, for time as a function of tender price, derived from this data. This poses two problems: how accurate is the derived equation?; how certain are the researchers that, say, design build project tender prices are comparable to traditional tender prices for the "same" project? For example, design fees, not included in traditional tender prices, are likely to be reflected in design build tender prices. If the different procurement methods produce different tender prices one cannot say with certainty that a project is quicker than average based on these equations!

In an unpublished paper from the BRE, by Korner (1986), construction times for 1037 commercial sector projects were analysed using an 'average speed' analysis technique. This method broke projects down into three size bands and then rated each project within a band statistically for speed performance against all other projects within that band. Valid comparisons of project speed with all projects in the sample regardless of size could thus be made. Projects were found to be less speedy when an architect was in charge of the building process and that for the speedy, non-traditional methods of contracting, builder appointment was by negotiation in sixty per cent of cases.

Building cost, project cost, construction time, project time, architectural quality and commercial quality are the aspects that Ireland (1983:94) identifies as likely to be affected by the use of managerial actions. Of these, Ireland found that project cost could not be measured satisfactorily and project time was not a reliable measure. Thus in his analysis four measures were used in hypothesis testing: architectural quality (a subjective measure); construction time per square metre; building cost per square metre (excluding foundation costs); commercial quality (income per square metre). Contract variations per unit of building cost was also included, as a managerial action, in the analysis but data on this variable were only available for twelve out of twenty five projects studied. These measures were first investigated for the way that managerial actions affected them (using a correlational approach) and then substituted in regression equations in order to determine the magnitude of the effect that each identified action had on the measure.

Other approaches to measurement of success can be envisaged. Comparison of achieved performance against the data contained in the BCIS database is one alternative (RICS). Unfortunately, the data recorded, at present, are tender prices rather than final accounts and, due to the classification system used, the standard deviation of values for industrial buildings is too large to be able to consider its use in this research. Productivity comparisons between different construction projects offer another alternative measure of performance and Griffith (1986) indicates how such data can be used to investigate the concept of buildability. He also indicates at least fifteen other 'managerial and project orientated factors' which influence productive activity. These and other factors, including data collection difficulties, caused labour productivity to be abandoned as a potential measure in this research. The pilot study undertaken on this is reported in Rowlinson and Langford (1986). Mohsini and Davidson (1986) adopt an interesting approach in their study of building team performance by measuring conflict as an indicator of the appropriateness of a procurement strategy. Wilemon and Baker (1983), in their study of behavioral dimensions in non-construction project management, see conflict as inevitable and measure performance in terms of the project managers ability to deal with this conflict. Might (1984) adopts a more conventional approach and uses the objective measures of time and cost overruns and four subjective measures of success - an overall rating and technical success related to: the initial plan; compared with other projects; the problem identification process.

Summary

Many performance measures have been identified within construction management and in more general project management research. Whilst many focus on the objective measurement of budget and schedule performance use is also made of subjective measures of these and other less tangible concepts such as quality, function and overall performance. The objective measurements can be made in terms of predictability of estimates (i.e. overruns) and also by comparison of absolute values with the sample, or population, norms (e.g. speed). The use of subjective measures is justified by the argument that they overcome, in part at least, the lack of data concerning individual, multiple and changing objectives.

Choice of Measures

This research aims to identify variables, and contingencies amongst variables, peculiar to the construction industry which affect construction project performance, whether they be variables which are intrinsic to a procurement form or variables determined by management strategies adopted. Such research requires study of a number of projects rather than intense investigation of one or two case studies. The client's objectives and criteria are adopted as the frame of reference. Thus, the use of novel measures such as labour productivity or conflict are rejected in favour of the use of the following measures:

- predictability of budget
- relative cost
- predicatability of schedule
- relative speed
- subjective assessments of quality and function
- subjective assessments of time and cost performance

The use of relative speed and cost allows the identification of those projects on which performance is particularly good or bad. Measurement of predictability allows identification of projects where management decisions have produced performance as planned. The relationship between relative performance and predictability can thus be investigated. The subjective measurements allow the fulfilment of objectives to be assessed whilst, inter alia, avoiding the disturbing effect of post-hoc rationalisation of good or bad performance on the stated objectives. The measurement of these performance indicators is discussed in Chapter 7.

Chapter 5

Factors Affecting Performance

FACTORS AFFECTING PERFORMANCE

Introduction

The research undertaken to date concerning procurement methods has focussed around developing and using performance measures (Bromilow, 1974; Wood, 1975; NEDO, 1983) to establish performance norms and using these norms to determine the variables which affect performance and so cause variance among the measures (Ireland, 1983; NEDO 1983; Sidwell 1982, Morris, 1986). Some such as Morris and Ireland, have used systems theory as a framework within which to conduct their studies (although Morris (1983:35) notes that a subtler model is required to investigate the project/outside world interface). Mohsini and Davidson (1986) make use of contingency theory to examine the effects of structure and environment on performance, measured using the concept of conflict. Ireland (1983:25) indicates that he has used contingency theory to identify managerial actions affecting project performance. Kelly and Fleming (1986) and Brandon (1987) have attempted to take this further and build models of the procurement system.

A major inconsistency in much of the work to date has been the understanding of the effect of what is commonly called procurement form, or contract strategy, on performance. For instance, Sidwell, Wood and NEDO all believe that design build can perform better than traditional contracts in certain circumstances. There is thus the basis for a contingency approach to contract strategy. However, Ireland (1984A) states that there are 'virtually meaningless distinctions between (these) nominally different procurement forms' and goes on to argue that managerial actions during the construction process, rather than the procurement form, are the determinants of performance. This argument is backed up by his research findings (1983) but it must be pointed out that the research did not in fact investigate design build, as data on the two managerial actions used to identify this form (single coordinator and contractor *responsible) formed* a sub-sample too small to perform any valid test. Thus, the problem: is Ireland's theoretical analysis correct - performance is affected only by managerial actions - or does procurement form have some (structural) effect on performance? The section Procurement Components attempts to provide a framework within which this question may be addressed.

The following sections, Client, Project, Building Team, Project Procedures, Human Aspects and Environment make use of systems theory (Checkland, 1982; Kast & Rosenweig, 1974; Cleland & King, 1972) in identifying from the literature and classifying the variables affecting procurement performance. The research model (Chapter 6) is formulated such that causal links between variables and contingencies among variables are identified as hypotheses for testing.

PROCUREMENT FORM

The procurement form adopted is a focal point in this research and the effect it may have on project performance is discussed below.

Procurement Components

In conducting his research Sidwell (1982) used the concepts of building team form and project procedures, including a combination of selection of contractor and payment method, to define the procurement forms that he was studying. Ireland (1983) extended this classification to cover cost determination; contractor selection; specialist's roles; process structure; conditions of contract. The author considers that the process structure (building team organisation) effectively determines the formal roles of the specialists and so adopts the following components as representing procurement forms:

- building team selection
- payment procedures
- legal framework
- overlap of the building phases
- building team organisation

It is contended that these five components define the approach that any client adopts to the process of building procurement and that all are in fact the result of choices made by the client during the building process or before it commences. The realisation of the project is further complicated by client and project characteristics and management as discussed below.

Building Team Selection

The method of building team selection was not found to affect project performance significantly when Bromilow (1974) undertook his studies in the sixties and seventies but the majority of the contracts that he investigated were of a traditional nature. Morris (1986:22) noted that competitive bidding can adversely affect the outcome of major projects and the number of separate contracts is related to the chances of success. Warszawski (1975) concluded that a major problem facing non-conventional contracting systems was the objective selection of the most suitable contractor. From interviews conducted during the course of the research it seems that construction industry opinion has it that the method of selection will vary according to the organisation form. During the period of the research, due to parlous economic conditions, it has been quite common for twenty and more contractors to be involved in design build tenders. This flies in the face of conventional wisdom which demands small tender lists and very limited competition for such contracts based on the cost of preparing detailed tenders(see p58 for comments on tender costs). Table 5.1 indicates what may be considered to be a reasonable relationship between organisational form and selection procedures when the cost of abortive tendering is taken into account.

Payment Procedures

It is often asserted by writers on construction management that certain payment procedures are most commonly used with certain organisation forms (Franks, 1984; CIRIA, 1983,1984,1985; Barrie & Paulson, 1978:24-32). Thus the client may be advised to adopt a target price with a management contract (NEDO, 1982) or a guaranteed maximum price with a design build contract (Building, 1983A). Such advice may or may not be good advice but it cannot be disputed that the method of payment to the builder will affect his attitude to any particular contract and that arguments can be advanced to justify advising a contingency approach to the choice of payment method. U.K. Government reports have discussed payment procedures (Banwell, 1964; Wood, 1975) and Ferry and Brandon (1986:17) discuss them with reference to fulfillment of client needs. Table 5.2 lists some of the procedures available and represents one classification of appropriate procedures. The inclusion of this variable provides a two-pronged approach to the research, current combinations of payment method and team form can be documented and the possible repercussions on performance investigated.

The Legal Framework

The legal framework of construction contracts, as defined by the conditions of contract and other contract documents, provides a basis within which the other components can fit. The adoption of standard forms of contract in the U.K. has provided a stable background within which the client and building team can operate

	Open Tender	Select Tender	Two-stage Tender	Negotiation
Traditional	*	*		
Alternative Method of Mgt	*	*		
Management Contracting		*		*
Construction Management		*		*
Design Build		*	*	*

Table 5.1: Organisational Form and Selection Procedures

	Fixed Price	Fluctuating Price	Fee	Fixed Package	Schedule of rates	GMP
Traditional	*	P				
Alternative Method of Mgt	P		*	*		
Management Contracting			*	*		P
Construction Management			*	*		
Design Build	*		P	P		*

(* - likely; P - possible)

Table 5.2: Organisational Form and Payment Procedures

but use of non-standard forms obviously shifts the balance of risk and responsibility for performance between the participants. Stocks and Male (1984:296) see the use of conditions of contract as an insurance policy (also noted by Graves (1978:21)) but Morris (1986:22) sees them as directly influencing the financial and organisational bases of the project and so the likelihood of success or failure. These disparate views can be reconciled perhaps when we consider the former were investigating human aspects in their research whilst the latter took a much broader perspective. Rubin (in Smith et al, 1975:918) sees the legal framework as apportioning risk and legal responsibility for: adequacy of design; cost of construction; liability to subcontractors; indemnification; financing; coordination of the work. Thus one may consider that the framework aids in clarifying roles and responsibilities as well as providing a safety net.

Overlap of the Building Phases

It is accepted that, by their nature, design build contracts are conducted in a mainly overlapping fashion, design is undertaken whilst construction is already underway. This has given rise to criticisms, for example, that earthworks are overdesigned or that superstructures are constrained by early design decisions on sub-structure before the project has been thought out fully (Ireland, 1983:44). The tendency in traditional methods of procurement has been to follow the "evolving brief" concept and certainly not to tender on a complete design. This being the case, decisions on overlapping are likely to have repercussions for both building speed and building quality. Overall project time should be reduced but, due to design constraints and uncertain planning data, the site construction time may well be increased. This may be offset however if a more buildable (constructable) design is forthcoming due to the builder's involvement in design. Additionally, Morris (1974) identified the need for integration at boundaries between design and construction and his work would suggest that the more integration that takes place in an organisation, the more capable it will be of dealing with building phase overlaps.

Organisational Form

Much confusion exists because the industry takes organisational form to represent procurement form. As previously stated, organisational form is a component of procurement form, albeit a major determinant of the appropriate procurement form. The trade journals are saturated with articles and advertisements for ostensibly different organisational forms which are basically the same. Design build is variously described as: design manage; design and construct; package deal; turnkey; develop and construct; etc.. The procurement form may be somewhat different but the organisational form is basically the same (N.B. Chapter 3 pp 62-67, Design Build Context also addresses this issue).

The rationale behind this statement is that, in a temporary organisation such as the building team which jointly or singly contracts to provide a building or parts or details of a building, the logical method of describing the organisation form is through the formal authority structure vested in the building team members by the client organisation. Personal, or informal, authority may follow the pattern of the formal structure but is a function of the psycho-social subsystem and so a modifying force on the building team and process (Crichton, 1966:46). Thus the work of The Administrative Management School (Fayol, Follet-Brown, Irwick, Breck,..) and, in particular the second of Fayol's fourteen principles of management, authority, is of relevance to organisational form (Storrs, 1945). Further support for this view comes from Wearne and Ninos (1984) who summarise the needs and problems of project control and their recommendations essentially describe the process in terms of delegation of authority.

Models of Organisational Forms

The traditional system, as depicted in Figure 5.1a, indicates that the authority for design and that for construction are vested in the architect and builder separately. The architect, whilst keeping a watching brief and monitoring construction, does not have any responsibility for the construction process: responsibility is divided.

The management contracting system, Figure 5.1b, is essentially the same in terms of division of responsibility except that the contractor monitors the design process, whilst having no responsibility for the design.

The construction management system, Figure 5.1c, lays responsibility for design and construction at the door of the client project manager who normally delegates his authority to the architect and subcontractors for design and construction works whilst monitoring their work, for which he is responsible to the client and for which they are responsible to him. In a formal sense the managing contractor has little responsibility or authority, his role is to monitor both design and construction works, although the informal system of authority and use of an appropriate legal framework ensure that he controls the progress of both design and construction effectively.

The design build system vests authority, and so responsibility, with one organisation, generally, but not exclusively, the building contractor. This single point responsibility, Figure 5.1d, distinguishes this system from the multi-point responsibility systems shown previously. An independent consultant, usually the quantity surveyor, often provides a monitoring service during design and construction.

In this manner it is possible to distinguish all organisational forms by the division of responsibility and delegation of formal authority for the design and construction processes whilst recognising the potential of informal systems of authority to modify relationships and so affect performance; i.e. the

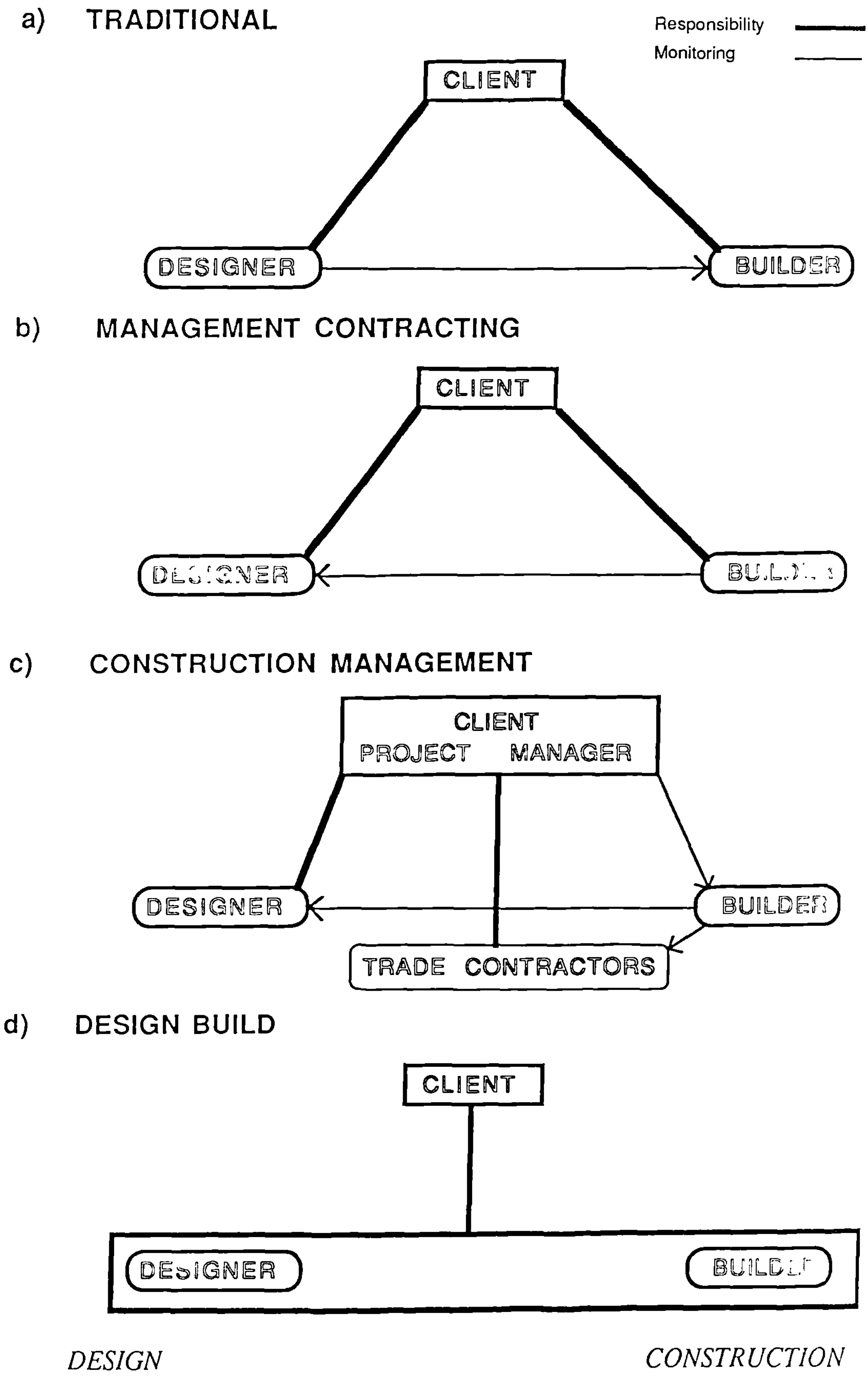

Figure 5.1: Responsibility in Procurement Forms

influence of human aspects on the performance of an organisational form.

CONTEXT

The context in which the construction project takes place is a major factor affecting the decision making process. The characteristics of the client and the project are important aspects of the context and are discussed below.

The Client

The nature and role of the client in the construction process have been reviewed in Chapter 2. This section thus highlights those aspects of the client body which have been identified in research as affecting project performance.

Client's experience of the construction industry has been identified by Nahapiet (1983:5) and Sidwell (1982) (using sophistication and specialisation variables) as affecting project performance. NEDO (1983:3) found that successful projects were for experienced customers and that, if a customer needed a building quickly, he must take on a good deal more than minimum involvement in specifying requirements (p17). This was a major theme of the Wood report (1975), a 'strong client' was seen as a prerequisite for a successful project. Wilson (1974) pointed out that a quarter of clients had either not clearly established their building requirements when the building team was engaged or had set no budget or timetable. This reinforced his opinion that the client must pay more attention to the important issue of client control of the project. Harper (1980) also emphasises the importance of the client project group.

Sidwell and Ireland (1978) produce a conceptual model of the design of organisational form within the building process which postulates that client and project characteristics influence procedures and so the building team organisation and thence performance. Nahapiet (1983) includes knowledge concerning building as one of these characteristics and Baker et al (1983A) identify the client parent as an influential force. Morris (1986) adds sponsor commitment and politics within and outside the sponsor organisation and classifies owners as weak, learners, strong, muddled, participating and non-existent!

Banwell (1964) criticised public clients for imposing excessively rigid procedures on the contractor selection process and Higgin (1965) found that many clients were ill-informed as to the options available to them; NEDO found this to be the case still in 1983. Sidwell (1983) found that the private client was more specialised and, in general, achieved improved performance. Bromilow (1974,1977) found that clients were responsible for delays in issuing approvals, signing contracts and allowing site access and that they were responsible for the largest proportion of variations, all of which have time and cost implications. Wearne and Ninos (1984) found that effective control of construction was dependent on the promoter's decisions on the authority vested in his project team.

The Project

The procurement process revolves around the characteristics of the individual project. These characteristics will have an effect on the project process and, ultimately, the success or otherwise of the new venture.

In their guide for foreign companies wishing to obtain a new industrial building in the U.K. the Department of Environment (1982) identified speed of the project, the project's complexity and the scale of the works as factors affecting the choice of procurement method. These same factors are also cited by Morris (1983:25) who also adds technical uncertainty to the list in a later study (1986:29). Thinking about Building (BDP, 1985:6) defines complexity as technical advancement or high levels of servicing and also includes early completion among nine factors considered to affect the choice, and so performance, of procurement method. Baker et al (1983B), using path analysis, identified seven primary difficulties to be overcome in public sector projects and one of these was simply the problem of dealing with the scale of the project, large projects. Nahapiet (1983:5) identified simplicity and standardisation of design as contributing to good performance. Stocks and Male (1984) point out that project complexity is actually confounded by the experience of the client, design team and contractor; it is not a variable to be treated on its own. Aram and Javian (1973) conclude that high complexity projects require direct communications between organisation units for successful outcomes and that priority and urgency correlate with time success (for R & D projects).

Sidwell and Ireland (1978) noted that complex, high value projects required special attention in determining appropriate procedures and organisation to be successful and Ireland (1984) showed that, in the technological sub-system, complexity increased time and cost per square metre and reduced architectural quality for high-rise commercial buildings. Irwig (1978) identified complexity and site and construction difficulties as major project constraints in a study of over 200 repeat clients. Difficulty, initial and final uncertainty were all found by Might (1984:136) to be significantly associated with cost and schedule overruns.

THE BUILDING PROCESS

Two major elements in the building process are the organisation and management of the building team. Both affect the outcome of the project and pertinent factors identified in the literature are discussed below.

The Building Team

The building team is that group of building industry professionals and personnel from one or more organisations who combine together to fulfill the necessary design, detailing and construction functions comprising the building process. The authority vested in individuals, the organisational framework and the structure of the team varies from project to project and so each of these factors has a contribution to make to project performance.

The Centre for Construction Market Information (CCMI, 1986) identified differing capabilities among design build contractors and Baker et al. (1983A & B) and Might (1984) noted that the ability of individuals and capability of organisations to repond to the problems posed by project management were characteristics strongly affecting perceived success and failure. Morris (1986) hypothesises that incapability can jeopardise project success. CCMI also indicated that previous experience of similar work was likely to lead to a successful project and, based on interviews with project managers, the author found that prior working relationships with other members of the team or client, familiarity, was considered to enhance performance. In their study of communications Klauss and Bass (1982:18) regard 'the structural constraints imposed by physical distance' as influencing communication behaviour (and, hence, effectiveness) and also introduce the impact of familiarity among communicators as another factor.

Authority

Wearne and Ninos (1984) indicated that authority was a key element in control of construction and Crichton (1966) discusses the working of informal and formal authority systems in the building process. Whilst authority needs to be delegated to a member or members of the building team it must not be forgotten that the client should provide an individual with authority to 'take decisions without reference back' (NEDO, 1983). Hodgetts (1968) discussed methods of overcoming authority deficiencies and Gemmill and Wilemon (1970) investigated authority as a method of influencing subordinates and gaining their support. In 1973 Gemmill and Thamhain reported that use of authority as a means of generating support led to low levels of project performance.

Hence, authority has been viewed as both formal authority conferred on members of the building team by the client through legal and other frameworks and also the exercise of individual and informal authority by project managers in an effort to motivate team members.

Structure

Arditi and Kutay (1978) investigated structure, measured along the dimensions of specialisation, decentralisation, departmentalisation, standardisation and formalisation using the instruments of Pugh et al (1968), in relation to the use of network analysis techniques. Lansley et al (1974) used the dimensions of control, boundary regulation and integration to investigate the flexibility of construction firms in adapting to change. Irwig (1984) investigated the similarity between the organisational behaviour of construction firms and other enterprises. He based his analytical framework on Mintzberg (1979) and indicates that the project organisational forms identified by Anderson and Woodhead (1981) fit well within Irwig's conceptual framework. Functional, matrix and project authority structures have been investigated by Ruskin and Estes (1986), Tatum and Fawcett (1986) and Thomas and Bluedorn (1986). Thomas, Keating and Bluedorn (1983) investigated factors influencing the choice of authority structure and concluded that project size and duration, organisational experience (familiarity) and technological and financial uncertainty were all contingencies affecting this choice. Tatum (1984) studied how managers decide on organisation structures and found that adaptation and behavioural choice were the main mechanisms employed rather than 'rational decision-making to design organisations optimally suited to project goals ... and unique constraints' which applied too many constraints.

All of the preceding are examples of the investigation of the concept of structure in the context of the corporation rather than the project (excepting, perhaps, Anderson and Woodhead) and thus their methodologies and instruments would need adaptation to the project level. What is missing from such analyses is a recognition of the inter-organisational dimension.

Stocks (1984) develops a framework for evaluating the construction process using communications, roles and responsibilities as the basis for his analysis of structure whilst Mohsini and Davidson (1986) investigate task structure, task interdependence and information in their study of inter-organisational conflict. Ireland (1984) includes the definition of roles, control, coordination, planning and timing of decisions as structural factors affecting performance, although, due to constraints, he only tests design construction coordination and construction planning during design. Thus it would seem that whilst structure of parent organisations has been investigated in the main, some researchers have adapted the concept to the building team, a temporary multi-organisation. This necessitates the adaptation of some measures and hypotheses to the alternative project, as opposed to corporate, environment but is seen to be feasible.

Organisation Form

Organisation form has been discussed in some depth earlier in this chapter (pp 92-94) and it was concluded that it is an area surrounded by considerable confusion of terminology. Whilst bearing this in mind it is possible to identify from the literature a number of findings concerning the performance associated with various organisation forms.

Wilson (1974:28) found that design build methods performed better than average in delivering buildings on time and remedying defects for industrial buildings but were worse than average when it came to performance on office projects. Wood (1975), in his investigation of public client projects, found that a high degree of success was associated with design build methods, adding the rider that there had been some criticisms of the quality of design. NEDO (1983) identified projects that had site times 30 to 50 per cent shorter than average and found these to have used design build, management contracting or construction management methods. Only two fast traditional contracts were identified and their performance was explained in terms of procedures for choice of contractor. This casts some doubt on the analysis, was the variation in performance related to organisation form or other procedures? (See next section for further discussion)

Franks (1984) rates six alternative building project management systems on five scales (complexity, aesthetic, economy, time and size) and concludes that use of a Project Manager is best closely followed by contractor's design. The traditional method falls into bottom place, just below the package deal. Whilst admitting that there is no 'universal system' this analysis can be turned around to offer a contingency approach to selection, as in 'Thinking about Building' (BDP, 1985).

Smith (in Smith et al, 1975) believes that turnkey contracts are more expensive (due to transfer of risk to the contractor) and that projects run under the construction management system have unpredictable costs. Sidwell (1982) found that design build methods were associated with projects with shorter time scales and high client satisfaction. Fleishmann-Hillard (1983) found that their clients used the general contractor approach most often and that design build methods were least favoured.

Project Procedures

Although a number of writers, some of whom have been identified above, consider organisation form to be a key determinant of success others, such as Ireland (1984A), consider success to be a function of the procedures adopted during the construction process. Those procedures which comprise the concept of procurement form, namely building team selection, payment procedures, legal framework and overlaps, have been dealt with on pages 88-92.

Managerial control, during design and construction is identified by Sidwell (1982) as being the most important factor affecting success. Graves (1978) also points this factor out with reference to the necessary client input during the project, as does Wood (1975). Baker et al (1983B) cite inadequate control procedures as a determinant of cost and schedule overruns and it has been found that most projects are reviewed for cost and progress solely on a monthly basis irrespective of size (APM, 1984). The use and control of subcontractors were seen to be areas requiring special attention by NEDO (1983) and Graves

(1978). Variations are identified as having a detrimental effect on project performance by Sidwell (1982), Bromilow (1970) and McDermott & Newcombe (1986) although Ireland (1983) indicates that they can be associated with an improvement in architectural quality.

Bromilow (1977) found that faulty programming, poor documentation and tardy decisions were factors affecting performance and timely decision making by the client is emphasised by Wilson (1974), Harper (1980) and Baker et al (1983A). Coordination between design and construction phases and participants is a pre-requisite for success identified by Morris (1972), Graves and Ireland (1983) who concludes that it is associated with a reduction in construction time. Coordination with outside bodies such as statutory undertakers, fire and planning authorities was identified as causing significant delays and increased costs by NEDO (1983) and Mobbs (1976).

Banwell concludes that the use of a bill of quantities is essential for cost planning and analysis although advances in cost planning and modelling (Brandon, 1982) may have rendered this conclusion inappropriate today. Optimistic cost estimates were found to reduce perceived success by Baker et al (1983A & B), as was timing and availability of funding.

Simplification of design and standardisation of construction details, making use of less labour intensive trades, are postulated by Mobbs (1976) and, later, Nahapiet (1983) as improving site efficiency and so performance. Might (1984) identified technical planning, perceived difficulty of the project and generation of project team support as important factors and Morris (1986) sees comprehensive project definition and planning, design and technology management as maxims for project success.

OTHER FACTORS

It cannot be denied that many factors, other than those already discussed, have the opportunity to affect project performance. Some of these are listed below and, despite being categorised here as other factors, are not necessarily less important than the foregoing.

Human Aspects - the Individual

The Tavistock reports (Higgin, Crichton) were based on the premise that the individual, his role, perceptions and attributes, had a major impact on the construction process, particularly through the medium of communications. Birrell (1978) concluded a discussion of construction management by stating that the person, not the role, was the primary determinant of the success of the system, perhaps suggesting that leadership was an important aspect in project performance. Bresnen et al (1986) adopted Fiedler's contingency theory of leadership style (1977) to investigate the relationship between project success and leadership style and to compare construction project manager scores with those of other professions. On average, these managers were found to have a greater task orientation than other work groups and it was also concluded that the scale of projects and workforce composition were moderating variables in the association between leadership and performance. Quinless (1986) investigated Handy's 'Best Fit' theory in the context of the building design organisation and found that, with some modification, the theory appeared to be valid for the construction industry. Baker et al (1983A) found a task orientation as a determinant of perceived success in projects.

Baker also found project managers' administrative ability as a significant factor, as did Might (1984), and they, Nahapiet (1985) and Banwell (1964) also saw the less tangible concept of good working relationships within the team and adequate communication patterns as indicators of a successful outcome. NEDO (1983) and Graves (1978) found that positive attitudes to cooperation and coordination eased the project process. Conflict, or its control and resolution, was studied by Thamhain and Wilemon (1975), Mohsini and Davidson (1986), Griffith (1984) and Sey, Orhon and Sozen (1978) (and aspects of conflict are reported by Wilemon in a series of papers summarised in Wilemon and Baker (1983)). Posner (1986) studied conflict during the phases of a project and identified issues which created conflict at different phases. He concluded that conflict is dynamic and not bad if it is managed effectively. Lansley (1974) used management style and problem solving expertise as variables in the study of the flexibility of construction organisations.

Skills of team members are included as a variable by Sey et al (as is goal commitment of the project team) and Ireland (1983) includes degree of competence and skill of personnel but admits that measurement of this variable was too difficult in the context of his work. Occurence of industrial disputes was also included in his analysis under this heading.

<u>The Environment</u>

Project planning models currently available have been criticised for considering the project as developing in a vacuum, an analytical assumption which is a gross oversimplification (APM, 1984). However, in Principles of Engineering Organisation, Wearne (1973) states that in devising a project team structure choices have to be made contingent on the environment and uncertainty so that external links are defined before the internal system is set up. He also notes that a system 'can only provide the opportunity, not the accomplishment, of coupling', as in marriage. Thus the success or failure of the working relationships provided by the system in response to the environment is in the hands of the participants, a recognition of the influence of the human aspects discussed above.

Lansley et al (1974) investigated the performance of organisations classed as either mechanistic or organic in their reactions to a changing environment and Might and Arditi looked at the situational and contextual variables which affected the performance of project teams and construction organisations. Sidwell and Ireland (1978) identified the client's needs as the principal influence in the micro-environment as opposed to influences external to the system in the macro-environment. Irwig (1984) found client budget constraints to be a major micro-environmental impact and Fleishmann-Hillard discovered that industry wide productivity and workmanship levels were a macro-level factor. Baker et al (1983A) found the competitive environment to be a factor affecting perceived success. Ireland (1983) indicates that his study was undertaken during a time of increasing economic activity, implying that perceptions, objectives and, so, performance may vary with a change in the general economic situation.

Sidwell (1979) notes that the price paid for building work is a function of supply and demand and not directly related to the work content of the building. This can be construed as implying that performance may be measured best in relative terms, e.g. cost overrun, rather than actual costs. Morris (1983, 1972) has written at length on the effect of boundary management and integration and emphasises the boundary with the external environment in his 1986 study. Von Scifer (1972), adopting contingency theory and the concept of temporary multi-organisations as his framework, focuses on the varying nature and intensity of coordination needs resulting from the uncertainty and interdependence of tasks in the project environment.

SELECTION OF VARIABLES FOR STUDY

Many factors affecting project performance have been identified from the literature and these are summarised below in Table 5.3. Obviously, all of these could not be incorporated into the research framework, so a limited number of measurable variables were selected, in the form of testable hypotheses, as discussed in the proceeding chapters.

CONTEXT OF PROJECT

The Client

The concept of TMO's
The decision making process
Uncertainty - within the client organisation
Control of the building team
Client objectives
Constraints on the client organisation
Sophistication and specialisation
Proximity to project and building team
Source and conditions of finance
Dependence
Accountability
Competence of personnel

Environmental Variables

Meteorology
Time of year and building rate
The Economy
Political influences
Legal restrictions and agreements

Situational Variables

Geographical location
Complexity of the project
Type of work - new build, refurbishment, etc..
Proximity of site
Budget and time constraints
Uncertainty over project definition
Technical uncertainty
Financial uncertainty
Sub-surface conditions

Table 5.3a: Factors Affecting Performance

PROJECT ORGANISATION AND MANAGEMENT

Procurement Form

Contractor and consultant selection procedures
Contractor payment procedures
Contract documentation and conditions of contract
Overlapping of the design and construction processes
Organisational forms

The Building Team

Subcontracting: of design; nominated; labour only
The contractor: his size and staff
his experience and capacity
his familiarity with the rest of the team
Size of the project team
Location of the project team
Site supervision
Planning methods
Differentiation among team members
Completeness of documentation
Informal and formal authority
Personnel, staff competence
Co-ordination and control of team members
Team leadership
Site quality control
Performance monitoring during project
Competition in appointment procedures
Relations with the client organisation
The effect and effectiveness of industry marketing
Long term quality performance
Architectural quality
Generation of alternative designs
Buildability
Productivity
Time control and planning techniques
Information flows
Contract procedures
Project team structure
Industrial relations policy
Conflict resolution
Contractor input during design
Defects and after-service
The effect of variations

Table 5.3b: Factors Affecting Performance

Chapter 6

The Research Model

THE RESEARCH MODEL

Introduction

The previous chapters have reviewed: the way researchers and practitioners view the building project; the way procurement has changed over the past two decades; the design build form of procurement; the factors affecting project performance; measures of project performance. Within this review a number of models have been discussed or alluded to. The model employed in this research, which has developed as a result of the foregoing, is presented below.

Context of the Model

The research objective is to analyse the building process for industrial facilities with particular reference to the performance of the design build form. This task is to be accomplished by the study of a number of industrial building projects and so the individual, unique project has become the focus of attention, rather than one or other of the organisations involved. Thus, an organisational system exists which comprises the sponsor or initiating organisation (client system), the production organisation (the contractor) and the planning, design and detailing organisations (the professionals, i.e. architect, engineer, etc.). These organisations form the building team and Morris (1972), Walker (1980) and Crichton (1966) have all identified subsystems within this team for detailed study. Hence, with the aid of prior building industry research and the background provided by Checkland (1982), Kast & Rosenweig (1974) and others, it is possible to produce a sophisticated, systems model of the building project but this would not lead to readily testable hypotheses for the model as a whole.

Research needs to be bounded and to concentrate on a specific domain if resources are not limitless. Given the aim of improving understanding of the procurement process, a reduction in the number of systems, and variables, included in the model is quite reasonable as long as it is recognised that some important variables may be excluded and that the model so produced may not predict performance accurately if the missing variables present themselves. Thus the model may contribute to understanding whilst being open to revision and amendment in the future.

The Variables and Model

'The design build form produces best performance' is the first proposition that the research addresses. Having defined the components of procurement form previously the effect of these can be studied and in so doing Ireland's assertion (1983), that managerial actions independent of procurement method affect performance, can be tested. If those components of procurement form as defined (and in general agreement with Ireland's definitions) are seen to affect performance then his model may be extended to include them as a system separate from the managerial actions system. In attempting to confirm this proposition the effects of the complexity of the project and the type of client

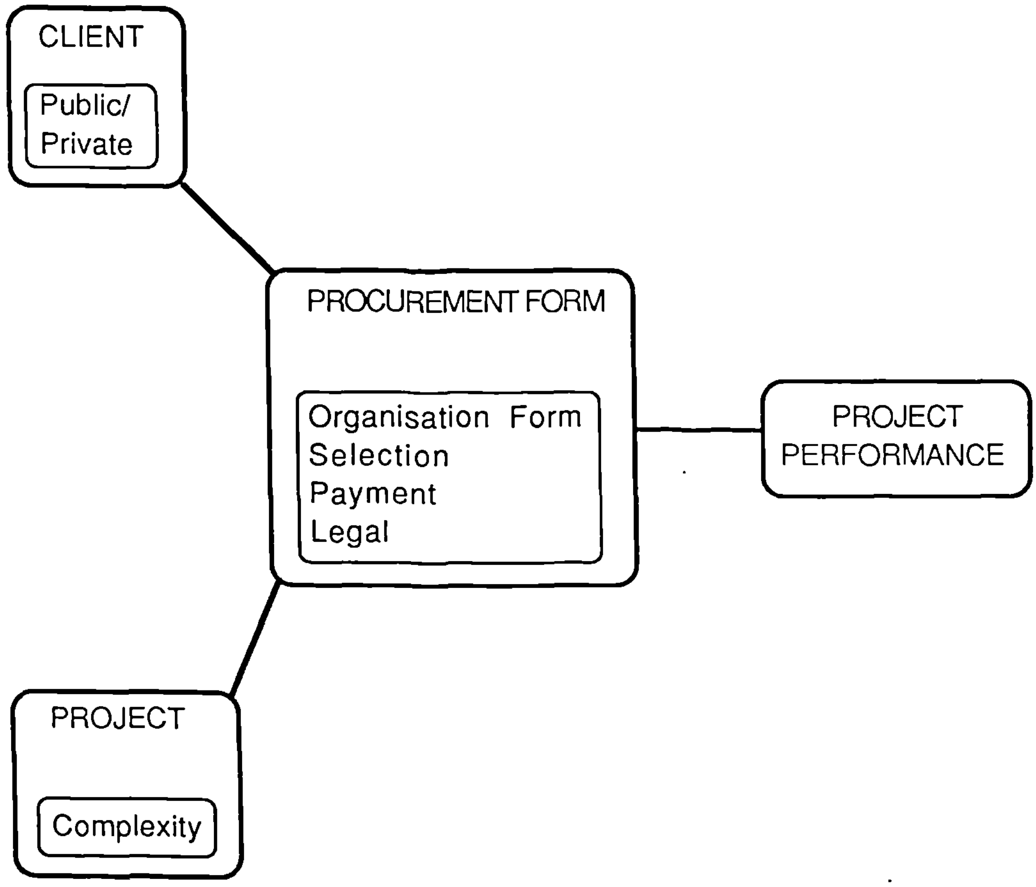

Figure 6.1: Research Model; Phase II

See Chapter 7, pages 126-128 for details of phases I, II & III.

are taken into account; these are contextual variables which may influence performance independent of procurement form. Complexity is introduced as a control because, although all the buildings are for industrial purposes, each is quite different in function and form from the next. It should be noted that, although the complexity in terms of the physical aspects of the building is included, this does not necessarily imply complexity in terms of building team management and organisation.

The model is represented in Fig. 6.1 and the specific hypotheses stemming from it are listed in Chapter 7. These hypotheses are in the form of direct relationships and contingent relationships designed to test the assertions concerning the design build form as discussed in Chapter 3.

A Stage Further

The simple model presented above is based purely around the notion of procurement form. However, it is possible to look at other domains and develop a more sophisticated model, Fig. 6.2, which takes into account the context of the building project and the organisation and management of the building process. This new model reflects the development of the research from the first proposition to a new proposition:

> Project performance is a function of both the context of the building process and its management and organisation.

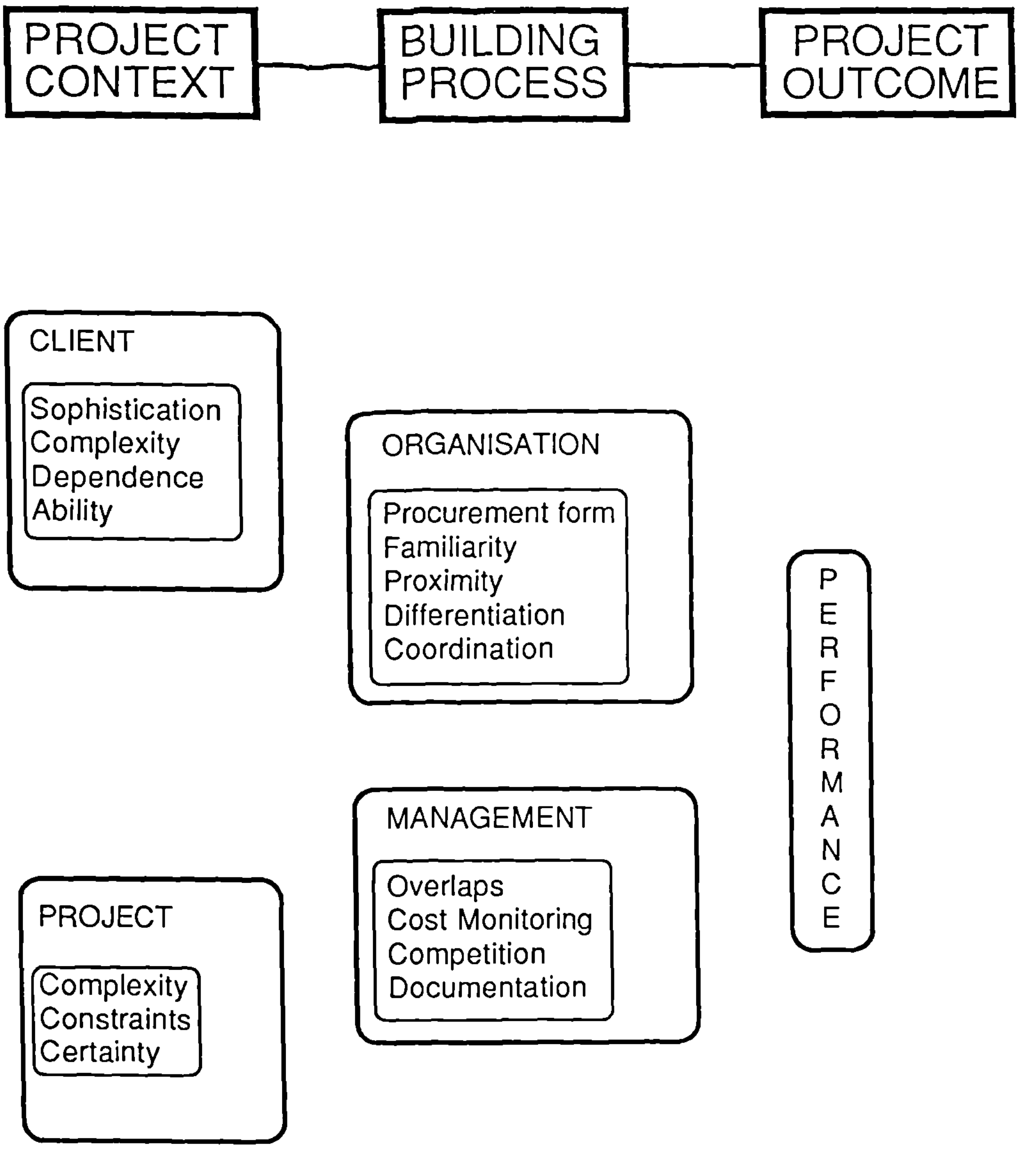

Figure 6.2: Research Model; Phase III

This proposition does not mean that the first has to fall, it simply extends the range of factors tested and which may contribute to performance. However, as the analysis will show, it became clear during the research process that procurement form as defined did not have the strong influence on all aspects of performance as hypothesised and that other variables were important.

Context

The second model adds dimensions to the contextual factors of client and project. The three dimensions of the client are:

> sophistication, in terms of the client's lack of need of construction expertise from outside the organisation;
> complexity, the levels and numbers of organisations involved in decision making on the project;
> dependence, the status of the organisation as far as ownership and project finance are concerned.

The dimensions of the project are:

> its physical complexity;
> constraints imposed on the project budget, schedule or function;
> uncertainty surrounding the project's viability and design and construction parameters.

Lack of sophistication, increased complexity and dependence of the client body may constrain the project team and increase project times as the team's energy is diverted from the project to educating the client and attending on tardy decisions.

Project constraints limit the options available to the building team, so threatening client satisfaction, and uncertainty acts as a break on progress. Increased complexity may affect time and cost performance and jeopardise quality unless recognised and appropriate management applied (e.g. use of cost monitoring system). A 'human' factor, a rating of the administrative ability of the project team (including the client project manager) was assessed and included in the client variables, poor administrative ability being likely to adversely affect the building process and so performance and satisfaction.

Hence, two, linked propositions are investigated: i) the contextual factors directly affect performance; ii) these contextual factors do not necessarily affect performance directly, rather they combine with managerial and organisational factors to influence performance. Thus, a contingency approach to performance is employed, i.e. in particular contexts appropriate organisation and management leads to high performance. The individual hypotheses stemming from this proposition are listed in Chapter 7 below.

Organisation and Management

The organisational variables selected for study have been chosen from the review of factors affecting performance as indicated in Chapter 5 and organisation form is included, of course. The other variables are: proximity, reflecting the physical separation of the main team members (territory); familiarity, indicating the extent of prior relationships and mutual understanding amongst the main team members; differentiation, a measure of the number of separate design organisations and nominated subcontractors involved in the process (technology);coordination, an assessment of the communications between designer and builder and the use of meetings in this context. Increases in familiarity, proximity and coordination and a decrease in the technological differentiation would be expected to improve the efficiency of the design and construction processes and contribute to a consequent improvement in performance. Contextual factors may act with these variables to enhance good performance or exacerbate poor performance.

Managerial variables included in the model are as follows. The extent of overlapping of the design and construction process; a high degree of overlap may well be appropriate for a sophisticated independent client who is able to make rapid decisions accurately. Use of a cost monitoring system during design and construction phases; particularly important for complex and uncertain projects and highly constrained projects. The extent of competition in the selection of the construction team and the degree of certainty concerning the project as expressed in the contract documents at the time of commencing site works.

These variables together affect the perceptions and attitude of the constructor to the project and may be expected to adversely affect project performance in terms of time, cost and quality if the context and organisation are not appropriate.

Other Concerns

Ireland (1983:179) looks for unique characteristics defining procurement forms and finds only lump sum, cost plus and package deal forms so defined. The author's contention is that gestalts, commonly occuring combinations of characteristics, exist and that these effectively define the procurement form e.g. a design build organisation form selected by direct negotiation on a guaranteed maximum price basis using the JCT 80 form of contract and incorporating much overlap between design and construction phases. Hence, as part of the exploration of procurement forms a further proposition is made, namely:

> each procurement form has associated with it particular managerial and organisational factors

This proposition follows from the previous two and may stand on its own without affecting the validity or otherwise of the others.

Hypotheses

The research model, Fig 6.1, and its extrapolation, Fig 6.2, along with the propositions above, provide the basis for the hypotheses presented in Chapter 7.

Variables Not Studied

It is apparent that many variables were not studied; this was for a variety of reasons as expounded below.

A cross-sectional study can only usefully collect data which is well documented or recalled easily. Longitudinal studies can collect data on more fluid situations and changing conditions and so aspects of decision making, information flows, team members who participate for short periods, such as subcontractors, and other such variables could not be dealt with appropriately by this study but concentration on the contextual characteristics of client and project and their influence has been facilitated. The effect of the environment requires large scale nation-wide study and the investigation of management contracting in detail would again require a parallel study of similar size and scope to that reported here (N.B. such a study is at present being undertaken by Naoum & Langford (1984)) Investigation of defects and after-service would have extended the timespan of the research greatly and so was not feasible.

With certain factors, such as use of network planning, it was found that there was little variation within the sample and a study of the programming methods adopted by each organisation would have been necessary to develop any useful measures. The most common response to questions regarding programming was that a network was prepared as required by the conditions of contract but that weekly, or even daily, planning at site level, based on

Gantt charts, was the main control mechanism. More sophisticated projects in other market sectors may well have provided a more appropriate domain to research this aspect. Much data, such as labour records, were not stored for any length of time, if at all. Thus, the analysis of productivity of design build and traditional sites, based around the, admittedly, very broad measure of labour input per square metre of building constructed and valuation, did not develop beyond a pilot study. Such an analysis required extensive attendance at individual sites, was heavily dependent on access to labour records (which were inaccurate and incomplete) and, due to heavy use of subcontracting on many sites, did not appear to reflect the difference between the two procurement forms but, rather, methods of labour employment. Details of the pilot study, which, bearing in mind its limitations, revealed no significant difference in productivity, are available in Rowlinson and Langford (1986).

The concept of buildability has provided many research projects to date without reaching the stage where a simple measure could be developed for industrial building construction. In order to relate this concept to procurement form it would be necessary to formulate the study in a similar manner to Griffith (1984), taking care to select readily comparable projects and involving suitable methodological amendments to incorporate procurement form as a variable.

In general then, lack of permanent (or any) records, lack of variance within the sample, the desire to explore more fully the impact of the client body and the need to reduce the scope of the research to a manageable scale have limited the research study to the variables described. The model adopted may be extended and adapted at a later date as it provides a framework which is flexible and which will allow incorporation of other variables (and models) into the contextual and process domains. These new variables may be additional to or a replacement of the variables used in this research.

Chapter 7

Research Methodology

RESEARCH METHODOLOGY

Introduction

The research undertaken can be described as basic, objective research in that it is directed towards a specific problem, the performance of different procurement methods, and is aimed at describing this performance and explaining why it is variable. Although it is not intended to prescribe any solutions, the sample allows conclusions to be drawn which are indicative of the performance of the population.

Strategy

The research was broken down into three distinct phases:

- i Investigation of industrial clients needs
- ii Analysis of the performance of procurement methods
- iii Analysis of the variables influencing performance on different projects other than procurement method

i Client Needs Survey

This was conducted in January of 1983 by postal questionnaire to named managers and directors of companies who were known to have commissioned or proposed industrial buildings at the time, or in the recent past. Names and addresses were collected from the contract news pages of trade journals such as Building Trades

Journal and Building Magazine. The questionnaire is attached as questionnaire No. 1 in Appendix 1; twenty seven per cent of the sample responded by completing the questionnaires in a useable form (61 No.). A pilot study was conducted on six organisations, clients and architects, in December 1982 to validate the form and content of the questionnaire before the main survey was undertaken.

This initial survey confirmed the need to adopt subjective measures of performance due to the diversity perceived in client priorities and was a successful means of establishing contact with a number of client bodies. The detailed outcome of the survey is described in Rowlinson and Newcombe (1984).

ii Procurement Method Performance

A separate questionnaire, shown as questionnaire No. 2 in Appendix 1, was circulated to all previous respondents in March and April 1983 in order to collect outline data on project performance. A total of forty one companies responded by completing questionnaires in a useable form (65%), although a number of other responses had to be discarded as the projects described were either too small,below £100,000, or involved refurbishment and extension rather than new building work. At this stage a number of the respondents, and some of the building team associated with them, were interviewed to determine data in more detail and ascertain the possibility of being able to extend the survey into a case study analysis. Again, an architect and a client co-operated in piloting the questionnaire before distribution.

iii Influence of other Variables

A total of twenty seven detailed case studies were undertaken in the period July 1983 to July 1985. These were based on companies who had responded to the second questionnaire and were a mixture of completed and current projects. This allowed the author to add to the richness of the factual data collected by actually observing some of the construction teams in operation. Another questionnaire (No. 3, Appendix 1) was developed which was administered by the researcher in person to appropriate members of the building team, in turn, for each project. The data collected were both factual and attitudinal, a semantic differential formulation (Oppenheim, 1966) was used for the latter. To ensure consistency in the data collected the author administered each questionnaire individually and in order to avoid misinterpretation a number of terms and concepts were carefully explained to the respondent before a response was obtained. At this stage the three categories of design build contractor referred to in Chapter 3 (pp 62-66) were identified as part of the data collection.

Statistical Analysis

In order to determine associations between variables and measures tests of correlation have been used, the coefficients being Pearson's product moment for interval data or Spearman's rho, for the ordinal data measures (Sprent, 1981). Partial correlation coefficients were calculated in order to control for the effect of variables in the model, other than the one under investigation, and so reveal spurious relationships (Open University, 1981). For some relationships the chi-square test was used to test for association between attributes of variables and ordinal measures in the sample and the F-test (analysis of variance, Sprent, 1981) was used to indicate association between attributes and non-ordinal measures (these are discussed in the analysis). Regression analyses were used to indicate the predictive capability of certain variables on a number of measures (Yeomans, 1976). In phases II and III an average pre-construction and construction time was calculated for three separate contract size bands and speed scores assigned to each case study for further analysis. A value of 50 represents average performance, values above 50 are faster and below 50 are slower. This approach was adopted as, by considering a range of contract values, it is not as dependent on the direct cost-time relationship that a regression equation is. The scores were determined by calculating the standard normal variable and then, assuming a normal distribution of times (tested as in Sprent (1979:87)), reading off the corresponding probability density function from the normal distribution table, expressed as a percentage.

All project tender data were indexed to the first quarter 1985 using BCIS tender price index and the final account data were normalised in a similar manner. Details of the sample, which is representative of industrial clients and building during the period of the research, are shown in Appendix 2. The final scales contained under five per cent of missing values; this is reflected, of course, in the coefficient values required to indicate statistical significance [1].

The Sample

Performance Measures

The measures used in the research are both objective and subjective. The objective measures allow investigation of propositions such as:

design build projects are quicker
design build projects are cheaper
design build projects are more predictable
typical times can be assigned to construction projects.

The subjective measures assess how satisfied clients are with the outcome of their building project, compared with their expectations, and establish the limits of performance at which dissatisfaction occurs.

[1] Ireland (1983:264) reports 9.4% missing values. Most other research omits any mention of the subject.

Objective Measures

Objective measures of time and cost performance were made in terms of times in weeks for construction and pre-construction and costs in pounds sterling of tenders, final accounts, etc..

Time

Data were collected on planned and actual pre-construction and construction times. Pre-construction time was taken as running from when the first member of the building team was appointed, normally the principal advisor, until the start of work on site. Construction time was assessed as the time from the start on site until the issue of the certificate of practical completion. In certain cases this was problematic, phased handovers and late signing of certificates meant that the author had to investigate and use his own judgement on difficult projects.

The raw data were used in producing regression equations and standard pre-construction and construction times and were manipulated to produce the following ratios:

$$\text{DTOVER} - \frac{\text{Actual pre-construction time}}{\text{Planned pre-construction time}}$$

This ratio is the pre-construction time overrun and is a measure of the predictability of the building team estimate.

$$\text{CTOVER} - \frac{\text{Actual construction time}}{\text{Planned construction time}}$$

This ratio is the construction time overrun and is a measure of the predictability of the building team estimate.

Time extensions were recorded where they occurred and an attempt was made to classify these as due to client causes, such as changes, or other causes. Any extensions attributable to client changes were deducted from actual site times.

Cost

The data on costs were used to investigate the cost of building in relation to the area of the building and to investigate cost overruns. Data were gathered on:

TENDER - the tendered price accepted or subsequently agreed at the outset of construction work.

FINAL ACCT - the sum eventually agreed on completion of the construction work and certified as the final account.

VARIATIONS - the total sums (additions and deletions) and number of variations occurring on each project were recorded. The algebraic sum was expressed as a percentage of the tender sum, VAR%, and an attempt was made to classify them as client or building team induced. Any variations deemed to be due to client changes were subtracted from the final account sum.

FEES - the total fees paid by the building client to all the members of the building team were recorded and expressed as a percentage of the final account, FEE%.

TOTAL COST - the total cost of the construction project was assessed as the sum of the final account, including variations, and the separate fees paid.

COSTOVER - FINAL ACCT / TENDER
This ratio reflects the cost overrun on a project and is a measure of the certainty of the cost to the client as quoted at the outset.

COSTPM - (FINAL ACCT + FEES) / AREA
This ratio measures the total cost of the building as far as construction services are concerned. Because of the diverse nature of the projects the complexity of the building must be accounted for when making comparisons using this figure.

PRESPEED & CONSPEED - calculated as indicated in the section describing statistical analysis (p129) and used as ameans of comparing the speed of the preconstruction and construction processes.

CRATE - AREA / actual construction time
This measure was calculated as an alternative to the preceding measure, conspeed.

There were no claims laid against the building team in any of the projects and so this aspect had no effect on the sample under investigation. Determination of the source and cause of variations proved most difficult.

Subjective Measures

In order to assess client satisfaction with the building team the client was asked to give his assessment of satisfaction on four counts by means of the questions M41-M47 on questionnaire No. 3 in Appendix 1. The client was asked to rate his satisfaction on the performance of the building project in terms of:

1 TIMELY COMPLETION
2 TOTAL COST OF CONSTRUCTION
3 PHYSICAL QUALITY OF THE BUILDING
4 SUITABILITY OF THE BUILDING FOR ITS INTENDED PURPOSE

The respondent was offered the semantic differential scale ranging from very satisfied, score 1, to very dissatisfied, score 5. Piloting of the questionnaire suggested that scores ranging to 7 or 9 were unnecessary.

The satisfaction ratings were always elicited last of all, and well after the time and cost information had been obtained, to ensure that the client representative had fully refreshed his memory of the project before giving his ratings.

Independent Variables

<u>Procurement Method Variables</u>

The following data were collected relating to procurement method in phase II:

Organisation Form	building team organisation was classified as being traditional, management or design build.
Selection Procedure	the classifications open tender, select tender, negotiation and hybrid were used.
Payment Procedure	the classifications fixed price, fluctuating price, target price, GMP, cost plus, fee basis and other were used.
Contract Documents	the main classifications were JCT63, JCT80, JCT81, contractor's own, client's own.
Complexity	a subjective assessment by the chief designer of the complexity of the project on a scale of 1 to 3

PHASE III

The following indicates the format of the data collected in phase III. The acronyms used in the statistical analysis are used to identify each variable. Further details of the individual components and scores for each scale are shown in Appendix 3.

CONTEXTUAL VARIABLES

The Project

Phycompx - the physical complexity of the project was measured using a scale which incorporated the scale of mechanical and electrical works in the contract, the type of production layout required, the location of the site and the designer's assessment of complexity. The scale values range from 3, for low complexity to 18, for high complexity.

Constrt - constraints on budget, time and the attainment of required quality levels at the outset were measured on a scale of 21, for unconstrained, to 4 for very tightly constrained projects.

Certnty - the degree of certainty that existed concerning the project was measured as a combination of three five point scales reflecting the designer's opinion on certainty of requirements during design and construction. A score of 15 reflected high uncertainty, 3 low uncertainty.

The Client

Three measures of the client body were used:

Client sophistication was measured on a scale ranging from a score of 2 for an unsophisticated client to 10 for the most sophisticated clients. The type of development, size of company and experience of building are all components of this scale.[1]

Client complexity, measured on a scale ranging from 3 for a low complexity client to 12 for a highly complex client, is an indicator of the number of people involved in the client project team and the amount of input from the end-user of the building.

Two measures of client dependence were used. The first, clidep1, was based around the measures used by the Aston Group (Pugh, 1968) and ranges from 7 for a very dependent organisation to 27 for a highly independent organisation. Source of finance was included as a dimension in the second scale, clidep2; details such as who was the originator of the project and who must authorise the project were included.

Adab - the perceptions of the administrative abilities of the participants in the building process were measured on a scale from very low, score 3, to very high, score 15.

[1] Scale values are made up of two or more scores from questionnaire 3 and so scales may be of different ranges and have different upper and lower bounds. As the analysis identifies relationships between different scales through correlation analysis, it is not necessary for each scale to be structured in the same manner.

INTERVENING VARIABLES

Management Variables

Overlaps - the overlapping of design and construction phases was measured on a scale ranging from 23, where there is much overlapping of construction phases, to 2, in which case there is no overlap at all. A subjective measure of the builder's design input was incorporated in this scale which was based on questions O13 & 14 in questionnaire 3.

Comptitn - the competition for the selection of construction team members, based on the selection process adopted and numbers of builders selected from, was scaled as 3 for low competition through to 16 for high levels of competition (questions O2-O6)

Doccert 1 & 2 - the degree of document completion at the start on site was measured by means of two alternative scales. The first ranged from a scale value of 2 for low completion to 13 for high completion and included data on: the tender documents used and a subjective assessment of their completion. The second scale ranged from zero to 100 and measured the percentage of 'bill' items which were prime cost, provisional and contingency items.

Costmonr - cost monitoring was assessed on a scale from 1 for no monitoring undertaken to 18 for comprehensive monitoring undertaken using questions M5 - M10.

Organisation Variables

Diffntn - the differentiation of the building team was measured by reference to the number of organisations involved in the design and construction process (technology) and their proximity (territory). This scale scores low differentiation as 4 through to 23 for high differentiation.

Coordn - measured on a scale of 2 for low coordination to 16 for high coordination this variable concerned the quality of communications in the building team and co-ordination of the building and client team by means of formal meetings (questions M50 - M55).

Proxty - a scale of proximity of the building team members, including the client, derived from DIFFNTN and expected to be associated with improved performance when the score is low, i.e. members are in close proximity. Scores range from 3 to 15.

Familiar - intended to measure the degree of familiarity in existence between the building team members and the professionals and familiarity with the type of work being undertaken, this scale scored 3 for low familiarity and 15 for high (questions M57 - M59).

Procform - the procurement forms identified in this phase were: traditional; fragmented design build; integrated (and pure) design build; management methods.

Structure

Lansley et al (1974) adapted the work of Burns and Stalker (1961) to examine the relationship between organisational structure (and management style) and organisational effectiveness in construction and printing organisations, taking into account contextual factors such as the environment of the company. They used the variables of control and integration to place companies on a grid reflecting the structure classifications of organic, bureaucratic, anarchic and mechanistic organisations. The companies were then classed as having appropriate or inappropriate structures in relation to their environment.

This research seeks to adapt this methodology and place individual project teams on a similar grid and hence classify them as having appropriate or inappropriate structures in relation to the procurement form adopted. Thus the control variable, which represents the "extent to which activities of members of the management structure are laid down by higher authority and subject to close review" (Lansley et al., 1974:469) is measured as the sum of costmonr and coordn. The variable integration reflects "the extent to which the activities of members of the management system are closely coordinated" (Lansley et al., 1974:469) and is measured as the sum of difftn and comptitn. Although these measures are much cruder than those adopted by Lansley et al. they are nevertheless indicative of the the concepts of control and integration.

An important distinction between this and the previous work is that project teams are being studied, not whole organisations, thus performance measures relate to the project, rather than the previous organisational effectiveness measures, and the propositions concerning appropriateness must be re-evaluated. The traditional system poses fresh and unfamiliar problems on each new contract with little routinisation, high levels of unfamiliarity and hence the need for flexibility. There is considerable need for coordination and teamwork and so an <u>organic</u> structure is appropriate (Lansley et al., 1974:478). Pure design builders, who specialise in particular building types and fields of work, are similar to Lansley's specialist contractors and so require a <u>bureaucratic</u> structure to facilitate teamwork and some routinisation. Fragmented design builders on the other hand (see p 65), are in a similar position to the small works firms, work is carried out by units working independently and the situation calls for high control but low integration, a <u>mechanistic</u> form. Finally, management contracts require high levels of control during both design and construction in order to maintain quality and budget but may operate with any level of integration that the client and building team see fit. Thus a bureaucratic <u>or</u> mechanistic structure may be employed. This differs from Lansley's view; he saw the contractor who sub-contracts most work as having an anarchic structure but this appears to ignore the need for control throughout the whole project that a management contract requires. The hypotheses relating to this section are presented as 3.5.1 and 3.5.2 below.

Hypotheses - Phase II

The following are the hypotheses tested in Phase II of the research process. The hypotheses are based on the views expressed in the literature, and in discussion, by practitioners and thus represent the conventional construction industry viewpoint. As such, the scope of exploration of factors affecting performance is somewhat limited.

The objective measures of performance are: speed and time overruns (both construction and preconstruction); cost overrun (predictability of cost); unit cost; construction rate. The subjective measures of performance are satisfaction ratings of project time, cost and quality. Reference to improved performance indicates improvement in both subjective and objective measures. Where it is believed that only certain of the measures are influenced by a variable these are specifically named (e.g. hypothesis 2.3).

It is assumed that increased speed and reduced time and cost overruns represent improved performance, as do reductions in unit cost and increases in construction rate. Increased satisfaction ratings indicate improved performance.

Hypothesis 2.1: The performance achieved by public sector clients is inferior to that achieved by their private sector counterparts.

Hypothesis 2.2: The performance of projects organised by the traditional method of procurement is inferior to that of projects organised by less conventional methods.

Hypothesis 2.3: a) Negotiated contracts are more predictable in terms of cost performance and
b) their time performance is better in all aspects than that of tendered contracts.
c) Negotiated contracts are more costly (per sq. m.) than tendered contracts.

Hypothesis 2.4: Fixed price contracts reduce the level of time and cost performance

Hypothesis 2.5: Standard forms of contract lead to increased client satisfaction but have no effect on objective performance measures.

Hypothesis 2.6: Increasing project complexity reduces all performance and satisfaction measures.

Hypothesis 2.7: The performance of a procurement form is contingent on selection method and project complexity.

This hypothesis aims to investigate the interaction of the three variables and test assertions such as: 'design build performs well on simple projects only'; 'design build is best undertaken through direct negotiation'.

Hypotheses - Phase III

The hypotheses presented below take a broader view of the construction process than those pertaining to phase II and are, in general, based on the management theory literature. Thus, they include many variables which are common to all organisations, not just construction project based companies. As such, they extend the scope of investigation considerably. The measures of performance used are essentially the same as those used in phase II, to ensure consistency, but an extra satisfaction measure, functional performance of the building, has been included.

The Client

Hypothesis 3.1.1: High levels of administrative ability in the project team improve performance.

Hypothesis 3.1.2 An increase in the client's dependence on other organisations decreases both performance and satisfaction.

Hypothesis 3.1.3	Both performance and satisfaction are reduced for those clients exhibiting high scores on the complexity scale.
Hypothesis 3.1.4	Project performance and satisfaction are enhanced for those clients exhibiting a high sophistication score.

<u>The Project</u>

Hypothesis 3.2.1	Increased complexity of the project leads to reduction in performance.
Hypothesis 3.2.2	Reduction in the level of constraints leads to a reduction in performance.
Hypothesis 3.2.3	Increased levels of certainty lead to improved levels of preconstruction and construction performance.

<u>Organisation</u>

Hypothesis 3.3.1	Design build methods perform better than traditional methods.
Hypothesis 3.3.2	Increased familiarity leads to higher levels of performance and satisfaction.

Hypothesis 3.3.3 — Proximity of team members to one another increases performance and satisfaction.

Hypothesis 3.3.4 — High levels of differentiation lead to low levels of satisfaction and performance.

Hypothesis 3.3.5 — High levels of coordination improve performance and increase satisfaction.

<u>Management</u>

Hypothesis 3.4.1: — A high level of overlapping leads to increased construction time and cost overruns.

Hypothesis 3.4.2 — Increased levels of competition lead to:

a) reduced preconstruction performance

b) reduced quality satisfaction

c) increased cost performance and satisfaction.

Hypothesis 3.4.3 — Increased document certainty:

i) reduces time performance

ii) reduces cost overruns

iii) reduces satisfaction.

Hypothesis 3.4.4 — As 3.4.3 - two measures of document certainty are used.

Hypothesis 3.4.5 — Increased levels of cost monitoring improve cost performance.

Contingency

Hypothesis 3.5.1 — Different organisation forms exhibit differing degrees of coordination and integration.

Hypothesis 3.5.2 — An organisation located appropriately in terms of coordination and integration will exhibit high performance.

Chapter 8

Results

RESULTS

Introduction

This chapter reports the results of the statistical tests undertaken on the data collected during phases II and III; discussion of these results and their implications and relationship to individual case studies follows in Chapter 9.

The main statistical tool employed is correlation analysis. Both zero-order and partial correlations are recorded: partial correlation analysis allows the investigator to hold other variables constant (mathematically) whilst investigating the causal relationship between the two variables under consideration. It is important to investigate this 'true' correlation; zero-order correlation amongst variables (which are often combinations of other variables) can be highly spurious (McCuen, 1985:253).

Results having a significance level of 5% downwards are assumed to be conclusive: that is, a particular result has a 5% probability, or less, of having occurred by chance and the null hypothesis (of no relationship) can be rejected (Sprent, 1981:40-45). Results having a significance level of between 5% and 10% are reported and classed as being indicative of a relationship existing but that relationship is considered to be unproven. In such cases the assumption is that a larger sample would be required to provide sufficient statistical evidence to reject the null hypothesis.

The analysis was undertaken on both micro- and main-frame computers using the SPSS/PC+ and SPSS-X statistical analysis packages (all partial correlations were undertaken using SPSS-X). The acronyms used for the variables are recorded in Chapter 7.

RESULTS - Phase II

Hypothesis 2.1: The performance achieved by public sector clients is inferior to that achieved by their private sector counterparts.

The zero-order correlations of the variable pub.pri with the performance measures are shown in Table 8.1. Examination of these figures indicates that significant correlations exist between the variable and preconstruction speed (prespeed) and rate of working on site (sqmwk). Indicative correlations (< 10% but > 5%) exist with the measures of site time overrun (siteover) construction speed (conspeed) and expressed satisfaction with the quality and cost of the project (qsat, csat). All the figures indicate that public sector projects' performance is inferior to that of their private sector counterparts.

When the effect of the other independent variables are statistically controlled by means of partial correlation analysis, as reported in Table 8.2, it can be seen that only two significant correlations remain: construction speed and satisfaction with quality. Thus the implication is that public sector contracts are constructed more slowly than those for

SCALE / MEASURE	MEAN	SD	PUB.PRI	PROCTYP	OT.ST.N	PAY	LEGAL	COMPLEX
COSTOVER	1.03	0.09	-5	-13	-20	-28*	-1	8
SITEOVER	1.05	0.17	-20+	-20+	-31*	-13	-3	-10
PREOVER	1.19	0.48	-15	-2	-10	-17	-10	4
CONSPEED	50.8	30.0	22+	18	23+	6	-2	-1
PRESPEED	50.6	29.5	40**	42**	32*	48**	-8	-7
LSQM	447	321	4	29*	3	29*	-5	25+
SQMWK	98	70	30*	22+	32*	20+	2	-3
TSAT			-11	13	-14	5	-24+	1
CSAT			-23+	-1	-33*	-6	-13	8
QSAT			-20+	-2	20	-5	1	-18
PUB.PRI				27*	31*	32*	-1	2
PROCTYP					38***	75***	-57***	-4
OT.ST.N						34*	-8	-9
PAY							-27*	-10
LEGAL								-15

Table 8.1: Spearman Correlation Coefficients(a)

(a) + p<.10 * p<.05 ** p<.01 *** p<.001

CONTROL VARIABLES		MEASURES									
		COSTOVER	SITEOVER	PREOVER	CONSPEED	PRESPEED	LSQM	SQMWK	TSAT	CSAT	QSAT
1 PROCTYP	*COEFF*	-8	-5	5	30	36	-3	25	-20	-14	-26
	PROB %	*34*	*40*	*39*	*5.3*	*2.7*	*44*	*9.3*	*15*	*23*	*8.5*
2 OT.ST.N		-5	4	7	32	32	-6	17	-13	-8	-34
		39	*42*	*35*	*4.0*	*4.3*	*37*	*18*	*24*	*34*	*3.1*
3 PAY		-8	-8	12	32	32	-1	26	-20	-20	-25
		34	*34*	*26*	*4.0*	*4.1*	*48*	*8.3*	*15*	*15*	*9.2*
4 LEGAL		-4	-5	7	37	39	3	25	-15	-13	-28
		43	*39*	*36*	*2.3*	*1.7*	*43*	*8.7*	*22*	*24*	*6.6*
5 COMPLEX		-4	-5	6	36	39	4	26	-15	-13	-28
		42	*41*	*38*	*2.6*	*1.8*	*42*	*8.0*	*22*	*25*	*6.8*
1-5		-6	1	20	39	26	-8	17	-14	-15	-34
		39	*49*	*16*	*2.4*	*10*	*34*	*21*	*25*	*24*	*4.3*

N.B. DEGREES OF FREEDOM = 28 (24 FOR 1-5)

Table 8.2: Partial Correlations of PUB.PRI with Performance Measures

private sector clients (significant at the 2.4% level) and that public sector clients are less satisfied with the quality of the building produced (4.3%). The statistics also indicate a relationship between a slow speed of the preconstruction process and the public client, but this is only significant at the 10% level, indicating the need for further investigation with a larger sample.

Having reported these correlations it should be pointed out, however, that none of the public sector projects was let on a negotiated basis. This makes control of the selection variable (OT.ST.N) somewhat difficult statistically. Thus, the poor relative speed performance of public sector contracts may well be attributable to, in part at least, the selection procedures (not) adopted. This point will be returned to when the contingency hypothesis (2.7) is reported and in subsequent discussion.

Interestingly, overruns on cost and time do not seem to be significantly different once the other variables are statistically controlled, all five independent variables tending to reduce the level of significance, compared with the zero-order correlations.

Hypothesis 2.2: The performance of projects organised by the traditional method of procurement is inferior to that of projects organised by less conventional methods.

Reference to Table 8.1 indicates that the only significant zero-order correlations are with preconstruction speed (0.2%) and unit cost (LSQM, 2.5%) whilst indicative correlations exist with construction time overrun (siteover, 9.1%) and construction rate (7.1%). On performing the partial correlation analysis (holding other variables including area constant as shown in Table 8.3) only one performance measure was found to be significantly correlated, that is construction speed (significant at a level of 3.4%). Reference to the analysis of variance within the data leads to the conclusion that there is a rank ordering of construction speed with traditional methods slowest and management methods quickest (Table 8.4). Surprisingly, despite this construction speed relationship, preconstruction speed does not show a significant relationship with procurement form although the correlation coefficient is significant at the 15% level, a very weak indication that some relationship may exist.

	Conspeed	Prespeed
Management	58	81
Design Build	52	43
Traditional	46	46
Significance	3.4%	15%

Table 8.4: Construction & Preconstruction Speed and Proctyp

CONTROL VARIABLES		COSTOVER	SITEOVER	PREOVER	CONSPEED	PRESPEED	LSQM	SQMWK	TSAT	CSAT	QSAT
		MEASURES									
1PUB. PRI	COEFF	18	-2	1	31	21	31	2	23	4	-8
	PROB %	*17*	*46*	*49*	*4.8*	*14*	*4.8*	*46*	*11*	*42*	*34*
2 OT.ST.N		18	10	4	33	15	22	-7	26	11	-21
		17	*30*	*42*	*3.5*	*21*	*12*	*35*	*8.5*	29	*13*
3 PAY		10	-16	33	37	-12	27	8.3	11	-22	-2
		30	*21*	*4.0*	*2.1*	*26*	*7.4*	*33*	*28*	*12*	*45*
4 LEGAL		6	-9	-17	27	29	37	20	2	-6	-8
		38	*31*	*19*	*7.3*	*5.7*	*2.4*	*15*	*46*	*37*	*33*
5 COMPLEX		17	-3	1.8	36	26	31	7	19	1	-13
		18	*44*	*46*	*2.6*	*7.9*	*4.6*	*36*	*15*	*48*	*25*
1-5		.3	-10	20	36	-21	27	9	1	-23	-11
		49	*31*	*17*	*3.4*	*16*	*8.8*	*33*	*48*	*13*	*29*

N.B. DEGREES OF FREEDOM = 28 (24 FOR 1-5)

Table 8.3: Partial Correlations of PROCTYP with Performance Measures

Study of the partial correlation coefficients indicates that the methods of payment and selection (pay and OT.ST.N) may exert a strong influence on preconstruction speed as they reduce the significance level considerably when partialled out. The relationships with construction rate and construction time overrun both disappear when the effect of other variables is accounted for but the relationship with unit cost is still significant at a level of 11.7%, indicative of the existence of a relationship. A major *influence mitigating the effect of* procurement form on unit cost appears to be method of selection (the siginificance level 'drops' from around 5% to 11% when this is introduced). It should be noted that the unit cost variable used in this analysis does not include design fees, which are often part of the design build "price", and this may account for the apparent increase in costs with this method (ommission of fees from the total cost of a traditional contract may account for a reduction of around 10% in cost). Thus, in Phase III, unit costs based on construction costs plus fees are used as the basis for comparisons.

Hypothesis 2.3: a) Negotiated contracts are more predictable in terms of cost performance and
b) their time performance is better in all respects than that of tendered contracts.
c) Negotiated contracts are more costly than tendered contracts.

The selection variable, OT.ST.N, can be seen to be significantly correlated with preconstruction speed, rate of construction (SQMWK), satisfaction with cost performance and overrun of site construction time; negotiated contracts overrunning less than other forms (Table 8.1). There is some indication of an association with construction speed (10.8% level). On controlling for the independent variables it appears that the only correlation that can be reported is that with quality satisfaction (7.4%); that is satisfaction is greater with tendered contracts (but the finding is indicative, not proven). The relationship between the selection variable and prespeed does not appear to be significant and there is no indication of a significant relationship with construction speed which might have been expected (Table 8.5). Inspection of Table 8.1 indicates that OT.ST.N is significantly correlated with Proctyp, Pay (method of payment variable) and Pub.Pri. Thus, by controlling for the effect of these variables, with a sample of less than fifty, it is possible that insufficient variance remains for a relationship to be discovered. Hence, on this evidence, the null hypothesis must be accepted that there is no relationship between time and cost performance and method of selection.

MEASURES

CONTROL VARIABLES		COSTOVER	SITEOVER	PREOVER	CONSPEED	PRESPEED	LSQM	SQMWK	TSAT	CSAT	QSAT
1 PUB. PRI	COEFF	4	-25	-6	1	18	26	22	-3	15	25
	PROB %	*43*	*9.4*	*39*	*48*	*17*	*8.1*	*13*	*44*	*22*	*9.3*
2 PROCTYP		-7	-27	-5	-4	20	14	29	-19	-21	21
		36	*7.8*	*41*	*42*	*15*	*24*	*6.2*	*15*	*13*	*13*
3 PAY		-15	-28	3	10	21	22	29	-12	-24	17
		47	*6.6*	*44*	*30*	*13*	*12*	*6.0*	*26*	*10*	*19*
4 LEGAL		0	-26	6	11	29	26	31	-12	-20	14
		49	*8.2*	*37*	*28*	*6.1*	*8.5*	*4.8*	*26*	*15*	*23*
5 COMPLEX		3	-23	-3	15	28	27	30	-7	-17	12
		43	*11*	*45*	*22*	*6.8*	*7.5*	*5.3*	*35*	*18*	*26*
1-5		1	-18	-14	-20	21	10	19	-8	-5	29
		49	*19*	*24*	*17*	*15*	*31*	*18*	*35*	*40*	*7*

N.B. DEGREES OF FREEDOM = 28 (24 FOR 1-5)

Table 8.5: Partial Correlations of OT.ST.N with Performance Measures

Hypothesis 2.4: Fixed price contracts reduce the level of time and cost performance

Significant zero order correlations exist between the payment variable (pay) and preconstruction speed and the unit cost variable (Table 8.1). Once the other variables are partialled out it is apparent that pay is significantly associated with both preconstruction speed (2.5%) and preconstruction overruns (2.4%), that is: fee based contracts are likely to exhibit fast preconstruction speeds and are unlikely to overrun on planned preconstruction schedules (Table 8.6). A significant relationship also exists with cost satisfaction (4.6%), with fee-based contracts providing inferior levels of satisfaction in the client's view.

An interesting, but not statistically significant, relationship is observed between pay and construction speed (8.4%) with fee-based payment methods having a tendency to perform less quickly than others, the reverse of the relationship with preconstruction speed. Thus it appears that evidence for the hypothesis is mixed. Preconstruction time performance appears to vary with pay as predicted but the variation of construction time and cost performance satisfaction appears to go against the predicted relationship. There is no evidence to indicate any significant difference in unit costs dependent on payment methods.

MEASURES

CONTROL VARIABLES		COSTOVER	SITEOVER	PREOVER	CONSPEED	PRESPEED	LSQM	SQMWK	TSAT	CSAT	QSAT
1 PUB. PRI	COEFF	15	11	-27	7	39	18	-5	20	24	-9
	PROB %	*21*	*29*	*7.7*	*35*	*1.8*	*17*	*41*	*14*	*10*	*32*
2 OT. ST.N		14	16	-24	12	40	13	-5	18	25	-18
		24	*20*	*9.7*	*26*	*1.5*	*25*	*40*	*17*	*8.9*	*17*
3 PROCTYP		1	18	-40	-20	38	-9	-5	1.6	29	-8
		47	*17*	*1.4*	*15*	*1.9*	*32*	*40*	*47*	*5.7*	*34*
4 LEGAL		8	7	35	9	45	19	7	7	17	-12
		34	*36*	*2.9*	*32*	*0.6*	*16*	*35*	*36*	*18*	*26*
5 COMPLEX		15	11	-24	16	43	19	3	16	21	-15
		22	*28*	*10*	*19*	*0.8*	*16*	*44*	*19*	*13*	*21*
1-5		7	18	-39	-28	39	-10	-7	8	34	2
		38	*19*	*2.4*	*8.4*	*2.5*	*32*	*36*	*35*	*4.6*	*45*

N.B. DEGREES OF FREEDOM = 28 (24 FOR 1-5)

Table 8.6: Partial Correlations of PAY with Performance Measures

Hypothesis 2.5: Standard forms of contract lead to increased client satisfaction but have no effect on objective performance measures.

This hypothesis was expected to be difficult to test as both procurement method and payment method are highly correlated with this variable, particularly in the case of traditional contracts (which are normally fixed price with standard documents) and management contracts (which are normally fee-based using non-standard documents). Inspection of Table 8.1 indicates that legal is not significantly correlated with any of the measures but has indicative relationships (< 10 % but > 5 %) with preover (9.3%) and tsat (7.4%). On consideration of the partial correlation coefficients (Table 8.7) it is obvious that the only relationship indicated is with preconstruction time overrun (ranging up to a level of 11%), performance improving (overruns reducing) with a move towards standard contracts. This indicates a similar relationship to that discerned between pay and preover suggesting that the impact of these two variables may best be investigated in tandem. The hypothesis of no effect on objective measures must thus be questioned, although, as a null hypothesis, it cannot be rejected.

Hypothesis 2.6: Increasing project complexity reduces all performance and satisfaction measures.

The only zero-order correlation coefficient significant at a level below 10% is that with unit cost (6.9%), indicating that cost increases with complexity. Study of the partial

CONTROL VARIABLES		MEASURES									
		COSTOVER	SITEOVER	PREOVER	CONSPEED	PRESPEED	LSQM	SQMWK	TSAT	CSAT	QSAT
1 PUB. PRI	COEFF	-22	-9	-28	-28	-5	-1	17	-32	-11	12
	PROB %	12	32	6.6	7	40	49	19	4.2	29	26
2 PROCTYP		-16	-12	-32	-7	14	20	25	26	-13	5
		20	26	4.2	36	23	14	9.2	7.9	25	41
3 PAY		-19	-7	-37	-21	11	5	18	-29	-6	7
		15	37	2.1	13	29	40	16	5.8	38	36
4 OT. ST.N		-22	-12	-28	-24	0	2	21	-33	-13	12
		12	27	6.4	11	49	46	13	3.6	24	26
5 COMPLEX		-20	-5	-27	-23	-6	1	19	-31	-9	10
		14	39	7	11	38	48	16	4.7	32	30
1-5		-13	-9	25	1	-6	24	23	-22	-15	4
		26	33	11	48	39	12	13	14	24	43

N.B. DEGREES OF FREEDOM = 28 (24 FOR 1-5)

Table 8.7: Partial Correlations of LEGAL with Performance Measures

MEASURES

CONTROL VARIABLES		COSTOVER	SITEOVER	PREOVER	CONSPEED	PRESPEED	LSQM	SQMWK	TSAT	CSAT	QSAT
1 PUB. PRI	COEFF	13	21	6	16	-13	9	11	8	13	-7
	PROB %	25	13	38	20	24	32	28	33	25	36
2 PROCTYP		14	21	6	14	-14	10	10	10	13	-6
		24	13	39	22	22	31	31	31	24	39
3 PAY		14	23	4	14	-12	11	10	10	15	-7
		22	12	43	22	27	29	31	29	21	36
4 OT.ST.N		13	19	5	15	-11	12	13	8	11	-4
		24	15	39	22	28	26	24	34	28	42
5 LEGAL		10	20	6	9	-15	9	13	3	12	-4
		31	14	49	32	22	32	25	43	27	42
1-5		11	20	-6	11	-8	15	18	3	13	-3
		30	17	39	29	34	23	19	43	26	45

N.B. DEGREES OF FREEDOM = 28 (24 FOR 1-5)

Table 8.8: Partial Correlations of COMPLEX with Performance Measures

correlation coefficients in Table 8.8, however, reveals that there are no significant relationships with the complexity variable when other variables are controlled for. Thus the null hypothesis can be accepted, that complexity does not affect project performance. This result indicated that the subjective measurement of complexity may not be a good one to adopt (as unit cost should rise with increased complexity) and a more sophisticated measure was developed for Phase III.

Hypothesis 2.7: The performance of a procurement form is contingent on selection method and project complexity.

Inspection of Table 8.9 indicates that there is a rank order order of overruns on preconstruction time which runs as follows: tendered design build; negotiated design build; traditional contracts; management contracts (design build overruns most, 48%, and management least, -12%, on average). However, pre-construction speed is seen to be quickest for management methods followed by negotiated design build and traditional contracts, with tendered design build performing worst, on average. These results are significant at a level of 0.2% (measured by the correlation coefficient) Thus, it may be concluded that management contracts are exceptionally quick in the preconstruction stage and are unlikely to overrun whereas negotiated design build contracts are quick but actually overrun predicted times i.e. the predicted preconstruction times are overly optimistic. Traditional contracts perform close to the norm in terms of time (speed = 46: norm = 50) and overrun by 7% on average but tendered design build contracts perform badly in terms of both speed (32) and overruns (48%).

	DTOver(%)	Rank	Precon Speed	Rank
Management	-12	1	81	1
Traditional	+ 7	2	46	3
Negotiated DB	+17	3	60	2
Tendered DB	+48%	4	32	4
All Projects	+17	2	50	2
DB & Simple	0	1	79	1
DB & Complex	+53	3	30	3

Table 8.9: Preconstruction Performance

Parenthetically, if one considers the 'planned' pre-construction speeds one finds that negotiated design build and management contracts have roughly similar 'planned' speeds (around 70) and that the tendered design build and traditional contracts also have similar 'planned' speeds of almost 50. Thus, it appears to be accepted by the industry that management and negotiated design build methods should (and in fact do) reach site more quickly than tendered design build and traditional methods. There is however, considerable variance in achieved performance between the four groups.

Turning consideration to the performance of design build methods on both complex and simple contracts Table 8.9 indicates that there is some support for the sub-hypothesis that design build methods are suitable for simple projects only. Again, attention focusses on the preconstruction period and simple projects showed no overruns compared to average overruns for the whole sample of 17% (correlation coefficient significance = 4.2%). Pre-construction speed was also high (79) compared to the norm (50). For complex projects the reverse situation appeared to be true with overruns averaging 53% (significance level = 3.8%) and speed very low at 30 (significance level = 1.2%). Hence, there appears to be some evidence that, for preconstruction performance, simple design build projects are performed far better than complex design build projects. There is no evidence to be found which distinguishes between performance on simple and complex projects for any of the other measures.

RESULTS - Phase III

The association of four sets of variables with the performance measures are reported below. The variables are grouped under the headings; client, project, organisation and management as discussed in Chapter 7.

CLIENT VARIABLES

The client variables and their correlations with the performance measures and other variables are listed in Tables 8.10 to 8.14. It was found that the first alternative measure for client dependence has no significant correlations with the performance measures when other variables are partialled out and so is not reported in this section. This first scale, clidep1, represents the organisational dependence of the company in general whereas the second scale, clidep2, represents dependence specifically related to the project. This second scale includes questions concerning source of project finance, originating source of the project idea, allegiance of the client project manager and the level in the group hierarchy to which the project manager had to refer in decision-making.

The other variables investigated in this section are: clicomp, a measure of the complexity of the client project organisation in terms of the number of people empowered to instruct the building team, the type of production facility required and the eventual end-user type (e.g. developer, owner-occupier). Clisoph, a measure of the sophistication of the client incorporating information on previous building experience, employment of building professionals, specialisation of form of construction and company size. Adab, a subjective assessment of the administrative ability of the members of the building team made by the client representative.

	ADAB	PMAB	CLIDEP1	CLIDEP2	CLICOMP	CLISOPH
PMAB	.6968*					
CLIDEP1	.1794	.1898				
CLIDEP2	-.2979	-.2962	.5324*			
CLICOMP	-.0492	.0807	.1394	.0029		
CLISOPH	-.2167	.1238	-.1653	-.3001	.3258*	
PHYCOMPX	.2755	-.0928	.1740	-.0208	.0930	-.3574
CONSTRT	.2032	.2431	-.1626	-.6556*	.0388	.3715*
OVERLAPS	.0908	-.0054	-.4298*	-.3647*	-.0600	-.2021
COMPTITN	-.3151	-.1551	-.0850	.1205	-.2262	-.1205
PROCFORM	.1620	.0758	-.4135*	-.1372	-.1250	-.2824
DOCCERT1	.0286	-.0304	.4162*	.2134	-.0603	-.1188
DOCCERT2	-.1858	-.1579	.1275	.2601	-.1684	-.1528
COSTMONR	-.0825	-.0532	.5151*	.2202	.2078	-.1371
CERTNTY	-.1049	-.3510*	-.3343*	-.0047	-.2055	-.1840
DIFFTN	.2064	.0132	-.1617	.0244	-.3312*	.0678
PROXTY	.1047	-.1450	-.3078	.0036	-.4341*	-.1723
FAMILIAR	.0512	-.1410	-.2045	.0377	-.1992	.2787
COORDN	.3451	.1768	-.2715	-.2751	.0079	-.2020

	PHYCOMPX	CONSTRT	OVERLAPS	COMPTITN	PROCFORM	DOCCERT1
CONSTRT	-.0318					
OVERLAPS	-.0089	.1103				
COMPTITN	-.3184	-.2786	-.1493			
PROCFORM	.0217	-.0881	.5739*	-.1931		
DOCCERT1	.3688*	.0273	-.7336*	-.0002	-.3719*	
DOCCERT2	.3086	-.2557	-.3650*	.0673	-.1811	.4649*
COSTMONR	.2825	-.2625	-.3539*	.0163	-.1258	.4127*
CERTNTY	-.0778	-.0014	.1222	.4540*	-.0373	-.1162
DIFFTN	-.0264	-.0535	-.3557*	.0708	-.0242	.4490*
PROXTY	-.1145	-.1143	.0291	.1335	.3545*	.1237
FAMILIAR	-.1626	.0356	.3879*	-.1957	.2661	-.3791*
COORDN	.0269	.1723	.7889*	-.2507	.6468*	-.5893*

	DOCCERT2	COSTMONR	CERTNTY	DIFFTN	PROXTY	FAMILIAR
COSTMONR	.3007					
CERTNTY	-.0513	-.3227*				
DIFFTN	.0611	.1015	.0891			
PROXTY	-.1934	.0257	.2029	.7644*		
FAMILIAR	.2757	-.1327	.1371	.0508	.0722	
COORDN	-.0865	-.2203	-.0195	-.3939*	.0644	.3591*

(* indicates p<.05

Table 8.10: Spearman Correlation Coefficients -- Phase III

Hypothesis 3.1.1: High levels of administrative ability in the project team improve performance.

Zero-order correlations can be seen to exist with construction time overrun (ctover), construction speed (conspeed) and satisfaction with time, functional and cost performance (tsat, fsat, csat). When the effects of the other client variables and those of the management, organisation and project variables are controlled for however, only one significant relationship remains - time satisfaction (2%). Reference to Table 8.11 indicates that the time satisfaction variable is significantly correlated with both construction speed and construction time overrun but shows that the correlation of both of these variables with adab becomes non-significant when the management variables are controlled (although the correlation with time overrun is indicative of a relationship, 7.7%). Thus, taking the five per cent level of significance as an absolute cut-off, one may conclude that increased administrative ability leads to greater client satisfaction with time performance but there is no evidence to indicate that actual time performance is affected. If, however, one concludes that a significance level of 7.7% is strong enough to accept as evidence of a relationship then one can conclude that high administrative ability is a factor which reduces time overruns (c.f. Might, 1984) and the relationship can be seen in this manner: high administrative ability leads to reduced time overruns which in turn leads to increased satisfaction (this is backed up by the fact that controlling for ctover reduces the significance of the relationship between

Measures	Control Variables 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-32	-39	-8	-15	-17	Coef
	13	*13*	*40*	*30*	*24*	Prob
2 CTover	-58	-49	-65	-70	-49	
	1.4	*7.7*	*0.8*	*0.2*	*1.2*	
3 DTover	33	5	9	13	14	
	12	*44*	*38*	*32*	*27*	
4 Conspeed	69	26	52	53	51	
	0.3	*23*	*3.3*	*2.1*	*1.1*	
5 Prespeed	6	-10	-9	28	-30	
	42	*39*	*38*	*16*	*9.9*	
6 Costpm	-1	-41	14	-1	8	
	49	*12*	*32*	*48*	*37*	
7 Crate	33	31	17	19	26	
	12	*19*	*28*	*25*	*13*	
8 Tsat	-86	-65	-73	-82	-80	
	0	*2.0*	*0.2*	*0*	*0*	
9 Csat	-36	-66	-40	-44	-41	
	10	*1.9*	*8.7*	*5.1*	*3.2*	
10 Qsat	-5	-60	-67	-30	-21	
	13	*3.3*	*0.6*	*13*	*18*	
11 Fsat	-26	-92	-78	-48	-53	
	19	*0*	*0.1*	*3.4*	*0.7*	
	DOF = 12	DOF = 8	DOF = 11	DOF = 13		

Table 8.11: Partial Correlations of Adab with Performance

satisfaction and administrative ability).

Hypothesis 3.1.2 An increase in the client's dependence on other organisations decreases both performance and satisfaction.

Zero-order correlations indicate only one significant relationship, that preconstruction speed decreases with client independence (1.7%). On partialling out the other variables the significance of this relationship is reduced to 9.8% and 8.6% through control by the project and organisation variables respectively. Further examination of Table 8.12 reveals that, on controlling for the effect of organisation variables, design time overrun is significantly related to dependence (4.9%). Furthermore, dependence and preconstruction time (not speed) are correlated highly (5%) and, importantly, as preconstruction time reduces, design overruns increase (0.4%). Thus, the cycle of events may be deduced to be as follows: highly dependent clients set, or have set for them, very short preconstruction times which inevitably lead to this target being missed. Hence, although design times overrun their planned duration they are nevertheless still relatively quick, evidence for which comes with the correlation between prespeed and clidep2 (0.9%-9.8%). Conversely, very independent clients experience slow preconstruction periods but lower overruns. As clidep2 and clisoph are correlated (7.7%) one may hypothesise that the short design times are set through a combination of inexperience and pressure from an experienced superordinate organisation.

Measures	Control Variables 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-21 *23*	21 *24*	16 *28*	-5 *42*	-13 *27*	Coef Prob
2 CTover	10 *37*	7 *41*	35 *9.2*	-1 *48*	-6 *38*	
3 DTover	32 *13*	48 *49*	5 *43*	25 *16*	13 *28*	
4 Conspeed	-42 *6.5*	-23 *23*	-33 *10*	-21 *20*	-27 *9.8*	
5 Prespeed	52 *2.8*	40 *8.6*	34 *9.8*	55 *0.9*	43 *1.7*	
6 Costpm	-18 *27*	-1 *49*	-9 *36*	-7 *40*	-19 *19*	
7 Crate	-25 *20*	8 *40*	-35 *8.9*	-14 *29*	-12 *30*	
8 Tsat	21 *23*	-3 *46*	31 *12*	3 *46*	11 *31*	
9 Csat	10 *37*	-12 *35*	14 *30*	9 *36*	6 *39*	
10 Qsat	15 *31*	-14 *33*	-3 *45*	-24 *17*	-15 *24*	
11 Fsat	32 *14*	-41 *8.4*	8 *38*	-14 *30*	-2 *47*	
	DOF = 12	DOF = 8	DOF = 11	DOF = 13		

Table 8.12: Partial Correlations of Clidep2 & Performance

On the basis of the statistics examined there are no grounds for accepting this hypothesis, in fact the reverse hypothesis (dependent clients experience increased (preconstruction time) performance) finds support.

Hypothesis 3.1.3 Both performance and satisfaction are reduced for those clients exhibiting high scores on the complexity scale.

Zero-order correlations do not reveal any strong support for the hypothesis, only coefficients indicative of relationships with construction speed (8.8%) and unit cost (9.4%); both indicate worsening performance with increasing complexity. The partial correlations in Table 8.13 show a different picture: when the project variables are controlled for both construction time overrun and construction rate are significantly correlated with client complexity (3.2% & 1.7%), performance deteriorating as complexity increases. Construction rate is also associated with complexity when the management variables are partialled out (1.3%) as is construction speed (1.7%). Construction speed is also significant at the 3.8% level when the other client variables are controlled. Indicative relationships can also be seen to exist with preconstruction speed (7.5%) and time satisfaction (6.1%) when these client variables are controlled. Functional satisfaction is also decreased significantly (4.9%) with increasing complexity. Thus it appears that, from the partial correlation coefficients, one can conclude that an increase in client complexity is likely to be accompanied by;

Measures	Control Variables 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	35	16	-15	-4	-4	Coef
	11	*29*	*28*	*43*	*43*	Prob
2 CTover	37	40	46	33	23	
	9.8	*6.7*	*3.2*	*7.6*	*13*	
3 DTover	4	-12	-15	1	14	
	45	*33*	*29*	*48*	*23*	
4 Conspeed	-49	-55	-35	-30	-27	
	3.8	*1.7*	*8.7*	*10*	*8.8*	
5 Prespeed	-41	-25	-11	-5	-6	
	7.5	*18*	*34*	*42*	*39*	
6 Costpm	38	33	30	30	27	
	9.0	*12*	*12*	*9.6*	*9.4*	
7 Crate	-37	-57	-51	-25	-43	
	9.9	*1.3*	*1.7*	*15*	*1.2*	
8 Tsat	43	17	32	17	1	
	6.1	*28*	*11*	*23*	*49*	
9 Csat	41	35	23	17	8	
	7.3	*10*	*19*	*24*	*36*	
10 Qsat	14	-17	11	16	7	
	32	*27*	*33*	*25*	*37*	
11 Fsat	12	-14	41	20	7	
	35	*31*	*4.9*	*20*	*36*	
	DOF = 12	DOF = 8	DOF = 11	DOF = 13		

Table 8.13: Partial Correlations of Clicomp & Performance

i) an increase in construction time overrun

ii) a reduction in construction speed

iii) a reduction in construction rate

iv) a reduction in satisfaction with the function of the building

There is also evidence from the same statistics to suggest that preconstruction speed, time and cost satisfaction are all reduced (7.5%; 6.1%; 7.3%); a larger sample could confirm these relationships.

Hypothesis 3.1.4 Project performance and satisfaction are enhanced for those clients exhibiting a high sophistication score.

The only significant zero-order correlations are with cost overrun (4.1%) and satisfaction with the building function (2.4%), higher levels of sophistication leading to reduced overruns and satisfaction levels. Table 8.14 indicates the partial correlation coefficients and these paint a different picture. The inclusion of other client variables as controls removes the relationship with satisfaction and the project variables reduce the significance of the relationship with cost overrun to a level of 23%, almost entirely due to the influence of phycompx (the project's physical complexity). As clisoph and the physical complexity of the project are not strongly correlated (14%) there are no grounds for concluding in favour of the hypothesis but there are grounds for considering the relationship further.

Measures	Control Variables: 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-59 *1.3*	-50 *3.0*	-19 *23*	-32 *8.4*	-35 *4.1*	Coef Prob
2 CTover	2 *47*	18 *27*	9 *37*	22 *18*	13 *26*	
3 DTover	-20 *24*	32 *12*	-5 *43*	-5 *42*	1 *47*	
4 Conspeed	24 *21*	-12 *34*	8 *38*	0 *50*	-3 *44*	
5 Prespeed	39 *8.2*	0 *50*	5 *43*	-22 *18*	-5 *40*	
6 Costpm	-10 *36*	2 *48*	42 *4.7*	11 *32*	6 *38*	
7 Crate	-4 *44*	-8 *39*	-30 *12*	-12 *31*	-12 *28*	
8 Tsat	-43 *6.1*	8 *39*	0 *50*	20 *20*	6 *39*	
9 Csat	-45 *5.3*	13 *32*	9 *37*	-9 *36*	1 *49*	
10 Qsat	-2 *48*	0 *50*	-1 *48*	54 *0.7*	6 *38*	
11 Fsat	9 *39*	40 *7.2*	22 *20*	62 *0.2*	39 *2.4*	
	DOF = 12	DOF = 8	DOF = 11	DOF = 13		

Table 8.14: Partial Correlations of Clisoph & Performance

There is a significant relationship with unit price when the project variables are controlled for (4.7%) but this is completely removed when the management variables are controlled for (48%), suggesting these variables control unit price to a great extent. Control of the other client variables reveals an almost significant correlation with cost satisfaction (5.3%), indicating increasing satisfaction with increasing sophistication. Inspection of the zero-order correlations reveals that the relationships between cost satisfaction and cost overrun and client sophistication and cost overrun are significant (2.3% and 4.1% respectively) indicating client sophistication contributes to reducing cost overruns and so cost satisfaction increases as a likely chain of events.

PROJECT VARIABLES

The three project variables tested were physical complexity of the building (phycompx), constraints imposed on the building process (constrt: low score equivalent to high constraints) and certainty regarding the project specification (certnty: low score indicating high level of uncertainty).

Hypothesis 3.2.1 Increased complexity of the project leads to reduction in performance and increased cost.

Three significant zero-order correlations are found to exist with unit cost (0.1%), cost satisfaction (4.3%) and number of variations (0.1%). However, when the other variables are partialled out the only significant relationship remaining is with unit cost (1.0% maximum, Table 8.15). This is as predicted and confirms phycompx as an effective measure of complexity. No relationship can be proven between performance and complexity. Both construction time overrun and construction speed are controlled by the management variables (26.7% and 35.4% significance levels respectively) as are the satisfaction variables related to time , cost and function. Design time overrun also appears to be strongly correlated (2.9%) until the other project variables are controlled for (see hypothesis 3.2.3).

Thus, it can be concluded that physical complexity alone does not affect contract performance other than to increase unit costs as hypothesised.

Hypothesis 3.2.2 Reduction in the level of constraints leads to a reduction in performance.

The constraint variable is significantly correlated with pre-construction speed (2.6%) and variation rate (4.4%, zero-order). On controlling for the management variables it can be seen (from Table 8.16) that the relationship with construction rate becomes significant (3.0%) and that with time satisfaction is indicative (7.2%). The correlation between cost overrun and constraints almost becomes significant (7.4%) when the client variables are partialled out, indicating a reduction in overruns (improved

Measures	Control Variables 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	37	47	39	25	25	Coef
	17	*7.4*	*5.7*	*19*	*14*	Prob
2 CTover	-46	-21	-43	-51	-30	
	10	*27*	*3.7*	*2.6*	*8.8*	
3 DTover	11	59	1	11	-11	
	38	*2.9*	*48*	*35*	*31*	
4 Conspeed	67	13	35	46	22	
	2.3	*35*	*7.9*	*4.2*	*17*	
5 Prespeed	10	-34	-18	0	-15	
	39	*15*	*24*	*50*	*26*	
6 Costpm	75	69	68	44	64	
	1.0	*0.9*	*0.1*	*0.1*	*0.1*	
7 Crate	-23	-34	-16	-9	-34	
	28	*16*	*27*	*38*	*6.4*	
8 Tsat	-56	-19	-40	-54	-26	
	6	*29*	*5.2*	*1.9*	*13*	
9 Csat	-66	22	-34	-43	-39	
	2.7	*26*	*8.4*	*5.4*	*4.3*	
10 Qsat	-16	-11	-19	-43	-25	
	34	*37*	*23*	*5.3*	*14*	
11 Fsat	-3	-6	-44	-48	-33	
	47	*44*	*3.3*	*3.5*	*7.6*	
	DOF = 7	DOF = 9	DOF = 16	DOF = 13		

Table 8.15: Partial Correlations of Phycompx with Performance

Measures	Control Variables 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	43 *7.4*	16 *28*	23 *18*	13 *30*	11 *29*	Coef Prob
2 CTover	37 *11*	31 *13*	28 *14*	21 *19*	26 *9.9*	
3 DTover	10 *38*	-43 *5.6*	-23 *18*	-27 *12*	-13 *26*	
4 Conspeed	-16 *30*	-32 *12*	1 *49*	2 *47*	3 *45*	
5 Prespeed	-23 *22*	-43 *5.4*	-38 *5.9*	-33 *7.5*	-39 *2.6*	
6 Costpm	-51 *3.9*	-10 *37*	12 *32*	-6 *40*	15 *24*	
7 Crate	20 *26*	-50 *3.0*	-1 *49*	11 *32*	-2 *46*	
8 Tsat	24 *21*	40 *7.2*	24 *17*	19 *21*	15 *24*	
9 Csat	-2 *47*	24 *20*	-21 *20*	-16 *25*	-15 *23*	
10 Qsat	-1 *49*	22 *21*	26 *15*	5.6 *5.6*	33 *33*	
11 Fsat	-30 *16*	1 *49*	-13 *31*	3 *45*	-4 *42*	
	DOF = 11	DOF =13	DOF = 16	DOF = 18		

Table 8.16: Partial Correlations of Constrt with Performance

performance) as constraints increase. These same client variables, when partialled out, reduce the correlation of preconstruction speed with constraints to 22% significance level.

From the foregoing it appears that as constraints are reduced the level of performance diminishes in terms of higher cost overruns (indicative, 7%) but the construction rate increases (proven, 3%). The client variables seem to control design time overrun and preconstruction speed performance.

Hypothesis 3.2.3 Increased levels of certainty lead to improved levels of preconstruction and construction performance

The only significant zero-order correlation is with cost satisfaction (0.3%), although the correlation with pre-construction speed is indicative (7.2%). When the other variables are partialled out (Table 8.17) the relationship with preconstruction speed becomes non-significant in all cases (15%-31%) but two new, significant relationships are uncovered: design time overruns reduce as certainty increases (1.5% with management variables controlled) and unit cost decreases with increasing certainty whilst controlling for the project variables (1.7%). The only other correlation that appears as significant is that with cost satisfaction which varies in level from 0.3% to 7% dependent on which variables are partialled out.

	Control Variables					
Measures	1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	2	23	25	30	24	Coef
	47	*20*	*16*	*10*	*12*	Prob
2 CTover	7	-19	-11	1	5	
	42	*25*	*33*	*48*	*40*	
3 DTover	-24	-56	-10	-30	-4	
	22	*1.5*	*34*	*9.8*	*41*	
4 Conspeed	-32	14	10	-5	-2	
	14	*31*	*35*	*42*	*47*	
5 Prespeed	-22	18	-12	-25	-30	
	24	*27*	*31*	*15*	*7.2*	
6 Costpm	-26	43	-50	-10	-5	
	20	*5.6*	*1.7*	*33*	*41*	
7 Crate	-16	-31	2	-39	-11	
	30	*13*	*47*	*4.4*	*29*	
8 Tsat	-37	24	4	26	11	
	11	*20*	*44*	*14*	*30*	
9 Csat	72	40	39	60	52	
	0.3	*7.0*	*5.5*	*0.3*	*0.3*	
10 Qsat	1	15	32	8	16	
	49	*29*	*9.9*	*37*	*22*	
11 Fsat	-23	-2	-15	0	-4	
	22	*47*	*28*	*50*	*42*	
	DOF = 11	DOF = 13	DOF = 16	DOF = 18		

Table 8.17: Partial Correlations of Certnty with Performance

One may conclude from the foregoing that both design time overruns and unit costs are decreased by increasing the degree of certainty attached to the project but, surprisingly, cost satisfaction is decreased. Thus the hypothesis holds for preconstruction time predictability and construction costs but certainty appears to have no effect on construction time performance.

ORGANISATION VARIABLES

The five organisation variables chosen for study in phase III are: procurement form; familiarity (high score indicates high familiarity); proximity (high score indicates close proximity); differentiation (high score indicates high differentiation); coordination (high score indicates strong coordinative effort).

Hypothesis 3.3.1 Design build methods perform better than traditional methods on all counts

A significant zero-order correlation exists between procurement form and construction time overrun (3.7%) and indicative relations with construction speed (6.8%) and construction rate (7.3%). The partial correlation coefficients (Table 8.18) indicate no significant correlations however but three relationships should be noted. Preconstruction speed is significantly related (1.3%) when client variables are partialled out but this significance is greatly reduced when the project and management variables are controlled for. The relationship

Measures	Control Variables					
	1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-12	-10	-11	10	-10	Coef
	35	*36*	*34*	*33*	*31*	Prob
2 CTover	-34	-38	-42	-25	-35	
	13	*8.3*	*4.7*	*14*	*3.7*	
3 DTover	-3	4	11	-6	-3	
	46	*45*	*34*	*40*	*44*	
4 Conspeed	37	29	20	5	30	
	11	*15*	*22*	*42*	*6.8*	
5 Prespeed	61	25	16	26	22	
	1.3	*18*	*27*	*13*	*14*	
6 Costpm	31	32	1	13	17	
	15	*13*	*48*	*28*	*20*	
7 Crate	21	11	29	-16	29	
	24	*35*	*13*	*24*	*7.3*	
8 Tsat	9	-11	-9	4	-19	
	39	*34*	*36*	*43*	*18*	
9 Csat	-36	-20	-27	-10	-17	
	12	*24*	*15*	*33*	*21*	
10 Qsat	7	-45	28	-4	15	
	41	*45*	*14*	*44*	*23*	
11 Fsat	-4	-7	17	19	5	
	45	*41*	*26*	*21*	*40*	
	DOF = 11	DOF = 13	DOF = 15	DOF =19		

Table 8.18: Partial Correlations of Procform with Performance

with construction speed appears to be most strongly affected by the organisation variables, the significance level dropping to 42%. Construction time overruns appear to be related to procurement form but the significance of this relationship drops to 13-14% when client and organisation variables are partialled out. Thus there is very weak evidence for some relationship between these two but, in general, procurement form appears to have no significant effect on any performance measures.

Hypothesis 3.3.2 Increased familiarity leads to higher levels of performance and satisfaction.

The only significant zero-order correlation is with construction rate (2.1%) but when the management variables are partialled out the significance of this correlation drops to 18%. However, the significance of the relationship with construction speed increases from 40% to 3.8% when the project variables are partialled out Table 8.19), indicating greater speed with higher levels of familiarity. A significant relationship also appears with construction time overrun (decreasing with increasing familiarity) when management and project variables are controlled but the significance drops to around 30% when client and organisation variables are partialled out. The correlation with cost overrun is significant with management variables partialled out but the client variables again control this relationship with significance dropping to 27%. Functional satisfaction is found to be significantly correlated, however, when the client variables are partialled out (3.3%). It may be concluded then,

Measures	Control Variables: 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-19	-65	-29	-17	-24	Coef
	27	*0.4*	*13*	*23*	*12*	Prob
2 CTover	-16	-46	-46	-11	-16	
	30	*0.4*	*3.3*	*32*	*21*	
3 DTover	-2	-8	28	7	9	
	47	*38*	*14*	*39*	*32*	
4 Conspeed	-15	25	44	10	5	
	31	*18*	*3.8*	*33*	*40*	
5 Prespeed	35	33	20	18	2	
	12	*12*	*22*	*21*	*46*	
6 Costp	1	9	5	-5	1	
	48	*37*	*42*	*42*	*48*	
7 Crate	33	25	54	28	39	
	14	*18*	*1.3*	*11*	*2.1*	
8 Tsat	14	-32	-42	-4	-14	
	33	*12*	*4.5*	*43*	*24*	
9 Csat	2	-21	-27	11	1	
	47	*23*	*15*	*32*	*49*	
10 Qsat	-28	-25	5	-19	3	
	18	*18*	*43*	*21*	*45*	
11 Fsat	-52	13	-10	11	7	
	3.3	*32*	*36*	*32*	*37*	
	DOF = 11	DOF = 13	DOF = 15	DOF =19		

Table 8.19: Partial Correlations of Familiar with Performance

that functional satisfaction and construction speed are both improved by an increase in familiarity but no other effects on performance and satisfaction are proven.

Hypothesis 3.3.3 Proximity of team members to one another increases performance and satisfaction.

Three significant zero-order correlations indicate improved performance: design time overrun (3.7%); preconstruction speed (4.7%); construction rate (3.7%). Additionally, indicative relationships exist for cost overrun and construction speed but these disappear when client and organisational variables are controlled for (Table 8.20). Both client and project variables reduce the significance of the relationship with design time overrun to 48%, the same being the case for organisation variables with preconstruction speed. Construction rate on the other hand maintains the relationship of increasing with proximity no matter which variables are controlled, significance levels varying from 0.6% to 3.7%. When the client variables are controlled for time satisfaction also becomes highly significant (0.2%) but the effect is opposite, satisfaction decreases with proximity. When management and project variables are partialled out cost satisfaction is significant at the 8% level suggesting that a relationship may well be proven with a larger sample: satisfaction increases with proximity.

Thus two relationships are statistically proven, construction rate increases with proximity whilst satisfaction on time

Measures	1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
	Control Variables					
1 Costover	-13 *33*	-39 *7.7*	-31 *11*	15 *26*	-30 *7.0*	Coef Prob
2 CTover	52 *3.3*	-14 *30*	3 *46*	6 *41*	-10 *31*	
3 DTover	2 *48*	15 *30*	2 *48*	21 *18*	-35 *3.7*	
4 Conspeed	-12 *35*	30 *14*	5 *43*	1 *48*	29 *7.7*	
5 Prespeed	28 *18*	63 *0.6*	31 *11*	1 *48*	34 *4.7*	
6 Costpm	-6 *42*	-10 *36*	31 *11*	-23 *16*	-9 *34*	
7 Crate	56 *2.4*	57 *1.3*	59 *0.6*	40 *3.5*	35 *3.7*	
8 Tsat	74 *0.2*	-10 *36*	-6 *41*	18 *22*	-6 *39*	
9 Csat	28 *17*	-38 *8.2*	-35 *8.1*	16 *24*	-5 *41*	
10 Qsat	41 *8.3*	10 *36*	8 *37*	46 *1.8*	16 *22*	
11 Fsat	11 *36*	25 *20*	-14 *30*	26 *13*	18 *19*	
	DOF = 11	DOF = 13	DOF = 15	DOF =19		

Table 8.20 Partial Correlations of Proxty with Performance

performance decreases. There is weak evidence that cost satisfaction also increases with proximity.

Hypothesis 3.3.4 High levels of differentiation lead to low levels of satisfaction and performance.

Only one zero-order correlation coefficient is significant, that is design time overrun (4.5%) but when the management variables are partialled out this relationship disappears (44%, Table 8.21). Cost overrun and differentiation show a significant relationship (varying between 1.5 and 6.6%) but the client variables negate this when partialled out (46%). The organisation variables account for any relationships that appeared to exist between differentiation and preconstruction speed and construction rate, the only correlations that are significant are with cost and time satisfaction, 4.8% and 4.6%, when controlled for management and client variables respectively. The client variables, when partialled out, reduce the significance of the other satisfaction measures to over 40%.

Construction time overrun is significantly related to differentiation (2.9%) when the client variables are partialled out (2.9%), although the inclusion of organisation variables does reduce the significance somewhat (48% c.f. 44% for zero-order). Thus it is concluded that increased differentiation is associated with increases in construction time overruns, and so decreases time satisfaction, but increases cost satisfaction.

Measures	Control Variables: 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-3 *46*	-56 *1.5*	-38 *6.6*	-35 *6.0*	-32 *5.6*	Coef Prob
2 CTover	54 *2.9*	-6 *41*	8 *38*	3 *44*	3 *44*	
3 DTover	-19 *27*	4 *44*	-25 *17*	-20 *20*	-33 *4.5*	
4 Conspeed	-2 *47*	27 *16*	5 *43*	10 *33*	22 *14*	
5 Prespeed	37 *11*	53 *2.0*	46 *3.1*	8 *37*	29 *7.6*	
6 Costpm	6 *43*	-16 *28*	-27 *15*	9 *36*	-16 *22*	
7 Crate	40 *8.6*	43 *5.7*	30 *12*	-3 *45*	25 *10*	
8 Tsat	49 *4.6*	-13 *33*	-16 *27*	-27 *12*	-12 *29*	
9 Csat	32 *15*	-44 *4.8*	-35 *8.1*	-20 *19*	-7 *36*	
10 Qsat	2 *48*	-20 *24*	-37 *7.3*	-39 *3.9*	-17 *21*	
11 Fsat	-4 *45*	15 *29*	-45 *3.5*	-35 *6.0*	-1 *48*	
	DOF = 11	DOF = 13	DOF = 15	DOF =19		

Table 8.21: Partial Correlations of Difftn with Performance

Hypothesis 3.3.5 High levels of coordination improve performance and increase satisfaction.

There are no significant zero-order correlations between this variable and any of the measures and inspection of Table 8.22 reveals only two indicative relationships: with cost overruns at 9.3% when client variables are partialled out and with functional satisfaction at 8.6% when organisational variables are partialled out. Both indicate improved performance but are only indicative, not proven relationships.

The management variables appear to be a major influence on design time overrun, construction speed and construction rate and, when partialled out, the project and client variables reduce greatly the highest zero-order correlation, unit cost. The other organisation variables appear to have a major influence on construction time overrun, particularly differentiation and familiarity.

MANAGEMENT VARIABLES

The variables investigated under the heading of management were overlapping of the design and construction processes (overlaps), the degree of competition in the selection of contractor (comptitn), the level of certainty concerning the project as expressed in the contract documents at commencement of construction (two measures: doccert1; doccert2) and the use and extent of cost monitoring (costmonr).

Measures	Control Variables: 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-40	-25	-7	-11	3	Coef
	9.3	*18*	*40*	*32*	*45*	Prob
2 CTover	-30	-43	-43	-4	-27	
	16	*5.6*	*4.4*	*43*	*9.0*	
3 DTover	20	-4	37	8	10	
	26	*44*	*7.4*	*37*	*31*	
4 Conspeed	17	4	18	7	18	
	30	*44*	*25*	*39*	*19*	
5 Prespeed	36	-9	-14	-25	3	
	11	*37*	*30*	*14*	*44*	
6 Costpm	-1	15	3	7	32	
	48	*29*	*45*	*38*	*5.3*	
7 Crate	32	-12	32	20	27	
	15	*34*	*11*	*19*	*8.6*	
8 Tsat	1	-22	-13	-16	14	
	48	*22*	*32*	*24*	*25*	
9 Csat	-29	-16	-9	-10	8	
	17	*29*	*37*	*34*	*35*	
10 Qsat	11	-12	37	10	28	
	37	*33*	*7.4*	*34*	*8.6*	
11 Fsat	-18	-35	14	-31	-5	
	28	*9.7*	*29*	*8.6*	*40*	
	DOF = 11	DOF = 13	DOF = 15	DOF =19		

Table 8.22: Partial Correlations of Coordn with Performance

Hypothesis 3.4.1: A high level of overlapping leads to increased construction time and cost overruns.

Inspection of Table 8.23 indicates a significant (zero-order) relationship between construction rate (4.2%) and quality satisfaction (2.2%) with overlaps but this relationship disappears when the effect of the client and organisation variables is controlled for. Design time overruns and overlaps are correlated highly (7.9%, zero-order) until the organisation and management variables are controlled for when the relationship becomes non-significant. No other significant relationships can be identified and so one must conclude that there is no direct relationship between the degree of overlapping of the design and construction processes and any of the objective or subjective performance measures.

Hypothesis 3.4.2 Increased levels of competition lead to:

a) reduced preconstruction performance
b) reduced quality satisfaction
c) increased cost performance and satisfaction

The zero-order correlations shown in Table 8.24 indicate that cost satisfaction (2.3%) and quality satisfaction (4%) are highly correlated with the degree of competition in contractor selection (both indicating increasing dissatisfaction with increasing competition). Again this relationship disappears on partialling out the project variables and client and management variables

Measures	Control Variables: 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-17	-4	10	19	13	Coef
	29	*44*	*35*	*22*	*27*	Prob
2 CTover	-2	-8	-24	24	-20	
	48	*38*	*17*	*15*	*15*	
3 DTover	25	-13	47	11	28	
	20	*31*	*2.8*	*32*	*7.9*	
4 Conspeed	-9	-3	17	-3	14	
	39	*46*	*26*	*45*	*25*	
5 Prespeed	13	-22	-23	-36	-17	
	34	*20*	*19*	*6.0*	*21*	
6 Costpm	-28	-2	-5	-42	9	
	18	*47*	*42*	*3.4*	*33*	
7 Crate	27	39	39	8	34	
	18	*7.0*	*6.2*	*37*	*4.2*	
8 Tsat	7	11	-9	-2	-7	
	41	*35*	*37*	*47*	*37*	
9 Csat	-31	-25	1	6	-4	
	15	*17*	*49*	*41*	*43*	
10 Qsat	11	-12	37	10	28	
	37	*33*	*7.4*	*34*	*8.6*	
11 Fsat	-26	-11	27	-4	17	
	20	*34*	*15*	*43*	*47*	
	DOF = 11	DOF = 14	DOF = 15	DOF =18		

Table 8.23: Partial Correlations of Overlaps with Performance

Measures	Control Variables: 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	6 *43*	15 *29*	8 *38*	0 *50*	12 *28*	Coef Prob
2 CTover	11 *37*	22 *21*	31 *12*	1 *48*	21 *15*	
3 DTover	17 *29*	5 *42*	15 *29*	6 *40*	-12 *27*	
4 Conspeed	-40 *8.6*	-21 *22*	-36 *7.4*	-22 *18*	-23 *12*	
5 Prespeed	-69 *0.4*	-55 *1.4*	-63 *0.3*	-35 *6.3*	-26 *10*	
6 Costpm	-29 *17*	-25 *17*	-25 *17*	-24 *16*	-23 *13*	
7 Crate	-33 *13*	-11 *34*	-34 *9.2*	-33 *7.7*	-18 *18*	
8 Tsat	3 *46*	31 *12*	14 *29*	16 *25*	26 *10*	
9 Csat	42 *7.7*	49 *2.8*	17 *26*	40 *4.1*	39 *2.3*	
10 Qsat	-9 *38*	-15 *29*	-27 *15*	-31 *9.4*	35 *4.0*	
11 Fsat	-8 *40*	1 *49*	-13 *32*	1 *49*	0 *50*	
	DOF = 11	DOF = 14	DOF = 15	DOF =18		

Table 8.24: Partial Correlations of Comptitn with Performance

respectively. However, a significant correlation with preconstruction speed is apparent when the client (0.4%), management (1.4%), project (0.3%) and organisation (6.3%) variables are partialled out (zero-order correlation - 10%). Thus it can be concluded that there is evidence to show that increased levels of competition in selecting a contractor reduces the preconstruction speed of a project. No other correlations or partial correlations can be identified as statistically significant and thus no evidence exists to support the other sub-hypotheses.

Hypothesis 3.4.3 Increased document certainty(1):

i) reduces time performance

ii) reduces cost overruns

This variable relates to the use of standard forms of contract and the degree of completion of the documents used at tender. Table 8.25 reveals two significant zero-order correlations with design time overrun (0.2%) and quality satisfaction (3.6%) but the partialling out of both client and management variables reduce the significance of the latter to over 25%. The significance of the correlation between design time overrun and certainty varies between 0.3% and 11% when the other variables are partialled out which provides sufficient evidence to accept that design time overruns reduce with an increase in document certainty.

When the organisation variables are controlled for the correlation between unit cost and document certainty reaches the less than 10% level (9.4%), indicating that unit cost may

Measures	Control Variables: 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	2	-15	-33	-15	-19	Coef
	48	*29*	*9.7*	*27*	*18*	Prob
2 CTover	11	-5	33	-16	15	
	36	*43*	*9.9*	*26*	*23*	
3 DTover	-37	-36	-65	-38	-54	
	11	*8.6*	*0.3*	*5.0*	*0.2*	
4 Conspeed	0	-9	-30	-10	-16	
	50	*37*	*12*	*33*	*21*	
5 Prespeed	8	2	44	31	23	
	40	*46*	*3.8*	*9.3*	*13*	
6 Costpm	23	-13	-26	31	-6	
	23	*32*	*16*	*9.4*	*39*	
7 Crate	-1	25	-6	18	29	
	48	*18*	*42*	*22*	*7.3*	
8 Tsat	-1	-1	16	0	13	
	49	*48*	*27*	*50*	*26*	
9 Csat	23	-30	-10	-18	-14	
	22	*13*	*36*	*22*	*26*	
10 Qsat	-20	11	-41	-30	-36	
	25	*34*	*5.3*	*10*	*3.6*	
11 Fsat	20	-25	-39	-30	-25	
	26	*18*	*6.0*	*10*	*11*	
	DOF = 11	DOF = 14	DOF = 15	DOF = 18		

Table 8.25: Partial Correlations of Doccert1 with Performance

increase with certainty but a larger sample would be needed to affirm or deny this. From the statistics there appears to be no support for either of the two sub-hypotheses.

Hypothesis 3.4.4 Increasing levels of document certainty:
i) reduce cost overruns
ii) reduce satisfaction

This variable was measured as the proportion of prime cost, provisional and contingency items in the total construction budget. Table 8.26 indicates significant and indicative zero-order correlations with the quality (1.5%) and functional satisfaction (8.7%) measures, both of which maintain a level of significance when the other variable groups are partialled out. Quality ranges from 3.5 to 10% and function from 3.7 to 11%. One may thus conclude that both functional and quality satisfaction increase as the level of certainty decreases i.e. as the proportion of PC, provisional and contingency items increases.

The client and project variables have a controlling effect on time and cost satisfaction and cost overruns, negating what would otherwise be classed as significant relationships. This is not the case with construction rate however which is strongly correlated with document certainty (3.4%) when the project variables are controlled. Thus it can be concluded that construction rate also increases as certainty (measured by doccert2) decreases.

Measures	Control Variables: 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-5	46	3	53	7	Coef
	45	3.7	46	2.0	38	Prob
2 CTover	0	26	11	28	10	
	50	16	36	16	34	
3 DTover	-63	-8	-33	-22	-12	
	4.5	38	13	22	30	
4 Conspeed	-30	-21	0	-32	-24	
	23	21	50	12	15	
5 Prespeed	53	-2	11	14	9	
	8.7	47	36	31	35	
6 Costpm	15	23	-21	32	15	
	36	20	25	12	26	
7 Crate	48	27	52	16	-5	
	12	15	3.4	29	46	
8 Tsat	14	39	4	40	26	
	4 37	6.7	45	6.8	13	
9 Csat	16	54	24	44	28	
	36	1.6	22	4.9	11	
10 Qsat	-61	-40	-38	-48	-47	
	5.5	6.1	10	3.5	15	
11 Fsat	-65	-31	-51	-38	-31	
	3.9	11	3.7	8.0	8.7	
	DOF = 6	DOF = 14	DOF = 11	DOF =13		

Table 8.26: Partial Correlations of Doccert2 with Performance

Hypothesis 3.4.5 Increased levels of cost monitoring improve cost performance

From Table 8.27 it can be seen that cost overrun and cost monitoring are strongly correlated (8.1% - zero-order) and whilst partialling out the project variables the significance level is raised to 2.5%. However, when the organisation variables are partialled out the significance increases to 20% thus removing the grounds for accepting a relationship between increased monitoring and reduced overruns. A larger sample, perhaps containing organisationally similar projects, could well provide conclusive support for the hypothesis.

The only other significant correlation coefficients are the partial coefficients for unit cost and construction rate. When the client variable is held constant the significance level rises to 7.8%, providing evidence that higher value projects make use of more comprehensive cost monitoring as one would expect. The reason why higher levels of cost monitoring should lead to lower construction rates (8.4% when management variables partialled out) is less clear. This requires further investigation to confirm the signifance of the relationship (less than 5%) and the causal links leading to the relationship.

STRUCTURE

The distribution of the various project teams on the integration-control grid is recorded in Figures 8.1 and 8.2. Inspection of

Measures	Control Variables 1 Client	2 Management	3 Project	4 Organisation	5 Zero Order	
1 Costover	-34 *13*	-29 *14*	-48 *2.5*	-20 *20*	-28 *8.1*	Coef Prob
2 CTover	-14 *32*	-18 *25*	2 *47*	-5 *42*	8 *34*	
3 DTover	3 *47*	6 *42*	-27 *15*	1 *48*	-25 *10*	
4 Conspeed	40 *8.8*	-5 *43*	-9 *37*	-1 *48*	-15 *23*	
5 Prespeed	17 *29*	34 *9.9*	7 *39*	28 *12*	23 *13*	
6 Costpm	42 *7.8*	22 *21*	-21 *20*	24 *15*	-12 *28*	
7 Crate	-20 *26*	-36 *8.4*	-17 *26*	8 *37*	-4 *42*	
8 Tsat	-18 *28*	-8 *38*	-9 *37*	-3 *45*	1 *49*	
9 Csat	-1 *49*	-30 *13*	-12 *32*	-5 *42*	-18 *19*	
10 Qsat	-33 *14*	-14 *31*	-27 *15*	-33 *7.5*	-25 *11*	
11 Fsat	10 *37*	18 *25*	-24 *18*	-3 *44*	8 *35*	
	DOF = 11	DOF =14	DOF = 15	DOF = 18		

Table 8.27: Partial Correlations of Costmonr with Performance

Figure 8.1 indicates that 33% (9 out of 27) project teams were appropriately organised; management contracts scored 100% whilst the lowest percentage was recorded by fragmented design builders, 14% (1 out of 7). Figure 8.2 reveals four traditionally organised teams (44%) and two fragmented design build teams (28%) in the anarchic sector of the grid. This sector was not deemed appropriate for any organisation and all but one traditional team performed badly on at least one of the objective measures. Design build teams were found mainly in the bureaucratic or mechanistic sectors, as were the management teams.

The correlations between structure classification and the performance measures are recorded in Table 8.28; zero-order and partial correlations, holding area and complexity constant, are reported. Significant zero-order correlations can be seen to exist with the value of variations, preconstruction speed and cost satisfaction; performance improves with appropriate structures. On controlling for area and complexity however the significant correlation with variations disappears (18%) but a new significant correlation with cost overrun (2.7%) manifests itself. The other two correlations remain significant; preconstruction speed at 3.2% and cost satisfaction at 3.6%. The average preconstruction speed score for the teams having appropriate structures is 65 compared with a norm of 50 and score of 40 for those teams having inappropriate structures and the cost overruns recorded by appropriately organised teams averaged 3% compared to the norm of 5%. Satisfaction on cost performance rated as very satisfied for those with appropriate structures

Figure 8.1: Structure Grid and Appropriateness

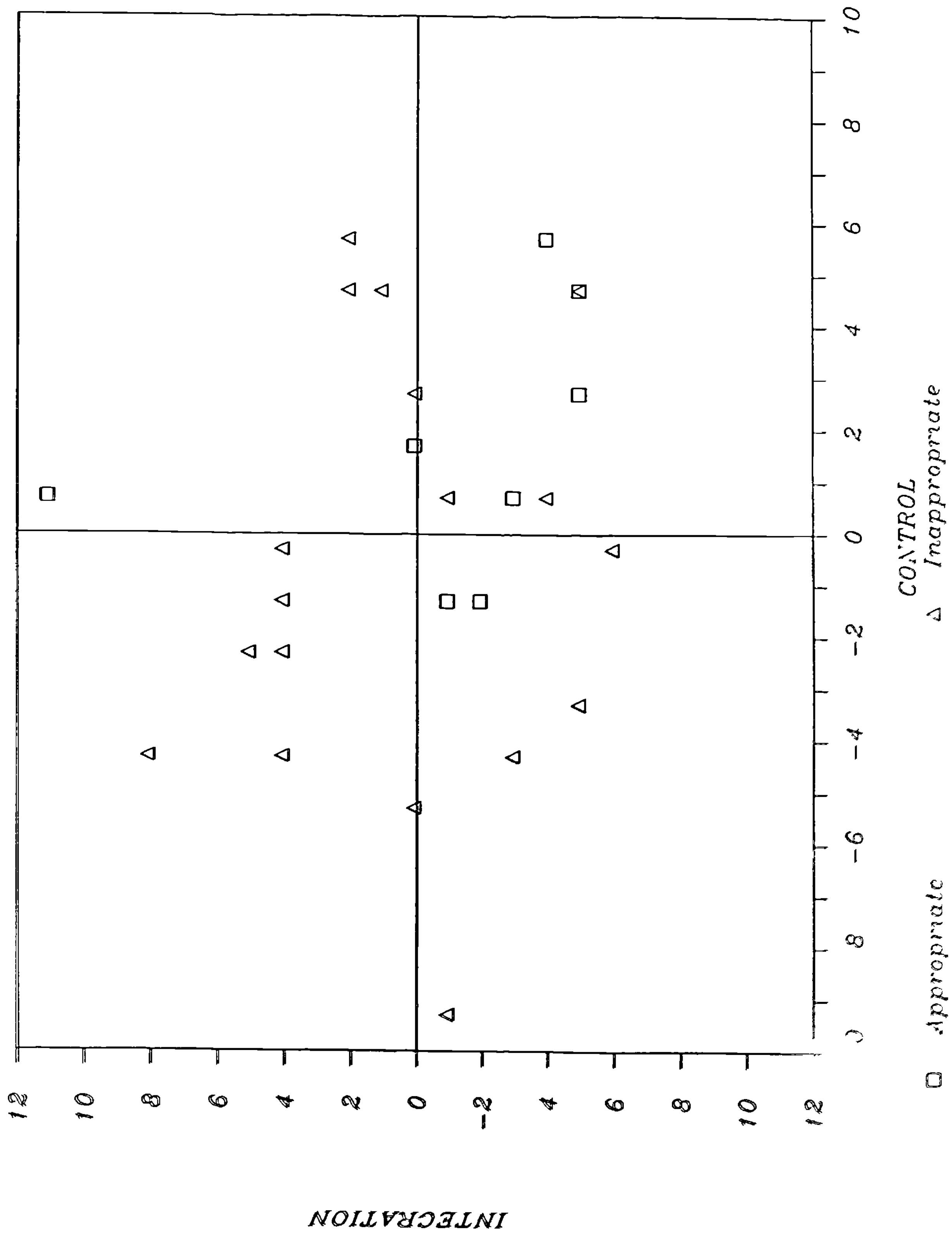

Figure 8.1: Structure Grid and Appropriateness

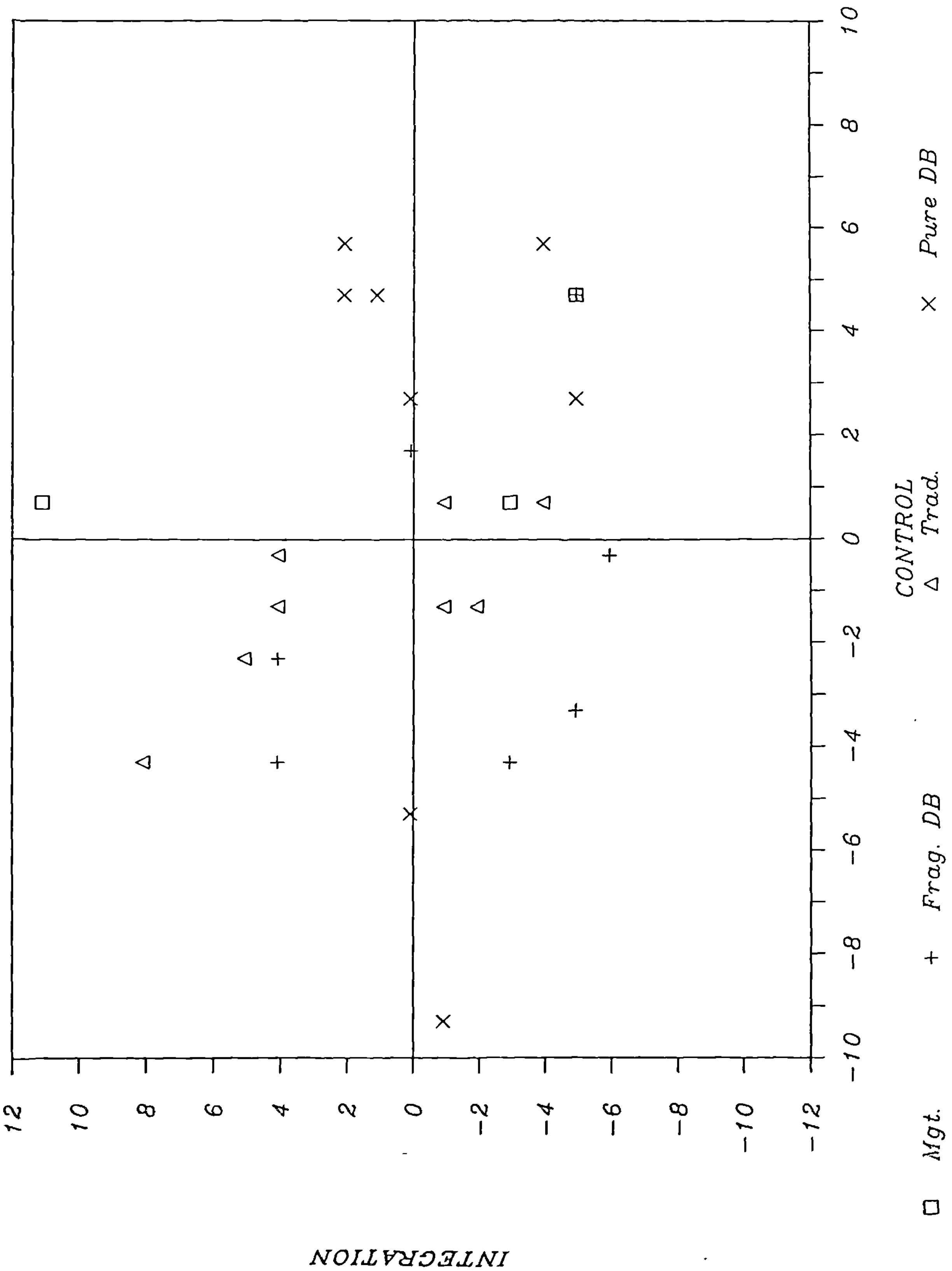

Figure 8.2: Structure Grid and Organisation Form

Measures	Zero-order	Controlling for Area & Phycompx	
1 Costover	19 *17*	46 *2.7*	Coef *Prob*
2 CTover	6 *38*	17 *25*	
3 DTover	13 *26*	32 *9.6*	
4 Conspeed	4 *43*	-13 *31*	
5 Prespeed	-46 *0.9*	-44 *3.2*	
6 Costpm	-17 *20*	11 *33*	
7 Crate	-10 *31*	-5 *41*	
8 Tsat	10 *31*	10 *34*	
9 Csat	*32* *5.6*	*43* *3.6*	
10 Qsat	6 *38*	-15 *28*	
11 Fsat	-1 *49*	-17 *25*	
12 Vars	30 *6.5*	-23 *18*	

Table 8.28: Correlations between Structure and Performance Measures

whereas that for teams with inappropriate structures rated only as acceptable.

There appeared to be no significant correlation between position on the grid and performance, hence it may be concluded that teams employing appropriate structures (as described in Chapter 7, p 141) perform better in terms of preconstruction speed, cost overrun and cost satisfaction than those which do not. Thus, the conclusion does not apply to the whole spectrum of performance measures but nevertheless indicates a significant performance differential.

Chapter 9

Discussion of Results

DISCUSSION OF RESULTS

Introduction

The following is a discussion of the significant results reported in chapter 8. Some findings are expounded by reference to the case studies as a means of explanation and provision of further supporting evidence; for others an attempt is made to interpret the outcomes and so generate new propositions for further testing. Thus the aims of research are fulfilled in that hypotheses have been seen to be proven or rejected and new propositions generated to assist in explaining further the performance variations inherent in construction projects. The relationship to past research is highlighted and some expected, but unproven, results are noted. A comparison of the usefulness of variables used in phases II and III concludes the chapter.

Discussion of Phase II Results.

Public sector contracts have been found to be constructed more slowly than their private sector counterparts, a point noted by both Sidwell (1982:58) and Wood (1975:4) from previous research. There is no evidence to indicate why this should be apart from Wood's view (1975:5) that inappropriate choices of project structure, brought about by rigid adherence to standing orders, are a cause and, in Sidwell's opinion (1982:58), there is no urgency in the public client's need for a building; for the most part budget plans prevail over need for occupancy. Similar arguments are made for the slow preconstruction process. (This point is returned to on p 210 when other, relevant results have been assessed).

The significant finding that public sector clients are less satisfied with the quality of the building produced may stem from two sources: the separation of ownership and occupation which is common with publicly funded projects (particularly industrial premises) so that the client does not actually experience the building in use; unfamiliarity, the application of inappropriate standards to industrial building - many of the client representatives were accustomed to supervising office or housing projects where higher quality finishes were the norm (case numbers 8, 18 are examples of this).

It is not surprising that a relationship is seen to exist between organisation form and construction speed, Faster Building for Industry (1983 :3 & 93) reported this same finding and, less directly, Ireland (1983:106-8) indicates that involvement of the contractor in design reduced the time per square metre for construction of commercial buildings (N.B. only two design build projects were included in his sample). This may be interpreted as the effect of improved buildability of the design, evidence for this however is not presented here (note Chapter 6 p124), nor in the two previous references. What is interesting to study is the rank order of organisation forms which runs traditional, design build, management from slowest to fastest: if design build is split into negotiated and tendered contracts the order becomes design build (tendered), traditional, management, design build negotiated. This again lends weight to the argument that a contingency approach should be adopted (hypothesis 2.7) and provides a good reason to investigate the organisational and managerial variables adopted in phase III.

The indication that negotiated contracts give rise to reduced quality satisfaction may be explained by the fact that in a negotiated contract all aspects of the project are up for negotiation and trade-offs inevitably occur; if the contractor's margin is pared during negotiation a reduction in specification (and so quality) is not unlikely. It should be noted that all negotiated contracts were undertaken by private clients. The correlation between payment method and preconstruction speed rather than selection method is, at first sight, perplexing. Intuitively, one expects negotiated contracts to be undertaken very quickly, for work to commence at once, but this is not necessarily the case. Often, negotiations can drag on for a long period of time before agreement is reached and this extends the pre-contract period (case numbers 1, 10 are examples). On the other hand, fee-based contracts accept a degree of uncertainty going into the construction phase, prime costs are used to produce a budget estimate, and this allows an early start on site, so reducing the preconstruction phase and generating an overlapping of the whole project process. Thus negotiation adds time to the start of preconstruction phase whilst fee-based contracts allow time to be saved at the end of the preconstruction phase, by overlapping design and construction. This may well account for the relationship indicated, but not proven statistically (8.4%), that fee-based methods tend to have slower construction phases because time is spent in detailed (or even conceptual) design during this phase, giving rise to variations and so extended times.

Fee-based contracts tend to generate greater dissatisfaction on costs but there is no evidence from the objective measures (unit cost and cost overrun) that their performance is any worse than other payment methods. This could possibly stem from the existence of some psychological contract instilled in the client that engaging a 'professional builder' should enhance all aspects of performance. Thus, even if the project is successful in objective terms, the lack of obvious cost savings may trigger the dissatisfaction.

The relationship between preconstruction time overruns and non-standard contracts may be explained on two counts: simply, a non-standard contract will take much longer for a client to inspect and agree, so increasing the preconstruction phase duration; forty per cent of the non-standard contracts were used with negotiation as the means of selection and this is likely to be a protracted process (as already noted).

The contingency views, that design build contracts are best when negotiated and should be used for simple contracts found limited support; that is, the views appeared to affect preconstruction time performance only. Case number 22 was a good example of the problems associated with tendered design build. Although the developer was an experienced, corporate client the planned preconstruction time overran by 100% due to the need for negotiations with (separate) designer and constructor as part of a two stage tender process. The client had to adjudicate between differing designs and prices and then, having made the adjudication, ask for further changes to meet his requirements. This is always likely to be a problem with tendered design build and is exacerbated by the use of a fragmented design build approach. However, by resolving the major changes required before construction started the project turned out to be relatively successful, although some time and cost overruns did occur.

Finally, returning to Wood's comments on 'structure leading strategy' (reported at the beginning of this section), the findings lend weight to this argument for slow progress as no public clients used fee-based payment methods or negotiation as a means of contractor selection. In certain cases this would have been appropriate (case studies 14 and 18 for example) and so it may be propounded that it is not the public client (and his internal structures) which are responsible for slow progress but the project structures that he adopts. Thus the correlation between client and poor performance may well be a spurious one: there is no causal link, the link is through the chosen strategy.

Discussion of Phase III Results

Client Variables

Highly dependent clients were found to experience significant design time overruns. This 'brake' on the design process was expected to originate from the the need to refer to super-ordinate organisations for sanction of both functional and financial decisions. Case 19 provides an example of such problems, an expanding micro-electronic component company was forced into the position where financial dependence (on Institutional funding) had lead to a loss of control of crucial design aspects. Contact with a regional design build firm provided the opportunity for greater control but with the associated 'cost' of time lost whilst new financial arrangements (and re-design) were made. Thus, a move to greater independence from a dependent position gave rise to considerable pre-contract delays.

Clients exhibiting a high degree of complexity are associated with both design time overruns and slow construction speeds. One of the measures of complexity was the number of people involved in communicating decisions to the building team and case 15 provides a good example of this. The pharmaceutical company in question appointed their Regional Engineering Manager to take charge of the building process but senior Production and Development Managers, more senior than the Engineering Manager, persistently added to or changed their specifications for the new facility. This process was facilitated by the lower status of the Engineering Manager and so the design and specifiation were never 'frozen'. As a consequence, with many inputs from numerous client representatives throughout the building process, it was almost inevitable that both design time and the construction period would be protracted. Case 16 provided a related example: a sophisticated pharmaceutical foundation provided its own conceptual design drawings and specifications but, despite this, internal disagreements between competing departments of equal status were compounded by the use of tendered design build for contractor selection and lead to a design time overrun of 29% on a generous planned schedule.

Surprisingly, the sophistication level of the client appeared not to have a significant impact on any of the objective performance measures. By way of explanation one may propose that factors such as dependence and complexity exert a much stronger influence directly on performance whereas sophistication acts on performance through the determination of the levels of complexity and dependence within the organisation. (The significance levels of the correlations between sophistication and complexity and dependence are 4.9% and 7.7% respectively).

Project Variables

Evidence that the measure of project complexity is more sophisticated and valid than that used in the phase II comes from the fact that the unit cost measure is seen to increase with increases in complexity, as one would expect and as reported by Ireland (1983:144). Thus, the variable can be assumed to be a good measure to use as a control, despite the fact that it was not found to be associated with construction speed (as found by Ireland, 1983:144). This anomaly may be explained by reference to Table 8.15 which indicates that the relationship with construction speed is negated when the management variables are controlled for, variables which Ireland did not include in his analysis.

Increased levels of uncertainty about the required project were seen to lead to both design time overruns and increased unit costs (with complexity controlled for). Case 15 again provides a good example in this respect. The complexity of the client manifested itself in a high uncertainty score (13, maximum = 15) which not only caused design delays but increased construction costs (24% overrun). This uncertainty, manifesting itself in numerous design and specification changes, is also reflected in the degree of document completion at the start of construction. This was rated as very low, with many P.C. and Provisional items, even for a design build contract where one would expect a higher proportion of such items when design and construction were overlapped and the tender was on a competitive basis.

Organisation Variables

An important point to notice about the organisation variable results is that the indicative and significant zero-order correlations with construction speed and construction rate are negated when the other organisation variables are controlled for. Thus the significant result in phase II indicating that construction speed is associated with procurement form (p 153) is called into question. The implication is that the other organisational (and managerial) variables have a more significant impact than the somewhat imprecise definition of organisation form. This result thus supports Ireland's proposition that the 'distinctions between nominally different procurement forms are virtually meaningless' (1984), i.e that managerial actions (and organisational choices) impact more significantly on project performance.

The closely related variables, familiarity and proximity, were found to be associated with improved construction speed and rate. The familiarity variable is similar in some ways to Ireland's variables 'construction planning during design' and 'design construction interface coordination' which he found to be associated with reduced construction time per square metre (1983:151). Thus, Ireland's findings are confirmed indirectly by use of a different but related measure. A good example of this in operation is case 7 where a long established relationship between client and management contractor allowed the builder to join the team at a very early stage and become familiar with all aspects of design, construction details and accepted quality standards. Although this arrangement precluded a conventional tendering arrangement the client was quite satisfied with the competition engendered in letting work packages and most satisfied with the quality of construction. This medium-large contract was completed on time with only a one per cent overrun on budgeted cost.

A contrary example is case 15 where a metropolitan authority employed a fragmented design build operation (with whom they had had few previous contacts) which had no previous experience of this organisation form. The lack of familiarity within the team concerning the organisational form and one another's working methods, and their separate locations, lead to disastorous consequences with a 51% overrun on construction time.

Increased differentiation was found to be associated with increased construction time overruns and this characteristic was particularly common with the fragmented design builders; the three with highest differentiation scores averaging overruns in excess of 20%. In terms of their structure, all these were classed as inappropriate and two were actually classed as anarchic.

Management Variables

The two document certainty measures produced different associations with the performance measures. The former, representing the degree of document completeness, was associated with reduced design time overruns (as completeness increased). It was found that design build contracts scored consistently low on this variable and that they experienced considerable design time overruns. One may deduce from this (and the comments on pages 164-5) that such contracts set unrealistically short pre-construction times and that the low level of documentation produced is a hindrance to meeting such targets. Hence, it may be proposed that there exists a minimum level of documentation (critical mass) which needs to be produced before progression to the construction phase. The implication is that organisations (particularly less-experienced design builders) underestimate this level.

The second measure of document certainty, the proportion of P.C., Provisional and Contingency items in the budget, was found to improve quality and functional satisfaction levels as it increased. This measure was also highly correlated with the incidence of variations (0.6%, zero-order) and the use of fee-based methods of payment. Hence, use of variations in conjunction with loosely defined budget items allowed considerable flexibility in the construction phase to achieve the functional and quality performance desired by the client but this was 'paid for' by cost and time overruns, such as those in cases 11 and 15. It appears then, from the case studies, that high document uncertainty may go hand in hand with a client desirous to control building details but that this control (or interference) has associated costs.

Structure

Case 4, a design build project, and case 7, a management project, are examples of projects where an appropriate structure was adopted and performance targets were met. The clients involved, both long-established enterprises (one an industrial property developer and the other a major retail outlet) were highly experienced and sophisticated in their approach to construction. In fact, seven out of the nine organisations choosing appropriate structures were highly experienced organisations. The other two, cases 6 and 21, both had managing directors who took a keen interest in the whole of the building process but were not described by the professionals as interfering. In fact they were seen as 'questioners' who wished to know what had to be decided and why. They explored alternatives with the design teams and, essentially, prompted high levels of interaction and particpation. Although case 6 was highly successful, case 21 could not be described as such. The design period overran considerably and, during construction, below ground obstructions were encountered which should have been known to the architect if a thorough search of available planning documents had been made. (Such negligence was rarely admitted during the case studies but is an important factor which undoubtedly affects some building projects).

Having noted that only experienced clients appeared to adopt appropriate structures for their projects one must query whether inexperienced clients are provided with adequate explanation and advice by the building industry. Certainly, Wilson (1974), Graves (1978:7) and NEDO (1983 :3) all believed that inexperienced clients required better quality advice and the findings on structure indicate that this is still the case: additionally, it may be argued that the industry must educate itself and improve research in order to make itself aware of which approaches are most appropriate for different projects and clients.

Other Results

Despite the analysis of the results reported in Chapter 8, a number of non-proven relationships need further comment. By studying the correlations between the independent variable and controlling variables it is possible to explain some of the non-significant partial correlation statistics. Thus, some unproven associations may be re-classified as indicative i.e. requiring further investigation.

Cost Overrun

A review of Table 8.19 indicates a highly significant relationship between cost overrun and familiarity when management variables are partialled out but a reduction in the correlation coefficients when client and organisation variables are taken into account. However, strong correlations exist between familiar and client variables (sophistication and complexity) and organisation variables (procform and coordn). It is possible therefore that controlling for the client and organisation variables may reduce the remaining variance to such an extent that the association between costover and familiar appears non-significant.

The failure to find a significant association between cost monitoring and cost overrun was surprising. Table 8.27 indicates a significant result (2.5%) when project variables are partialled out but the associations with the client, management and organisation variables held constant may well be masked, as for the familiar variable, by high zero-order correlations with client dependence, overlaps and document certainty and coordination respectively.

The discussion of the association between complexity and performance measures reported on p 177 does not mention the almost significant relationship with cost overruns when the management and project variables are partialled out. This ommission was on the basis that the correlation coefficient reduced (below that for the zero-order correlation) when both organisation and client variables are partialled out. Complexity is stongly correlated with client sophistication, thus the variance in this (when controlled for) may mask the variance due to the complexity variable and a larger or controlled sample could lead to a significant association being proven. Although the same argument does not hold for the organisation variables the effect of complexity on cost overrun requires further consideration: it would seem reasonable to suppose that if complexity goes unrecognised during design, cost overruns are likely when it is finally recognised.

Preconstruction Speed

The indicative relationship (6%) between prespeed and the degree of overlapping which appears when the organisation variables are controlled is negated when client variables are controlled. There is a strong association between overlaps and client dependence however (4%) and so, following the previous arguments, it may well be that a larger sample or better controlled sample would reveal a significant association.

Strength of Effect of Variables

It is possible that the strength of effect of each variable on the various performance measures could be assessed by reference to regression equations. However, strictly speaking, regression equations produced using the SPSS statistical package are only valid for interval data and the constructed scales cannot be regarded as such. Additionally, the strength of association, measured by means of the beta coefficient, indicates the number of standard deviations in the independent variable required to cause a one standard deviation change in the dependent variable. The concept of standard deviations applied to constructed variable scales is not easy to visualise or apply. Finally, this strength of association is not universally applicable, it only applies to the present sample from the whole population of industrial building projects and only for the range of variables tested here, not for those identified in other research. Thus, it seems unreasonable to present such equations in the body of this thesis but equations for construction time, preconstruction speed, construction time overrun, unit cost and cost overrun are presented as an appendix for the reader's information.

Case Studies

The collection of data from individuals involved in the building process provided an excellent opportunity to verify the statements made in response to the questionnaires. Thus, apparent anomalies could be discussed and resolved and much additional information outside the questionnaire format was recorded. This information has proved useful in providing concrete examples of the associations proven by statistical analysis (as used in the opening section of the discussion). Such case data are very difficult to analyse without a formal data collection schema but do add greatly to the understanding and visualisation of research findings once analysis has been undertaken. Information collected in this way cannot be confirmed or denied statistically but is nevertheless an important additional source to be reported.

Two interesting points to come from this 'additional data' concern the clients' perceptions of what they want from the building team and the approach of the pure design builder. Firstly, many clients described the designers and builders involved in successful projects as 'professional' in their approach. On further probing it appeared that what they meant by this in the majority of cases was that the building team came to the client with questions concerning alternatives that were available to them and with a resume of what effect each alternative would have on temporal, financial and functional performance. They were regarded as professional also because they explained these points in lay man's terms whenever necessary; they did not hide behind the mystique of industry jargon. The Managing Director involved in case study 10 described the design build firm that he was dealing with as 'proactive', whereas traditional teams that he had dealt with previously were 'reactive', responding to problems rather than foreseeing them and alerting the client.

Pure design build firms generally appeared to be very customer-oriented. Many organisations could be said to be market-oriented; marketing as a discipline is firmly entrenched now in the construction industry. The difference with design builders and, to a lesser extent, management contractors is that they are prepared to spend much more time investigating the customers' needs whereas the rest of the industry is still at the stage of attracting clients rather than cultivating and getting to know the customers' organisations. This, in general, appears to lead to a better quality of service to the customer, a better informed customer (with realistic expectations) and good working relationships leading to high satisfaction and repeat work. This style is more akin to the Japanese way of working (Bennett et al., 1987) and may be expected to become more widely used in the future.

Performance Measures

In general, the performance measures adopted have been effective in analysing project performance. The use of three types of measure has been useful in determining the variables which affect different aspects of performance (as summarised in Table 9.1). The measures of predictability (Costover, CTover and DTover) were associated with different variables than the absolute measures of performance (Conspeed, Prespeed, Costpm and Crate). Similarly, the satisfaction measures were associated with another different set of variables but were found to be linked also to the predictability measures. Crate, an absolute measure, was included in order to allow comparison with Ireland's research (1983:151). Ireland concluded that design construction interface coordination, construction planning during design, complexity of form of construction and gross area were all associated with changes in construction time per square metre. This research identified four different factors: client complexity, document certainty, design constraints and proximity of the building team members as influences on this measure. Area also contributed greatly to the predictability of the regression equations reported in Appendix 4. Thus, complexity of form of construction has not been identified here as a factor affecting time performance; this may be due to the fact that

Measures	Variables				Mean	S.D.
1 Costover		*Costmonr*	*Phycompx* *Constrt*	*Familiar* *Coordn*	4.7	7.7
2 CTover	**Clicomp** *Adab*			**Difftn**	6.0	18
3 DTover	**Clidep2**	**Doccert1**	**Certnty**		27.5	58
4 Conspeed	**Clicomp**			**Familiar**		
5 Prespeed	*Clidep2* *Clicomp*	**Comptitn** *Overlaps*				
6 Costpm		*Doccert1* *Costmonr*	**Certnty** **Phycompx**		511	38
7 Crate	**Clicomp**	**Doccert2** *Costmonr*	**Constrt**	**Proxty**	99	70
8 Tsat	**Adab** *Clicomp*		*Constrt*	**Proxty** **Difftn**		
9 Csat	*Clicomp*		*Certnty*	**Difftn** *Proxty*		
10 Qsat		**Doccert2**				
11 Fsat	**Clicomp**	**Doccert2**		**Familiar** *Coordn*		

Bold - significant at <5%
Italic - indicative (5%<p<10%)

Table 9.1: Associations between Performance Measures and Variables

industrial buildings are more homogeneous and simpler in nature than the commercial buildings that Ireland studied. The planning and coordination variables that Ireland included are similar in nature to the familiarity variable, which influences the other absolute measure of time performance, construction speed. Thus, there is some indirect confirmation of some of Ireland's conclusions and identification of other variables which may be specific to the industrial building sector, the U.K. or both.

Factors affecting building cost per square metre identified by Ireland were variations, architectural quality, construction planning during design and complexity. This research found that complexity and cost monitoring were associated with fluctuations in unit costs along with document completeness and certainty concerning the required building. Variations were found to be strongly associated with complexity, thus the effect of these two variables appears to be inter-related, with complexity determining variation rates as one explanation. Thus, Ireland's findings on complexity are confirmed but modified on variations due to the link between the variables. Document completeness and cost monitoring are two additional factors identified as being influential.

In 1975, Wood found that 75% of public projects overran on cost by no more than 5%; this research found 40% of projects overrunning by greater than this figure. Although this sample included public and private clients there was no significant difference in the overruns recorded by each class. The average overrun was 4.7%, with a maximum of 24% being recorded. Using Wood's time yardstick, completion within not more than 5% over the contract period (1975:4), 65% of projects were successful on time performance compared with Wood's success rate of 33%. However, public client performance differed significantly from that of the private client with only 40% being classed as successful. Thus, the public client has improved little in over a decade, based on this sample. Average time overruns were 6%, with a maximum of 51% being recorded.

The performance measure which should cause most concern is the design time overrun which averaged over 27% and one project was 250% overdue. This measure showed a very large variation (standard deviation = 58) and is obviously an area requiring further investigation.

<u>Variables</u>

The variables chosen in Phase III for investigation proved to be useful in the most part, although clidepl, clisoph and procform were not found to be associated with any of the performance measures. Thus dependence, based on the Aston Group's measurements, may be omitted from future studies but client sophistication was seen to be associated with the complexity and financial dependence of the client. These latter two may thus be substituted for sophistication in future research. The fact that procform was found not to be associated with any of the performance measures is a significant finding. By introducing managerial and organisational variables into the analysis it appears that much of the variation in performance can be explained. This supports Ireland's proposition (1984A) and indicates that future research should concentrate on these managerial actions, and structure, as a means of deepening understanding of the construction process. Additionally, the work of Cherns and Bryant (1984), Bresnen et al (1986) and Fiedler (1987) add further dimensions to the study of the building team and its processes. Thus, this work adds another piece to the model being constructed.

The conventional construction industry variables have been seen to be of limited use in predicting performance, except in the contingency form reported in testing hypothesis 2.7. However, when incorporated into the broader ranging variables in Phase III a more useful model has emerged. Thus the fusion of conventional construction wisdom and management theory has lead to a more worthwhile model of the project process.

Revised Model

Based on the analysis of data and discussion of the results of this analysis a revised model can be drawn up to illustrate the research findings. This model admits of the fact that both the project context and the actions taken during the building process affect project performance. However, under the client variables, only client complexity and client dependence are seen to directly afffect performance; client sophistication is seen to act through its influence in determining a client's complexity and dependence. The three project variables, complexity, constraints and certainty, all have an effect on different aspects of performance, as hypothesised in the original model. The organisational variables shown to have an influence on performance are familiarity (and proximity), differentiation and coordination. The management variables affecting performance significantly have been identified as cost monitoring, level of competition and document certainty. As an addition to the original model, structure (defined by the management and organisational variables) has been found to be associated with performance. In particular, a structure appropriate to the procurement form adopted has been shown to be associated with superior performance. Thus, the procurement form variable has been displaced from its position in the original model and it has been concluded that the relationship between procurement form and performance is contingent on the adoption of an appropriate structure. Notwithstanding this conclusion, the revised model indicates that a more sophisticated contingency model which includes the elements of project context and the building process can now be developed and tested. The revised model is shown graphically in Fig. 9.1.

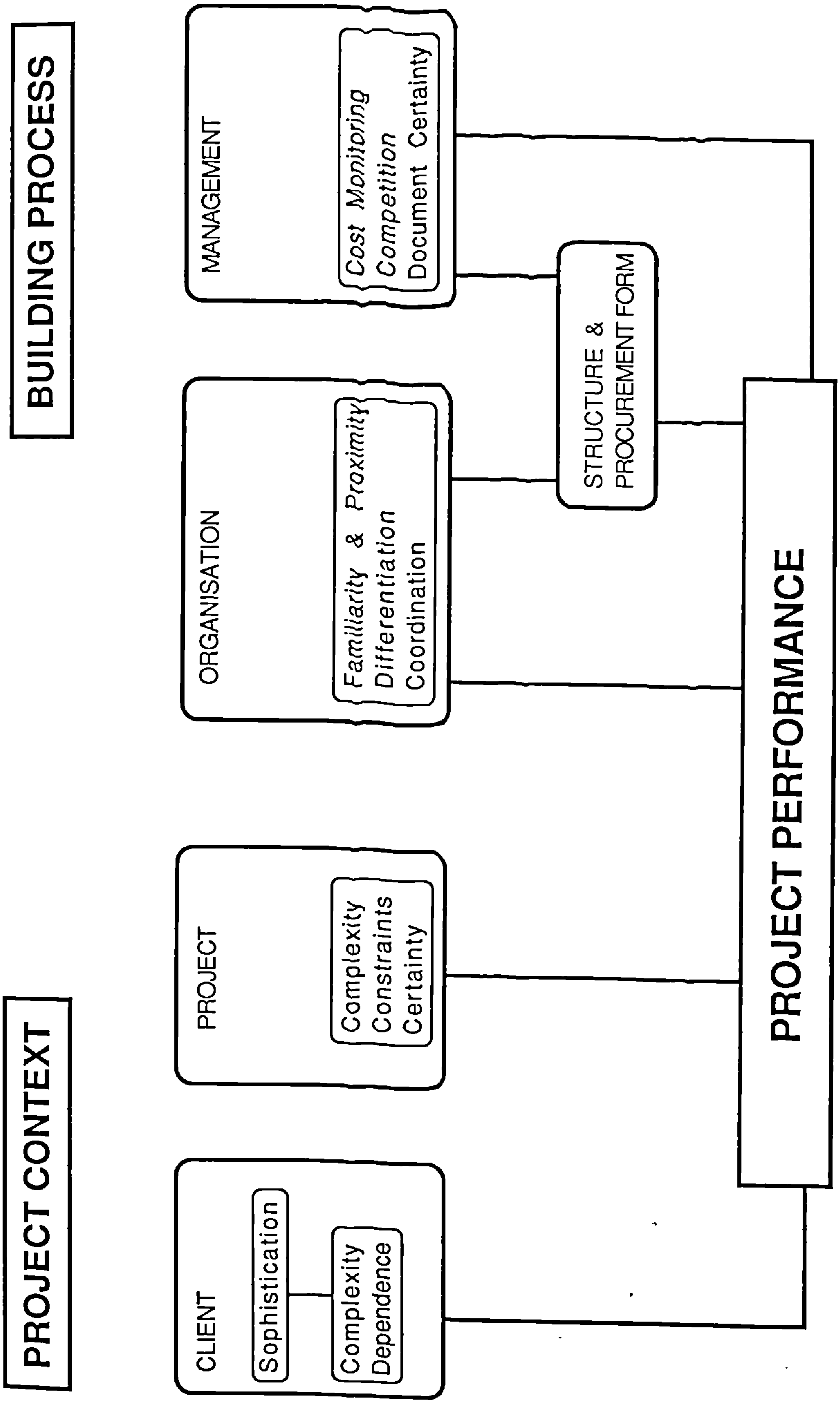

Figure 9.1: Revised Model of the Factors Affecting Project Performance

Chapter 10

Conclusions

CONCLUSIONS

Introduction

The aim of this research has been to identify variables which lead to systematic differences in the performance achieved during industrial building projects. The variables studied have been both the conventionally accepted construction industry variables (phase II) and other, more general, variables identified from management theory (phase III). Three sets of measures have been used to measure performance: objective, absolute measures; objective, predictability measures; subjective measures of client satisfaction.

Three propositions have been addressed. The proposition that design build methods lead to best performance was the starting point for the investigations. This lead to a second proposition, that performance is a function of both the context of the project and its management and organisation. Such a proposition, if proven, lays the basis for adopting a contingency approach to procurement. Finally, the proposition that commonly occuring procurement forms can be identified and that these lead to differing levels of performance was addressed.

Performance

The performance of the construction industry in providing industrial buildings has been shown to be highly variable with some highly successful projects (18% of projects were completed in less than the contract period) and others very unsuccessful (high preconstruction time overruns were common and 40% of the projects overran on cost by more than 5%). This great variability agrees with the findings of NEDO (1983) but performance was generally better than that recorded by Wood (1975) for public clients. NEDO (1983) explained the variability in performance primarily in terms of the procurement form adopted. This research has come to a different conclusion.

Factors Affecting Performance

The primary conclusion to be drawn from the research is that procurement form is not a good predictor of performance. This conclusion supports Ireland's proposition that managerial actions, rather than non-discrete procurement forms, form a rationale for action in the management of building projects. However, it was found that the building industry's conventional views on appropriate combinations of procurement variables (hypothesis 2.7) were useful in predicting the outcome of some projects. This finding notwithstanding, the conventioanl construction industry variables as tested in Phase II were not found to be good predictors of performance.

The general, management variables adopted in Phase III were found to be much better predictors of performance in this sample of projects. These variables also included the variables used in Phase II but in a compound form. The Phase II variables were combined with other, more general measures, into scales representing aspects of the client organisation, the nature of the project, the organisation of the building team and its management.

Client Variables

The complexity of the client organisation was found to be particularly important as an influence on construction time performance and also affected the rating of functional satisfaction whereas increasing client dependence was significantly associated with preconstruction period overruns. The rating of the administrative ability of the building team was highly correlated with the time satisfaction measure. The client sophistication variable was not found to be associated with any performance measures but was associated with changes in dependence and complexity, thus its effect on performance is through these intervening variables.

Project Variables

Uncertainty surrounding the needs and specification of the project was found to be associated with preconstruction period overruns and increased unit costs, as was an increase in the complexity of the project. The imposition of constraints on the project at the outset was found to be associated with increases in construction rates.

Management Variables

The degree of document certainty was found to affect construction rate, this was linked to the use of subcontractors and management methods, and satisfaction in terms of both quality and function. The degree of completeness of the contract documents was associated with preconstruction time overruns. The variable measuring competition for the construction work was found to be associated with preconstruction speed, reduced competition increasing the pace of preconstruction. The level of cost monitoring was found to affect both cost overruns and unit costs.

Organisation Variables

Differentiation in the building team was found to be associated with construction time overruns and time and cost satisfaction. The degree of familiarity within the building team significantly affected construction speed and the level of functional satisfaction attained. Proximity of the members of the team was found to be associated with construction rate and time satisfaction.

Stucture

It was determined from testing hypothesis 3.5.2 that the different procurement forms can be located on a grid according to their structure and that those organisations which are located appropriately achieve higher levels of performance, particularly in the preconstruction phase. Only 33% of the teams in the sample were found to be located appropriately which lead to the conclusion that the construction industry does not pay sufficient attention to adopting appropriate structures for the various organisation forms that it offers.

It was found, in phase II, that commonly occuring arrangements of procurement forms do exist e.g. public clients let construction work on a traditional basis by select tender. There was little evidence to indicate that such an approach enhanced performance except that negotiated design build and design build on simple projects lead to better than average performance. Thus, in general the commonly occurring forms, as identified by conventional construction variables, were not seen to be prerequisites for good performance.

Measures

The use of a number of different measures has enabled the research to fully investigate the performance of the different procurement forms and the effect of other variables. The use of total building cost, including fees, in Phase III was essential in this work to conduct a comparison of like costs and appears to have worked well. The satisfaction measures correlated well with their objective counterparts and indicated the impact of other variables on performance which would not otherwise have been noted.

Variables

The range of variables used was not intended to be exhaustive but manageable. A major aim of the research was to investigate the influence of different client attributes on performance and both client complexity and client dependence, reliance on other organisations, appeared as a strong influence on performance. Little work has been conducted on producing scales such as these for building projects and many of those used in other contexts are inappropriate. As a consequence there are no agreed formats against which those presented here can be compared. Thus future work should examine these scales critically to assess their validity in different situations and their scope of applicability.

Other Research

This work agrees with the conclusions drawn by Ireland that managerial variables (actions) affect project performance and adds to that work the significance of the situational variables of the nature of the project and the client. Further research in this area might usefully progress from a comparison of the measures used here, and in Ireland and elsewhere (as mentioned in Chapter 9), leading to the production of a fuller, contingency model of the building process. Both this work, and that of Ireland, have been aimed at identifying those key variables which affect project performance. Thus, it would be invalid to formulate and test a contingency model based on these sample data, a new set of data are needed.

It has been found that the distinction between public and private clients in terms of performance that Sidwell (1982) noted has been upheld but the influence of client sophistication, measured on a different scale, has not been confirmed (complexity and dependence were found to be more significant predictors). Evidence supporting Wood's views on structure leading strategy (and resulting poor performance) has been found however. Overruns on all counts appear to have reduced since the publication of the reports of Wilson (1974) and Wood (1975).

Applicability

The research undertaken here is immediately applicable only to the field of industrial building. It can however be extended to other forms of building provided that the thorn of architectural quality can be grasped. This is an intangible concept which has a greater influence in other sectors of the building market and must be accounted for. The author sees no reason, other than this, why the results presented here will not be applicable to all forms of new construction in the U.K..

Data Collection

The methodology set out and used in this work lead to a long and arduous period of data collection for twenty seven separate projects in detail (47 in total). The cross-sectional study, as undertaken, has provided a sound basis for comparison of design build, management and traditional methods as indicated but much more useful information on the differences between the forms of design build could now be collected using a longitudinal study.

Such an alternative approach could have been adopted by selecting only three or four contracting organisations, one from each category of organisation form, and following a number of their projects through to completion. This would reduce considerably the amount of data needed to be collected and probably speed the process. It would have the added advantage of holding constant a number of variables. In particular, the study of the interfaces between organisations and phases needs more attention and the control mechanisms can only be fully understood by adopting such a detailed approach. The concepts of leadership style, learning style and cognitive resource theory provide other avenues worthy of exploration in the context of building team performance. Hence, a correlation approach has proved effective in identifying those factors which significantly affect project performance but it has limitations. Although it may show the existence of relationships, which have been hypothesised, it cannot indicate how or why these relationships exist. By conducting detailed case studies some information on these aspects has been collected and presented in the discussion of the results; further research should use the groundwork of proven relationships to conduct longitudinal studies at this more detailed level.

Concluding Remarks

An attempt has been made to divine a comprehensive model of the construction industry's procedures and this has been possible to the point where cause and effect relationships have been shown to exist for certain selected variables. One cannot, however, account for the irrationality of many transactions which take place and the pressure to produce or win which leads to the taking of uncommercial decisions. There is a sound basis for scientific decision making in the construction industry but more research is needed to turn this into an acceptable procedure.

The place of design build methods in the U.K. industry has been more clearly defined. It can no longer be regarded solely as the realm of package dealers and system builders but includes many professional and specialised organisations offering an extensive range of services as well as the range of fragmented design builders.

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Appendix 1

Questionnaires

STEVE ROWLINSON

BRUNEL UNIVERSITY

CONSTRUCTION PROJECT QUESTIONNAIRE

4.0 AUTHORISED TIME EXTENSIONS

4.1 TOTAL LENGTH IN WEEKS

4.2 TOTAL NUMBER

5.0 VALUE OF WORK AND DATE FIXED

	DATE	POUNDS
5.1 TENDERED / NEGOTIATED CONTRACT VALUE	....	....
5.2 FINAL ACCOUNT SUM	....	....
5.3 PROFESSIONAL FEES (state professions)	----	....
5.4 VALUE OF RETENTIONS	----	....

5.5 METHOD OF PAYMENT:
MONTHLY CERTIFICATION / STAGE PAYMENTS / MONTHLY LUMP SUM / ONE LUMP SUM / OTHER (please state)...................

6.0 VARIATIONS , ETC.

	POUNDS	
6.1 VALUE OF VARIATIONS-authorised by client	......	(+/-)
-other (please state)	......	
6.2 TOTAL NUMBER OF VARIATIONS	......	
6.2 TOTAL FLUCTUATIONS (rise & fall)	......	(+/-)
6.4 LIQUIDATED DAMAGES /week =	......	
Enforced?	Y / N	

COMMENTS

Thank you for your attention

6.1 In your opinion , when compared to the Traditional approach , are premises procured by the Design and Build approach built ;

More quickly	YES / NO / SAME
More cheaply	YES / NO / SAME
Of a better quality	YES / NO / SAME

6.2 In your opinion , should contract documents specifically for INDUSTRIAL BUILDING projects be developed?

YES / NO

COMMENTS

Thank you for your attention

Appendix 1

Questionnaires

IN CONFIDENCE

QUESTIONNAIRE SECTION 1

This section deals with your organisations experience of the building industry and your expectations of it . Below are a number of definitions set out in order to clarify the information required . If you have never built before but are considering doing so please complete questions 1 , 2.1 , 3 and 5 .

TRADITIONAL APPROACH

method of procuring a building in which independent professionals (i.e. Architects, Engineers, Quantity Surveyors) are employed by the client to complete the design work and then the client enters into a separate contract with a building contractor who constructs the previously designed building .

DESIGN AND BUILD

commonly referred to as Package Dealing or Design and Construct, the whole building process is undertaken by one organisation, normally a building contractor, who takes responsibility for the design and construction of the facility . The client enters into one contract only .

INDUSTRIAL BUILDING

is a facility which is built specifically to house any form of manufacturing or production process . This research is directed to new building only (rehabilitation, conversion and refurbishment are excluded) .

STANDARD FACILITY

is a factory or production facility of a particular design and form which is repeated at a number of the company's sites .

Room is left on most pages for any additional comments to be made, these are welcomed . Responses will be treated in confidence but sections may be left blank if you feel this is necessary . An addressed envelope is enclosed for your convenience .

IN CONFIDENCE

SECTION 1

1.1 Name of Organisation

1.2 Address

1.3 Name of Respondent

1.4 Position within Organisation

1.5 Please circle response

PUBLIC CO / PRIVATE CO / DEVELOPMENT CORPORATION /
LOCAL AUTHORITY / PENSION FUND / OTHER(state).........

1.6 Annual Turnover, 1982

....

1.7 Number of Full-time Employees

1.8 Development Fields (indicate those in which Company is involved)

INDUSTRIAL / HOUSING / COMMERCIAL
/ RETAIL / OTHER (Please state) ....

PTO

Please cicle your response to the following questions

2.1 Have you ever commissioned an Industrial building?

YES / NO

If the answer to 2.1 is NO COMPLETE SECTIONS 3 & 5 ONLY

2.2 When did you last build?

less than 1

between 1 & 2

between 2 & 5

greater than 5 YEARS AGO

2.3 Do you employ any construction professionals on your permanent staff, other than maintenance staff?

YES / NO

Are they	Architects	
	Quantity surveyors	
	Building surveyors	
	Others (please state)	

....

(Please give numbers employed)

2.4 Have the projects you commissioned been of the standard facility type?

YES / NO

If YES please state number of such projects

....

2.5 How many projects in total have you commissioned in the past 5 years?

....

2.6 Do you plan to build in the next 18 months?

YES / NO

PTO

Please tick the appropriate box

3.1 What type of industry are the Organisation's developments provided for?

High technology	[ ]
Heavy engineering	[ ]
Light engineering	[ ]
Assembly	[ ]
Other (please state)	[ ]

....

3.2 Does your organisation produce

Advance Industrial Units	[ ]
Purpose Built Premises	[ ]
A I U's to tenant's specification	[ ]
Other (please state)	[ ]

....

PTO

4.1 Please give the approximate proportions in which the following procurement methods are used by your organisation (in terms of contract value) by means of a X on the appropriate scales

Design and Build/Construct or Package Deal

```
¦---------¦---------¦---------¦---------¦
0         25        50        75        100 %
```

Traditional (Design/tender/build)

```
¦---------¦---------¦---------¦---------¦
0         25        50        75        100 %
```

Other (please state) ....

```
¦---------¦---------¦---------¦---------¦
0         25        50        75        100 %
```

PTO

5.1 <u>Overleaf are a number of criteria which are commonly applied by clients of the building industry in assessing the performance of that industry</u>
<u>Please assign a rating to each of these criteria , by placing one tick in each row , based on your company's experience of the building industry and reflecting their importance to you in your approach to building procurement .</u>

PTO

	ESSENTIAL	PREFERRED	UNNECESSARY	NOT CONSIDERED
A Speed of the building process once the decision to invest has been made				
B Accuracy of the estimated construction time supplied by the building professional engaged for the project				
C Low Building costs (including fees)				
D Low Maintenance costs				
E Low Running costs				
F Accuracy of the original estimated cost supplied by the building professional engaged for the project				
G Architectural quality of the design solution				
H Functionality of the design solution				
J Confidence in the building contractor				
K Communications between you and the builder				
L Communications between you and the designer				
M Competitive tenders				

PTO

	ESSENTIAL	PREFERRED	UNNECESSARY	NOT CONSIDERED
O Comprehensive brief development prior to commitment to building				
P Capacity to make variations during construction				
R Flexibility for change or modification to the building sometime after completion				
S Use of standard building industry contract forms				
T A building professional who takes full charge of the DESIGN operations and who involves you only when absolutely necessary				
V A building professional who takes full charge of the CONSTRUCTION operations and who involves you only when absolutely necessary				
W Accurate predictions of cash flow commitments				
X Unitary responsibility for the design and construction processes				
Y Use of your own building contract				
Z Use of fixed price contract				
AA Your own criterion				

PTO

5.2 From the criteria on the previous page please rank the TEN most important criteria in the table in order of importance to your organisation .

i.e. if Low Building Cost is most important place letter C under 1 in the table .

Rank

1	2	3	4	5	6	7	8	9	10

Criterion

6.1 In your opinion , when compared to the Traditional approach , are premises procured by the Design and Build approach built ;

More quickly	YES / NO / SAME
More cheaply	YES / NO / SAME
Of a better quality	YES / NO / SAME

6.2 In your opinion , should contract documents specifically for INDUSTRIAL BUILDING projects be developed?

YES / NO

COMMENTS

Thank you for your attention
smr/683

IN CONFIDENCE

QUESTIONNAIRE SECTION 2

This section seeks data on completed projects in order to set up a database to compare different procurement approach outcomes . It would be helpful if you could complete this section as fully as possible, although partially completed returns may still be of use .

Please supply information for your most recently completed project (of the procurement type that you most regularly use - SECTION 1 Q 4.1)

Any additional comments that you care to make will be welcomed .

PROJECT DATA

All money value in Pounds Sterling

1.0 PLEASE STATE

1.1 CLIENT

1.2 ARCHITECT

1.3 CONTRACTOR

1.4 PROJECT

1.5 PURPOSE OF BUILDING

1.6 FLOOR AREA Sq m or Sq ft

1.7 YOUR ASSESSMENT OF THE COMPLEXITY OF THE PROJECT HIGH / MEDIUM / LOW

2.0

2.1 PROCUREMENT METHOD: (circle response)
TRADITIONAL / DESIGN & BUILD / MANAGEMENT CONTRACT / PROJECT MANAGEMENT / OTHER (please state) ....

2.2 BUILDER SELECTION:
OPEN TENDER / SELECT TENDER / TWO STAGE TENDER / FEE BASIS / NEGOTIATION / OTHER (please state) ....

2.3 CONTRACT FORM:
JCT 63 / JCT 80 / CLIENT'S OWN / CONTRACTOR'S OWN / OTHER (please state) ....

3.0 DURATION OF FOLLOWING STAGES IN WEEKS

	PROGRAMMED	ACTUAL
3.1 BRIEF DEVELOPMENT		
3.2 DESIGN PERIOD		
3.3 TENDER PERIOD		
3.4 CONSTRUCTION PERIOD		
3.5 DEFECTS PERIOD		

4.0 AUTHORISED TIME EXTENSIONS

4.1 TOTAL LENGTH IN WEEKS

4.2 TOTAL NUMBER

5.0 VALUE OF WORK AND DATE FIXED

	DATE	POUNDS
5.1 TENDERED / NEGOTIATED CONTRACT VALUE	....	....
5.2 FINAL ACCOUNT SUM	....	....
5.3 PROFESSIONAL FEES (state professions)	----	....
5.4 VALUE OF RETENTIONS	----	....

5.5 METHOD OF PAYMENT:
MONTHLY CERTIFICATION / STAGE PAYMENTS / MONTHLY LUMP SUM / ONE LUMP SUM / OTHER (please state)....................

6.0 VARIATIONS , ETC.

	POUNDS	
6.1 VALUE OF VARIATIONS-authorised by client	......	(+/-)
-other (please state)	......	
6.2 TOTAL NUMBER OF VARIATIONS	......	
6.2 TOTAL FLUCTUATIONS (rise & fall)	......	(+/-)
6.4 LIQUIDATED DAMAGES /week =	......	
Enforced?	Y / N	

COMMENTS

Thank you for your attention
smr/683

STEVE ROWLINSON

BRUNEL UNIVERSITY

CONSTRUCTION PROJECT QUESTIONNAIRE

smr11/84

THE CLIENT

COMPANY NAME ....

RESPONDENTS NAME ....

POSITION ....

Please circle the appropriate number.

C1 Is your company engaged in;

PURPOSE BUILDING	DEVELOPMENT	SPECULATIVE DEVELOPMENT
1	2	3

C2 Is your company a;

PUBLIC AUTHORITY	QUOTED CO./ COOP	UNQUOTED CO.
1	2	3

C3 Is your company;

PRINCIPAL UNIT	SUBSIDIARY	HEAD BRANCH	BRANCH
4	3	2	1

C4 When was the company formed ? ....

C5 When was the parent co. formed ? ....

C6 What was the company turnover in 1983-4 ? ....

C7 How many people do the company employ ? ....

C8 Is the company represented on the;

MAIN BOARD	OPERATING BOARD	NOT REPRESENTED	OTHER
			.....
3	2	1	

C9 Have you ever built before ? YES / NO

1 0

C10 How many buildings in the last 5 years ....

C11 Do you employ directly any building professionals ?

YES / NO

1 0

C12 How would you describe the production process that you employ (FOR THE CURRENT PROJECT)?

HIGH TECH	MASS	BATCH	ASSEMBLY	DISTRIBUTION
5	4	3	2	1

C13 How is the present project financed ?

OWN FUNDS	HOLDING CO FUNDS	SHARE ISSUE	OVERDRAFT	INSTITUTION FUNDING	CONTRACTOR FINANCE
6	5	4	3	2	1

If none please state other source ....

C14 Where did the decision to build originate ?

MAIN BOARD	OPERATING BOARD	DEPARTMENT	OTHER ....
3	2	1	

C15 Who authorised the decision ?

MAIN BOARD	OPERATING BOARD	OTHER ....
3	2	1

C16 Did you appoint a client representative ? YES / NO

1 0

C17 Was he assigned full-time YES / NO

1 0

C18 Where was he appointed from ?

MAIN BOARD	OPERATING BOARD	DEPARTMENT	EXTERNAL APPOINTEE	COMMITTEE SET UP
5	4	3	2	1

C19 How many people were authorised to instruct the building team ?

....

C20 How would you assess your company's involvement in;

CONCEPTUAL DESIGN

VERY HEAVILY INVOLVED	HEAVILY INVOLVED	MODERATELY INVOLVED	LIGHTLY INVOLVED	VERY LIGHTLY INVOLVED
5	4	3	2	1

C21 DETAIL DESIGN

VERY HEAVILY INVOLVED	HEAVILY INVOLVED	MODERATELY INVOLVED	LIGHTLY INVOLVED	VERY LIGHTLY INVOLVED
5	4	3	2	1

Note: a benchmark is that moderately involved = 1 manday/week

THE CONTRACTOR

COMPANY NAME ....

RESPONDENT'S NAME ....

POSITION ....

B1 Is your company a ;

PRINCIPAL UNIT	SUBSIDIARY	HEAD BRANCH	BRANCH
4	3	2	1

B2 How many people are employed by

THE COMPANY	THE GROUP
....	....

B3 What was the turnover in 1983-4 of

THE COMPANY	THE GROUP
....	....

B4 Is the company represented on;

MAIN BOARD	OPERATING BOARD	NOT REPRESENTED
3	2	1

B5 What percentage of your work is from repeat customers

0-25%	25-50%	50-100%
3	2	1

B6 Does one customer account for more than 10% of your turnover

YES / NO

0 1

B7 If yes, how much

0-10	10-30	30-50	more than 50%
4	3	2	1

B8 Circle those numbers describing work that you undertake

BUILDING	CIVIL ENGINEERING	REFURB	SYSTEM BUILDING	CERTAIN BUILDINGS ONLY ....
5	4	3	2	1

If other types of work, please state ....

B9 Please mark the areas in which your company works by a tick on the map overleaf.

B10 How many regional offices do you have ....

B11 TODAY, how many sites do you have in operation ....

B12 How many projects, of the type being used as the case study ,have you undertaken in the past 2 years

....

B13 What is the cumulative value of these

£...............

THE PROJECT

P1 Where is the project located

INNER CITY	GREENFIELD	ESTABLISHED INDUSTRIAL ESTATE
1	2	3

P2 How many distinct design organisations were involved in the design of the project (and subcontractors separately)?

....

P3 (.............)

P4 As design team leader how would you assess the TECHNICAL COMPLEXITY of the design?

VERY COMPLEX	QUITE COMPLEX	OF AVERAGE COMPLEXITY	QUITE SIMPLE	VERY SIMPLE
1	2	3	4	5

P5 What percentage of total cost is the M & E work.

100% 50% 0%

1____________________1____________________1

SUBCONTRACTORS
Please state the number and value of work for

P6 DOMESTIC number ....

P7 value £..............

P8 NOMINATED number ....

P9 value £..............

P10 As the client were the following constraints apparent at the outset of the work?

BUDGET

VERY LIMITED	QUITE LIMITED	ADEQUATE	MORE THAN ADEQUATE	UNLIMITED
1	2	3	4	5

P11 TIME SCHEDULE

VERY TIGHT	QUITE TIGHT	ADEQUATE	MORE THAN ADEQUATE	UNLIMITED
1	2	3	4	5

P12 QUALITY OF CONSTRUCTION

VERY DIFFICULT TO ATTAIN	DIFFICULT TO ATTAIN	ATTAINABLE	EASILY ATTAINABLE
1	2	3	4

BUILDING TEAM ORGANISATION / SELECTION

01 What form of building team organisation was used ?

PURE DB HYBRID DB DISPARATE DB MANAGEMENT TRADITIONAL

7 6 5 4 3 2 1

02 How was the builder selected ?

OPEN TENDER SELECT TENDER HYBRID NEGOTIATION

1 2 3 4

03 Were pre-selection interviews used to reduce the tender list ?

YES / NO

1 0

04 If yes, how many builders were seen ? ....

05 Which organisation lead the building team ?

BUILDER PROJECT MANAGER CLIENT QS ARCHITECT ENGINEER OTHER ....

6 5 4 3 2 1

06 How was the builder paid ?

FIXED PRICE FIRM PRICE TARGET PRICE GMP FEE BASIS COST PLUS OTHER ....

6 5 4 3 2 1

07 What criterion was used in selecting the builder ?

LOWEST COST	SHORTEST TIME	OTHER
1	2	3

Please give dates:

	PROGRAMMED	ACTUAL
A) INCEPTION	XXXXXXXX	....
B) BUILDING TEAM APPOINTED	XXXXXXXX	....
C) TENDER	....	....
D) SITE START	....	....
E) SITE COMPLETION	....	....
F) DEFECTS PERIOD ENDS	....	....

08 DESIGN TIME (C-A) PROGRAMMED ....

09 CONSTRUCTION TIME (E-C) PROGD ....

010 DESIGN TIME (C-A) ACTUAL ....

011 CONSTRUCTION TIME (E-C) ACTUAL ....

012 GROSS FLOOR AREA OF BUILDING ....SQ M

This question investigates the overlap between phases of the design and construction process. Please indicate by placing a circle under the letters the stages in which the builder had an input. Indicate with a triangle the overlap of phases D-F with G-K.

PHASE	A	B	C	D	E	F	G	H	J	K	L
			"A"					>|<	"B"		

OVERLAPS

Phases are taken from RIBA Plan of Work and are as follows:

A INCEPTION
B FEASIBILITY
C OUTLINE PROPOSALS
D SCHEME DESIGN
E DETAIL DESIGN
F PRODUCTION INFORMATION
G BILL OF QUANTITIES
H TENDER ACTION
J PROJECT PLANNING
K SITE OPERATIONS
L COMPLETION

An example is given below where production drawings were produced during construction and the builder provided an input to the scheme design.

A	B	C	D	E	F	G	H	J	K	L
							>|<			
			O						F Δ	

013 TOTAL OVERLAPS IN "A" ....

014 TOTAL OVERLAPS IN "B" ....

015 GRAND TOTAL OVERLAPS ....

CONTRACT ADMINISTRATION

A1 What contract form was used ?

JCT 63	JCT 80	JCT 81 (DB)	CLIENT'S OWN FORM	CONTRACTOR'S OWN FORM	OTHER ....
5	4	3	2	1	

A2 What form of tender document was used ?

BILL OF QUANTITIES	ELEMENTAL BILL	SPECIFICATION	OTHER ....
3	2	1	

A3 How complete were the accompanying drawings at the time of tender ?

VERY COMPLETE	QUITE COMPLETE	PARTIALLY COMPLETE	QUITE INCOMPLETE	VERY INCOMPLETE
5	4	3	2	1

Example: very incomplete drawings would consist of the sketchiest of outline drawings; very complete drawings would consist of a full set of working drawings which were only added to by revisions of existing drawings.

A1 What value, if any, was attaches to liquidated damages in the contract.

£ ..../wk

A5 Were liquidated damages invoked ?

YES / NO

0 1

A6 If YES, how many weeks or total sum £...............

A7 What time extensions were authorised?

	DUE TO CLIENT CAUSES	DUE TO BUILDING TEAM
NUMBER	A7	A8 ....
DAYS (TOTAL)	A9	A10 ....

A11 What was the tender sum ....

A12 What was the final account sum ....

A13 What percentage was retained ....%

A14 What separate fees were charged ....(total)

A16 What variations were ordered

	DUE TO CLIENT CAUSES	DUE TO BUILDING TEAM
NUMBER	A17..............	A18..............
VALUE (+/-)	A19..............	A20..............
TOTAL	A21..............(£)	A22..............(£)

BUILDING TEAM MANAGEMENT

M1 How involved was the builder in the design process during:

DESIGN

VERY HEAVILY INVOLVED	HEAVILY INVOLVED	MODERATELY INVOLVED	LITTLE INVOLVEMENT	NO INVOLVEMENT
5	4	3	2	1

M2 CONSTRUCTION

VERY HEAVILY INVOLVED	HEAVILY INVOLVED	MODERATELY INVOLVED	LITTLE INVOLVEMENT	NO INVOLVEMENT
5	4	3	2	1

M3 What percentage of work was designed by NOMINATED SUBCONTRACTORS (by value of work)

100% 0%

1________________________1___________________________1

M4 What percentage of work was designed by DOMESTIC SUBCONTRACTORS (by value of work)

100% 0%

1________________________1_________________________1

M5 Did cost planning take place ?

YES / NO

1 0

M6 Who undertook the planning ?

CONTRACTOR	CLIENT	ARCHITECT	QS	OTHER
				.....
1	2	3	4	

M7 Did cost monitoring take place ?

YES / NO

1 0

M8 Who undertook the monitoring ?

CONTRACTOR	CLIENT	ARCHITECT	QS	OTHER
				......
1	2	3	4	

M9 How often were cost monitoring reports prepared ?

QUARTERLY	MONTHLY	WEEKLY	DAILY	NOT AT ALL
1	2	3	4	0

M10 Was cost monitoring undertaken during

DESIGN	CONSTRUCTION	BOTH	NEITHER
1	2	3	0

M11 How was price estimating undertaken ?

BILL OF QUANTITIES	ELEMENTAL BILL	WORK PACKAGES	OTHER ....
3	2	1	0

M12 What form of scheduling was used ?

NONE	LINE OF BALANCE	BAR CHART	CRITICAL PATH	PERT
0	1	2	3	4

M13 How many site supervisory staff were employed ? ....

M14 How experienced was the chief supervisor / agent ? That is how many years of service has he had in such a post ?

....

M15 Is his background in one of the following areas ?

TRADESMAN	TECHNICIAN	GRADUATE
1	2	3

M16 What percentage on site operatives were directly employed by the contractor ?

0% 100%

1________________________1________________________1

ALL SUBCONTRACTORS ALL DIRECT LABOUR

M17 What percentage of the contract sum were PC sums at tender ?

100% 0%

1________________________1________________________1

M18 What percentage of the contract sum were provisional sums at tender ?

100% 0%

1________________________1________________________1

M19 What percentage of the contract sum were contingency sums at tender ?

100% 0%

1________________________1________________________1

The following questions require reference to the construction programme.

Total activities:

M20 Busiest 75% of work complete in ....%

M21 Busiest 50% of work complete in ....%

Activity starts:

M22 Busiest 75% ....%

M23 Busiest 50% ....%

M24 How would you, as the client, rate the technical expertise of

THE DESIGN TEAM

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M25 THE BUILDING TEAM

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M26 THE PROJECT MANAGER

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M27 How would you rate the administrative ability of

THE DESIGN TEAM

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M28 THE BUILDING TEAM

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M29 THE PROJECT MANAGER

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M30 What degree of uncertainty existed about the desired project

DURING DESIGN

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M31 DURING CONSTRUCTION

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M32 COMPARED TO AN AVERAGE PROJECT

VERY HIGH	HIGH	AVERAGE	LOW	VERY LOW
5	4	3	2	1

M33 How good were the communications between

CLIENT TO BUILDER

VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
5	4	3	2	1

M34 BUILDER TO CLIENT

VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
5	4	3	2	1

M35 CLIENT TO DESIGN TEAM

VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
5	4	3	2	1

M36 DESIGN TEAM TO CLIENT

VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
5	4	3	2	1

M37 DESIGN TEAM TO BUILDER

VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
5	4	3	2	1

M38 BUILDER TO DESIGN TEAM

VERY GOOD	GOOD	AVERAGE	POOR	VERY POOR
5	4	3	2	1

M39 How close was the client project manager to

CLIENT

VERY CLOSE	CLOSE	INTERMEDIATE	DISTANT	VERY DISTANT
5	4	3	2	1

M40 BUILDING TEAM

VERY CLOSE	CLOSE	INTERMEDIATE	DISTANT	VERY DISTANT
5	4	3	2	1

M41 THE SITE

VERY CLOSE	CLOSE	INTERMEDIATE	DISTANT	VERY DISTANT
5	4	3	2	1

E.G. very close is in the same building, very distant is more than two hours drive away.

M42 Please indicate your degree of satisfaction with the building in terms of:

TIMELY COMPLETION

VERY SATISFIED	SATISFIED	ACCEPTABLE	DISSATISFIED	VERY DISSATISFIED
1	2	3	4	5

M46 TOTAL COST OF CONSTRUCTION

VERY SATISFIED	SATISFIED	ACCEPTABLE	DISSATISFIED	VERY DISSATISFIED
1	2	3	4	5

M47 ITS PHYSICAL QUALITY

VERY SATISFIED	SATISFIED	ACCEPTABLE	DISSATISFIED	VERY DISSATISFIED
1	2	3	4	5

M48 AS SUITABLE FOR ITS INTENDED PURPOSE

VERY SATISFIED	SATISFIED	ACCEPTABLE	DISSATISFIED	VERY DISSATISFIED
1	2	3	4	5

M49 THE BUILDING METHOD CHOSEN

VERY SATISFIED	SATISFIED	ACCEPTABLE	DISSATISFIED	VERY DISSATISFIED
1	2	3	4	5

CLIENT TEAM

M50 Was one person made responsible for coordianating the client project team?

YES / NO

1 0

M51 Was this person responsible for calling and chairing these meeings?

YES / NO

1 0

M52 Were meetings held on a regular basis throughout the project?

YES / NO
1 0

BUILDING TEAM

M53 Was one person made responsible for coordianating the client project team?

YES / NO

1 0

M54 Was this person responsible for calling and chairing these meeings?

YES / NO

1 0

M55 Were meetings held on a regular basis throughout the project?

YES / NO
1 0

DESIGN TEAM

M57a Were you familiar with the type of work being undertaken, that is, had you ever undertaken such a project before?

NEVER	OCCASSIONALLY	SOMETIMES	OFTEN	REGULARLY
1	2	3	4	5

M58a Had you ever worked with this client before?

NEVER	OCCASSIONALLY	SOMETIMES	OFTEN	REGULARLY
1	2	3	4	5

M59a Had you ever worked with the construction team before?

NEVER	OCCASSIONALLY	SOMETIMES	OFTEN	REGULARLY
1	2	3	4	5

BUILDING TEAM

M57b Were you familiar with the type of work being undertaken, that is, had you ever undertaken such a project before?

NEVER	OCCASSIONALLY	SOMETIMES	OFTEN	REGULARLY
1	2	3	4	5

M58b Had you ever worked with this client before?

NEVER	OCCASSIONALLY	SOMETIMES	OFTEN	REGULARLY
1	2	3	4	5

M59b Had you ever worked with the construction team before?

NEVER	OCCASSIONALLY	SOMETIMES	OFTEN	REGULARLY
1	2	3	4	5

AVERAGE M57	1	2	3	4	5
AVERAGE M58	1	2	3	4	5
AVERAGE M59	1	2	3	4	5

Appendix 2

Case Studies

CASE STUDY SUMMARIES - PHASE III

Case Number:1

Client: A major paperback publishing company who required to rationalise their storage facilities onto one site. The company had built previously but not recently. The idea originated with the present site manager.

Project: A new storage and distribution warehousewas to be built next to the existing warehouse and was to have installed the latest stock control systems requiring a floor laid to very tight tolerances. The building was steel-framed and brick clad and specialist materials handling consultants were engaged in design.

Tender value: #1428,000 Overrun: 5%

Area: 5574sq m #/sq m : 256.19

Design period: 78weeks Overrun: 11%

Start on site: February 1984

Constn period: 35weeks Overrun: -24%

Procurement Form: DESIGN BUILD
Details

The contractor was a local firm which had been expanding quite rapidly and looking to increase its workload in the design build market. Four companies were invited to tender for the works, although the original tender submitted in August was revised in the light of changes required for planning permissions from local authorities and the DoE. The construction period was telescoped from 12 months to less than 43 weeks to meet a need to transfer all stock during the Christmas holiday period.

Case Number:2

Client: A large, long-established property developer dealing in the industrial sector but diversifying recently into commercial and retail sectors. The company has vast experience of construction and does undertake some construction work itself. It employs a large number of building industry professionals and the director is of the opinion that "Architects are not trained to manage and should not attempt to do so!"

Project: The development was originally planned as two advanced industrial units but was pre-let part way through the contract to an airline to be used as a flight simulator. This required a number of changes to the design whilst work was continuing on site.

Tender value: #1834,000 Overrun: -11%

Area: 6140sq m #/sq m : 298.70

Design period: 6weeks Overrun: 0%

Start on site: June 1980

Constn period: 47weeks Overrun: 0%

Procurement Form: TRADITIONAL
Details

The client has a wealth of experience to draw on and so was able to get work started on site within 6 weeks of starting detailed design. Outline planning permission had already been obtained and the contractor was selected from four on a competitive bill of rates. The contractor was a regional company of a national contracting organisation and had good working relationships with the client. Despite a very short pre-design period the project was completed on time with little difficulty; it must be pointed out that the building was a fairly simple steel-framed steel-clad 'shed'.

Case Number:3

Client: A small, plastics manufacturer employing about 50 people requiring a new plastic sheeting production facility. The client had never built before.

Project: The building was erected on an existing production area and so the client was in close proximity to the construction work. The building's complexity came from the plant installation, the structure itself was a straightforward steel frame with metal cladding.

Tender value: #360,000 Overrun: 4%

Area: 2370sq m #/sq m : 151.90

Design period: 8weeks Overrun: -27%

Start on site: May 1981

Constn period: 26weeks Overrun: 0%

Procurement Form: TRADITIONAL
Details

The contractor was chosen by select tendering from six and was chosen on the basis of lowest cost. The company came from outside the region and were classed as a small contracting organisation. A comparatively simple project was complicated by the client M.D. changing his mind a number of times on internal equipment, thus affecting below floor service intakes. As a consequence seven day working was required to maintain the programme.

Case Number:4

Client: A large property development and management company employing nearly 400 people. The company employs its own architects and engineers but in recent years has let 75% of its work on a design build basis.

Project: The project consisted of seven large factory units in Greater London for mixed factory and warehouse use. Little of the space was pre-let so there were a number of provisional items in the contract.

Tender value: #1096,000 Overrun: -2%

Area: 6300sq m #/sq m : 173.97

Design period: 17weeks Overrun: 0%

Start on site: September 1979

Constn period: 43weeks Overrun: 0%

Procurement Form: DESIGN BUILD
Details

This experienced client determined to negotiate directly with one of the largest, well-established design build contractors. The client, as usual, had developed an outline scheme and obtained planning permission; the contractor in effect was involved in 'deveolpment and construction', although complete design services were well within his capabilities. An amended version of the contractor's own form of contract was used. The cost under-run was due almost exclusively to non-expenditure of provisional bill items.

Case Number:5

Client: A medium sized property development company involved in the commercial and industrial fields having a number of architects and project managers on the pay-roll. Company policy is to commission all work on the traditonal basis once the in-house team has produced an acceptable scheme. Tight progress control is maintained through the project managers.

Project: The project was made up of three large warehousing units of different sizes on a Bedfordshire industrial estate. The completion of the units was to be phased and linked to lettings.

Tender value: #1,554,000 Overrun: -8%

Area: 12000sq m #/sq m : 129.50

Design period: 18 weeks Overrun: 0%

Start on site: March 1982

Constn period: 60 weeks Overrun: 46%

Procurement Form: TRADITIONAL
Details

The contract was let on a select tender basis to the lowest tenderer of six contractors, a London-based subsidiary of one of the country's largest contracting groups. The JCT '63 contract was adopted and the contract ran smoothly; the cost reductions were due to non-expenditure of contingency items and client variations due to the units not being let on completion. This vacancy led to slowing of the works during the last quarter as the client was in no undue hurry to achieve completion!

Case Number:6

Client: A large vehicle body manufacturing company employing over two thousand workers and formed in 1923. The company had built before but not recently. Part of a larger group, the company has gone into liquidation since the completion of the project.

Project: A new manufacturing facility was to be built to cater for increased production and a new product line. The design and construction of the facility was of above average complexity due to the nature of the manufacturing process and the form of contract chosen.

Tender value: #1,453,000 Overrun: -10%

Area: 5680sq m #/sq m : 255.81

Design period: 9weeks Overrun: -25%

Start on site: January 1980

Constn period: 52weeks Overrun: 0%

Procurement Form: MANAGEMENT
Details

The client was very heavily involved in conceptual and detail design work and the architect recommended adopting an alternative method of management approach to the letting of the contract. A general contractor was appointed, from a list of six, to undertake all general work and attendances and fourteen separate trade contracts were let under the supervision and management of the architect. Despite tight cost and time budgets the works were completed on time and within budget. Savings were made mainly on the estimates for the bid packages which the architect let separately.

Case Number:7

Client: A major national retail outlet with a continuous building programme of about eight major new facilities per year. A separate company has been set up within the group, staffed by only six people, to locate and develop sites with considerable freedom and discretionary authority to expedite works.

Project: A major new cold store was required to supply the burgeoning South-Eastern food market and it was decided to locate this on an existing site near headquarters. Consideration had to be given to distribution and material-handling problems as well as the technical aspects of cold store operation.

Tender value: #2,687,000 Overrun: 1%

Area: 6600sq m #/sq m : 407.12

Design period: 3weeks Overrun: 0%

Start on site: February 1984

Constn period: 35weeks Overrun: 0%

Procurement Form: MANAGEMENT

Details

The client has a policy of letting almost all its construction work to a well-known market-leader in management contracting. This contractor keeps an in-house team specifically allocated to the client's works; care is taken to ensure that this team is independent of and quite separate from other teams working on a similar basis for competitor clients. The contract was let on a negotiated fee basis and design was undertaken by an architect with whom both client and contractor had worked often. Works were completed to time and budget: site visits confirmed the stringent quality control applied by the managing contractor to all subcontractors, a feature which evidently impressed the client greatly.

Case Number:8

Client: The Valuation & Estates Dept of a large Metropolitan Authority engaged in industrial development in an attempt to stimulate industrial regeneration. The officers were commissioned to locate sites and produce viable development proposals, for mainly small business accomodation, and then build and let the proposed premises. Considerable lattitude was allowed in the choice of procurement form in an attempt to achieve value for money. All proposals and contracts had to be approved by relevant Council Committees.

Project: A number of small Advance Industrial Units were to be built in a run-down inner city area. Some of the units were pre-let but the majority were not. They ranged from 250 sq m downwards in size.

Tender value: #543,000 Overrun: 0%

Area: 1500 sq m #/sq m : 362.00

Design period: 69weeks Overrun: 33%

Start on site: January 1984

Constn period: 30weeks Overrun: 0%

Procurement Form: DESIGN BUILD
Details

The design work was undertaken by a private Architect under the supervision of the contractor who won the design build contract in select competition with four others. This was an example of the disparate design build approach, the contractor having very little in-house capacity for design work and employing a professional, with whom he had a long-standing relationship on a 'no job, no fee' basis. The contractor was the London & South-East Division of a major U.K. contractor and had worked with the client before and had previous experience of similar design build contracts. Major design delays were caused by a Council directive on the use of asbestos cement which caused considerable redesign, delays on approving tenders and planning problems.

Case Number:9

Client: The Engineering Services and Research Division of a major International oil production and processing company. This division alone employs 1750 people and has its own Estates Branch to maintain and procure premises. The branch has overseen production of seven facilities during the past five years.

Project: This highly complex project centred on the construction of a laboratory for research into organic chemistry. This highly serviced laboratory contained 56 sophisticated fume cupboards and numerous industrial gas line installations. This sophistication was reflected in the cost of the premises.

Tender value: #1,860,000 Overrun: 11%

Area: 1768sq m #/sq m : 1052.04

Design period: 39weeks Overrun: 0%

Start on site: September 1981

Constn period: 56weeks Overrun: 0%

Procurement Form: TRADITIONAL
Details

The contract was let to one of the country's largest contractors through select competitive tender, five tenderers being invited. Unusually, the contract was let on a fluctuating price basis which accounted for over 60% of the increased costs. Brief taking was done in house by the client's staff of architects and building service engineers but design was undertaken by private architects and engineers with whom the client had a long-standing relationship. The chief architect was of the opinion that such a complex building needed very careful control at all stages and thus considered the design build path unsuitable - he knew of no company with the expertise to cope with such a project.

Case Number: 10

Client: A jointly-owned subsidiary company of a brewing company and a freight distribution company. The subsidiary was founded in 1982 to cope with an increasing workload and employs 250 people. The joint-ownership has not been a hindrance to decision making so far, both boards being fairly dynamic and giving the operating companies board a good deal of discretion.

Project: On formation of the new company it was deemed necessary to rationalise the seven existing sites onto two new sites. This particular project was the company's North London depot, on the site of an old railway siding, a striking building providing a high bay warehouse for storing and delivery of beers with high specification flooring and computerised stock control

Tender value: #3,472,000 Overrun: 14%

Area: 9383sq m #/sq m : 370.03

Design period: 25weeks Overrun: 92%

Start on site: April 1983

Constn period: 39weeks Overrun: 0%

Procurement Form: DESIGN BUILD

Details

Time was an important factor in this project. A previous scheme for the site, already designed and with institutional funding, could not be guaranteed to be complete in time and had to be unhooked and the new scheme built by a deadline set for vacant possession of the seven existing sites. Having had problems with the traditional approach in constructing the other new distribution centre the client opted for direct negotiation with a small design build company based in Bristol. Negotiations in taking over the previous architectural scheme caused some design delays but the building was completed in time to meet the deadline. The client M.D. praised highly the positive nature of consultations with the design builders compared with the adversarial approach of the participants in the traditional contract.

Case Number:11

Client: A small electronics company, founded in 1974 and based in the North West, which designs and manufactures microprocessors for energy consumption management in buildings. Much time is spent on design and customer support and production is undertaken in a clean environment by a relatively small number of people.

Project: The building had to act as an office, showroom, factory, laboratory and training centre. It also had to have a striking appearance in order to project the image of good design and permanence that the client required. Not a typical industrial building!

Tender value: #586,000 Overrun: 13%

Area: 2087sq m #/sq m : 280.79

Design period: 25weeks Overrun: 9%

Start on site: November 1981

Constn period: 49weeks Overrun: 23%

Procurement Form: TRADITIONAL

Details

An architect was appointed to lead this project and set about producing an impressive building but time and cost controls were poor. Many variations were initiated, often originating with the architect or consultants. A local contractor was selected in competition with five others and, although expressing reservations about the final cost, the client was very satisfied with the design and functional performance of his building.

Case Number:12

Client: A national cooperative operating in the dairy industry. The client employs an architects division which has recently been decentralised. The client has considerable building experience and maintains a substantial and continuous building and development programme.

Project: An extension to an existing foodstore at a depot in the North West of England. The project is fairly complex as the storage facility and handling equipment have to maintain a delicate product in good condition.

Tender value: #508,000 Overrun: 1%

Area: 759sq m #/sq m : 669.30

Design period: 24weeks Overrun: 0%

Start on site: November 1982

Constn period: 25weeks Overrun: 0%

Procurement Form: TRADITIONAL
Details

A small contractor, based in the South Midlands, was chosen for the project by select competition among five tenderers. The client organisation did all the design work although external consultants, structural engineer and quantity suveyor, were employed. The facility was completely designed and detailed before construction but a small number of changes were made once the contract was under way. The site and ground conditions were well known as other buildings had been erected on the site.

Case Number:13

Client: A large confectionery manufacturing company employing over 20,000 people on a number of sites. Architects are employed by the company which has built twice before in the past five years. Company policy is for one person only to follow the project from design to completion and operation.

Project: A distribution depot of moderate complexity in the North East of England. The Distribution Engineering Manager was put in charge of the project from the outset, he was appointed full-time and had been the source of the original idea to build.

Tender value: #725,000 Overrun: 6%

Area: 2840sq m #/sq m : 255.28

Design period: 27weeks Overrun: 0%

Start on site: April 1980

Constn period: 39weeks Overrun: 0%

Procurement Form: DESIGN BUILD
Details

A design build contractor from Scotland (part of a national group) was appointed after a select competition between three rival contractors. The contractor did not have adequate in-house design capability, he employed consultants to undertake much work for him. The only extra fees paid by the client were to a civil engineer for soil surveys but a number of variations, which cost the client money, were initiated by the builder. Client variations were instigated from a number of sources, a point of contention as far as the client representative was concerned.

Case Number:14

Client: The industrial development committee of a London Borough engaged in building on an industrial estate in collaboration with a local development company and architects. Thirteen units had already been put up on this particular estate; the client body had a mainly overseeing role, ensuring that the developments met Council guidelines.

Project: Two buildings for storage and distribution of newspapers and periodicals on an existing estate. The project had been pre-let to a major retailer who intended to move from unsuitable premises locally.

Tender value: #788,000 Overrun: 0%

Area: 1505sq m #/sq m : 523.59

Design period: 61weeks Overrun: 17%

Start on site: March 1984

Constn period: 32weeks Overrun: 0%

Procurement Form: TRADITIONAL
Details

The private developer-architect had produced a detailed scheme after protracted negotiations with the intended tenant and this was put to seven contractors on a select tender basis. A local firm, a large subsidiary of a major national group, won the contract and progress was relatively trouble free apart from redoing some work due to mis-reading of the contract drawings. The tenant did instigate a number of variations.

Case Number:15

Client: A medium-sized pharmaceutical company which has built a number of facilities over the past five years. The company does not employ any building professionals of its own but construction work is entrusted to the regional engineering manager.

Project: A major new production facility was to be produced with a number of state of the art facilities incorporated. This did create problems as specification changes were made during construction.

Tender value: #1830,000	Overrun: 24%
Area: 2080 sq m	#/sq m : 879.81
Design period: 28weeks	Overrun: 0%
Start on site: February 1983	
Constn period: 104weeks	Overrun: 21%

Procurement Form: DESIGN BUILD
Details

The contractor was one of the major companies specialising in both design build and high technology production facilities. Specification was undertaken in conjunction with the regional engineering manager and construction work commenced when most drawings were only at a sketch design stage. The contractor employed the company's standard cost control procedures but these could not prevent the large overruns due, in part, to changing specifations and requirements.

Case Number: 16

Client: A major pharmaceutical foundation employing over 7,000 people having in-house building professionals and a record of building many projects in the recent past which had been completed successfully.

Project: A major new high technology production facility on a completely new site. The work is highly complex and involved production of clean areas requiring high levels of servicing. The products are low volume, high value articles.

Tender value:	#3100,000	Overrun:	0%
Area:	6150sq m	#/sq m :	504.07
Design period:	45weeks	Overrun:	29%
Start on site:	June 1981		
Constn period:	76weeks	Overrun:	6%

Procurement Form: DESIGN BUILD

Details

The contractor selected, in competition with three others, was one of the larger general contractors which had set up a division to deal with alternative procurement methods, i.e. design build and management contracting. Specification and general arrangement details were provided by the client and tenders were assessed based on outline drawings and payment was agreed on a fee basis.

Case Number: 17

Client: A major national dairy products company with manufacturing and storage facilities throughout the country. The company has its own building professionals and has extensive experience in construction. A building project manager was appointed to oversee the project.

Project: A regional dairy product storage facility on an established industrial estate. Obviously, special attention had to be paid to the refrigeration and hygiene aspects of this project thus making the project quite complex.

Tender value: #2000,000 Overrun: 0%

Area: 1440sq m #/sq m : 1388.9

Design period: 4weeks Overrun: 0%

Start on site: June 1983

Constn period: 44weeks Overrun: -15%

Procurement Form: MANAGEMENT
Details

One of the larger medium-sized building contractors with a specialised projects group dealing with design build and management projects. The contract was negotiated through the company's marketing manager. The contractor worked closely with the architect appointed by the client and with the client's project manager to achieve good performance on budget (target estimate) and schedule.

Case Number: 18

Client: The Valuation & Estates Dept of a large Metropolitan Authority engaged in industrial development in an attempt to stimulate industrial regeneration. The officers were commissioned to locate sites and produce viable development proposals, for mainly small business accomodation, and then build and let the proposed premises. Considerable lattitude was allowed in the choice of procurement form in an attempt to achieve value for money. All proposals and contracts had to be approved by relevant Council Committees.

Project: Addition of over 3000 sqm of industrial units to an established industrial estate in the Northern part of a major city. This space comprised a variety of sizes of unit to cater for new and expanding local industry. Some units were pre-let but the majority were not.

Tender value: #952,000 Overrun: 0%

Area: 3352sq m #/sq m : 284.01

Design period: 44weeks Overrun: 2%

Start on site: November 1983

Constn period: 53weeks Overrun: 51%

Procurement Form: DESIGN BUILD

Details

The contractor, appointed in competition with three others, was a rapidly expanding organisation (TO #60M) with a work concentration in the South of England. The company had undertaken little design build work in the past and, at the time of this contract, the design build team consisted of the marketing director (a Civil Engineer) and the managing director for the local region. This limited experience, and desire to break into a different market sector from general contracting, made for a particularly difficult project which overran badly on time and was the subject of extensive, unsuccessful claims for extensions of time. Personality clashes, between the MD and Chief Surveyor, were a contributory factor in this case.

Case Number: 19

Client: A small but rapidly expanding company dealing in the design and assembly of instruments using the latest micro-electronic components. The company has just gone public and is expanding into a new production facility from a nearby industrial unit. The company has never built before and the maintenance engineer has been given the task of dealing with the building industry.

Project: The building is located on a greenfield site within two miles of the existing premises. The production area is fairly conventional with many individual assembly stations and a few more sophisticated manufacturing stations. No special environmental constraints apply other than the need to cope with a large amount of heat generation. Offices and reception area within the building are to be of a high standard.

Tender value: #1200,000 Overrun: 2%

Area: 4645sq m #/sq m : 258.34

Design period: 42weeks Overrun: 250%

Start on site: October 1978

Constn period: 50weeks Overrun: -11%

Procurement Form: DESIGN BUILD
Details

One of the smaller, local design build and industrial building specialists was appointed to undertake the building works. Originally, institution funding had been arranged for the project but this had caused a number of design constraints. The contractor produced an alternative design within 6 weeks but then followed a protracted period of negotiation and finally unhooking of the institutional funds from the project. The client was very pleased with the final result despite roof and drainage problems which were eventually remedied at no cost to the client by the contractor who placed great emphasis on after service.

Case Number: 20

Client: A large dairy product firm (TO >#300M) supplying a number of major high street retail organisations with in-house engineering staff specialising in plant rather than building design. The company has built in the past and is very experienced at dealing with the construction industry.

Project: A major new facility required to produce a high quality product for the nation's leading high street retail store. The building specification was to a high quality and the time scale very tight as the client's target date could not be missed as large penalties would accrue.

Tender value: #,000 Overrun: 0%

Area: 3208sq m #/sq m :

Design period: 30weeks Overrun: 131%

Start on site: March 1984

Constn period: 48weeks Overrun: -26%

Procurement Form: DESIGN BUILD

Details

The leading, long-established management contracting organisation undertook this contract on a design build basis (fee payment) at the request of the client who required single point responsibility to ensure an appropriate design and adherence to time schedule. Design was protracted with many meetings between the contractor and architect (appointed by the client but responsible to the builder) and planning permission delays but the time lost here was made up on site through careful scheduling, overlapping of design and construction and the input of the builder during design.

Case Number: 21

Client: A small printing company outside London wishing to move from existing, leased property to their own site adjacent to the old building. The company had never built before and the two directors of the company took it on themselves to oversee the building project.

Project: The new building was a steel framed production building on the site of a smaller, now demolished, property within an established industrial estate. The production area was at ground level with offices and facilities at ground and mezzanine levels. The structure was founded on bored piles.

Tender value: #669,000 Overrun: -100%

Area: 2800sq m #/sq m : 238.93

Design period: 39 weeks Overrun: 50%

Start on site: February 1984

Constn period: 54weeks Overrun: 32%

Procurement Form: TRADITIONAL
Details

The contractor was a subsidiary company of one of the nation's three largest building groups and the architects were a small local practice. builder's appointment was by select tender and extensive use was made of subcontracting , as is common in this area. Major problems arose in construction on the discovery of buried oil tanks beneath the proposed site whilst piling was underway. This was the major cause of delay and the architect accepted responsibility for the non-discovery of this obstruction prior to construction. The knock-on effect of the delay was mitigated as far as possible by the builder.

Case Number: 22

Client:	A property develoment company specialising in industrial buildings with ample experience of construction in this city. Outline planning permission and minimal architectural work were undertaken by a practice with whom the company had worked previously.
Project:	Two almost identical blocks of industrial units of varying size with a minimum of services and facilities. Maximum possible coverage was made of this site on an existing industrial estate.

Tender value:	#1541,000	Overrun:	4%
Area:	4880sq m	#/sq m :	315.78
Design period:	16weeks	Overrun:	100%
Start on site:	February 1981		
Constn period:	43weeks	Overrun:	8%
Procurement Form:	DESIGN BUILD		

Details

The builder was the regional divison of a major national company and this was one of their early attempts at design build construction. An architect was engaged on a no job, no fee basis to prepare outline drawings at tender and complete drawings once the contract was awarded during a two stage tender process (followed by renegotiation, hence the overrun). The builder had worked with this architect previously and was confident that an economic design would be produced.

Case Number: 23

Client: A local brewery requiring additional production and storage facilities at their main site. The company had previous building experience and a working relationship over many years with a local architectural practice. A senior surveyor, head of the breweries estates department, oversaw the financial aspects of the project.

Project: Additional production and storage facilities on an inner city site. The project was not particularly complex, about 25% of the tender value was tied up in M & E works.

Tender value:	#760,000	Overrun:	5%
Area:	4391sq m	#/sq m :	173.08
Design period:	58weeks	Overrun:	29%
Start on site:	March 1983		
Constn period:	52weeks	Overrun:	8%

Procurement Form: TRADITIONAL
Details

A local builder was appointed to construct the works, being chosen in select tender. Over 40% of the value of the contract was in nominated subcontracts which, as might be expected, lead to time and cost overruns. The project was not urgent, as can be deduced from the more than adequate time allotted to design and construction. The need to continue production on the site whilst construction took place did dictate the pace of construction to a large extent.

Case Number: 24

Client: The Development Committee of a local district council engaged on one of a small number of capital projects.

Project: The project was funded by a financial institution and comprised a number of industrial units on an existing industrial estate.

Tender value: #567,000 Overrun: 0%

Area: 2782sq m #/sq m : 203.81

Design period: 52weeks Overrun: 0%

Start on site: September 1979

Constn period: 52weeks Overrun: 0%

Procurement Form: DESIGN BUILD
Details

A local builder was engaged on a design build basis and design work was undertaken by a local architectural practice. The work was won in open competition and is a good example of the disparate (fragmented) approach to design build.

Case Number: 25

Client: The U.K. subsidiary of a top Japanese producer of electrical goods and home appliances. This company had already built on a number of occasions in the U.K. and had a policy of allowing the appointed installation manager to oversee construction works.

Project: The company's central distribution depot for the U.K.. The brief for the automatic warehousing was devised by a materials handling consultant and the scope of the project was widened during this process as the centre became a national, rather regional, depot in the firm's changing distribution strategy.

Tender value: #5870,000	Overrun: 4%
Area: 17130 sq m	#/sq m : 342.67
Design period: 19weeks	Overrun: 0%
Start on site: August 1983	
Constn period: 55weeks	Overrun: 6%

Procurement Form: DESIGN BUILD
Details

The leading design build and industrial process company in the U.K. entered into direct negotiations with the client project manager and were awarded the contract on a very tight overall schedule. The company's top executives made a point of becoming involved in this prestigous project and the firm's top site and professional staff were assigned to the project. The guaranteed maximum price form of payment was used.

Case Number: 26

Client: A subsidiary company of a large group, this firm produces EDM equipment and, thanks to dynamic management from its MD, requires new production facilities after almost going to the wall six years previously.

Project: New production facilities at the site of the existing factory. Due to the nature of the product these facilities are to a higher specification than is common with most industrial producers.

Tender value: #1540,000 Overrun: 12%

Area: 4087sq m #/sq m : 376.80

Design period: 16weeks Overrun: 0%

Start on site: February 1984

Constn period: 56weeks Overrun: 8%

Procurement Form: TRADITIONAL

Details

The contract was let to a medium sized design build company by negotiation. The original intention had been to refurbish the existing premises but the design build marketing director suggested that purchase of an adjacent site and new build would be economically more sound. This suggestion, and the desire of the MD to have single point responsibility, clinched the contract. Problems with watertightness did arise on completion however and took many months to resolve. German subcontractors were blamed for the poor performance but this buck-passing was not what the MD required of design build!

Case Number: 27

Client: A world leader in micro-electronics, telecommunications and defence systems, this company has built many times and uses its own project managers to monitor projects. These managers may come from any discipline, but not construction.

Project: A new office and development complex on a huge existing site within the inner city. The building was to be of above average quality and house groups relocating from dispersal all over the existing site.

Tender value: #2635,082 Overrun: 6%

Area: 3,800 sq m #/sq m : 693.44

Design period: 48 weeks Overrun: 37%

Start on site: September 1984

Constn period: 48 weeks Overrun: 0%

Procurement Form: DESIGN BUILD
Details

The builder was a specialist design build company which won the contract in select competition with four other bidders. The client required single point responsibility and was against the fragmented form of design build as he saw "too many fingers in the pie". On the other hand, the client project manager did not want the builder to completely control the process, he required to have an input. The encouragement of this client input clinched the project for the chosen company.

MEASURE	MEAN	STD DEV	MAXIMUM	MINIMUM	UNITS
TOTAL COST	1926	1384	6721	438	£(,000)
AREA	4653	3568	17130	759	Sq M
COST PER SQ.M.	511	381	1585	141	£/Sq M
TIME: Construction	48	16	104	25	Weeks
Pre-construction	29	20	78	3	Weeks
OVERRUNS: TIME Construction	+5.9	18	+51	-27	%
Pre-construction	+27.5	58	+250	-26	%
COST	+4.7	8	+24	-11	%

Summary Statistics, Phase III

CASE STUDY SUMMARY - PHASE II

CASE	PROCTYP	PRESITE TIME (weeks)	SITE TIME (weeks)	PRE-SITE OVERRUN	SITE OVERRUN	AREA (sq m)	TENDER [1985i] (#000)	COST OVERRUN
1	DESIGN BUILD	78	35	1.11	0.76	5574	1499	1.05
2	TRADITIONAL	6	47	1.00	1.00	6140	1981	0.89
3	TRADITIONAL	8	26	0.73	1.00	2370	400	1.04
4	DESIGN BUILD	17	43	1.00	1.00	6300	1469	0.98
5	TRADITIONAL	18	60	1.00	1.46	12000	1756	0.92
6	MANAGEMENT	9	52	0.75	1.00	5680	1744	0.90
7	MANAGEMENT	3	35	1.00	1.00	6600	2821	1.01
8	DESIGN BUILD	69	30	1.33	1.10	1500	570	1.10
9	TRADITIONAL	39	56	1.00	1.00	1768	2102	1.11
10	DESIGN BUILD	25	39	1.92	1.00	9383	3750	1.14
11	TRADITIONAL	25	49	1.09	1.23	2087	668	1.13
12	TRADITIONAL	24	25	1.00	1.00	759	554	1.01
13	DESIGN BUILD	27	39	1.00	1.00	2840	783	1.06
14	TRADITIONAL	61	32	1.17	1.00	1505	827	1.00
15	DESIGN BUILD	28	104	1.00	1.21	2080	2013	1.24
16	DESIGN BUILD	45	76	1.29	1.06	6150	3441	1.00
17	MANAGEMENT	4	44	1.00	0.85	1440	2180	1.00
18	DESIGN BUILD	44	53	1.02	1.51	3352	1038	1.00
19	DESIGN BUILD	42	50	3.50	0.89	4645	2280	1.02
20	DESIGN BUILD	30	48	2.31	0.74	3208	*	1.00
21	TRADITIONAL	25	54	1.00	1.32	2800	702	1.00
22	DESIGN BUILD	16	43	2.00	1.08	4880	1757	1.04
23	TRADITIONAL	58	52	1.29	1.08	4391	828	1.05
24	DESIGN BUILD	19	55	1.00	1.00	17130	6398	1.04
25	DESIGN BUILD	16	56	1.00	1.06	4087	1617	1.12
26	TRADITIONAL	73	56	1.46	0.58	2676	983	1.19
27	TRADITIONAL	29	38	1.00	1.09	3136	998	0.94
28	TRADITIONAL	40	73	1.11	1.04	14000	5400	1.16
29	TRADITIONAL	30	55	1.00	1.17	10217	2740	1.01
30	TRADITIONAL	22	52	1.00	1.00	4273	1164	1.00
31	TRADITIONAL	24	44	1.00	1.10	3000	1332	1.04
32	TRADITIONAL	24	30	1.00	1.05	5420	698	1.00
33	DESIGN BUILD	8	28	1.00	0.80	1208	382	1.00
34	MANAGEMENT	9	26	0.75	1.44	1765	94	1.33
35	DESIGN BUILD	7	40	1.00	1.11	745	191	1.05
36	TRADITIONAL	41	39	1.00	1.00	825	234	0.87
37	TRADITIONAL	15	28	1.36	1.12	139	44	1.08
38	TRADITIONAL	17	28	1.21	1.08	1100	229	1.01
39	DESIGN BUILD	10	20	1.00	1.00	1500	243	1.00
40	MANAGEMENT	14	36	*	1.10	8333	1944	0.95
41	MANAGEMENT	10	92	*	1.00	23148	11742	1.00
42	MANAGEMENT	9	68	*	1.00	5500	5198	1.00
43	MANAGEMENT	16	74	*	0.90	6000	8100	1.00
44	MANAGEMENT	12	52	*	1.03	6000	3675	1.00
45	MANAGEMENT	10	70	*	*	5600	3150	1.00
46	DESIGN BUILD	42	52	1.17	1.18	3060	612	*
47	DESIGN BUILD	48	48	1.37	1.00	3600	2460	1.06

Appendix 3

Scales

SCALES

These scales are used in Phase III of the research process and have been developed from the questionnaire responses. The relevant questions in Questionnaire 3 are noted opposite the variable names.

The comment ordinal indicates that the values for the variable under consideration have been converted to an ordinal scale (1 to 5 in most cases). Generally this was based around the even-numbered deciles for the distribution of the variable. Reversed indicates that the scale values for a variable have simply been reversed i.e. 1 => 5; 2 => 4, etc..

Client Complexity

This scale is composed of three components:

devtype	C1
number	C12
prodpro	C19

The scale measures the complexity of the client organisation in terms of its production process, the eventual user of the building and the number of people empowered to instruct the building team.

CLIENT COMPLEXITY - CLICOMP

ROW	prodpro	number	devtype	CLICOMP
1	1	1	1	3
2	3	1	1	5
3	1	1	3	5
4	3	1	2	6
5	3	3	1	7
6	1	2	3	6
7	1	1	1	3
8	2	3	2	7
9	1	1	5	7
10	1	2	1	4
11	1	2	2	5
12	1	1	5	7
13	1	1	1	3
14	2	1	1	4
15	1	1	5	7
16	1	4	5	10
17	1	1	5	7
18	2	2	2	6
19	1	1	3	5
20	*	*	*	*
21	1	2	3	6
22	3	2	1	6
23	1	1	3	5
24	2	3	1	6
25	1	1	3	5
26	1	1	3	5
27	1	1	5	7

Correlation Coefficients

	prodpro	number	devtype
number	.219		
devtype	-.247	-.131	
CLICOMP	.465	.646	.496

Client Dependency Scale

The components of this scale are:

cotype	C2
codep	C3
corep	C8
finance	C13
origin	C14
author	C15
repfrom	C18

excluded from the scale were:

coto	C6
coemp	C7

The correlation of finance with the scale was fairly low but it was considered important to include it.

CLIENT DEPENDENCE SCALES - CLIDEP1, CLIDEP2

ROW	cotype	codep	corep	DEP1	finance (rev)	origin	author	repfrom	DEP2
1	3	3	2	8	1	1	2	2	1
2	2	3	3	8	2	3	3	3	11
3	2	4	3	9	5	3	3	5	16
4	2	4	2	8	1	3	1	3	8
5	2	4	3	9	1	3	3	3	10
6	2	3	3	8	2	2	3	3	10
7	2	3	1	6	1	2	3	3	9
8	1	1	2	4	1	1	2	3	7
9	3	3	2	8	1	1	2	3	7
10	2	3	2	7	2	2	3	3	10
11	3	4	3	10	4	3	3	5	15
12	2	4	3	9	1	3	3	4	11
13	2	3	3	8	1	2	3	4	10
14	1	1	2	4	2	1	2	2	7
15	3	3	1	7	4	1	3	3	11
16	3	3	3	9	1	3	3	3	10
17	3	3	2	8	2	2	3	4	11
18	1	1	2	4	1	1	2	3	7
19	2	3	3	8	4	3	3	3	13
20	*	*	*	*	*	*	*	*	*
21	*	*	*	*	*	*	*	*	*
22	2	*	*	*	*	*	*	*	*
23	2	4	3	9	2	3	3	3	14
24	1	2	1	4	2	2	3	3	13
25	3	3	1	7	1	1	3	3	8
26	2	3	2	7	1	2	3	2	8
27	3	2	2	7	1	1	2	3	7

Correlation Coefficients

	cotype	codep	corep	finance	origin	author	repfrom
codep	.489						
corep	-.004	.446					
finance	.083	-.137	.000				
origin	.000	.695	.693	-.267			
author	.154	.341	.190	-.378	.372		
repfrom	.188	.478	.406	-.426	.480	.346	
CLIDEP2	.507	.837	.672	.170	.716	.547	.543
CLIDEP1							

Client Sophistication Scale

The components of the scale are:

devtyp	C1	
coto	C6	(nominal)
coemp	C7	(nominal)
blt?	C9	
bldno	C10	
bldprof	C11	

CLIENT SOPHISTICATION - CLISOPH

ROW	devtyp	coto	coemp	blt?	bldno	bldprof	INDEX
1	1	1	1	1	0	0	3
2	3	1	1	1	2	1	8
3	1	1	1	0	0	0	2
4	3	1	1	1	1	1	7
5	3	1	1	1	2	1	8
6	1	2	2	1	0	0	4
7	1	1	1	1	2	1	6
8	2	2	*	1	2	1	8
9	1	2	2	1	2	1	8
10	1	1	1	1	0	1	4
11	1	1	1	0	0	0	2
12	1	3	2	1	2	1	8
13	1	2	3	1	1	1	6
14	2	2	1	1	2	1	8
15	1	1	2	1	1	0	4
16	1	2	2	1	2	1	7
17	1	1	3	1	1	1	5
18	2	2	*	1	2	1	8
19	1	2	*	0	0	0	3
20	1	1	1	1	1	1	5
21	1	1	1	0	0	1	3
22	3	2	*	1	2	1	9
23	1	1	2	1	1	1	5
24	2	1	1	1	1	1	6
25	1	1	*	1	0	0	3
26	1	1	*	0	0	0	2
27	1	2	3	0	0	1	4

Correlation Coefficients

	devtyp	coto	coemp	blt?	bldno	bldprof
coto	-.290					
coemp	-.480	.659				
blt?	.304	-.294	-.021			
bldno	.480	.043	-.054	.592		
bldprof	.420	.302	.187	.508	.714	
INDEX	.468	.376	.333	.441	.765	.752

Ability Scale

The components are:

techdes M24
techcon M25
techpm M26
admindes M27
adminpm M29

Admincon, M28 was not used as it appeared to add little to the scale, having a very high correlation compared to the other components.

ADMINISTRATIVE ABILITY SCALE - ADAB

ROW	techdes	techcon	techpm	admindes	admincon	adminpm	INDEX	ADAB
1	5	5	5	5	5	5	30	10
2	4	4	4	4	5	4	25	8
3	*	2	2	*	2	3	*	5
4	3	3	*	3	3	*	*	*
5	4	3	4	3	3	3	20	7
6	*	5	5	*	4	4	*	9
7	5	5	5	4	5	4	28	9
8	3	4	4	5	5	4	25	8
9	4	4	5	4	4	5	26	10
10	4	4	1	5	4	2	20	3
11	5	4	4	4	4	4	25	8
12	4	4	3	3	3	3	20	6
13	3	4	4	3	3	3	20	7
14	4	4	3	4	3	3	21	6
15	4	4	3	2	3	2	18	5
16	4	5	5	5	5	5	29	10
17	4	4	2	4	4	5	23	7
18	1	1	4	3	2	4	15	8
19	4	4	4	5	4	4	25	8
20	4	4	5	3	5	4	25	9
21	*	*	*	*	*	*	*	*
22	3	4	4	3	3	3	20	7
23	*	*	*	*	*	*	*	*
24	2	2	3	2	2	3	14	6
25	4	4	3	5	4	4	24	7
26	*	*	4	*	*	3	*	7
27	4	5	2	4	3	3	21	5

Correlation Coefficients

	techdes	techcon	techpm	admindes	admincon	adminpm	INDEX
techcon	.822						
techpm	.111	.271					
admindes	.452	.537	.031				
admincon	.639	.714	.486	.678			
adminpm	.193	.251	.572	.484	.583		
INDEX	.723	.752	.542	.713	.911	.698	
ADAB	.727	.752	.559	.702	.854	.713	.993

Physical Complexity Scale

The components of the scale are:

m&e%	P5	
tchcompx	P4	(reversed)
prodpro	C12	
site	P1	(reversed)

excluded from the scale were:

area	O11
weeks	O10
cost	A12

and derivatives from these three as they were not considered to improve the scale.

PHYSICAL COMPLEXITY - PHYCOMPX

ROW	m&e%	prodpro	area	weeks	cost	site (rev)	tchcompx (rev)	PHYCOMPX
1	1.50000	1	5574	35	1493	1	3	7
2	0.83333	1	6140	47	1629	1	2	5
3	2.83333	3	2370	26	374	1	3	10
4	1.00000	2	6300	41	1069	1	1	5
5	1.00000	1	12000	60	1437	1	1	4
6	1.26667	3	5680	52	1301	2	5	11
7	3.33333	1	6600	33	2725	1	3	8
8	0.83333	2	*	*	*	3	1	7
9	4.00000	5	1768	56	2060	1	5	15
10	4.83333	1	9383	39	3945	3	1	10
11	3.33333	2	2087	49	664	1	3	9
12	4.00000	5	759	25	514	1	1	13
13	*	1	2840	39	765	3	*	*
14	*	1	1505	32	*	1	*	*
15	*	5	2080	104	2270	1	*	*
16	*	5	6150	76	*	2	*	*
17	4.00000	5	1440	44	2000	1	3	13
18	1.00000	2	3352	53	1037	1	2	6
19	4.00000	3	4645	50	1223	1	3	11
20	*	*	3208	48	*	1	*	*
21	3.33333	*	2800	54	759	1	*	*
22	0.55000	1	4880	43	1607	3	*	7
23	3.83333	3	4391	52	800	3	3	13
24	1.00000	1	2782	*	*	1	1	4
25	4.50000	3	17129	55	6130	2	3	13
26	4.83333	3	4087	56	1728	1	4	13
27	4.16667	5	3500	48	2500	1	3	13

Correlation Coefficients

	m&e%	tchcompx	prodpro	site	area	weeks	cost
tchcompx	-.071						
prodpro	.446	-.241					
site	.179	-.189	.218				
area	.222	.153	-.289	-.290			
weeks	.254	-.222	.414	.022	.104		
cost	.393	.038	.028	-.202	.723	.193	
PHYCOMPX	.747	.494	.794	.118	.091	.520	.197

Certainty and Constraint Scale

The components of certainty are:

descert	M30
concert	M31
avecert	M32

low score => uncertain

The components of constraint are

budget	P10
time	P11
quality	P12

low score => constrained

CERTAINTY & CONSTRAINTS - CERTNTY, CONSTRT

ROW	budget	time	quality	fince	descert	concert	avecert	CERTY	CONSTRT
1	3	3	3	6	4	3	4	11	15
2	3	1	3	5	4	4	3	11	12
3	3	1	2	2	4	4	3	11	8
4	2	2	3	6	3	1	3	7	13
5	3	4	2	6	2	2	2	6	15
6	2	1	2	5	4	1	3	8	10
7	4	1	3	6	2	1	3	6	14
8	3	3	4	6	5	2	4	11	16
9	3	3	3	6	1	1	1	3	15
10	3	1	3	5	2	4	4	10	12
11	2	2	3	3	2	3	3	8	10
12	3	3	3	6	3	2	3	8	15
13	3	2	3	6	3	1	3	7	14
14	3	2	3	5	5	3	4	12	13
15	4	3	2	3	4	4	5	13	12
16	3	3	4	6	2	2	3	7	16
17	1	1	3	5	2	2	3	7	10
18	3	4	3	6	5	1	4	10	16
19	1	3	3	3	3	2	2	7	10
20	2	1	1	*	5	1	4	10	9
21	3	2	3	3	2	2	2	6	11
22	3	2	2	3	2	2	3	7	10
23	*	*	*	2	4	4	3	11	*
24	3	2	3	2	3	3	4	10	10
25	2	1	3	6	3	3	3	12	9
26	4	4	3	6	4	3	4	11	17
27	2	1	3	6	4	2	3	9	12

Correlation Coefficients

	budget	time	quality	descert	concert	avecert	CONSTRT
time	.354						
quality	.071	.230					
descert	.095	.029	-.226				
concert	.251	-.117	.011	.145			
avecert	.366	.000	-.081	.613	.356		
CONSTRT	.686	.843	.523	-.020	.045	.135	
CERTNTY	.296	-.040	-.136	.784	.671	.827	-.001

Competition Scale

tender	02	(reversed)
intrv	03	
bldrno	04	ordinal
paymnt	06	

Crit, 07, was not used as there was little variation in the sample and it had a small correlation with the scale when included.

COMPETITION SCALE - COMPTITN

ROW	intrv	paymnt	crit	bdrno	tender	INDEX2	COMPTITN
1	1	6	3	3	3	16	13
2	1	6	1	3	2	13	12
3	1	6	1	4	3	15	14
4	0	6	3	1	1	11	8
5	0	6	1	0	3	10	9
6	1	6	*	4	3	*	14
7	0	2	3	0	1	6	3
8	1	6	3	3	3	16	13
9	0	5	1	0	3	9	8
10	0	6	3	0	1	10	7
11	1	6	3	4	3	17	14
12	0	5	*	0	3	*	8
13	1	6	*	2	4	*	13
14	1	6	*	5	3	*	15
15	1	6	3	4	3	17	14
16	1	2	3	3	1	10	7
17	0	4	*	0	1	*	5
18	1	6	*	3	3	*	13
19	1	6	3	3	3	16	13
20	0	4	3	2	2	11	8
21	0	6	1	0	3	10	9
22	1	6	*	2	3	*	12
23	0	6	3	0	3	12	9
24	1	6	3	4	2	16	13
25	1	3	3	5	1	13	10
26	1	3	3	2	1	10	7
27	1	3	3	4	3	14	11

Correlation Coefficients

	intrv	paymnt	crit	bdrno	tender	INDEX2
paymnt	.084					
crit	.236	-.311				
bdrno	.877	.047	.289			
tender	.258	.611	-.358	.169		
INDEX2	.724	.505	.225	.766	.532	
COMPTITN	.743	.647	-.058	.749	.685	.960

Document Certainty Scale

Components are:

conform	A1	
tendoc	A2	
docomp	A3	
pricest	M11	
pcsums	M17	(ordinal)
provs	M18	(ordinal)
contgcy	M19	(ordinal)

Var1, A18, and var2, A19, were not included as they did not correlate highly with the scale and are a post-, rather than pre-, contract phenomena.

DOCUMENT CERTAINTY - DOCCERT1 & DOCCERT2

ROW	conform	tendoc	docomp	pcsums	provs	contgcy	CERT1	CERT2
1	3	1	1	2	10	1	5	13
2	5	0	1	17	5	3	6	25
3	5	1	5	3	5	2	11	10
4	1	1	1	0	2	0	3	2
5	5	3	4	*	*	2	12	*
6	5	3	5	0	5	2	13	7
7	1	3	4	52	6	4	8	62
8	2	1	1	0	2	0	4	2
9	4	3	4	*	*	*	11	*
10	3	1	1	0	3	0	5	3
11	4	3	4	56	0	1	11	57
12	5	3	4	*	*	*	12	*
13	1	1	3	*	*	*	5	*
14	5	3	4	27	1	3	12	31
15	2	1	2	79	10	1	5	90
16	1	2	3	5	3	2	6	10
17	4	2	1	0	10	10	7	20
18	2	1	1	0	1	0	4	1
19	1	1	1	0	5	1	3	6
20	1	1	2	0	5	5	4	10
21	5	3	4	50	8	2	12	60
22	0	1	2	10	11	0	3	21
23	5	3	3	47	2	2	11	51
24	3	1	1	*	*	*	5	*
25	5	1	1	82	12	1	7	95
26	3	1	3	0	2	0	7	2
27	3	1	1	0	20	10	5	30

Correlation Coefficients

	conform	tendoc	docomp	pcsums	provs	contgcy
tendoc	.434					
docomp	.406	.737				
pcsums	-.002	.017	-.151			
provs	-.069	-.248	-.295			
contgcy	.237	.219	-.029			
CERT2						
CERT2						

Familiarity Scale

The components are:

project	M57
client	M58
team	M59

FAMILIAR SCALE

ROW	project	client	team	FAMILIAR
1	3	1	4	8
2	5	5	4	14
3	4	1	1	6
4	5	3	4	12
5	4	3	2	9
6	3	3	1	7
7	5	5	3	13
8	4	3	3	10
9	1	3	2	6
10	5	1	5	11
11	1	1	2	4
12	3	3	1	7
13	4	3	4	11
14	5	3	2	10
15	3	5	5	13
16	3	3	4	10
17	3	4	3	10
18	4	1	2	7
19	4	1	5	10
20	4	2	3	9
21	3	1	2	6
22	5	4	4	13
23	4	5	4	14
24	4	2	2	8
25	4	3	5	12
26	3	1	4	8
27	3	2	4	9

Correlation Coefficients

	project	client	team
client	.253		
team	.281	.144	
FAMILIAR	.693	.693	.697

Differentiation and Proximity Scales

Differentiation; components are:

desorg	P2	
nsubno	P8	(ordinal)
cliprox	M39	(reversed)
teamprox	M40	(reversed)
siteprox	M41	(reversed)

Not included in the scale were:

desuborg	P3	(insufficient values)
domsubno	P6	(insufficient values)
dlap	013)	
clap	014)	(did not improve scale)
C9 (totlap)	015)	

Proximity; components are:

cliprox	M39	(reversed)
teamprox	M40	(reversed)
siteprox	M41	(reversed)

DIFFERENTIATION & PROXIMITY - DIFFNTN & PROXTY

ROW	desorg	desuborg	domsubno	dsub2	nsub2	dlap	clap	cliprox	teamprox
1	1	2	19	2	1	5	2	1	4
2	2	2	20	2	2	1	3	1	4
3	2	2	*	*	3	*	*	1	5
4	1	*	*	*	1	6	2	1	3
5	2	*	*	*	3	0	1	1	2
6	3	2	14	1	3	1	4	4	4
7	3	15	20	2	5	2	2	1	4
8	5	*	*	*	1	4	2	1	3
9	2	*	*	*	3	0	0	1	1
10	1	3	*	*	0	4	2	4	5
11	2	5	3	1	3	0	0	2	2
12	2	*	*	*	3	0	0	2	2
13	1	*	*	*	1	*	*	1	1
14	2	*	22	2	4	0	0	3	3
15	1	*	*	*	1	3	2	2	2
16	4	*	*	*	1	3	2	1	1
17	1	*	*	*	3	3	1	1	3
18	3	*	*	*	1	4	2	1	4
19	1	2	37	3	1	4	2	1	5
20	4	*	*	*	1	5	2	1	1
21	2	*	*	*	3	0	1	1	4
22	3	1	14	1	1	3	2	1	2
23	3	4	*	*	4	1	1	1	2
24	1	*	*	*	1	0	2	1	2
25	1	2	49	3	1	3	7	1	5
26	1	3	21	2	1	6	2	1	5
27	1	10	36	3	1	5	2	1	1

ROW	siteprox	DIFFNTN	PROXTY
1	1	8	6
2	4	13	9
3	1	12	7
4	3	9	7
5	3	11	6
6	4	18	12
7	2	15	7
8	2	12	6
9	2	9	4
10	3	13	12
11	2	11	6
12	2	11	6
13	1	5	3
14	2	14	8
15	2	8	6
16	1	8	3
17	3	11	7
18	3	12	8
19	2	10	8
20	1	8	3
21	1	11	6
22	2	9	5
23	*	11	4
24	*	8	6
25	5	13	11
26	1	9	7
27	1	5	3

	desorg	nsub2	desub2	cliprox	teamprox	siteprox	DIFFNTN
nsub2	.325						
desub2	.028	.302					
cliprox	.025	.109	-.008				
teamprox	-.096	-.147	-.395	.173			
siteprox	.097	-.143	-.362	.298	.358		
DIFFNTN	.381	.428	-.199	.382	.459	.600	
PROXTY	.601	.551	.084	.424	.410	.547	.960

Coordination Scale

Components are:

clicord	M50, M51, M52
teamcord	M53, M54, M55
bldrdes	M1
d/c comm	M37

COORDINATION SCALE - COORDN

ROW	clicord	teamcord	bldrdes	d/c comm	COORDN
1	3	2	5	5	15
2	3	3	2	5	13
3	0	3	1	4	8
4	3	3	5	4	15
5	3	2	1	4	10
6	2	2	1	5	10
7	3	2	4	5	14
8	2	1	5	3	11
9	3	2	1	5	11
10	0	3	4	4	11
11	3	1	1	5	10
12	3	1	1	4	9
13	1	2	5	4	12
14	2	1	1	4	8
15	3	3	5	4	15
16	3	2	5	5	15
17	3	3	4	4	14
18	2	1	5	4	12
19	3	3	5	5	16
20	2	3	4	3	12
21	2	1	1	4	8
22	3	2	4	3	12
23	2	2	1	3	8
24	3	2	5	2	12
25	3	3	5	5	16
26	3	3	5	5	16
27	3	3	5	4	15

Correlation Coefficients

	clicord	teamcord	bldrdes	d/c comm
teamcord	-.011			
bldrdes	.167	.391		
d/c comm	.204	.120	-.074	
COORDN	.519	.618	.624	.358

Cost Monitor Scale

Components are:

costpln	M5
planner	M6
costmon	M7
monitor	M8
reports	M9
period	M10

COST MONITOR SCALE - COSTMONR

ROW	costpln	planner	costmon	monitor	reports	period	COSTMONR
1	1	2	1	4	2	2	12
2	1	2	1	2	2	2	10
3	1	4	1	3	3	2	14
4	1	4	1	4	2	3	15
5	1	4	1	4	2	3	15
6	1	4	1	4	2	3	15
7	1	4	1	1	2	2	11
8	0	2	1	2	2	2	9
9	1	4	1	4	1	3	14
10	1	2	0	0	0	1	4
11	1	3	1	4	2	3	14
12	1	4	1	4	2	2	14
13	1	1	1	1	2	2	8
14	1	3	1	3	2	2	12
15	1	4	1	4	2	2	14
16	1	1	1	1	2	3	9
17	1	4	1	4	2	3	15
18	1	2	1	2	2	2	10
19	1	4	1	4	2	2	14
20	1	1	1	1	2	3	9
21	1	4	1	4	2	3	15
22	1	2	1	5	2	3	14
23	1	4	1	4	2	3	15
24	0	0	1	4	0	2	7
25	1	5	1	1	2	3	13
26	1	1	1	4	2	2	11
27	1	4	1	4	2	2	14

Correlation Coefficients

	costpln	planner	costmon	monitor	reports	period
planner	.409					
costmon	-.055	.136				
monitor	.008	.305	.434			
reports	.408	.363	.615	.144		
period	.205	.288	.491	.316	.294	
COSTMONR	.400	.776	.547	.731	.570	.584

Overlaps Scale

Components are:

blddes	M1
bldcon	M2
deslap	O13
conlap	O14

Totlap, O15, was not used as it is purely the sum of O13 and O14 and as such added little to the scale.

OVERLAPS SCALE - OVERLAPS

ROW	blddes	bldcon	deslap	conlap	totlap	OVERLAPS	INDEX1	INDEX2
1	5	2	5	2	7	14	9	11
2	2	3	1	3	4	9	7	7
3	1	1	1	1	2	4	6	4
4	4	4	6	2	8	16	10	14
5	1	2	0	1	1	4	3	4
6	1	2	1	4	5	8	7	6
7	4	3	2	2	4	11	7	9
8	5	3	4	2	6	14	9	11
9	1	2	0	0	0	3	2	3
10	4	4	4	2	6	14	10	11
11	1	2	0	0	0	3	2	3
12	1	1	0	0	0	2	1	2
13	5	4	5	2	7	16	11	13
14	1	3	0	0	0	4	3	4
15	5	4	3	2	5	14	9	12
16	5	4	3	2	5	14	9	12
17	4	4	3	1	4	12	8	10
18	5	4	4	2	6	15	10	12
19	5	5	4	2	6	16	11	13
20	5	4	5	2	7	16	11	13
21	1	2	0	1	1	4	3	4
22	4	5	3	2	5	14	10	12
23	1	3	1	1	2	6	5	5
24	5	3	0	2	2	10	5	7
25	5	4	3	7	10	19	14	14
26	5	4	6	2	8	17	12	13
27	5	4	5	2	7	16	11	13

Correlation Coefficients

	bldes	bldcon	deslap	conlap	totlap	OVERLAPS	INDEX1
bldcon	.755						
deslap	.820	.661					
conlap	.448	.361	.336				
totlap	.796	.635	.885	.736			
OVERLAPS	.950	.794	.915	.647	.958		
INDEX1	.889	.796	.880	.721	.973	.988	
INDEX2	.963	.828	.912	.589	.925	.994	.971

Cronbach Alpha Reliability Coefficients

CLICOMP	.54	CLIDEP1	.53
CLISOPH	.74	CLIDEP2	.72
ADAB	.77	PMAB	.73
PHYCOMPX	.44	CERTNTY	.65
CONSTRT	.53		
COMPTITN	.67	DOCCERT1	.77
OVERLAPS	.84	DOCCERT2	.41
COSTMONR	.71		
FAMILIAR	.49	DIFFNTN	.23
COORDN	.39	PROXTY	.54

Appendix 4

Strength of Effect of Variables

STRENGTH OF EFFECT OF VARIABLES

Introduction

In order to assess the strength of the effect that different variables had on the prediction of performance measures within the sample regression analyses were undertaken. Variables, identified in the partial correlation analysis were entered in a stepwise fashion (using the SPSS-X package), and the most significant results are shown below. The beta value indicates the change in value of the predicted variable brought about by an increase of one standard deviation in each predictor: the value is thus an indication of the strength of the effect of the predictors.

Time Measures

The regression equation for construction time is given below (9.1).

Eq 9.1a

TIME	=	36.5	+.005FINACT
BETA			.68

R-squared = .447 p<0.00 cases = 44

Eq 9.1b

TIME	=	57.4	+ .006FINACT	- .34SPEED	-.01SQMWK	- .007AREA
BETA			.73	-.56	-.04	-.17

R-squared = .76 p<0.00 cases = 44

Equation 9.2 indicates the result of the regression of the competition and degree of overlaps variables on preconstruction speed. These two explain 63% of the variation in speed and their effects are similar in magnitude, as can be seen from the beta value.

Eq 9.2

PRESPEED	=	164	-	4.1COMPTITN	-	6.6OVERLAPS
BETA				-.70		-.50
R-squared = .631				p<0.8%		cases = 26

The introduction of other predictor variables did not improve the adjusted R-squared value for this measure.

The third regression equation for the time measures which produced a significant result was Eq 9.3 which predicted construction time overrun. This equation explains 65% of the variation in overrun using construction speed, differentiation and administrative ability as the predictors. The beta values indicate that one standard deviation increase in the value of construction speed causes a 0.7 standard deviation reduction in overrun (similarly such a change in differentiation increases overrun by .35 SD and administrative ability reduces overrun by .26 SD)

Eq 9.3

CTOVER = 1.26	− 0.40CONSPEED	+ 0.02DIFFTN	− 0.02ADAB
BETA	−.71	.35	−.26
R-squared = .651	p<0.1%	cases = 19	

Cost Measures

Two cost measures were found to produce significant results using the regression technique: unit cost (Eq 9.4) and cost overrun (Eq 9.5). Physical complexity and uncertainty can be seen to have a major influence on unit cost, with increases in the area of the building and costmonitoring reducing unit costs (but to a lesser extent).

Eq 9.4

COSTPM = 1.33	+ .06PHYCOMPX	− 0.10CERTNTY	− 0.03AREA	− 0.03CSTMR
BETA	.56	−.56	−.33	−.25
R-squared = .64	p<0.1%	cases = 20		

The three variables familiar, costmonr and phycompx explain 80% of the variation in the cost overrun variable. Increases in familiarity and cost monitoring reduce overruns (by a similar amount) and increased complexity increases overruns, but not as markedly as the others reduce them.

Eq 9.5

COSTOVER = 1.34	− 0.02FAMILIAR	− 0.17COSTMONR	+ 0.12 PHYCMP
BETA	−.87	−.77	.51
R-squared = .80	p<0.3%	cases = 21	

The high levels of the adjusted R-squared statistics reported above result in part from the use of this fairly homogeneous sample of industrial projects.