DECISION SUPPORT SYSTEM

FOR

CONTRACT BIDDING

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INTERIM REPORT

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Preface

My first encounter with contract bidding as a decision-making activity was in Martin Barnes' 1971 PhD thesis *The Design and Use of Experimental Bills of Quantities for Civil Engineering Contracts* which I came across at UMIST in 1979 the course of my masters research. Barnes' reference to Friedman and Gates led me to the American Society of Civil Engineers and their *Journal of the Construction Division* as it was then known. Here I found a veritable saga of claims and refutations going back to 1956 when Friedman published his seminal work on bidding strategy. Of course the party had long since moved on by the time I arrived on the scene but the thrill of the chase and excitement engendered still lingered on the pages of the Journal.

Having finished the masters in 1981 I started, tentatively at first, my own approach to the subject for my doctoral research. For a long while I simulated bids from uniform probability distributions, plotting the frequency distribution of the winning bids. Every spare minute of time I would spend drawing the shapes of the resulting curves and trying to find their mathematical origin. By the end of 1991, I had the answer, but only in the form of an algorithm wrapped up in a Fortran program. The main feature of this algorithm involved computing the area of sections under curves, with narrower and narrower sections giving better and better results. Even to my distant 'O' level maths knowledge, this clearly spelled out 'integration', an insight duly confirmed by Ernest Wilde, my good friend and colleague in the University's Department of Mathematics. After Ernest kindly spent some time over the weekend putting my algorithm into mathematical form, my work really started - first on a method of deriving parameter estimates for the statistical models and later on determining the most suitable type of model for 'real world' construction contract bids.

By 1985 I had finished the bulk of the analysis and spent most of the summer reading everything I could get my hands on that was remotely connected to construction contract bidding. This amounted to a lot of reading, and most of this had nothing to do with mathematical models or with economic theory. By the time I had run out of steam reading I had accumulated a hugh amount of material and began the task of organising it into some coherent structure to set the scene in the thesis. I had anticipated this taking a day or so as had my masters thesis. In the event, this task took rather more than three months. The essential cause of the problem was the lack of any existing structure at that time in any of the obviously related fields - economics and management - or in the more remote areas such as Management Science, Behaviourial Science, Pricing Theory, Decision Theory, Operations Research. Even Psychology and Biology failed to contribute a great deal (Biology did provide some interesting analogies on the evolutional aspects of bidding, but far too off beat for a PhD introduction!).

As I have mentioned on previous occasions, three books were to have a major influence on the final outcome. First Johnson & Scholes' *Exploring Corporate Strategy* suggested the basic structure of the decision process to be that of option evaluation and selection, and from this I was able to develop an idea of strategic option identification as a means of restricting option sets independently of the selection decision. Secondly, Loomba's *Management: a Quantitative Perspective* suggested the very fruitful idea of breaking the problem down into deterministic and non-deterministic approaches, thus providing a means of separating the many aspects relating to

uncertainty. And finally, Ansoff's *Strategic Management* showed how a morass of this kind can be got together into a whole by shear perseverance and bloodymindedness.

The results of these labours helped to gain me my PhD in 1986 and eventually Longman publishing my book *Contract Bidding in Construction: Strategic Management and Modelling* as an unexpected additional honour. The fact remains however that most of the work and thoughts reviewed were very much culled from a wide variety of sources with very little cognisance of their relative reliability or even importance. Such emphasis that I have made has been in the context of the framework developed and, as such, must be counted as largely theoretical. What has not yet been considered is the emphasis the 'real-world' places on these theoretical notions. The tendency of the theorist is to overlook the acute lack of information that surrounds many decision-making situations. As has been found with theories involving 'perfect information', the prevalence of imperfect information invariably requires new theories rather than just modifications to the old ones. In my view, construction contract bidding as a subject of study has been dying for some time through over-theorising, lack of assumption testing, and general lack of 'real-world' input. It urgently needs some empirical injections to bring it back to life.

In 1987 the Science and Engineering Research Council (SERC) let it be known that they would give priority funding to the so called 'rolling programmes' of research activities. As a result the Construction Industry Research Consortium (CIRC) was formed comprising a team of academics from six universities in the UK. CIRC met several times over a two year period. Eventually a rolling programme was agreed in the procurement of construction work and several bids were made to SERC by pairs of researchers in the group relating to this theme. By this time SERC had reorganised their priorities and 'rolling programmes' was no longer *de rigueur*! However, some of the proposed projects had gained momentum and eventually proceeded to grant award. This is one such project.

Martin Skitmore
October 1992

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We would like thank our two anonymous collaborating construction companies for their time and willingness in contributing to the work described in this report. Thanks also go to the several contracting organisations who helped us by completing the questionnaire.

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List of Abbreviations

CBIS	Computer Based Information System
CSF	Critical Success Factor
DDE	Dynamic Data Exchange
DFD	Data Flow Diagram
DSS	Decision Support System
EDP	Electronic Data Processing
EIS	Executive Information System
ESS	Executive Support System
ISP	Information Strategy Planning
LAN	Local Area Network
MIS	Management Information System
NEDO	National Economic Development Office
MSS	Management Support System
OR	Operations Research
SOP	Standard Operating Procedures
SSADM	Structured Systems Analysis and Design Method

1Introduction

This introductory chapter introduces the significance of the problem area and outlines the nature of the problem scenario upon which the research is centred. An overview is given of the generic processes involved and the restraints upon the support of current industry practice.

GENERAL INTRODUCTION

A large percentage of all construction work is awarded on the basis of competitive bidding. Under this system, the owner of a project invites a number of prospective contractors to compete for a project by tendering bids or proposed bid prices. The award is made on the basis of the proposed bid prices, the project generally being awarded to the lowest responsible bidder.

It is contended that since any one particular project contributes a relatively significant part of a construction firms' turnover, the bidding decisions on any one project will have a significant effect on the short term profit or loss of the firm and therefore repercussions on the firms long term strategy and performance (Hillebrandt, 1977). In addition, in an analysis of UK contracting firms from 1983 to 1987, Cook (1990) estimated bidding costs at a mean of 1.2 percent of total turnover, with the smallest and largest firms incurring the highest costs. Consequently, the investigation of the bidding process and the development of bidding strategy models has been of interest to researchers and practitioners since the 1950's.

This research is concerned with the investigation of the contract bidding scenario and the application of a computer based information support system to the real world problems of contract bidding strategic decisions. The research focuses on decisions relating to final adjustment of cost estimates and formalisation of a suitable bid price.

INTRODUCTION TO THE PROBLEM AREA

The Contract Bidding Process

The generic process of competitive bidding is loosely described by McCaffer and Baldwin (1986) as comprising two unique but interrelated stages, namely "cost estimating" and "tendering". Cost estimating commences upon receipt of the bid documents from the owner or owner's representative and is described as "... calculating the probable cost to the contractor of efficiently carrying out the construction work if awarded the contract to construct the project." Tendering, on the other hand, is described as "... establishing the final price and terms for the contract that will be submitted [tendered] to the promoter or his representative. This involves an assessment of the likely margin of error in the cost estimate together with the risk and possible financial effects of undertaking the project." The term "bidding" however, is used to describe the generic bidding process, the term "bid adjudication" is preferred and is used within this text to describe this second stage. It is this stage of the bidding process which is principally investigated in this research.

Bid adjudication decisions form one of the two principal strategic decisions affecting the contracting firms' work procurement and subsequent long term performance, the other being the

earlier bid/no bid decision. Together these two decisions considerably influence the nature of projects undertaken by the contracting organisation and consequently effect the strength of the firm in the industry.

Bid Adjudication Decisions

Decisions relating to the strategic formulation of the final pricing and terms for a project bid are generally made in bid adjudication meetings.

The recommended practice is that bid adjudication meetings take place a few days before the final bid tender dates, to allow sufficient time for finalisation of the bid documents prior to tender. Summary reports should be prepared, based on the findings of the cost estimating process, and presented at the bid adjudication meeting. The adjudicators, normally senior managers or directors reflecting the significance of such decisions, are then required to review the cost estimate and associated information and finalise the contract price (making any necessary amendments or additions for risks, uncertainties overheads and profit) as a *commercial* decision (CIOB, 1983).

Clearly, if the bid is too high, the contractor will fail to get the contract at the expense of the time and money spent on preparing the bid proposal. If the bid is too low, then the contractor will fail to make an adequate profit.

Contracting firms have a number of expressed or implied general objectives and goals to obtain. Decision makers are therefore urged to know what these objectives and goals are, how they are related to each other, what their relative importance is and how a particular decision on any one project is going to effect these objectives and goals.

SUPPORT FOR BIDDING DECISIONS

To date, support for bidding decisions has been based on the OR models of Friedman (1956) and Gates (1967), focusing on the optimal strategy from the bidders' perspective. By their formulation, adjudication is taken to be a matter of finding an optimal bid mark-up which maximises expected profit. This, like many other early OR approaches to real-world problem solving, suffers from the existence of a plethora of simplifying assumptions regarding the context of the problem.

The assumption of the profit maximisation objective has been most heavily criticised in the context of construction contract bidding. Wong (1978), Stark (1976), Lansley (1983) and Green (1989) all agree that such an assumption of rationality is, in general, not favoured by contractors. The work of Toffler (1971) and later Ahmad and Minkarah (1988), Eastham (1986) and Green (1989) indicates that other factors and objectives, many of an non-economic nature, are considered in bid adjudication.

A further factor is that endemic commercial pressures and time constraints often results in adjudication decisions being made in haste immediately prior to tender of bids.

Thus, despite the importance of adjudication decisions, contractors invariably make heuristic decisions based on experience, judgement and perception. Gut feelings are relied upon to make decisions in the face of the uncertainties surrounding the contract bidding scenario.

Empirical studies by Cusack (1981) and Pin (1990) however indicate that many contractors possess, or at least have access to, extensive information in one form or another but which is not fully utilised to support or improve their decision-making processes. The potential of this information for use in supporting bid adjudication decisions is not yet known.

SUMMARY

Contract bidding in general, and bid adjudication decisions in particular, necessarily have a significant correspondence with the strategy and performance of the contracting firm. Such decisions are known to be highly context dependant relying on a multiplicity of objectives, goals, individual factors and subject to high uncertainty and severe time constraints. It is therefore not surprising that decision makers have found little use for formal techniques such as OR, relying instead largely on experience and intuition.

What seems to be needed is fast access to relevant data concerning adjudication decisions. That many contractors may already have such data in their organisations is very encouraging and suggests that, when suitably structured, relevant data could be made available in digestible form for decision makers.

2Aims and Objectives

INTRODUCTION

This chapter indicates the principal aim upon which the work is based. This aim is supported by the objectives of the research. An outline is given of the general research philosophy adopted to navigate towards these aims and objectives.

AIM

The aim of this project is to develop an information system for supporting construction major contract bidding decisions.

OBJECTIVES

In support of this aim and against the background described in chapter 1 a three year research programme was initiated to develop a computer based information system to facilitate direct access to the available information, both internal and external to the firm, relating to adjudication decisions. This system will provide decision makers, responsible for bid adjudication strategy decisions, with access to the information and tools to support and enhance, rather than replace, the decision makers' own judgements and perceptions.

The specific objectives were to:

1.identify a sample of construction firms outline business strategy and objectives

2.develop conceptual models of the contract bidding and adjudication scenario and management objectives and goals

3.identify the critical success factors governing the bid adjudication scenario

4.identify the critical decision set and critical information set associated with critical success factors

5.develop a bid adjudication strategic data and information model

6.translate the strategic data model to a prototype system for iterative development

7.validate and implement the system within the collaborating firms' environments.

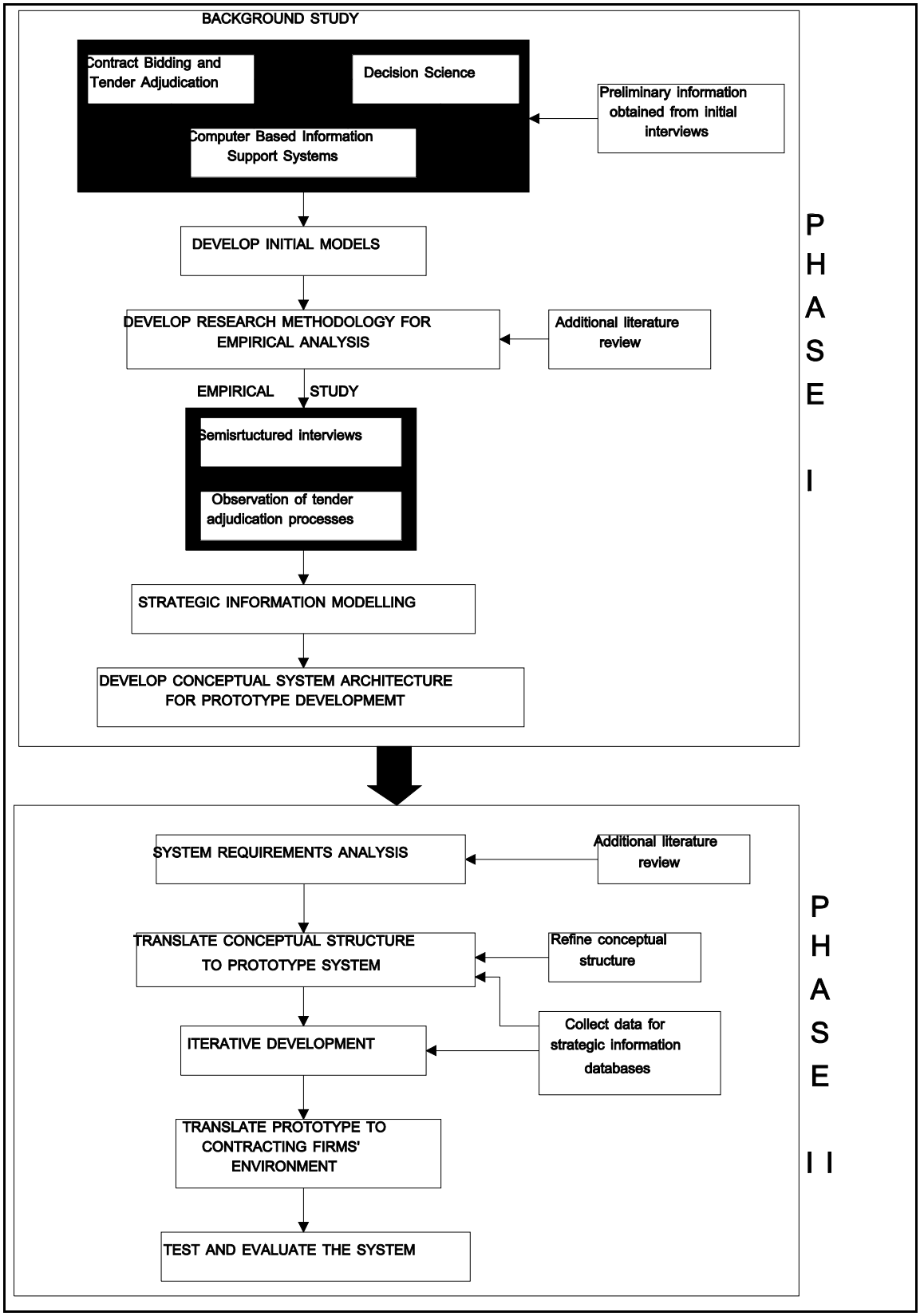

Fig 2.1: Research philosophy

RESEARCH PHILOSOPHY

The research has been divided into two principal phases, namely:

PHASE 1 Problem analysis through to the development of a conceptual prototype system

PHASE 2 Initial construction and iterative development of the prototype system through to final testing and implementation of the system.

The nature and relationship of these two principal stages of the research is illustrated in Fig 2.1.

Phase 1

The first phase of the research was initiated with a literature review of the relevant subject areas in order to gain a clearer perception of the problem scenario and possible solutions. This provided a starting point from which to undertake the empirical analysis of the two collaborating firms. This background study was supported by initial informal interviews with the two collaborating firms.

The two contracting firms studied may be described as major UK contracting firms, both being placed within the top 30 UK contracting firms according to turnover (Carr, Kitkat & Aitken, 1990).

The principal aim of this empirical study was to broadly examine the real world procedural aspects of strategic contract bidding decisions. This was followed by a more detailed analysis of the procedure, nature and information requirements of bid adjudication decisions. The analysis of the two participating firms is supported by a questionnaire survey of a larger number of UK building contracting firms.

The next stage of phase 1 served to translate the empirical research into a logical representation of the data and information requirements of the adjudication decision maker. The methodology and techniques adopted for this purpose are discussed in greater detail later. The strategic information models produced support the conceptualisation of the prototype system requirements.

Phase 2

This phase of the research involved the development of the conceptual system architecture into a working prototype system.

A review of the hardware and software and general system requirements for production of the prototype at this stage was supported by the phase 1 background study relating to computer based information support systems.

Following selection of a suitable hardware and software tool set a prototype system was constructed. The prototype was then iteratively developed within the participating firms environment. Finally the system was tested and evaluated within the firms' environments.

Programme for the Research

The research period consisted of approximately 18 months within each of the two collaborating academic institutions. An overview of the progress of the research is provided in Fig 2.2.

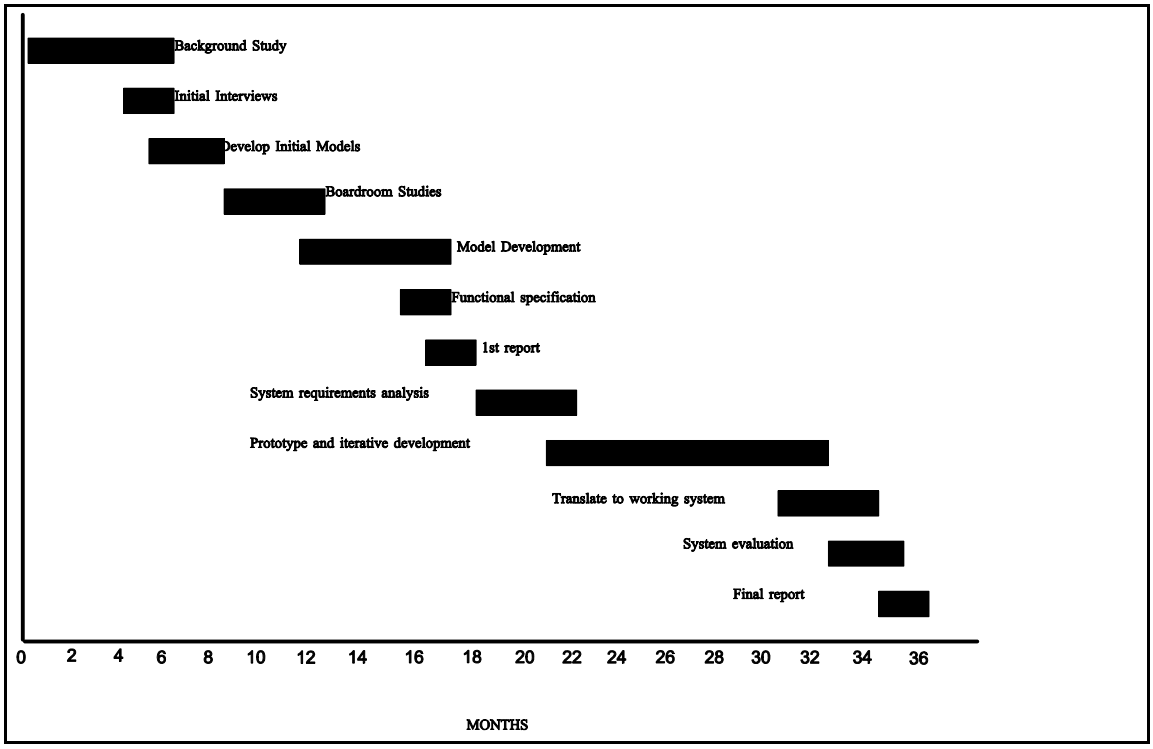

Fig 2.2: Original programme of research

ORGANISATION OF REPORT

This report outlines the principal findings and results of the first stage of this research. The report covers the initial background study of contract bidding and bidding theory, decision-making and computer technology; the development of a research methodology for analysis of the problem scenario; the empirical analysis of the two participating contracting firms; the resultant strategic information modelling; and finally the development of a conceptual system structure.

3The Background Study: General Introduction

INTRODUCTION

The aim of this chapter is to provide an overview of the background research undertaken as a precursor to the more formal analysis stage of the work. The chapter opens with a synopsis of the three principal problem areas reviewed. This statement is in the form of a general statement of the problem scenario. An analysis of the principal points of interest for each of the areas reviewed is then discussed.

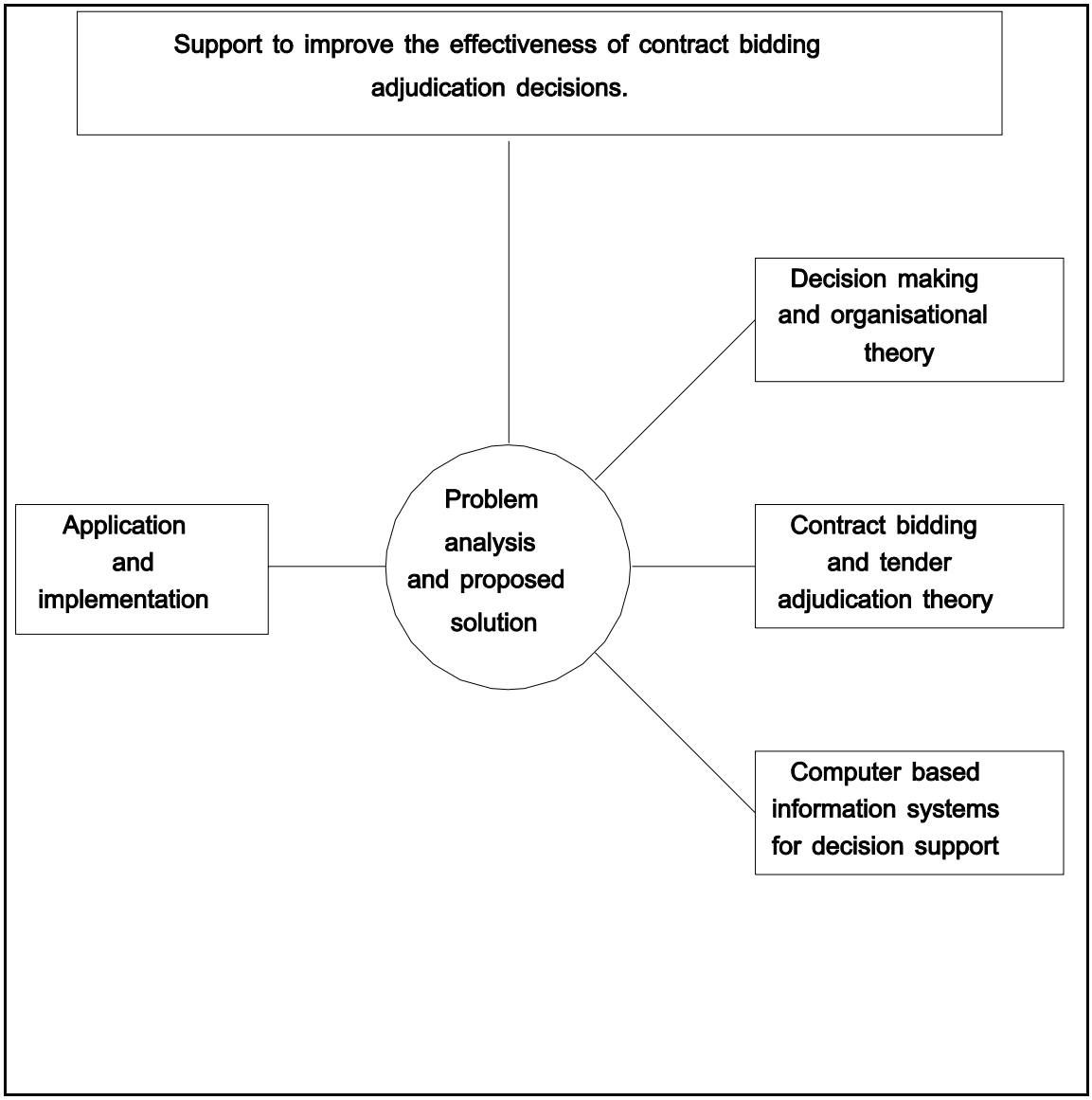

Fig 3.1: Problem analysis and principal areas for review

STATEMENT OF THE PROBLEM

Referring to the aims and objectives of the research, as given in the previous chapter, it is possible to partition the general problem scenario into three areas of established research, namely:

•organisational theory and decision-making
•contract bidding and bid adjudication theory
•computer based information systems for decision support

These three schools of research form the basis for the background study undertaken as the foundation for this research. Fig 3.1. illustrates the three principal areas within the problem scenario, from a research perspective.

Each of these three areas contains an extensive body of research theory and empirical analysis. Consequently, the analysis and review of the literature relating to these areas proved to be a lengthy and formidable task. Much of the research associated with the first two areas, decision theory and contract bidding, is, however, reviewed in Skitmore's (1989) treatment of contract bidding in construction. Indeed, within much of the literature reviewed these two areas were often symbiotic. For the purpose of this study, however, the two are treated, as far as possible, as separate topics.

The following is a brief analysis of the principal theoretical aspects of the three areas.

4The Background Study: Organisational Theory and Decision-Making

INTRODUCTION

Decision-making is the heart of managerial practice. The day to day operation of any organisation stems from the decisions made by its management.

According to Keen and Hackathorn (1984), "A central theme in decision support is that one cannot improve something one does not understand. The act of 'supporting' a manager implies a meshing of analytic tools into his or her activities". Unfortunately, there is no position in the organisational hierarchy that is less understood than that of the top level managers.

Decision-making is by no means a straightforward process and there has been an enormous amount of research work on the subject by psychologists, behavioral scientists and applied mathematicians since the 1950s (Kharbanda and Stallworthy, 1990). This section of the background study provides a general overview of theory relating to the decision-making process and its relation to organisational structure.

MINTZBERG'S ACTIVITIES VIEW

Although decision-making is possibly the most important aspect of the senior manager's organisational activates it is not their only role. Before dealing specifically with management decision theory it is necessary to grasp the overall perspective of the manager's principal functions.

Mintzberg's (1973) model of management roles is probably the best known characterisation of the activates of senior managers. He divided executive manager's activities into ten distinct roles, which are further divided into three general groups: interpersonal; informational; and decisional.

INTERPERSONAL ROLES

Figurehead. Carries out a symbolic role as head of the organisation, performing routine duties of a legal or social nature.

Leader. In the widely recognised managerial duty, is responsible for motivation and "activation" of subordinates, as well as staffing, training, promoting.

Liaison. develops and maintains a personal network of external contacts who provide information and favours.

INFORMATIONAL ROLES

Monitor. Seeks and receives a wide variety of special information to develop a thorough understanding of the organisation and the environment. In this role, the executive serves as the nerve centre of internal and external information about the organisation.

Disseminator. Transmits information received from outsiders or from subordinates to other members of the organisation. Information ranges from factual information to value statements designed to guide subordinates in decision-making.

Spokesman. Communicates information to outsiders on the organisation's plans, policies, actions results, etc.

DECISIONAL ROLES

Entrepreneur. Searches the organisation and environment for opportunities and initiates "improvement projects" to bring about change; supervises design of certain projects as well.

Disturbance Handler. Responsible for corrective action when the organisation faces important, unexpected disturbances.

Resource Allocator. Allocates organisational resources of all kinds.

Negotiator. Represents the organisation in negotiations.

Although Mintzberg's activities view relates specifically to the roles of executives, many of these roles are similarly adopted by the managers of organisational sub-units.

DECISION THEORY - PRINCIPLE SCHOOLS OF THOUGHT

Throughout the literature decision-making is discussed in terms of five main schools of thought (Allison, 1971; Keen *et al*, 1978):

•the rational or normative view
• the "satisficing" view
•the organisational view
•the political view
•the individual differences view

The *rational* school of thought advocates that decisions are made by an individual, rational decision maker who is always consistent, considers economic factors, and is cognisant of the relevant cost/benefit ratios. This school of thought assumes that a decision maker has all the required tools and information for making and implementing a decision and also assumes an ideal situation that rarely exists in the real world of decision-making. Bass (1983), Mintzberg *et al*. (1976) and Pounds (1969) suggest that a complete rational or normative model of decision-making would contain the following seven steps: (1) Recognition of a problem (awareness); (2) definition of the problem; (3) identification of causes; (4) development of alternatives; (5)

evaluation of alternatives; (6) implementation of chosen alternatives; and (7) evaluation of outcomes and the process used.

The ideal situation necessary for the rational view does not often exist. If the requirements for the rational view are present, this school is the best, since it seeks the optimal solution, a solution that yields the highest payoff in monetary or non-monetary terms. The *satisficing* view seeks a "good enough" alternative and uses feedback to improve the next solution if possible. This school advocates that an organisation should survive with the present solution and should try to obtain a more satisfactory solution in the future.

The *organisational* school of thought tries to generate and implement decisions as the output of SOPs imposed by organisational units within the organisation. A typical business organisation may include marketing, finance, personnel and production departments as its organisational units. For any one particular decision each organisational unit will propose an optimum solution for its unique set of concerns. The organisation as a unit then chooses a solution that is good enough for all the players and is consistent with the SOPs of the organisation as a whole. For this approach understanding organisational roles, relationships and channels of communication is very important.

The *political* school emphasises the bargaining process involved in decision-making. There are several players involved in this process, and each one may influence the outcome of the decision-making process differently. The power and influence of each player determine the outcome of any decision. Usually this type of decision-making ends with a compromise among the players. The major difference between this school and the organisational view is the lack of control imposed by the organisation as a unit on the final outcome. In the political decision-making process, there is no organisational entity to have the final word on the decision.

The *individual differences* school puts a heavy emphasis on the individual decision makers' personality, background, style and so forth.

TYPES OF DECISION IN AN ORGANISATION

The concept of structure and types of decision in decision-making is defined by Ackoff (1967) in his classification of managerial decisions into three types:

- **Structured Decision-Making** - Decisions for which adequate models are available or constructed and from which optimal solutions can be extracted;
- **Semi-Structured Decision-Making** - Decisions for which adequate models can be constructed but from which optimal solutions cannot be extracted;
- **Unstructured Decision-Making** - Decisions for which adequate models cannot be constructed.

Ackoff's first classification does not need a decision maker as it represents an area where standard well defined operating procedures exist. Record keeping operations, payrolls and simple inventory problems are examples of this kind of task, in which computer technology have already been of significant help.

Semi-structured decisions are those that are not quite as well defined by standard operating procedures as are structured decisions. However, these decisions include structured aspects that greatly benefit from information retrieval, analytical models and information technology in general.

Unstructured decisions are unique in nature, are mostly non-recurring, and have no standard operating procedure. In these circumstances, the decision makers' intuition plays the most significant role.

Ackoff's second and third type of managerial decision represent areas where neither intuitive judgements or heuristics (as a result of the complexity of computation) or an algorithmic model (because of a need for subjective analysis) are wholly adequate.

Fig 4.1 illustrates organisational levels (Anthony, 1965) and types of decisions in the organisational environment.

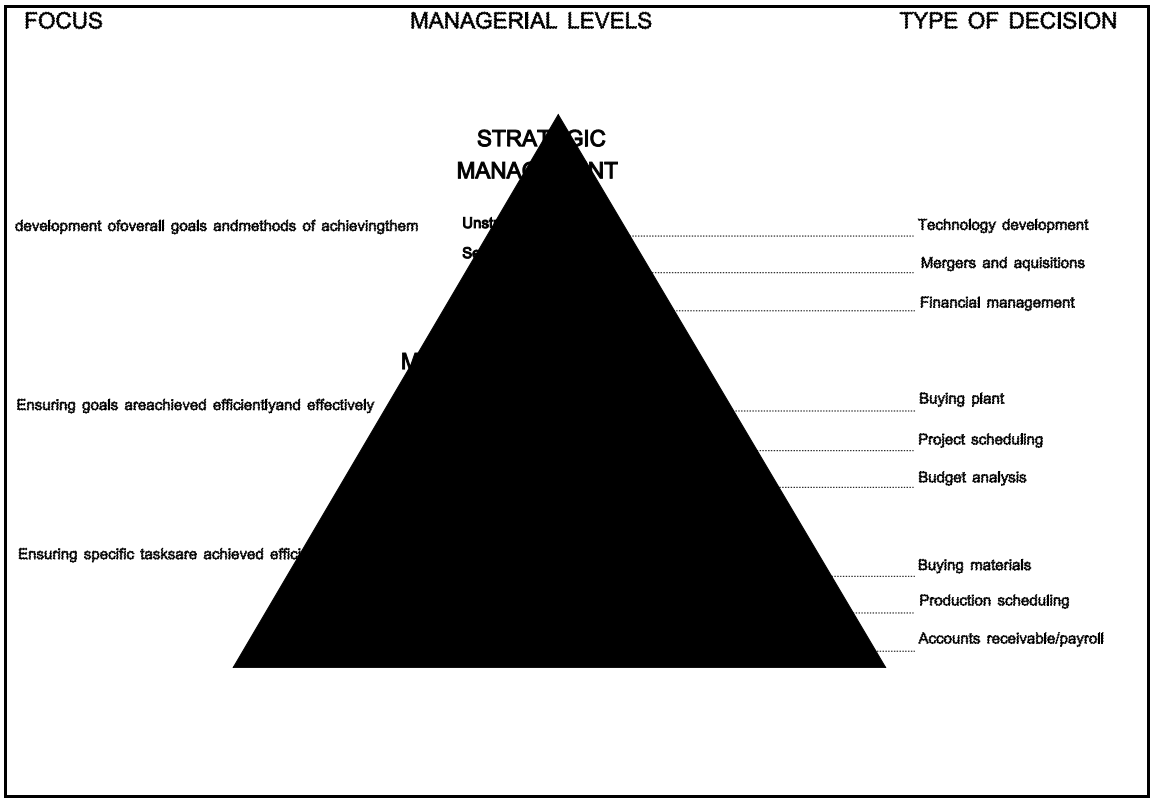

Fig 4.1: Managerial levels and types of decision in the organisation

RELATING INFORMATION TO THE DECISION PROCESS

Information is the basic input to organisational decision-making. Executives and senior organisational unit managers devote significant amounts of time to the acquisition of information through interacting with people and processing documents. A direct relationship between the quality of information used by decision makers and the quality of their decision-making performances has been well established (Halpin *et al.*, 1971; Manis *et al.*, 1978; March, *et al.*, 1982; and Mintzberg, 1973). Even for high quality information however, too much information past some optimal point can actually lead to decreased decision-making performance. Ackoff (1967) suggests that managers suffer more from an over abundance of irrelevant information, rather than a lack of relevant information.

Information sources are discussed under two general classifications:

1**Location of the information source** - This refers to whether the information source is located inside or outside the organisation. Both Aguilar (1967) and Keegan (1974) use this external/internal dichotomy.

2**Medium of information transmission** - Mintzberg (1973) classifies access to information sources according to five basic media: mail, telephone, unscheduled meeting, scheduled meeting and tours. A more simple dichotomy would be verbal versus written media.

Mintzberg (1973) suggests the information collected by executives and senior managers is used if four ways: (1) to disseminate it to others; (2) to develop value positions for the firm; (3) to identify business problems and opportunities; and (4) to develop mental images - 'models' of how the organisation and its environment function.

Mintzberg contends that mental models help the executive deal with the complexity inherent in his job. He says, "In effect, the manager absorbs information that continually bombards him and forms it into a series of mental models of the internal workings of his organization, the behaviour of subordinates, the trends in the organization's environment, the habits of associates and so on.

STAGES OF THE DECISION-MAKING PROCESS

The decision-making process itself is defined as three distinct stages, intelligence, design and choice (Simon, 1960), however, these stages are generally integrated by the decision maker into a single process. Mintzberg *et al.* (1976) similarly conclude that although distinct phases of a strategic decision process could be identified there was no simple sequential relationship between the phases. A fourth phase 'review', was later added to this model (Simon, 1977). Fig 4.2 illustrates the relationship of these three principal stages.

The *Intelligence* phase involves the study of an environment for conditions requiring decisions. Data are collected from a wide variety of sources (internal and external) and processed to provide the decision maker with information from which the decision maker may find ways of approaching the problem. The intelligence phase is akin to the 'informational role' of Mintzberg's (1973) activities view of managerial roles.

In the *Design* stage, the objective is to generate alternatives and invent, develop and analyze possible courses of action. This involves the development of models to carry out such explorations.

The *Choice* phase involves the selection of the best and most effective course of action from those investigated.

The design and choice stages may be collectively associated with Mintzberg's activities view relating to managerial 'decisional roles'.

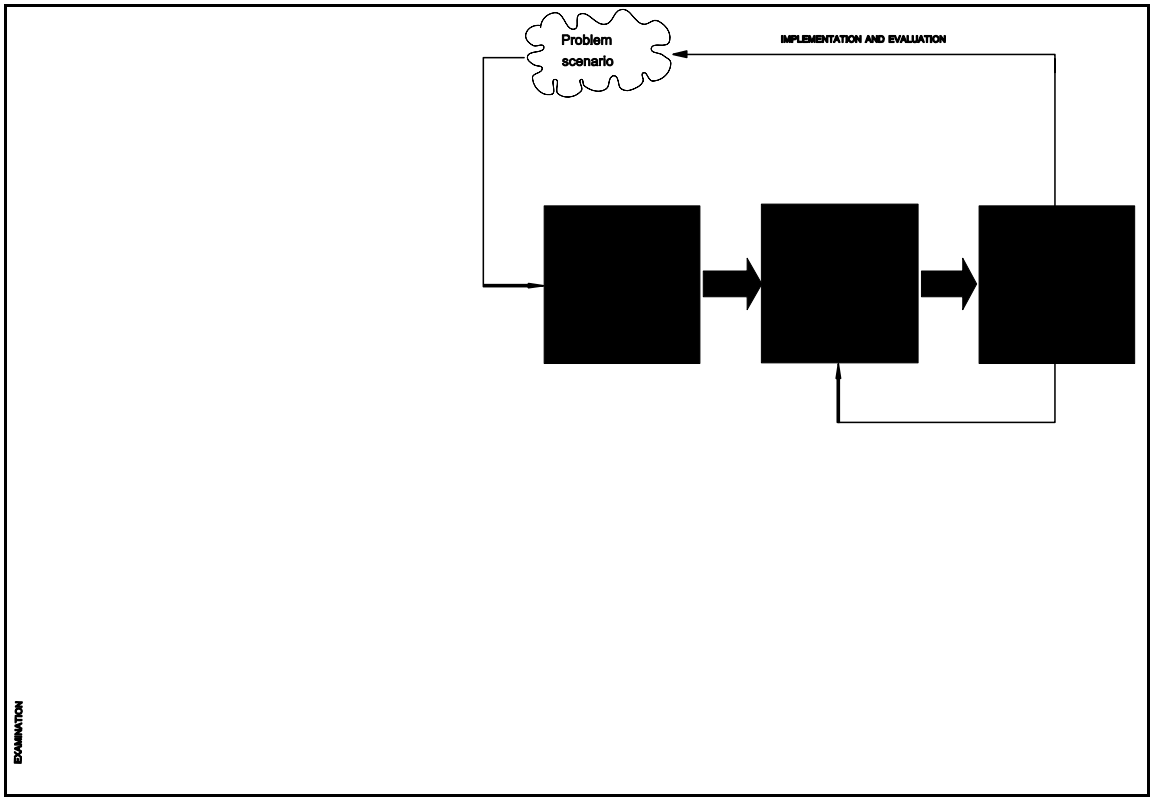

Fig 4.2. Stages in the decision making process

MOTIVATION FOR DECISION-MAKING

Alderfer (1972) proposes three basic categories describing motivation for decision-making: existence needs, relatedness needs; and growth needs. Existence needs relate to the need for physical entities that are in limited supply, such as food, clothing, etc. Relatedness needs involve the social aspects of human intercourse such as communication and the need for self-respect or the respect of others. Growth needs refer to the drive to achieve fulfilment of objectives, goals and potential. This type of theory is often referred to as a 'need-based' theory of motivation.

Alternative views (e.g., Vroom, 1964) propose an 'expectancy' theory of motivation. These theories of motivation tend to focus on the expectations people have regarding the outcomes associated with different courses of action. Thus individuals will make choices based on the attractiveness of possible outcomes and their relative probability of occurrence (Skitmore, 1989).

EFFICIENCY AND EFFECTIVENESS IN DECISION-MAKING

Efficiency in decision-making is concerned mainly with reducing costs, turnaround time and reducing clerical staff. Effectiveness, however, is concerned with the appropriateness of a decision.

A decision may be efficient by reducing costs and turnaround, yet may be ineffective if the task does not accomplish any known goal. For example, assume you can build a high tech office building for 10 million. You may have made a big effort to minimize the cost/benefit ratio through value analysis etc. and it may be true that you have produced this building at the lowest

possible cost. In this case you can say you have been efficient. However, if nobody is willing to pay even 5 million for this building then you have been efficient but not effective.

PRINCIPAL AXIOMS OF THE DECISION ENVIRONMENT

In general, commercial decisions take place in a dynamic environment. The decision environment is in a continuous state of flux ensuring that any state of environment will most likely be different some way at the next moment. The decision environment is discussed here in terms of the principal stimuli influencing it, namely: (1) internal and external constraints; (2) time pressures; (3) uncertainty; and (4) bias and inconsistency.

Internal and External Constraints

After defining a problem the next step in our model involves analysis of the problem in terms of the constraints surrounding the problem. These constraints take the form of two sets: internal and external (Bidgoli, 1989:39). A decision maker has some control over internal constraints, i.e., those constraints imposed internally. Under certain conditions some of these constraints may be removed or modified in order to fit a particular situation. Typical examples of internal constraints are:

•Resource limitations (labour, plant, materials, etc.)
•Physical limitations (operating capabilities)
•Organisational policies
•Employee welfare
•Geographical layout (region, location, etc.)
•Staffing policies
•Corporate arrangements (contracts, procurement etc.)
•Image issues
•Human issues (morale, motivation, etc.)
•Economic factors (investment structures, loans, etc.)

The more exacting constraints imposed on decision makers are the external constraints, deriving from the organisations external environment. These constraints are usually fixed, i.e., the decision maker cannot change or alter them. The organisation must modify its decisions and operations in order to comply with these constraints. Typical external constraints are:

•Resource suppliers
•Customers
•Unions
•Public images
•Labour pools
•Legal issues
•Environmental constraints
•Cultural issues
•Financial communities
•Tax structures
•Market conditions
•Government regulations
•Economic conditions

•Political changes
•Advances in technology
•Infrastructure changes (distribution)

Time Pressure and Decision-Making

A large proportion of the literature concerning managerial decision-making has been concerned with whether or not managers adhere to the rational model in practice (e.g., Bass, 1983; McCall and Kaplan, 1985; Nutt, 1984). Kenny and McQuade (1988) suggest that at least some of the variations in decision processes observed, in a series of empirical studies, are the result of 'general and selective time pressures'.

General time pressure refers to those situations in which the entire decision process occurs within a framework of time restriction. Selective time pressures occur where the restriction on available time becomes known to the decision maker at a particular stage of the decision-making process.

Decisions under time pressure, according to Bronner (1982), are characterised as situations in which it is not sufficient merely to find a solution or the most effective result. Rather, the solution must also be completed within a limited time-frame. Bronner observes that limited time is one of the most significant factors affecting decision processes. He goes on to suggest three conditions necessary for the occurrence of time pressure: (1) decision time - a defined interval within which the decision must be made and thus a formal declaration of action taken; (2) sensitivity - individuals possess different biological constitutions and cognitive characteristics, individuals also possess varying degrees of sensitivity to time pressure; and (3) problem intensity - subjective evaluation of the importance of the problem from the perspective of the decision maker.

Holsti (1978) also suggests that time pressure: (1) increases the propensity to rely on stereotypes; (2) narrows the focus of attention and impedes the use of available information; (3) reduces the resistance to premature closure; and (4) impairs the ability to estimate the range of possible consequences arising from a particular policy choice.

Decision-Making and Uncertainty

In the design and choice and implementation stages of the decision-making process decisions are made either under certainty or in the face of uncertainty (Bidgoli, 1989: 34). In decision-making under certainty, a decision maker has access to all the needed information for making and implementing a decision. With decisions made under uncertainty the decision maker is faced with a series of alternatives and states of nature. Sometimes there is a probability factor associated with each state of nature, or there may be no probability information available to the decision maker.

Bias and Inconsistency

Skitmore (1989:18) suggests that decision-making ability, when considered in isolation from motivation and constraints, is a function of decision makers' limited judgemental process in dealing with the three stages of our decision model. Such limitations are the result of the decision maker's information processing capabilities, necessary to support decision-making. These limitation are discussed in terms of *bias* and *inconsistency*.

Skitmore discusses the work of Tversky and Kahneman in examination of biases in decision-making. A limited number of factors (termed heuristics) were identified. These factors seemed to guide human behaviour in performing complex information processing tasks. It is suggested that in many cases these heuristics appear to result in reasonable judgements but they can often lead to distorted and systematically erroneous decisions. Three fundamental heuristics involved

in judgement are discussed: representativeness; availability; and anchoring and adjustment (Kydd, 1988 describes a similar set of biases based on the work of Hogarth and Makridakis, 1981).

Representativeness, or similarity basically suggests that a decision maker's judgement is made on the assessment of the degree to which one situation resembles another. The examples given relate to the description of a number of individuals to a group of people who are also given a selection of occupations from which they must select one which they consider best suits any one individual. The results of the study indicated that perceived stereotypes were used to assess the degree to which the individual was representative of a certain occupation, rather than more tangible factors, such as for example, the fact that the sample of individuals contained a majority percentage of one particular profession.

Availability is described as a situation in which decision makers assess the frequency of a class or the probability of an event by the ease with which instances or occurrences can be brought to mind.

Adjustment and anchoring occurs where decision makers make estimates by starting from an initial value or situation that is adjusted to yield the final answer. These adjustments are suggested as being typically insufficient.

Skitmore suggests that inconsistencies in decision-making mean that identical circumstances do not always lead to identical decisions. Judgement is inconsistent because human judgement is not a fully analytical and controlled process, therefore inconsistency is an inherent characteristic.

GROUP DECISION-MAKING

The rational models of managerial decision-making assume a solitary decision maker taking decisions in isolation, this scenario is seldom valid. Overwhelmingly, such strategic choices are made as a result of extensive group interactions, where the wisdom and judgement of a number of individuals are employed to refine the decision in the face of complexity and uncertainty.

In the group decision-making scenario the need for effective communication between the participants within each of the decision stages, intelligence, design and choice, becomes an essential requirement.

Group problem solving is often an ineffective process, involving a complex trade-off between process gains and losses (Steiner, 1966). Janis (1973) analyzed the foreign policy decision-making of groups in several presidential administrations. He concluded that these very cohesive and close-knit groups may be prone to "group-think", which he defines as deterioration of mental efficiency, reality testing, and moral judgement in the interest of group solidarity. For example, group members involved in the Kennedy administration decision to invade Cuba in April, 1961, reported having reservations about the decision, but did not let their differences be known for fear of appearing week and unintelligent or upsetting the cohesiveness of the group. If the group members involved in the process had employed a mechanism for safely displaying their different opinions, this potentially disastrous situation might have been avoided.

ORGANISATION DECISION-MAKING

Management scientists and researchers have, for some time, advocated the exercise of business planning (eg., Ansoff, 1965; Argenti, 1974). The purpose of business strategy is to give direction to an enterprise; specifically to give long-term direction to the firm. In the commercial organisation, the business strategy is the result of corporate/organisational strategic decisions.

These strategies are laid down in the firms policy and strategy statements. These corporate 'rules', dictates or procedures can determine the nature and scope of other decision options and the mode of selection (Skitmore, 1989).

Mintzberg's model of management roles, discussed previously, outlines one management role as an 'informational disseminator'. In relation to organisational decision-making, the manager is responsible for transmitting organisational decision policies and value statements to subordinates in order to guide their decision-making.

ANALYTICAL DECISION MODELS

It is not within the scope of this research to examine all the analytical methods that can be used in the course of decision-making: they include linear programming; inventory models; network models; Markov chains; simulation; project evaluation using net present value; return on investments; payback period and risk analysis; and the life cycle concept for process selection and product planing.

These models may be classified in one of many ways, they are described here as two unique classes: optimisation models and non-optimisation models (Bidgoli, 1989: 96).

Optimisation models are designed to generate the best possible solution to a particular problem, such models are generally suited to structured decision problems. Optimisation models include the so called Linear Optimisation Models (Allocation models, Assignment models, Transportation models, Network models); Inventory Optimisation Models (Economic order quantity, Economic manufacturing quantity); Portfolio Optimisation models (Present value, Future value, Internal rate of return); Dynamic Programming Optimisation Models; and Nonlinear Optimisation Models.

Non-optimisation models are designed to provide a "good enough" answer to a problem using different techniques. These type of model are largely suited to semi-structured decision problems. Non-optimisation type models include Statistical Models (Exponential smoothing, Moving average, Mean, Simple linear regression, Multiple linear regression, Nonlinear regression); Decision Tree Models; and Simulation Models.

For a more comprehensive exposition of these models see: Anderson *et al.* (1988); Jones and Twiss (1978); and Martino (1978).

INTUITIVE DECISION-MAKING

Whilst it is true that quantitative optimisation and non-optimisation models, such as those listed above, can help the decision maker, it remains equally true that there is still no substitute for a managers intuition, experience and judgement. These judgements can and should override the conclusion that is reached using quantitative factors.

Kharbanda and Stallworthy (1990) identify two basic types of intuitive decision-making: formal and informal.

Formal intuitive decision-making involves:

- **check-listing**
- **a rating and priority system**
- **morphological analysis**

- **brainstorming** - this concept seeks to find a few worthwhile ideas by crating a climate for suggestions
- **synetics** - this word is derived from the Greek, and means the joining together of different and apparently irrelevant elements. This should result in the generation of creative solutions to a problem. The problem is looked at in a new and previously unthought of way, by making the strange familiar and the familiar strange
- **the Delphi method** - this is designed to develop creative solutions to problems by using groups of experts, structuring group communications in such a way as to make it effective
- **the Kepner-Tregoe approach** - this method distinguishes problem analysis from decision-making. These two aspects are closely interrelated, but it helps managers to appreciate that there are two separate aspects involved They are thereby enabled to use the information they have more efficiently; and
- **statistical decision theory** - this is the Bayesian procedure for utilising both numerical data and judgemental evaluations for making decisions in conditions of uncertainty.

Informal intuitive decision-making involves the use of heuristics and cognitive modelling. This type of decision-making is described by Kharbanda and Stallworthy as '...creativity, a sixth sense or even a gut feeling.' Intuitive decision-making is said to utilise lateral thinking, which the *Concise Oxford Dictionary* describes as "seeking to solve problems by unorthodox or apparently illogical methods".

SUMMARY

In this section different approaches to the decision-making process were discussed. Contract bidding is essentially about decision-making in a dynamic environment. An understanding of the principles and axioms of decision-making within the organisation is therefore a prerequisite to the development of any system aimed at supporting contract bidding decisions.

Phases in the decision-making process, different types of decision within an organisation, managerial roles and the role of information in decision-making have been discussed. These principal aspects of organisation and decision theory are pulled together in a generic model of organisational decision-making, represented in Fig 4.3. In addition the model highlights the existence of the internal and external information requirements of the decision maker.

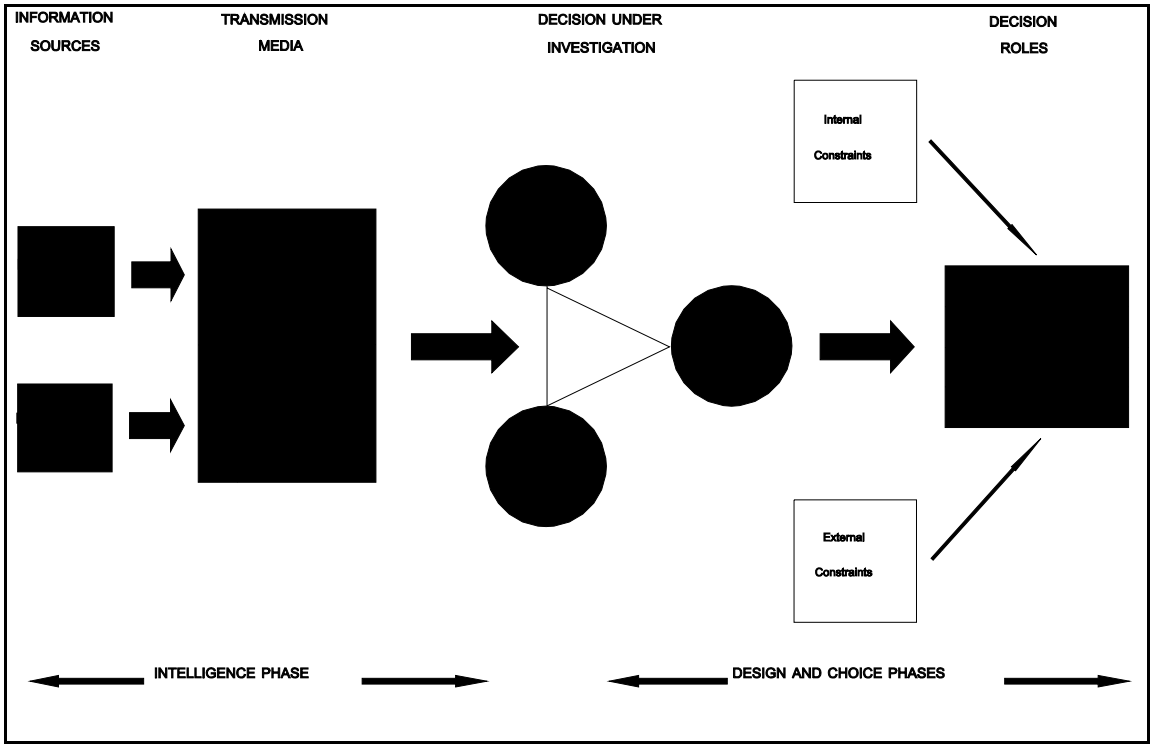

Fig 4.3: Organisational Decision-Making Environment

This generic model, representing a large body of the literature relating to decision theory forms the basis for the analysis of contract bidding adjudication processes (*cf.*, Skitmore, 1989: fig. 5.4.)

5The Background Study: Contract Bidding and Adjudication Theory

INTRODUCTION

A review of the literature revealed an absence of any distinct body of research relating 'specifically' to bid adjudication theory. Bid adjudication theory was largely found, throughout the literature, to be synonymous with the theory relating to 'contract bidding'. The nature of this relationship is further explained in examination of the general taxonomies of contract bidding.

The following review outlines the general principles and axioms of contract bidding and more specifically, bid adjudication. The objectives of the firm in bidding are discussed, together with the adjudication decision environment. The review ends with an overview of the large body of research relating to analytical models for competitive bidding.

CONTRACT BIDDING - PRINCIPLES AND PRACTICE

A large percentage of all construction work is still awarded on the basis of competitive bidding. Under this system, the owner of a project invites a number of prospective contractors to compete for a project by tendering bids or proposed bid prices. The award is made on the basis of the proposed bid prices, the project generally being awarded to the lowest responsible bidder.

Contract bidding is a complex process involving the management and co-ordination of a large number of parties involved in the assimilation of a large amount of divergent information. This information is processed and subsequently collated and explained to senior management. All this is generally done within narrow time constraints (Cusack, 1981). The following describes the principal participants and processes of contract bidding, highlighting the relationship with bid adjudication.

Participants

Harris and McCaffer (1989) divide the parties involved in contract bidding into three classes, as described in Fig 5.1.

The client's staff or professional representatives are the person or organisation, or agents of the former, for whom the building work is undertaken. Generally the client's representatives are responsible for producing the development, design and technical direction of the works including the preparation of specifications, bills of quantities, drawings and other contract documents. It is these documents that describe the nature and extent of the work to the contractor.

The construction contractor's personnel are further divided by Harris and McCaffer into seven classes: senior management; estimators; planners; buyers, plant managers, temporary works designers; and site management.

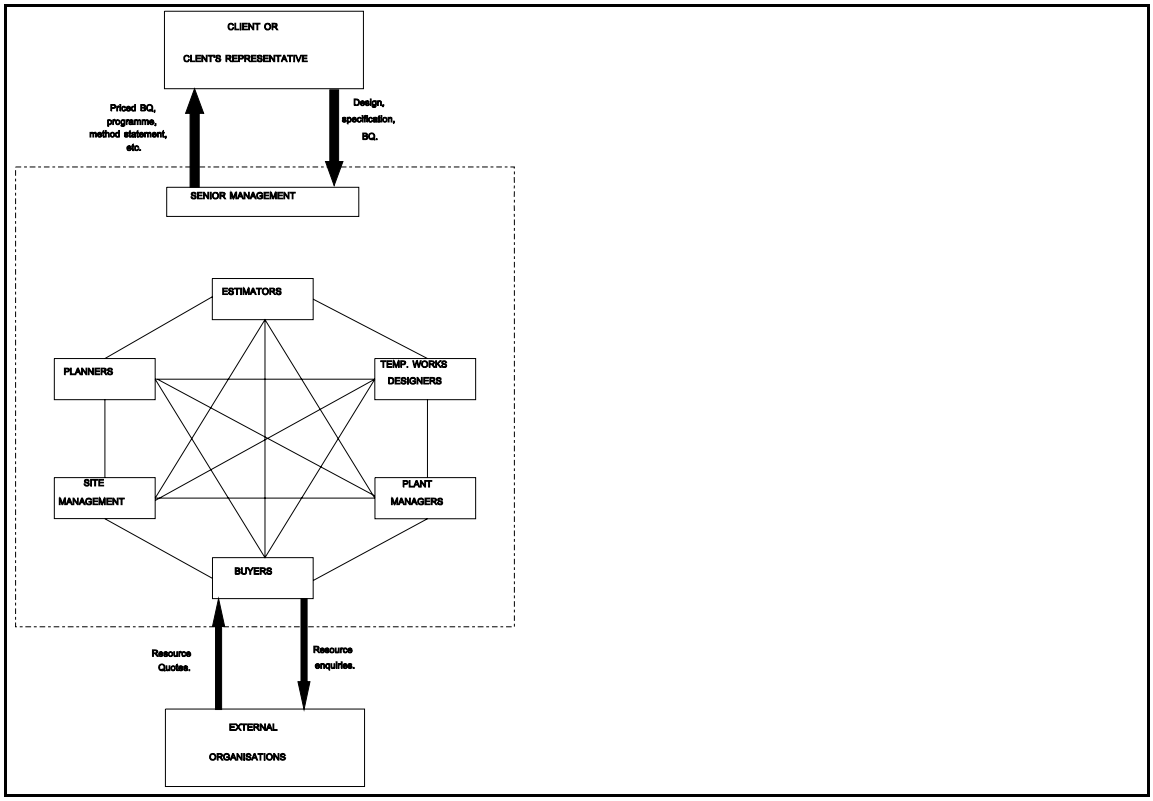

Fig 5.1: Participants in the contract bidding process

Senior management implies company directors or those of similar status. Their role is principally twofold: (1) decisions relating to whether or not to bid on any one contract; and (2) final decisions relating to the bid to be tendered, having considered the estimate of cost and resources involved, as produced by the estimators, and other relevant information.

The estimators are the personnel responsible for producing the cost estimates. Generally it is the estimating team that control and coordinate the bidding process. In addition they are responsible for producing the summary documents for presentation to senior management.

The planners are responsible for producing the construction plans or programmes. These programmes provide the overall duration of the project and the duration and sequence of key activities.

Buyers are responsible for purchasing materials and placing orders with hire companies and sub-contractors. They coordinate the procurement of quotations for resources.

Plant managers are responsible for the company's plant department and supply estimators with current hire rates and availability.This role is often assimilated by planners.

Temporary works designers are responsible for designs of major temporary works.

Site management are responsible for the subsequent execution of projects on-site. Their role in bidding is in advising on methods of construction and development of the method statement.

External organisations include materials suppliers, plant hire companies and sub-contractors responding to enquiries for quotations from the contractor.

Relating specifically to the bid adjudication process, the emphasis is on the involvement of senior management and senior estimators reviewing summary documentation collectively produced by the above participants.

Principal Stages

Most studies relating to contract bidding have proposed that the scope of activities cover a range of tasks that are carried out between the receipt of the bid documents and a decision being made by the contractor to tender a bid, and the point at which the bid is tendered to the client's representative (e.g., Fellows and Langford, 1980; McCaffer and Baldwin, 1986; Ward and Chapman, 1988; Harris and McCaffer, 1989; and Betts, 1990).

Numerous other researchers have produced similar process models of the contract bidding process, most of which exhibit an analogous nature. Fig 5.2 identifies the principal stages of the contract bidding process as discussed in the literature reviewed.

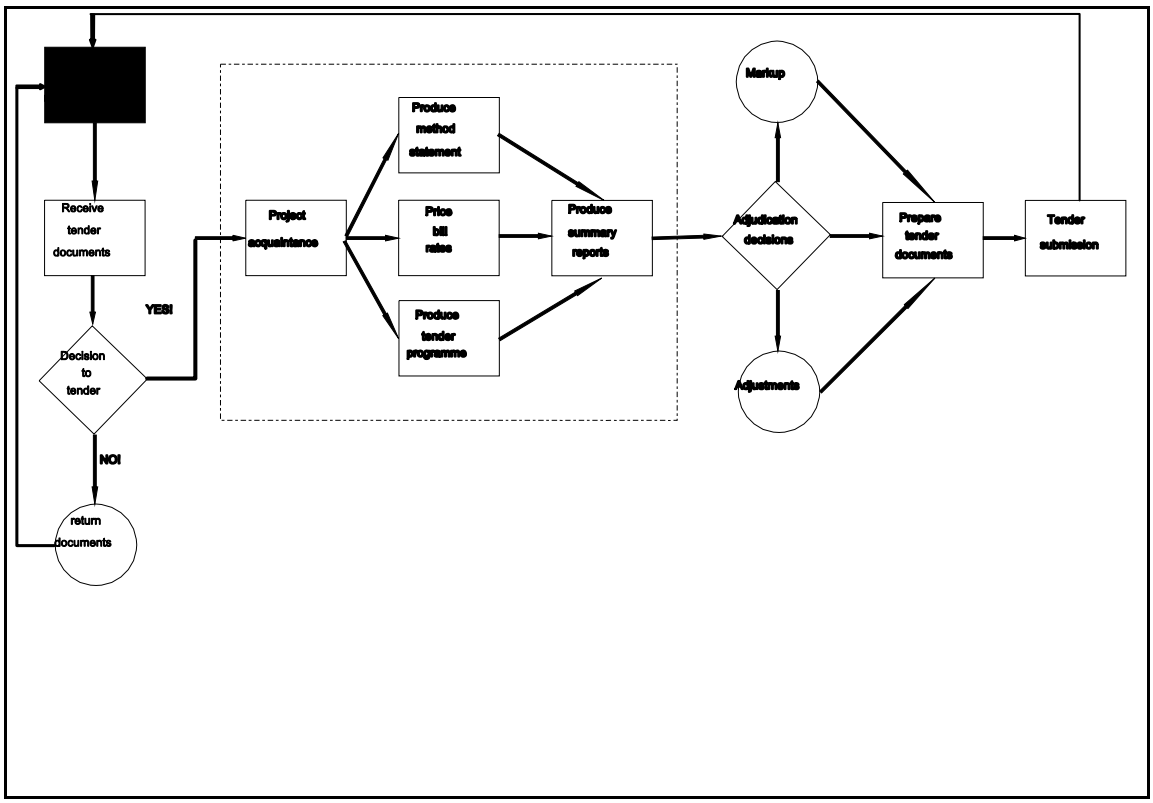

Fig 5.2: Conceptual model of contract bidding procedure

Harris and McCaffer (1989) discuss the process of contract bidding under three principal headings; (1) the cost estimating process; (2) bid adjustments; and (3) tendering the bid. The latter two stages often being integrated in a single process more frequently referred to as 'bid adjudication'. Green (1989:54) cites Farrow, in developing a distinction between [cost] estimating and tendering [bidding], who suggests:

"... 'estimate' will mean the quantity, description, unit rate and total cost (prime cost) of the works inclusive of preliminary items, but excluding overheads and profit allowances. 'Tender' [bid] will mean the sum of the [cost] estimate plus a lump sum or percentage addition to the unit rate to cover overhead charges and profit."

The *estimating process* is further subdivided by Harris and McCaffer into the following seven steps:

1Decision to bid - this stage is mainly the responsibility of senior management. Three stages are identified, during the contract bidding process, where this decision may be made:

during pre-selection, if a pre-selection procedure is used; after receipt of the bid documents; and finally after the cost estimate has been prepared.

2Programming the cost estimate - after receipt of the bid documents, and a positive decision to bid, the tasks required to complete the cost estimate are programmed.

3Collection of cost information - the cost information required by the estimator for labour, plant, materials and sub-contractors.

4Project study - to gain a more thorough understanding of the nature of the project the estimator/planner undertake: a study of the drawings; and a site visit and meeting with the client's representatives. These studies will assist in the development of a method statement.

5Preparing the cost estimate - preparing an estimate to determine the direct costs to the contractor of executing the work defined in the contract documents.

6Site overheads - the estimator assesses the site overheads, eg., accommodation, small plant, water, heating, etc. Such costs are normally allocated to the preliminaries section of the bill.

7Estimators' reports - on completion of the cost estimating process the estimators are responsible for producing a set of reports for consideration by senior management.

Bid adjudication, or bid adjustments, is carried out by senior management in consultation with those involved in the bid preparation on any one project. Based on the reports prepared by the estimating team, the senior managers assess the cost estimate and decide on the adjustments and additions to cater for risk, company overheads and profit. The addition for risk, overheads and profit are frequently referred to in the literature as the 'mark-up'. It is the bid adjudication process, and its information requirements, that is of primary interest in this research.

Tendering the bid. The bid value arrived at after the adjudication meeting is entered by the estimators into the bid documents as required by the contract documents. Apportionments are made, where a priced bill of quantities is used, for strategic adjustments and for the mark-up.

Adjudication Summary Information

The adjudication meeting and subsequent adjudication decisions are based largely on the analysis and evaluation of information disseminated by the estimating team. Much of this information is contained within a number of summary reports. These reports typically contain the following information (Harris and McCaffer; 1989:237):

- a brief description of the project
- a description of the method of construction
- notes of any unusual risks which are inherent in the project and which are nor adequately covered by the conditions of contract or bills of quantities
- any unresolved contractual problems
- an assessment of the state of the design process and the possible financial consequences thereof
- notes of any major assumptions made in the preparation of the cost estimate
- assessment of the profitability of the project
- any pertinent information concerning market and industrial conditions

In addition the estimating team produce cost reports outlining the cost of the work included in the cost estimate. These reports typically give details of:

•main contractor's labour
•main contractor's plant allocated to rates and in preliminaries
•main contractor's materials
•main contractor's own subcontractors
•sums for nominated subcontractors
•sums for nominated suppliers
•provisional sums and dayworks
• contingencies
•amounts included for attendance on domestic and nominated subcontractors
•amounts included for materials and subcontract cash discounts

In addition the estimator's may produce a cash flow forecast based on a range of assumed mark-up values.

These reports are evaluated in conjunction with other information produced during the cost estimating process, eg., programme, temporary works design, etc. This is then transposed with more general corporate and environmental information, and the decision makers' own judgement and perceptions.

The Cost of Bidding

The direct effect of cost estimating on the operating overheads of the construction firm has been investigated by several researchers. Broemser (1968), in an analysis of one construction company, found the cost of estimating to represent 9.1 per cent of total assets and 1.8 per cent of total receipts, this figure representing 0.18 per cent of the value of each project estimated, as only 10 per cent of the estimated projects were actually obtained. Park (1966) suggests a figure between 0.5 and 2.0 per cent of project value. Park offers the following rule of thumb used by some contractors on larger projects:

total estimating cost = 0.005 x estimated direct material cost + 0.015 x estimated direct labour costs

ie., 1 per cent on a $1m contract.

More recently Cook (1990), in a study of 50 UK contracting firms, proposes that the mean bidding costs are around 1.2 per cent of total turnover. In addition Cook suggests that the greater scope for reducing bidding costs lies with large and small contractors as, on average, they appear to incur higher costs than medium sized contractors.

OBJECTIVES OF THE FIRM IN BIDDING

The significance of bid adjudication decisions to the firms success in the market has already been discussed. Such decisions are akin to the primary strategic objective of the firm i.e., its continued existence and further development (Dressel, c1980).

Fellows *et al* (1983), in an examination of the nature of business strategy, differentiate between strategic and tactical decision objectives. Strategic decisions are described as the few

broad long term decisions which affect the future of the whole business. Tactical decisions (or goals) are described as operational decisions made for part of the business.

Bid adjudication decision may be described as tactical decisions that assume strategic significance directly relating to achievement of the firms business strategy.

Strategic Objectives

Skitmore (1989) categorises the strategic objectives of the firm into three general groups, monetary objectives, non-monetary objectives and market-related objectives.

OBJECTIVE	SOURCE
Efficient use of resources	Fryer (1985)
Filling plant Capacity	Benson (1980)
Maintain size of workforce	Cusack (1981)
Keeping key workers	Niss (1965)
Serving client Well	Fryer (1985)
General Community	Barnard (1981)
Improving quality of service	Niss (1965)
Retain confidence of suppliers and subcontractors	Moore (1984:19)

Source: Skitmore (1989:84)

Table 5.1: Non-Monetary Objectives

Monetary objectives usually expressed in terms of profit or profitability follow the convention of profit maximisation. Wright (1970) describes the concept of profitability as a function of three factors: turnover; capital investment necessary to support turnover; and the margin of profit earned. This view has been much criticised throughout the literature (Fellows *et al*, 1983; Hillebrandt, 1974; Green, 1989; Ahmad, 1988, for example) and the current trend is towards the profit 'satisficing' theory proposed by Simon (1957).

Non-monetary objectives are those not directly associated with profit generating. Table 5.1. summarises some of the principal non-monetary objective discussed in the literature.

Market related objectives are expressed in terms of aspirations. A summary of some of the principal objectives discussed in the literature is given in Table 5.2.

OBJECTIVE	SOURCE
Increase in market Share	Fellows *et al.* (1983); Barnard (1981)
Staying in existing markets	Adrian (1973: 371); Cook (1981); Foster (1974)
Enter new markets	Woodward (1975: 170); Foster (1974)

Growth in number of markets	Barnard (1981), Fellows *et al.* (1983: 27)

Source: Skitmore (1989: 86)

Table 5.2: Market-Related Objectives

Skitmore also discusses Bengtsson's (1985) hypothesis that there is no single unambiguous company goal, and that multiple objectives are required if the relations of an organisation to the environment are to be understood. Fellows *et al* (1983: ch 1-3) provide a more detailed discussion of strategic planning within construction organisations.

Tactical Objectives (Goals)

Specifically relating to bidding, Hudson (1988) suggests that a more tangible tactical objective of the contracting firm is not simply to win the project, but rather to win it at a price which will enable him to properly complete the work on time and make a profit.

Taking this concept a stage further a reversion to an emphasis on the objective of profit maximisation at the tactical stage may be suggested. Profit margin aggression, as opposed to margin protection has been forced upon the contracting organisation as a result of increasing competition. The margin aggressive contractor sees opportunities beyond estimated profits, looking for apparent risks which can be evaluated and opportunities for labour productivity in project selection. Potential change orders are approached as opportunities for gain through negotiation. At the adjudication stage margin aggression is evident in strategic adjustments or bid unbalancing. Green (1986) identifies three categories of bid unbalancing: front end loading; individual rate loading; back end loading. Green goes on to discuss the extent of implementation of these techniques in practice.

STRATEGIC DECISIONS IN CONTRACT BIDDING

Numerous researchers have underlined the strategic significance of contract bidding (eg., Hillebrandt, 1977; Fellows *et al.*, 1988; and Skitmore, 1989). As previously suggested, contract bidding is essentially concerned with decision-making.

Sheldon (1982) suggests that in its simplest form, the decision problem facing the bidder, in the construction scenario, relates to the mark-up of the bid, over and above the estimated cost. This basic concept underlies the rationale for the bid adjudication process, and supports McCaffer and Baldwin's (1986) description of the bid adjudication meeting as the review of the cost estimate and finalisation of the contract price for preparation of the bid documents for subsequent submission.

Sheldon adds, however, that such a basic conceptualisation of the bidding problem assumes that a decision to bid has already been made. Hence a more general perception outlines two principal problems facing the bidder. Ahmad (1988) focuses this concept, suggesting that contract bidding may be classified as two distinct but interrelated decision-making stages, namely; (1) the bid/no bid decision; and (2) the percentage mark-up decision or adjudication decision.

Collectively these two decision stages represent the firms project selection decisions which Skitmore (1989) suggests as being a vital and recurring decision for contracting organisations.

Bid/No Bid Decision

The first stage of the problem of bidding is suggested, by Ahmad as being a binary decision problem; whether to bid or not to bid. This decision depends on the overall worth of the project, the position and goals of the firm and the prevailing market conditions. As previously discussed, Harris and McCaffer (1989) propose that this decision may be made at one of three stages in the contract bidding process.

Adjudication/Mark-up Decision

The second stage of bidding decision-making is the selection of mark-up. Ahmad suggests that the mark-up is based on the estimated cost of the project and is expressed as a percentage of this cost, the mark-up itself contains the intended profit and a prorated portion of the general overhead expenses. This view is one largely supported within literature, however other researchers have additionally suggest that the allowance for profit may also include an element for general risks eg., Harris and McCaffer (1989). Depending on the influence of uncertainties arising from; the competitive situation; estimate accuracy; and contingency expenditures and in addition, the ability to evaluate risks, the outcome may fall within any of three ranges; (1) loss; (2) break-even ie., meet overhead requirements; and (3) profit. The outcome on each bid may have a different perceived value to different bidders depending on their subjective attitude and perception of their own environmental situation.

Ahmad and Minkarah (1988b), in a questionnaire survey of 400 US contracting firms, suggest that these two unique decision stages are governed by almost identical decision rules and factors. They add that the principal difference between the two decision would appear to be that of emphasis placed on the factors involved.

THE DECISION ENVIRONMENT

The bidding process, including specific bid adjudication decisions, is the result of a complex decision-making process. The complexity arises from the inherent characteristics and 'imperfect knowledge' (see Skitmore, 1989:103) endemic to the construction bidding scenario. Ahmad and Minkarah (1988) outline the following attributes of the problem as being primarily responsible for its complexity:

•Competitive situation
•Uncertainty in the estimated cost
•Unpredictability of the construction site
difficulties
•Value difference amongst the components (profit or loss, general overhead etc.) of mark-up

These attributes give rise to the aspects of uncertainty and risk associated specifically with contract bidding problems and contribute to the low profit margins and high failure rates found within the construction industry (Park, 1979). Skitmore (1989:127) suggests that the effects of imperfect knowledge introduces the necessity to consider more indirect influences on bidding decisions.

The contract bidding decision environment is considered here on two levels: (1) the 'contextual' environment of the firm; and (2) the 'bidding' environment, ie., the environment directly associated with bidding/adjudication decisions.

Contextual Decision Environment

The contextual environment has been reduced to five principal factors by Bahrami (1981). The factors identified as principally affecting the background environment of the firm were as follows:

- economic factors
- political factors
- technological factors
- legal and legislative factors

A similar set of environmental factors has been identified by Eastham (1986). These factors are further discussed by Skitmore (1989:110).

Bidding Decision Environment

Skitmore (1989) proposes a model of the contract bidding project decision system environment. This model outlines three principal type of 'decision machine' contributing to the project selection decision process. Attributes directly associated with contract bidding and adjudication decisions are discussed under three general headings synonymous with Skitmore's decision machines: (1) project decision machine; (2) organisation decision machine; and (3) marketing decision machine. These headings are supported by Ahmad (1988), who proposes a similar classification in a hierarchical grouping of bidding attributes. Ahmad's classification however, discusses a fourth dimension, 'resources'. The nature of the attributes associated with these classifications are discussed here under the three headings proposed by Skitmore, as described in Fig 5.3.

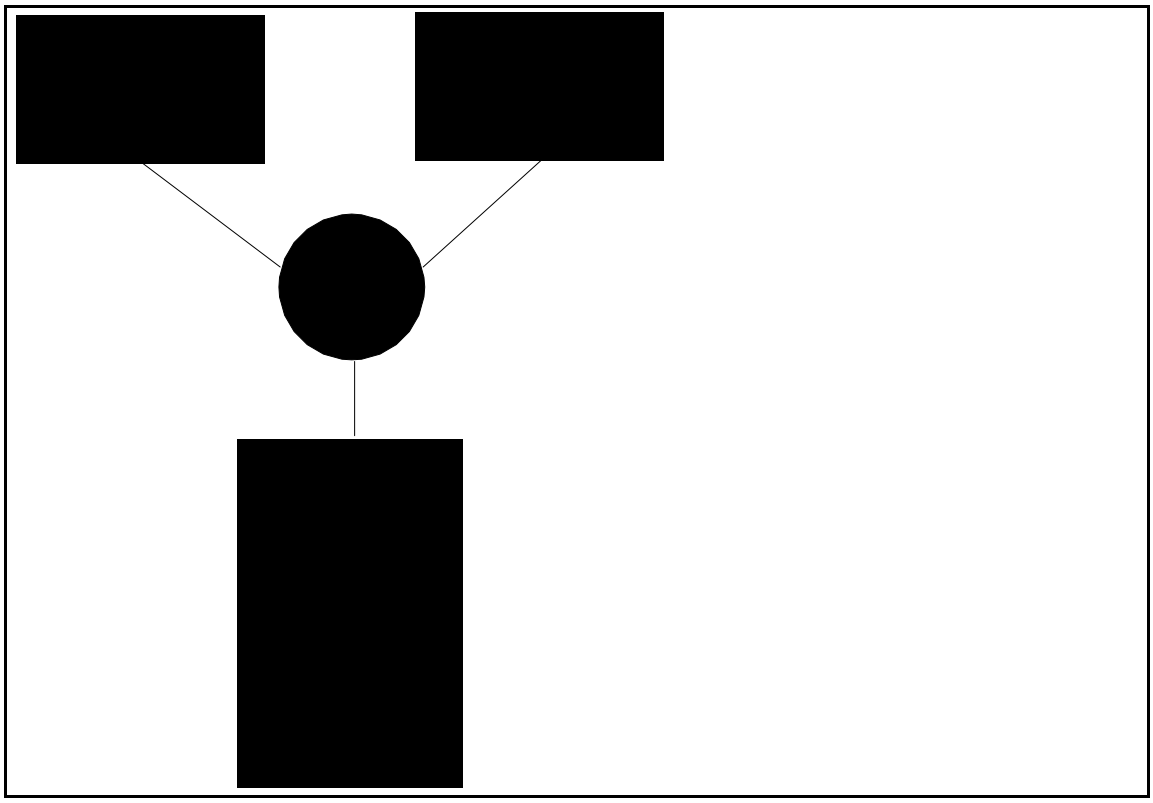

Fig 5.3: Factors affecting bidding decisions

1*Project related attributes* are those directly associated with the particular contract in consideration. This includes attributes related to the: design and construction; direct costs and resources; and commercial aspects of any one bid. This information is largely contained within the estimators summary reports.

2*Organisational related attributes* are those factors relating to the strategic operation of the organisation, as a whole, which are directly and indirectly affected by bidding decisions.

3*Market related attributes* are the external factors relating to bidding decisions, over which the contractor has no direct control.

Risk and Preference In Adjudication Decisions

Ahmad (1988) and later De Neufville and King (1991), in examination of the mark-up/adjudication decision, discuss factors associated with the three attribute groups in terms of: (1) uncertainty and probability; and (2) preference and utility.

Fig 5.4. describes the relationship of the three attribute groups with these two aspects of adjudication decisions, and in addition the process of mark-up selection, as influenced by these factors.

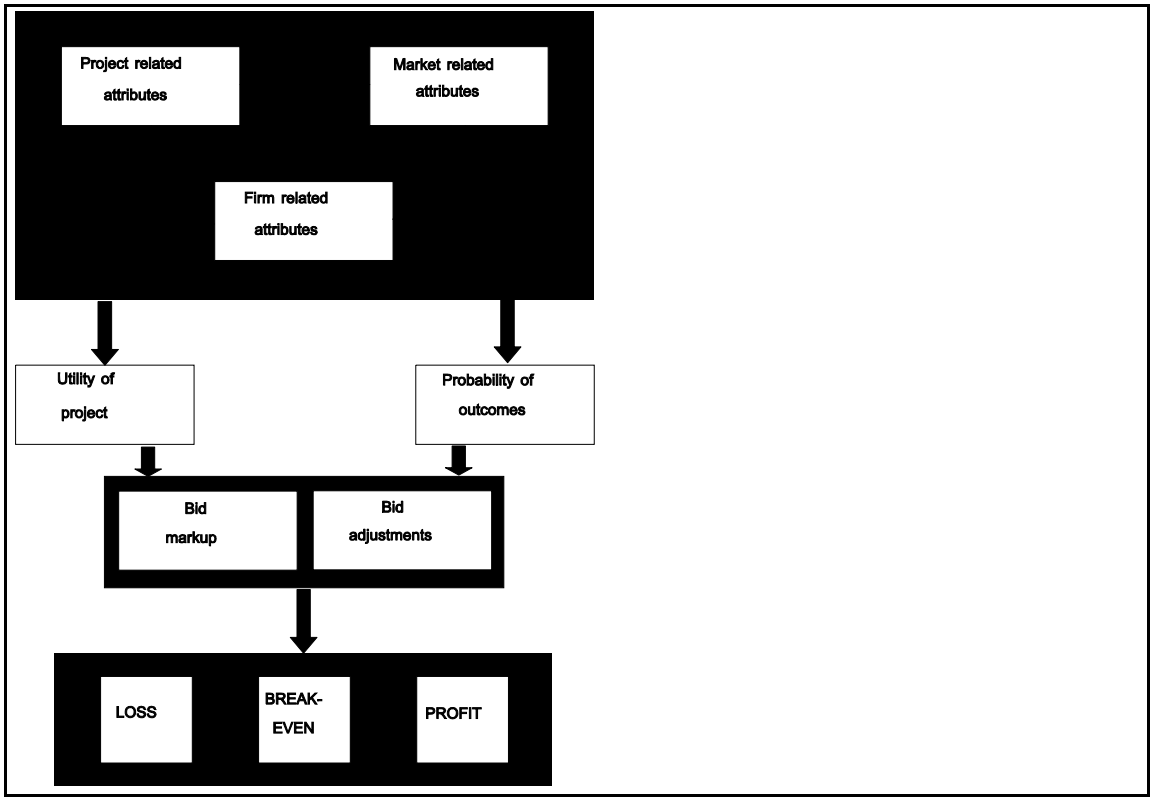

Fig 5.4: Probability and Utility in Bidding Decisions

Risk and uncertainty are generally assessed in terms of probability of outcome. The adjudication decision is highly influenced by factors relating to the assessment of uncertainties and risk. Generally it is the decision makers' judgement in assessing the probability of these, largely project related factors (eg., degree of difficulty, degree of hazard, uncertainty in cost estimate, competition, etc.), that dictates the final outcome environment, ie., loss, meet overheads, or profit.

Preference is evaluated in terms of subjective value, or utility, and the causal effect any one project has on the preference related attributes (eg., need for work, type of job, current workload, profitability, economic conditions etc.).

ADJUDICATION DECISION MODELS

Decision models in contract bidding have typically assumed the form of mathematical models focusing on the production of optimal bidding strategies for contracts. These models tend to evade the wider issues, both quantifiable and unquantifiable, that influence the contractor's bidding adjudication decisions (Lange, 1973). The initial requirement here, is for a model that reflects the adjudication decision environment, in particular the type and extent of available information and its relation to the adjudication decision makers' decision processes.

In the previous chapter the basic elements of the decision-making process were examined, and a general decision model outlined (Fig 4.3). This basic model is now fused with the aspects of bidding adjudication decision-making discussed above. The resulting model then, illustrated in Fig 5.5, represents a general conceptualisation of the decision process and information flow relating to bidding adjudication decisions.

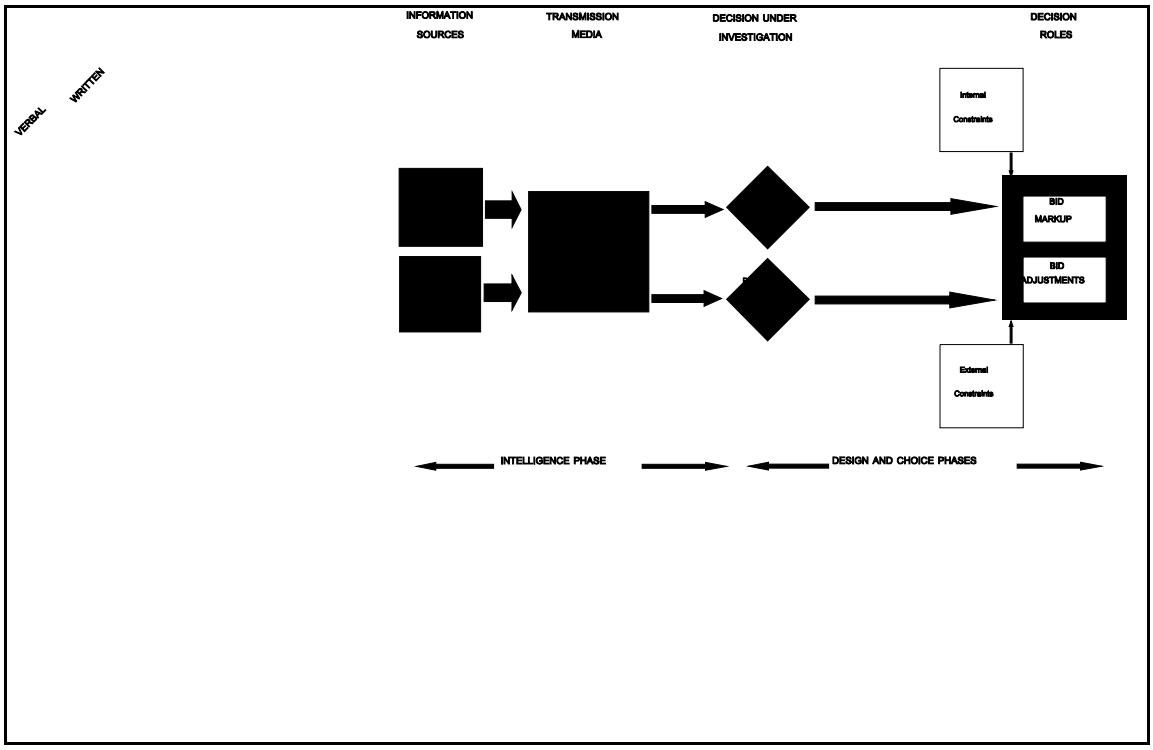

Fig 5.5. Adjudication information flow and decision criteria

COMPETITIVE BIDDING - REVIEW OF ANALYTICAL MODELS

Studies relating to the analysis of bidding strategy date back as far as the 1950s. Consequently there is a large body of contradictory research within the literature relating to this field. The object of most of the research has been to develop a model which will predict the probability of winning in the competitive bidding scenario endemic to the construction industry. Other

researchers have tried to derive an 'optimum mark-up' that will, in the long term produce the maximum profit.

Friedman and Gates

The seminal competitive bidding strategy model was developed by Friedman (1956) and was bases around maximising the bidder's monetary value. This model is further elaborated by a series of researchers (Park, 1966; Rosenshine, 1972; Fuerst, 1976; Ioannou, 1988).

In its most basic form , it is assumed that the contractor is bidding on one contract, with the objective of maximising the expected profit of bid *'b'*, given that the winning bid is selected on the basis of price; non-price factors are implicitly assumed not to affect the decision function. Therefore if *P(b)* is the probability that a bid of *b* will be the lowest and hence secure the contract, expected profit of bid *b, E(b),* can be expressed as:

$$E(b) = P(b)\,(b-c).$$ Where c = estimated cost

Therefore the profit maximising bidder will choose that bid that maximises *E(b).*

The problem for the bidder then, is to calculate *P(b),* the probability of bid *b* being the lowest, and hence the winning bid. Friedman (1956) suggests that *P(b)* can be calculated by studying the previous bidding patterns of actual and potential competitors. Harris and McCaffer (1989) describe this method as follows:

1data are collected on bids tendered by a particular competitor on past contracts in which contractor x has competed with him;

2each competitor's *bid* is divided by the *estimated cost* of contractor x;

3the data is grouped and a histogram plotted. This histogram represents a picture of this competitor's historical performance against contractor x. This histogram is usually converted into a cumulative frequency curve, as shown in Fig 5.6, with scales that show a direct relationship between contractor x's intended mark-up and the probability of beating a particular competitor.

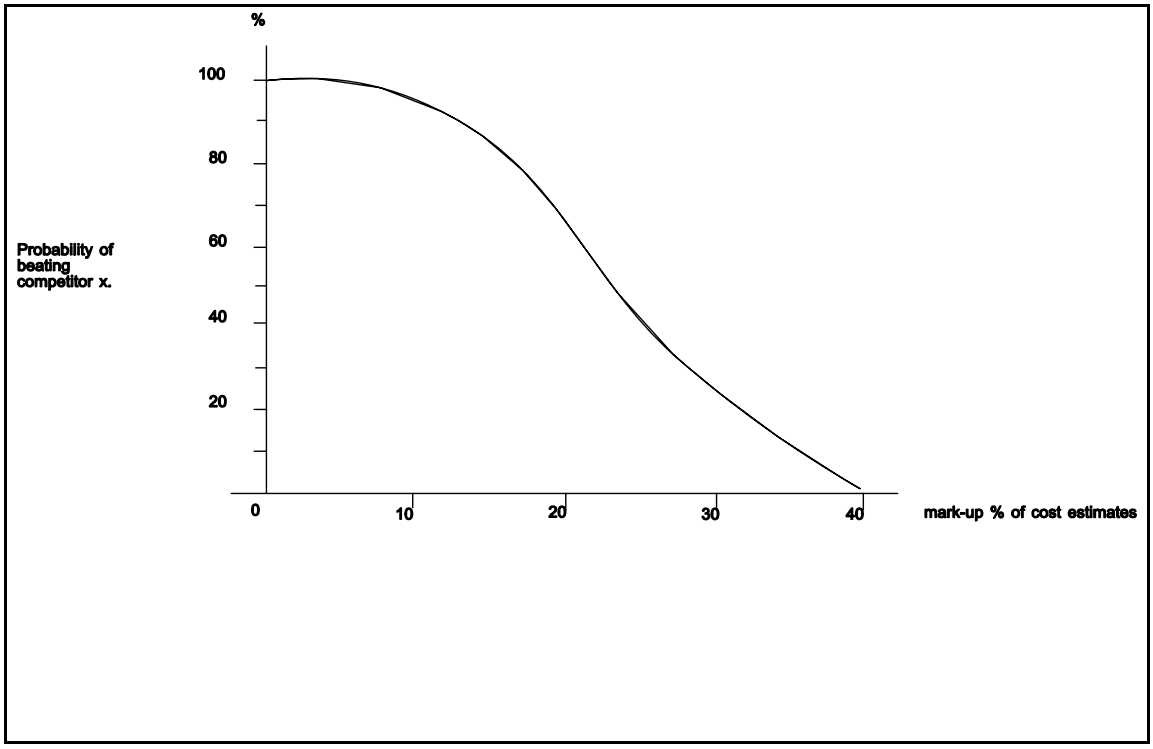

Fig 5.6: Probability of beating competitor x vs. mark-up

Thus if the bidder knows the identity of the *n* other bidding firms, assuming that their past bidding behaviour is a good indicator of their present behaviour, the probability of beating each rival bidder can be calculated. Hence the joint probability of beating *n* bidders, ie., the expected profit, is expressed by Friedman (1956) as follows:

$$E(b) = P(b)_1 \, x \, P(b)_2 \, ... \, x \, P(b)_n \;\; (b\text{-}c)$$

If the identity of competing bidders is not known, Friedman postulates that the probability of *b* being the lowest bid would have to be calculated on the basis of an average probability. In this case expected profit would be:

$$E(b) = \sum_{i=1}^{n} [P(b_i)/n](b - c)$$

If the bidding firm had an idea of how many unknown competing firms were bidding for the same contract, the probability of success of *b* would be the squared, cubed, etc. value of the average probability of beating one unknown competitor, hence expected profit would become:

$$E(b) = \sum_{i=1}^{n} [P(b_i)/n]^k (b - c)$$

Where k = estimated number of unknown competitors.

This analysis of bidding has formed the basis of much of the subsequent work on bidding strategy.

A parallel family of models is set forth by Gates (1967) and similarly elaborated by others (Baumgarten, 1970; Rosenshine, 1972; Dixie, 1974) as well as by Gates (1976). Gate's model is again based on the collection of historical data and the creation of a distribution of competitor's bids against a contractor's cost estimates. Friedman's model implies that there is no uncertainty in the opponent's cost estimates by assuming that, for a particular project, the estimated cost is the same for all bidders. Uncertainty is due only to the difference in the mark-up values. On the other hand, Gates assumes just the opposite, arguing that in the construction industry uncertainty is mainly due to variation in cost estimates, not in the mark-up. For a more detailed comparison of the two models see Benjamin and Meador (1979).

Utility Functions

Benjamin (1969), and later Willenbrock (1973), introduce the concept of utility to the basic models of bidding. This basically involves a method of constructing a bidder's 'utility' function that gives a value or utility to the money a bidder expects to earn from a contract. Then the expected utility, instead of expected mark-up/profit, is maximised. Consideration of the wider factors such as size of project and the bidder's subjective attitude to risk are implicit in the utility function.

Other researchers have explored the application of similar multi-attribute utility function approaches to the bidding problem (eg., Fellows and Langford, 1980; Ibbs and Crandall, 1982; Ahmad, 1988; and Kidd and Prabhu, 1990). In simplistic terms these approaches estimate values of individual criteria by relying mainly on the decision maker's judgement. Consequently these approaches acknowledge the fact that mathematics is unlikely to supersede judgement entirely, in relation to bidding decisions, a view supported by Harris and McCaffer (1989:252). Multi-criteria decision analysis provides a framework for choosing among alternative courses of action when the outcomes resulting from these alternatives are clouded by imprecision and uncertainty. Probability theory is applied to allow the decision maker to make maximum use of the information available, while utility theory guarantees that the choice will reflect the decision maker's true preferences. Studies by Bengtsson (1985) support the use of such an approach. Bengtsson's work failed to reveal any single unambiguous goal and suggested that multiple objectives are required if the relations of an organisation to the environment are to be understood.

A comprehensive analysis of the theories and findings related to utility theory and multi-attribute analysis can be found in Keeney and Raiffa (1976).

Relating Cost Estimating Accuracy to Bidding Models

Whittaker (1970) and Barnes and Lau (1974) are in accord that cost estimating accuracy is one of the principal variables controlling the probability of producing a winning bid. Consequently numerous researchers (eg., Neil, 1978; Ashworth and Skitmore, 1983; and Abdel-Razek, 1987) have examined the nature of estimating accuracy in some detail. Harris and McCaffer (1989) ask the question: "If output varies from 50% to 200% around the mean of 100%, how accurate can any estimator be in forecasting the cost of a contract?"

Given the nature of the problem facing the cost estimating department, different estimators are liable to produce a range of cost estimates. Assuming that a contract has a 'likely cost' (Harris and McCaffer, 1989:256) the range of cost estimates produced by each company will be:

$$\text{Cost estimate range} = \text{likely cost} \pm A\%$$

Where *A%* is a measure of the accuracy of present cost estimating methods.

Harris and McCaffer (1989:256) use this simplification to explain why contractors' achieved profit/turnover is significantly less than the average of the profit margins added to the cost estimates at the tender stage. Harris and McCaffer refer to this phenomena as 'the margin lost in competition'. This theory suggests that the winning bid is normally based on a bid which is probably less than the likely cost, as a result of estimating inaccuracy. Consequently the achieved mark-up on the contract is generally less than the mark-up included in the bid. Over a large number of contracts the average difference between the mark-up included in bids and achieved mark-up is the average difference between the likely cost and the estimated costs. Harris and McCaffer refer to this average difference as the 'breakeven mark-up'.

Thus if a contractor did not wish to make a profit but wanted merely to break even and attempted to do so by including a zero profit mark-up in his bids, he would, because of estimating inaccuracies, make a net loss over a number of contracts. In order to break even over the long term he would have to apply a profit mark-up grater than zero to compensate for estimating inaccuracies. The mark-up needed to break even depends on (1) the general level of estimating accuracy and (2) the number of competitors.

Harris and McCaffer (1989:263) conclude that:

- the achieved profit margin will be increased if the accuracy of cost estimating is improved
- if the cost estimating accuracy is improved and the contractor wishes to maintain the same turnover, he will need to (a) reduce his applied profit margin or (b) increase the number of bids he tenders or (c) make some reduction in his applied profit margin and also increase the number of bids he tenders
- the achieved profit margins will be grater than the original profit margins when all contractors improve their estimating accuracy. This assumes that contractors fix their mark-up without reference to the current profitability of the company. However, the competitive nature of the industry would probably cause contractors to cut their margins once enhanced profitability had been achieved. It is difficult to assess this effect but at least one residual benefit would remain, namely the reduction in loss making contracts
- there are serious consequences for any contractor who allows the accuracy of his cost estimating to deteriorate

Constraints On Use In Current Practice

Several surveys (eg., Lansley, 1983) indicate that contractors do not favour the use of mathematical models. Researchers at Brunel University (Langford and Wong, 1979) found that all but a few of the largest contractors still use the traditional approach of experience, judgement and intuition. The general view seems to be that mathematical and statistical models are being ignored primarily because of the fundamental assumptions made in their development.

Models based on the seminal works of Friedman (1956) and Gates (1967) assume that the only objective of a construction firm is to maximise the margin of bid over cost ie., profit, coupled with a simultaneous consideration of only one source of uncertainty that arises from the competitive situation. A study by Ahmad and Minkarah (1988) revealed that "... in both bid/no-bid decisions and percent mark-up decisions, many other factors are considered to be more important than just competition and profitability." In addition Park (1962) has criticised these approaches expressing concern with the basic assumption that competitors will follow the same general bidding patterns in the future as they have in the past.

In general it may be suggested that these models involve overly simplistic assumptions about what people want and how they make decisions.

De Neufville and King (1992) suggest that models applying utility and multi-attribute analysis are more realistic and underscore the fact that more factors affect bid decisions than allowed for in the univariate Friedman (1956) and Gates (1967) models. However, models including utility still do not overcome the reliance upon the use of distributions of past bid results to determine how competitors might bid on future projects.

ASPECTS OF AN ADJUDICATION DECISION SYSTEM

Referring to our basic adjudication decision model, as illustrated in Fig 5.5, we can identify some fundamental requirements for the development of an effective adjudication decision system. Primarily the requirement is for a system that deals with the wider internal and external environments, both on a qualitative and quantitative basis. Such a system subtends the philosophies of an array of goals other than just pure economic (Toffler, 1971; Johnson and Scholes, 1984; Skitmore, 1989).

The failure of mathematical optimisation models to replace managerial judgement suggests the need for a system that can inform the decision maker of the likely effects of decisions formulated by his own judgements and perceptions, a view supported by Wagner (1971). Similarly Cusack (1981) suggests that there is no shortage of available data, what is lacking is a quick and accurate method of analysis enabling evaluation of the alternative solutions.

Levinson (1953) and later Skitmore (1989) suggest the use of a combination of formal and informal methods. The more structured aspects of the decision problem are dealt with by quantitative formulation. These sub-optimised solutions can then be considered by the decision maker together with the more unstructured aspects of the problem. The decision is therefore based partly on basic analytical techniques, on other information produced by the system but also on the judgement and intuition of decision makers.

SUMMARY

The general principles and practice of contract bidding and adjudication decisions have been discussed and a general model of the processes associated with contract bidding is outlined.
Contract bidding has been identified as an essential component in the strategic performance of the contracting organisation. This aspect of bidding decisions is made clear in analysis of the strategic and tactical objectives of the contracting firm in bidding.

Two principal decision stages are identified: (1) bid/no-bid decisions; and (2) mark-up/adjudication decisions. These decisions are made by management in the endemic scenario of risk and uncertainty associated with contract bidding. Attributes and factors associated with contract bidding, and in particular adjudication decisions, are discussed in terms of three groups: (1) project related attributes; (2) firm related attributes; and (3) market related attributes. Collectively these attributes are evaluated in terms of risks and preferences in reaching an 'optimal solution' to the bid/no bid and mark-up decisions.

A conceptual model of the adjudication decision scenario has been evolved from the general decision model outlined in the previous chapter. This model encompasses the wider aspect of the adjudication decision scenario, and in addition information sources and flow associated with adjudication decisions.

The numerous analytical models and techniques reviewed have been largely ignored by construction decision makers. Such models have, understandably, failed to replace decision makers' own judgement and intuition in bidding decisions.

The chapter end with a discussion of the general requirements of a system to support the adjudication decision scenario outlined in the conceptual model. The principal requirements of such a system are as follows:

•evaluation should not be restricted to just pure economic factors
•information from both internal and external sources should be incorporated
•both quantitative and qualitative information should be supported
•provide analytical support for the more structured aspects of the decision problem
•provide suitable information to support judgement and intuition for the more unstructured aspects
•the system should facilitate 'what if?' analysis of alternative solutions

6The Background Study: Computer Based Information Systems for Decision Support

INTRODUCTION

Bonczek *et al* (1981:18), in examining the CBIS environment, conclude that '... there is no clear breaking point between any two adjacent areas ... where it can be said that one ends and the other begins'.

Traditionally such systems have all been regarded as systems covered by the generic term of 'Information Systems' or 'Computer Based Information Systems' (Senn, 1990; Parker and Al-Utaibi, 1985; Watson and Hill, 1983).

CONCEPT OF MANAGEMENT SUPPORT SYSTEMS

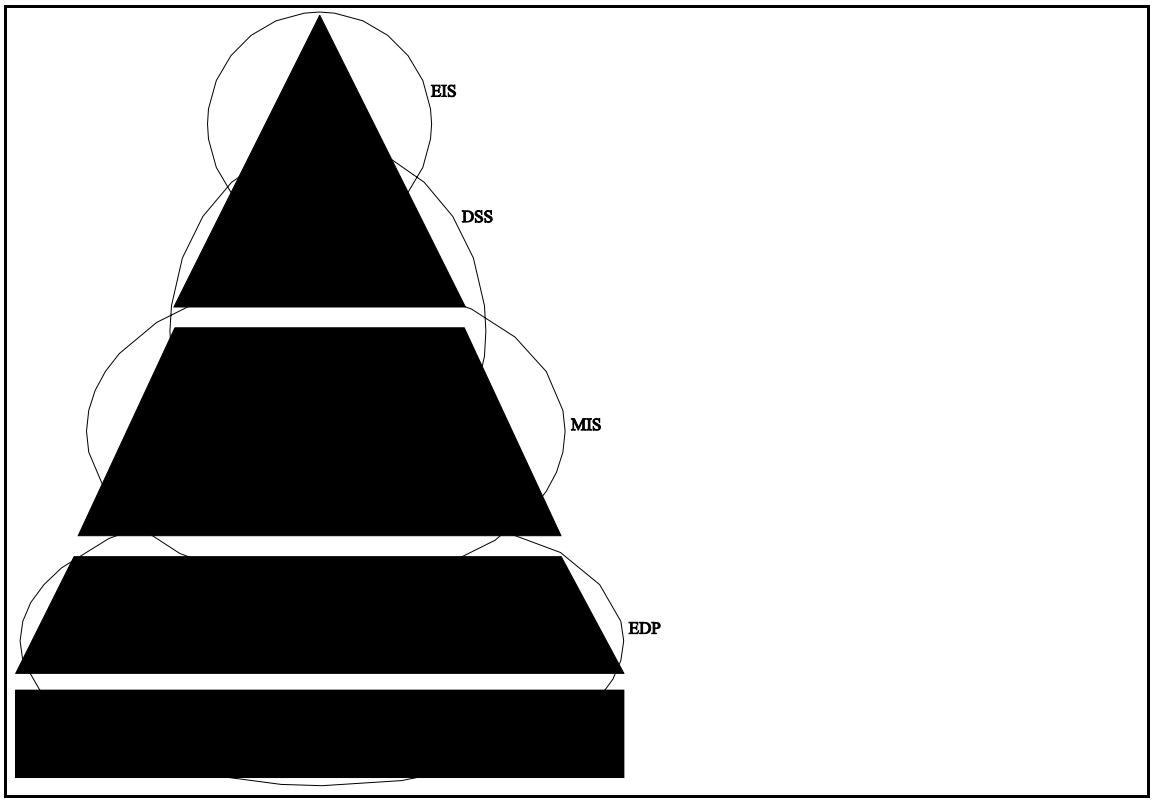

Fig 6.1: Organisational management support systems

Scott Morton (1984) introduced the concept of 'Management Support Systems' (MSSs), defining them as 'the use of Information Technologies to support management'. Finlay (1990a) advocates

the use of the concept of MSS as a generic description with the caveat that the term can encompass systems that do not rely on IT.

It is suggested that the term MSSs be adopted as a collective description of systems providing data, information and intelligence or assistance to the cognitive constructs and processes of managers and decision makers, thus including:

- electronic data processing systems (EDP)
- management information systems (MIS)
- decision support systems (DSS)
- executive information systems (EIS)

The nature of the relationship between these four principal types of management support system, together with their principal functions, is illustrated in Fig 6.1. All four technologies can be viewed as unique classes of MSSs, however they are often interrelated in an evolutionary manner.

EIS and DSS - AN INTEGRATED TECHNOLOGY

The semantics and taxonomies of ESS and related EIS and DSS technologies are not of direct interest to this paper. However, given the relative obscurity of these technologies in construction information management a brief outline is given below.

Fig 6.2 contrasts the principal characteristics and relationship of DSS and EIS technologies, the cornerstones of the ESS technology.

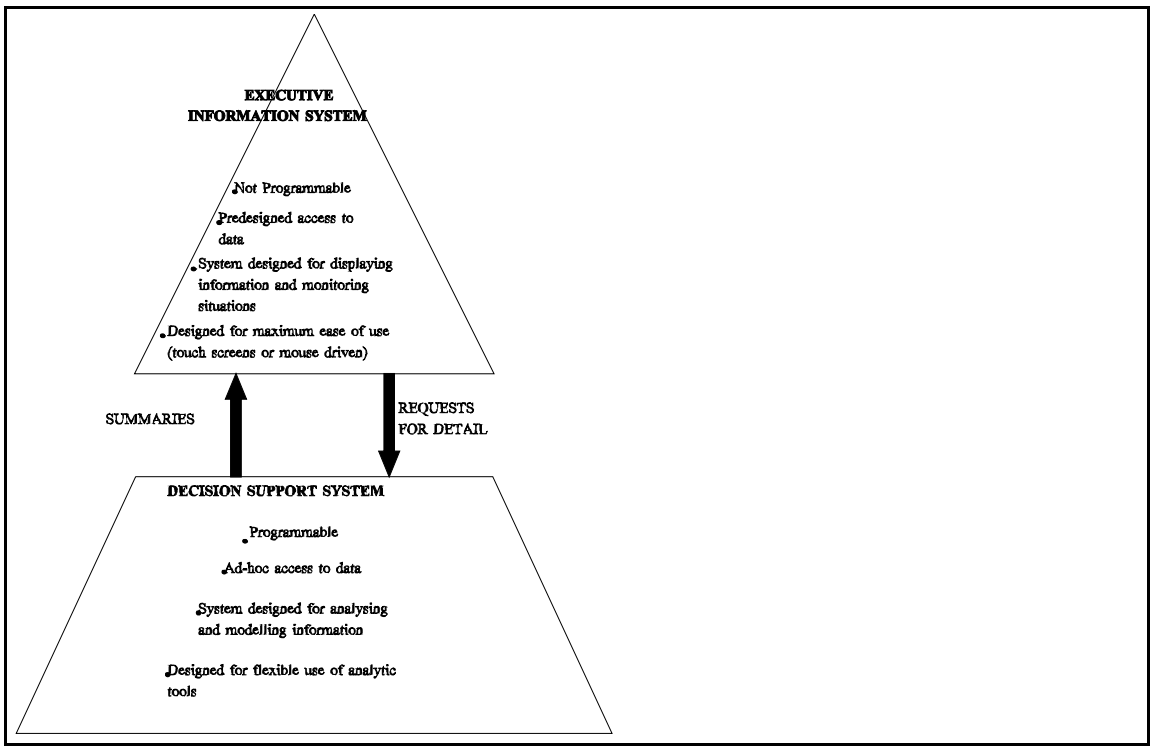

Fig 6.2: Contrasts between Decision Support Systems and Executive Information Systems

Watson *et al* (1991) have collated from previous research the following principal characteristics of EIS:

- tailored to individual executive users
- extract, filter, compress, and track critical data
- provide on-line status access, trend analysis, exception reporting, and "drill-down" (drill-down allows the user to access supporting detail or data that underlie summarized data)
- access and integrate a broad range of internal and external data
- are user-friendly utilising graphical interfaces, touch screen and mouse driven technology
- are used directly by executives without intermediaries
- present graphical, tabular, and/or textual information

The term "executive support system", however, usually refers to a system with a broader set of capabilities than the basic EIS (Rockart and Delong, 1988). The ESS may be seen as an integration of EIS, DSS and other support capabilities (E-mail, computer conferencing etc.). For our scenario the ESS technology may be conceptualised as the addition of the following capabilities to EISs:

- data analysis and modelling
- ad-hoc access to data
- flexible use of analytic tools

Once associated only with top executives, such systems are now able to run in PC LAN environments broadening EIS/ESS use to middle-level managers, fostering the philosophy that the more a piece of information is shared among different users, the more utility it has.

SUMMARY

This chapter has reviewed the principal modes of computer based support for management decision-making. Four primary groups of system have been identified, however these four types of system would appear to have overlapping boundaries when operating in an organisational environment.

The concept of an integrated technology, combining the features of decision support systems and executive information systems has been explored. Such a fusion provides a powerful range of tools for use by senior management to support decision-making:

- tailored to individual executive users
- extract, filter, compress, and track critical data
- provide on-line status access, trend analysis, exception reporting, and "drill-down" (drill-down allows the user to access supporting detail or data that underlie summarized data)
- access and integrate a broad range of internal and external data
- are user-friendly utilising graphical interfaces, touch screen and mouse driven technology
- are used directly by executives without intermediaries
- present graphical, tabular, and/or textual information
- data analysis and modelling
- ad-hoc access to data
- flexible use of analytic tools

Referring back to the aspects of an adjudication decision system, outlined in the previous chapter, it would appear that such a hybrid 'executive support system' (ESS) supports many of the requirements discussed. It would seem logical therefore, that
ESSs may be the solution to supporting the adjudication decision process.

7Empirical Study and Evaluation

INTRODUCTION

This chapter opens with a description of the nature and method of the empirical study. This is followed by a more detailed analysis of the principal observations made during the analysis.

DATA COLLECTION

The empirical study was undertaken in two principal stages. The initial first stage analysis was conducted in the form of semi-structured interviews. The second stage of analysis involved a more detailed study, through passive observation, of the adjudication meetings on two live contracts within each of the two collaborating firms.

Stage 1 Analysis

A period of two week was spent working permanently in the cost estimating departments of the two participating contracting firms. The objective of this period was to broadly examine the general context of the adjudication scenario i.e., the contract bidding process, and subsequently the general nature of the bid adjudication process. The initial objective was to identify the principal participants of the contract bidding strategic decision process and their general responsibilities. This information, in both instances, was obtained in the initial induction meeting held with the estimating director (firm 1) and estimating manager (firm 2).

Semi-structured interviews were conducted with each of those individuals (or groups of individuals) principally involved in the contract bidding decision process. Table 7.1 summarises the principal observations made relating to the participants and their roles in the contract bidding process.

In addition to those listed in Table 7.1 interviews were conducted with the information systems managers of each of the two firms. The objective here was to get some background on the current state and proposed direction of the two firms' information systems.

The differences between the two firms highlighted in Table 7.1. were found to be principally the result of their different organisational structures. Firm B has a much flatter organisational structure than firm A, having not yet devolved to regional management. Hence the managing director of firm B tended to take a much more hands-on approach to management than the managing director of firm A.

In addition to collecting this basic information, an attempt was also made in the interviews to develop a picture of the general objectives and goals of the organisation and its adjudicators.

Stage 2 Analysis

The second stage of analysis involved the observation of two live adjudication meetings within each of the collaborating firms. The objective here was to gain a detailed

FIRM A: PARTICIPANT	FIRM A: PRINCIPAL ROLE	FIRM B: PARTICIPANT	FIRM B: PRINCIPAL ROLE

Managing Director (regional)	Ultimate decision maker, generally only directly involved on larger/prestige projects or if problems occur. Strategic rather than tactical i.e., specific decision role.	Managing Director	Principal decision maker, generally responsible for all contract bidding decisions. Adjudication decision maker.
Commercial Director	As above, not normally involved in individual bidding decisions.	Commercial Director	More significant role in bidding process than in firm A. May be viewed as deputy to managing director, assumes his role in absence. Co-ordinates with estimating manager and marketing director for project selection activities. Involved in commercial evaluations of larger projects.
Estimating Director	Principal bidding decision maker. Co-ordinates with other participants for adjudication decisions and project selection decisions.		
Marketing Director	Participates in project selection process, decides which projects to actively pursue from the project environment. Co-ordinates with estimating director, chief estimator and planning manager in selecting suitable contracts and forecasting project opportunities.	Marketing Director	Participates in project selection process, decides which projects to actively pursue from the project environment. Co-ordinates with commercial director and estimating manager in selecting suitable contracts.
Contracts Manager	Decision support role in adjudication process, advises on contractual and general commercial issues.	Estimating Manager	Responsible for co-ordinating estimators activities. Assumes similar roles to those of estimating director and chief estimator in firm A. Principal decision support role in bid adjudication decisions.
Estimating Team	Perform the detailed analysis and preparation of the direct cost estimate and cost related summary documents for bid adjudication. Provide the detail for adjudication decisions.	Estimating Team	Perform the detailed analysis and preparation of the direct cost estimate and cost related summary documentsfor adjudication
Planning Manager	Coordinates planning activities of planning engineers. Not normally any decision role in adjudication process	Planning Manager	Coordinates activities of planning engineers. Not normally any decision role in adjudication process
Planning Engineers	Prepare the detailed project schedules and programmes together with method statements and temporary works design	Planning engineers	Prepare the detailed project schedules and programmes together with method statements and temporary works design
Sub-Contract Enq.	Responsible for maintaining resource database (subcontractors and suppliers) and issuing enquiries on individual projects. Project estimator performs evaluations of resource quotes.	Buyers	Responsible for maintaining resource database (subcontractors and suppliers) and issuing enquiries on individual projects. Project estimator performs evaluations of resource quotes.

Table 7.1: Participants and Principal Roles in Contract Bidding

understanding of the processes and information used by decision makers in an adjudication meeting. Appendix 1 contains detailed transcripts taken during these four sessions.

DETAILED ANALYSIS OF THE EMPIRICAL STUDY

Having outline the method adopted and principal analysis of the empirical study, the following sections discuss the observations made, first relating to the bidding process in general and secondly, more specifically to the adjudication process.

Overview of Bidding Decision Processes

The scope of bidding activities is normally taken to cover the range of tasks that are carried out between the receipt of the bid documents, the decision of whether to tender a bid, and the point at which the bid is tendered to the client's representative (e.g., Fellows and Langford, 1980; McCaffer and Baldwin, 1986; Betts, 1990). This definition of scope, although suitable for analysis of the functional aspects of bid preparation, was found in this research to be rather restrictive in examining the strategic decisions involved in bidding. Here the evidence supports the view that there are two distinct strategic decision stages in the bidding process, (1) the decision to bid for a specific project and (2) bid adjudication, where the level of mark-up is decided (see also Ahmad and Minkarah, 1988). It was also found that the decision to bid, or project selection decision, is often made long before receipt of the actual bid documents, and these two decisions, particularly the project selection decision, are made progressively, evolving iteratively over a period of time. This is very much in line with the findings of Harris and McCaffer (1983) who suggest that the decision to bid is made at three distinct points in time, during pre selection, upon receipt of the bid documents and after preparation of the cost estimate.

Fig 7.1 shows the scope of definition for bidding decisions found to be suitable for this study. The figure also illustrates the progressive and iterative nature of bidding strategy decisions (*cf.*, Hogarth, 1981).

Strategic Planning and Bidding Policy

It was found that the participating contractors operated a two tiered approach to corporate planning, as suggested by Skitmore (1989). Both contractors operated under a medium term strategy plan, based on a five year period, and a short term, 2 year policy plan. The medium term business plan is used to establish the general objectives of the managing directors and senior management for the strategic development of the firm, in consideration of the long term objectives. These general objectives are filtered down into the 2 year plans which set out, amongst other things, the firms' general bidding policies aimed at satisfying the objectives established in the medium term plan.

The firms' bidding policies are formulated from monetary, market related and other objectives. These objectives are analysed within the context of internal and external factors affecting the firms environment (*cf.*, Bahrami, 1981 and Ansoff, 1984), in conjunction with information fed back in summary reports, outlining the general statistics of bid results and performance.

The general guidelines set down in the bidding policy determine targets for the amount and mix of future contract business, an acceptable level for the proportion of contracts won, and the average profit margin to be achieved on contracts (see also Ward and Chapman, 1988).

These policy rules and criteria are interpreted and regulated by the decision makers involved in project selection and bid adjudication decisions in consideration of the individual merits and outcomes of specific project opportunities.

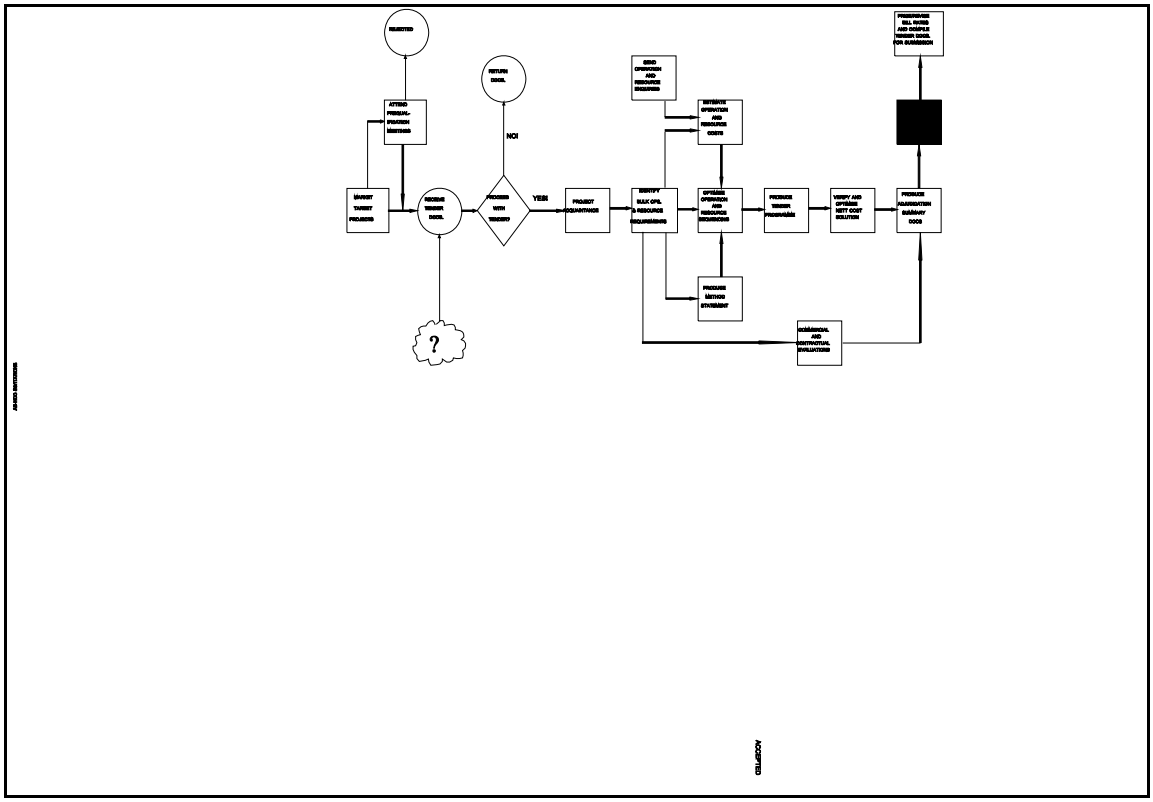

Fig 7.1: Overview of strategic decision process in tendering

The Project Selection Process - Bid/No bid Scenario

Of the two strategic decision stages identified, the project selection decision process proved the most difficult to delineate as a result of its complex and progressive nature. The procedure and process of project selection decisions within both the contracting firms was ill-defined and discursive. In this respect Fig 4.1 represents a somewhat idealistic interpretation of this stage ie., the model outlined was not followed rigorously, but forms the general processes involved. In many cases the decision to bid is made prior to receipt of the bid documents, largely as a result of marketing activity. The scope of marketing activity and its influence on project selection were observed to be far more significant than suggested in earlier works (eg., Lansley *et al*., 1979 and Sidwell, 1984), a view supported by Fisher (1989).

The marketing departments within the contracting firms were well established and consisted of both business development (sales) and research activities. The source of project selection decisions stems from a pool of project opportunities existing in what we term the project generating environment. Knowledge relating to the possibilities and characteristics of such project opportunities is sustained through active marketing relationships with existing clients, personal contacts and other historical information, and through a variety of external stimuli. These external stimuli take the form of a variety of published information (eg., trade papers and journals, records of planning applications, NEDO forecasts etc.), externally compiled market research (eg., *ABI* and *Glennigan*), personal contact with the leading property, insurance and

investment companies and also regular contact with design team consultancies (*cf*., Jepson and Nicholson, 1972:51, Rajab, 1981 and Harris and McCaffer, 1983:182-8).

From this stream of project opportunities a pool of projects are selected which best fit the hierarchal existence, relatedness and growth needs of the firm (Alderfer, 1972), and the objectives of the corporate strategy plan and bidding policy. Project selection at this stage was observed to be extremely subjective and lacking in any structured approach. However, a number of factors may be identified which were considered to affect the outcome of such project selection decisions, in conjunction with the corporate bidding policy. These factors are grouped under three distinct but inter-related headings:

- Job or project related factors
- Firm related factors
- Market related factors

Coincidentally, these sets of factors are identical to the factors considered at the bid adjudication stage. However, the level of detail is far coarser and the tradeoffs and emphasis of the factors are different. Following this decision stage the selected projects are tracked and efforts are made by business development teams whose primary task is to secure a place on the prequalification/tendering list.

At this stage certain projects emerge as having a greater potential utility to the firm than others or there may be a particular corporate interest in a specific project. Consequently at this stage the potential utility, together with the anticipated tender dates and workload, is discussed in regular meetings between the marketing, cost estimating, planning and buying departments of the company[1]. Such meetings are generally production oriented. Within both firms, however, the access and utilisation of the necessary information was poor, although the information needed was generally available. The result of these meetings is a report scheduling the likely tender dates of selected projects and, in the case of one of our collaborating firms, an alphabetical priority ranking of each project. These priorities and anticipated tender dates are constantly reviewed as new project opportunities enter into the system.

Formal invitations to tender bids then may be received as expected (eg as a result of successful prequalification) or just 'out of the blue', ie., without any prior knowledge or marketing activity. One of the firms suggested that up to 35% of invitations are a result of such *ad hoc* requests. Upon receipt of the bid documents, a formal bid decision is made based on the more detailed information contained in the bid documents. Corporate policy and the four groups of factors are considered at this stage in finer detail - the detail of the evaluation generally being proportional to the value of that particular project. Both firms then complete a formal record of the bid decision.

Preparation of the Bid Documents

Preparation of the bid documents commences following a positive decision to tender a bid for a project. Although the preparation of bids is a complex process, as shown by Betts (1990), very little corporate strategic input occurs at this stage, other than purely profit or cash flow related considerations. There were some differences however between the two collaborating firms concerning the role of the estimator in making strategic financial decisions during the cost

[1]In general, 75% of the project opportunities involve the contractors in some formal prequalification procedure prior to their being invited to tender a bid. In this case, information relating to (1) the project, client and clients representative and (2) the available and suitable personnel is necessary to put together a suitable prequalification team, is needed.

estimating process. For one firm, emphasis was placed on standardisation and continuity in preparation of the cost estimates and project schedules. Any possible bid unbalancing or other such profit related decisions were presented and discussed at the bid adjudication stage. For the other firm however, the estimators identified and implemented profit and cash flow related unbalancing policies, which were later in the adjudication meeting. The utility of each project and its anticipated bid schedule were continually reviewed throughout the bid preparation stage as new opportunities occurred.

The Bid Adjudication Process

The completed cost estimate breakdown, schedule and other various reports relating to the bid to be tendered were presented to senior management for adjudication in a bid adjudication meeting. The cost estimate was evaluated in consideration of the four groups of factors (ie., job related, resource related, market related and firm related) in conjunction with corporate bidding policies. Adjustments for overheads, risk and profit were then made to the bid on the basis of these considerations. Any late quotes or increased costs were also dealt with at this stage along with any necessary revenue recovery analysis.

This adjusted bid was then tendered to the clients representative who, for the successful bidder, issued an invitation to contract. Even at this eleventh hour, the contractor may still decline the invitation. In practice however such an event is extremely unlikely.

Principles and Components of Adjudication Decisions

Decision Environment

Bid adjudication decisions, although more readily defined than project selection decisions, are still the result of a complex decision-making process. These complexities are inherent in the nature of the problem and decision environment, ie., competitive situation, uncertainty in the estimated cost, elements of production risk and uncertainty, accelerated bidding periods and insufficiency and poor quality of information. These complexities are amplified by the dynamic nature of the construction market and by the use of apparently irrational bidding policies in the face of reducing project opportunities, eg., 'buying in' work.

Factors Considered

Bid adjudication decisions, as previously noted, were observed to be largely subjective and intuitive - based on the decision makers experiences, judgements and perceptions - an observation supported in a questionnaire survey of bidding in construction by Ahmad and Minkarah (1988). Because of the time constraints involved in the bidding process, it is not possible for decision makers to identify and analyse all the related factors that might form the basis of such decisions. The lack of any observed structured approach to bid adjudication decisions, however, results in only a small and inconsistent subset of the many possible factors that might be considered for each project. As previously discussed, the factors relating to decisions in bid adjudication may be grouped under three inter-related headings. *Job related factors* are those factors specific to each individual project, or type of project. The majority of these factors are considered during bid preparation and the analysis presented in the bid adjudication meeting. *Market related factors* cover the external environment of decision makers who are aware of their influence even if they did not always consider them specifically. *Firm related factors* are closely associated with the corporate bidding policy and business plan of the company. In bid adjudication, the aim was to assess the outcome effect of the project on the objectives outlined in the general corporate plan. Again, these decision makers were aware of their influence even though they did not always consider them specifically.

In the companies studied, bid adjudication decisions involved analysis, evaluation and preference tradeoffs of a largely indeterminate and inconsistent combination of these factors. The majority of the evaluations made were performed subjectively. Cash flow modelling, risk estimation and other forecasting techniques were generally applied to only the largest projects, where the outcome effect was considered more carefully and results aggregated into corporate cash-flow requirements.

Bias and Inconsistency of Decision Makers

Bid adjudication was observed to be a quasi group decision-making process, although the final adjustment decisions were ultimately made by a single decision maker of corporate status. The decision was highly dependent on the advice and recommendations of those present in the adjudication meeting who had been involved in preparation of the bid documents. In general, the bid adjudication decision maker had little or no involvement in the production of the bid documents up to this stage. The project estimators had the most significant influence on the final bid decision by outlining the perceived principal characteristics, risks and potential profit areas of the project. Other parties with a lesser but still significant contribution were the planners, buyers and commercial/contract managers.

In addition to the personal biases of adjudicators, an element of inconsistency existed due to the estimator, planner etc,. being different for each bid. The adjudicator is therefore also influenced by the biases and inconsistencies of a variety of human judgements, as suggested in numerous studies by Tversky and Kahneman.

The results of such biases and inconsistencies is that attention is focused on certain aspects a project more as a result of the personal biases of both decision maker and advisors than valid recognition of their intrinsic importance.

Information Sources and Utilisation

Information is a fundamental resource in decision-making. It has been said that bidding is largely a problem of managing and co-ordinating information (Betts, 1990). The information used by the decision maker in bid adjudication takes many forms, eg., reports and analyses formulated as part of the bid preparation process, subjective evaluation of project estimators, informal conversations with subcontractors and suppliers and miscellaneous information relating to the many internal and external factors stimulating the adjudication decision environment.

Very little value was placed by our collaborating companies on the analysis of historical information to support their adjudication decisions. For example, although information on the historical performance of competing contracting firms was available, suggesting in some cases that a particular competitor was 'buying work' for instance, the information was rarely used as there was no guarantee that competitors would continue to behave in the same way in the future as in the past. Despite this however, it was thought that it may be useful for decision makers to have access to information relating to the historical performance of the company's own bids for differing types of projects in different geographical locations.

In general, information relating to the keenness of competition is normally obtained through subcontractors, suppliers and other personal contacts, rather than through any form of analysis or statistical extrapolation. Thus, feedback of information relating to the performance of bids is always incomplete - detailed information concerning the likely competition may be available for one auction, but not another.

The inconsistency and inaccuracy of information, particularly relating to competition has been the principle frustrations of the numerous probabilistic approaches to bidding models. Such models are based on a series of interrelated assumptions that suggest that firstly there is an adequate supply of information on competitors bids, secondly, that competitors will continue to

bid as in the past and finally that there is no significant difference between the competitors' cost estimates (King and Mercer, 1988).

SUMMARY

The empirical study evaluated the principal participants and their roles in the contract bidding adjudication process. A detailed examination of adjudication decision-making processes revealed that such decisions are complex, involving a wide variety of economic and non-economic factors. This also applies to the objectives of the decision maker. Generally such decisions are made by senior management, reflecting the significance of such decisions. These decisions are made largely on the basis of experience, heuristics and intuition. The information used in adjudication is principally related to project details, the bulk of the time being taken up in ratification of direct cost estimates and analysis of resource quotes.

8Strategic Information Modelling

INTRODUCTION

The aim of this chapter is to develop a more structured view of the processes and information utilisation within the single aspect of bid adjudication. The methodology adopted for this purpose and its application to the empirical study is described.

METHODOLOGY - INFORMATION STRATEGY PLANNING

Martin's (1986) 'information strategy planning' (ISP) was also examined. This is part a wider philosophy of 'information engineering' which follows a top-down approach to analysis. ISP forms the top layer of the information engineering strategy. Fig 8.1 shows the principal stages of the ISP methodology and sequence of analysis. This identifies the key areas of the business and information entities and attributes used within each area. The process allows the development of 'strategic information models' without the rigours of more structured approaches such as SSADM.

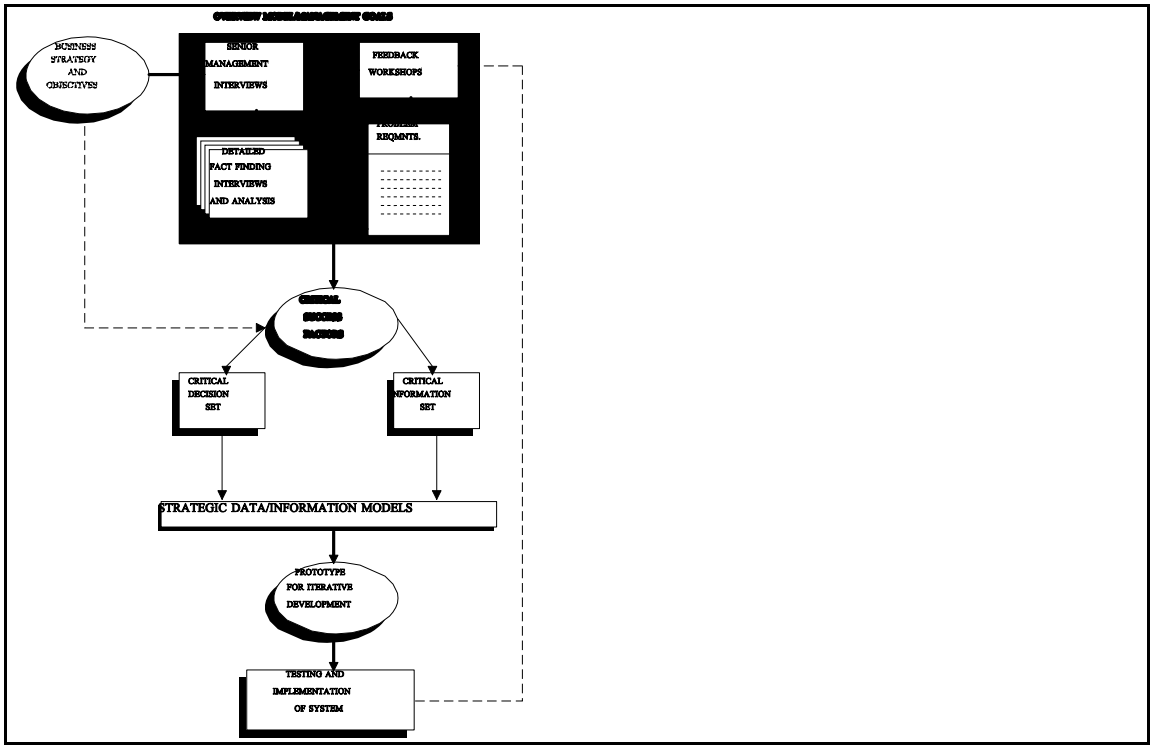

Fig 8.1: ISP top-down analysis methodology

Consequently the ISP methodology described was adopted for analysis of contract bidding adjudication and a series of models were produced representing the processes and information used by adjudication decision makers.

Many techniques are available for the structured analysis of systems and process information (eg Gane and Sarson, 1980; DeMarco, 1979; Ward and Mello, 1985; Yourdon, 1979; SSADM). The Gane and Sarson and SSADM methodologies were examined in detail as possible candidates for the structured analysis of the contract bidding adjudication process. However, it soon became clear that these techniques are generally not suited to the semi-structured nature of adjudication decision-making processes. These techniques are not easily applied to strategic decision processes, being suited more for the analysis of transaction processes. The techniques proposed by Gane and Sarson (1980), for the analysis of data flow between entities 'data flow diagrams' (DFDs), was however found useful in producing an overview model.

OVERVIEW MODEL - GOALS AND OBJECTIVES

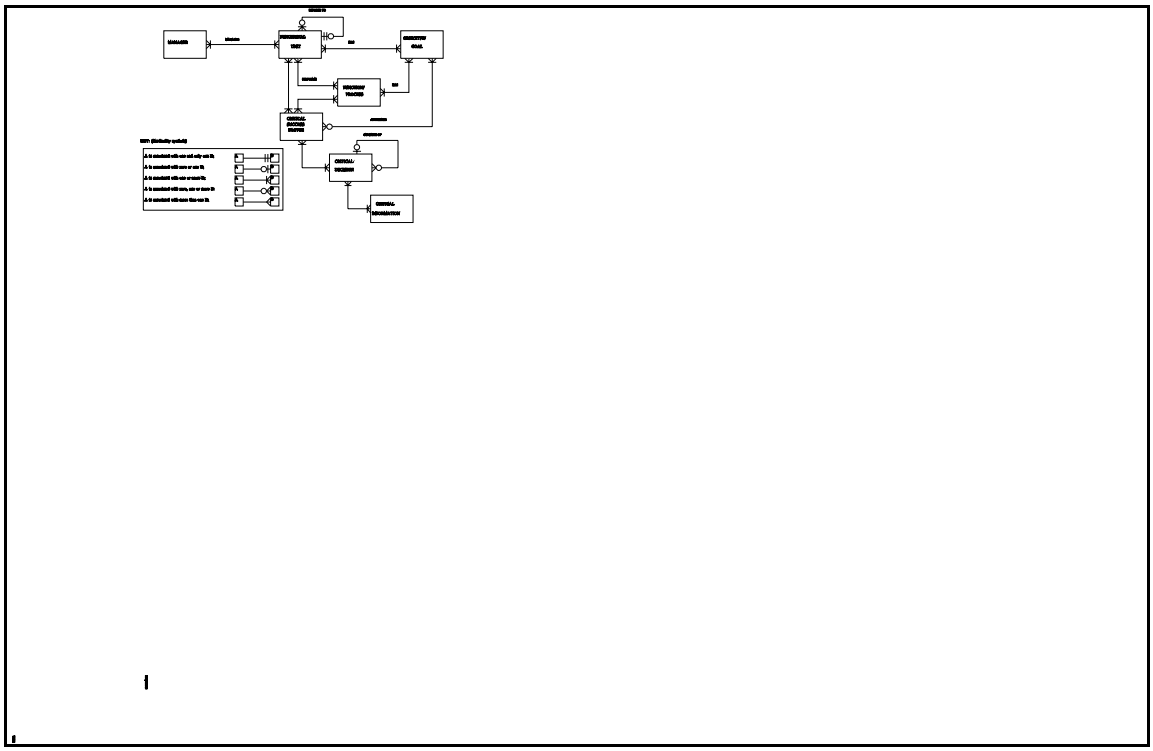

Fig 8.2: Metastructure for tender adjudication goals and CSFs

Senior managers from each of the two collaborating firms were interviewed, starting from the lower level managers and working up to the most senior managers involved in adjudication decisions, ie., the adjudication decision makers. At this stage informal semi-structured interviews were the main method employed to gain an initial overview of adjudication decisions, the internal organisation of the company and general management goals and requirements. From these initial interviews a provisional model of adjudication decisions and processes was developed, within the context of the overall bidding process. This 'metastructure' for bid adjudication goals, processes and critical success factors is illustrated in Fig 8.2.

These interviews also identified the following principal aims (general statements about direction without stating specific targets to be reached at a particular point in time) and

objectives (specific targets intended to be reached at a given point in time) associated with the firms bid adjudication strategy:

•Reduce overheads associated with bidding
•Increase profit margins on jobs
•Increase bid success ratio
•Meet corporate turnover requirements
•Satisfy clients
•Meet corporate overhead requirements
•Reduce the number of claims (from clients and agents)
•Increase throughput of bids

The next stage involved a detailed analysis of the adjudication decision process on the two 'live' bids preparations within each of the participating firms. All four of the projects analyzed were based on traditional lump sum contract apart from one design and build contract. The transcripts of these meetings can be found in Appendix I.

From this more detailed overview study, a series of data flow diagrams (DFDs) were prepared based on the notation used in the Gane and Sarson (1980) methodology. The DFDs represented three levels of detail:

• Level 0 - Bidding procedure (Summary Level)
• Level 1 - Bid adjudication (13.00)
• Level 2 - Expansion of adjudication processes (13.01 - 13.07)

The data flow diagrams, reproduced in Appendix II, model the processes associated with the bid adjudication. The identified principal processes and decisions were then used as the basis for mapping the strategic information requirements of the adjudicator.

CRITICAL SUCCESS FACTORS

From our observations, the decision makers, in order to ensure competitive performance and achieve the bidding aims and objectives identified in the overview study, aimed to achieve satisfactory results in a certain number of key areas. These specific areas, in which satisfactory results are paramount, are referred to here as the bid adjudication Critical Success Factors (CSFs).

The principal CSFs in bid adjudication were found to be:

•Profitability of job
•Optimisation of bids (Profitability vs competitiveness)
•Risk assessment of bids
•Optimisation of mark-up (overheads and profit vs competitiveness)
•Accuracy of cost estimate
•Meet or exceed specification requirements
•Meet or improve on schedule requirements
•Competitiveness of final bid value
•Maximise potential resource discounts
•Soundness of construction methods

CRITICAL DECISION/INFORMATION SET

Associated with the achievement of these critical success factors are the critical decision/information sets. The critical decisions, or processes relating to the bid adjudication are represented in the Level 1 and Level 2 DFDs. These critical decisions are made on the basis of data from the 'critical information set'. Together the critical decision and critical information sets formed the basis for the development of the strategic data model which is represented in the form of a matrix of decisions against information.

Appendix III contains a detailed analysis of information entities and attributes critical to adjudication decisions together with the principal sources of such information.

Appendix IV contains the series of entity/process matrices which map the many to many relationship of the adjudication processes identified in the DFDs and the associated critical information entities and attributes described in Appendix III.

SUMMARY

Following several attempts to utilise a number of existing structured analysis type methodologies for mapping bidding adjudication processes it was found that a less structured approach was better suited. The approach adopted facilitated the production of a series of models representing the strategic information used in supporting adjudication decisions.

These models can be used for the development of a conceptual structure for the proposed system. The information attributes, represented in the strategic information models may then be translated to the architecture of a prototype system.

9Conceptual System Structure

INTRODUCTION

Having developed models of the principal processes and information utilisation of the bid adjudication this chapter translates the structured analysis, described in the previous chapter, into a description for a prototype system architecture.

The general structure of a proposed system is discussed followed by a general analysis of its principal components.

THE 'MULTIPLE SYSTEMS' APPROACH

In contrast to the current trend towards the development of 'monolithic' integrated databases we propose the use of the more traditional 'multiple systems' approach of MIS (*cf.* Crow, 1990).

This approach recognises that the ideal 'integrated' system cannot be designed (Senn, 1990). The MIS multiple systems approach integrates information from identified **functional area information systems** (eg., planning, cost estimating, marketing, accounts) to provide an encyclopedia of details and information.

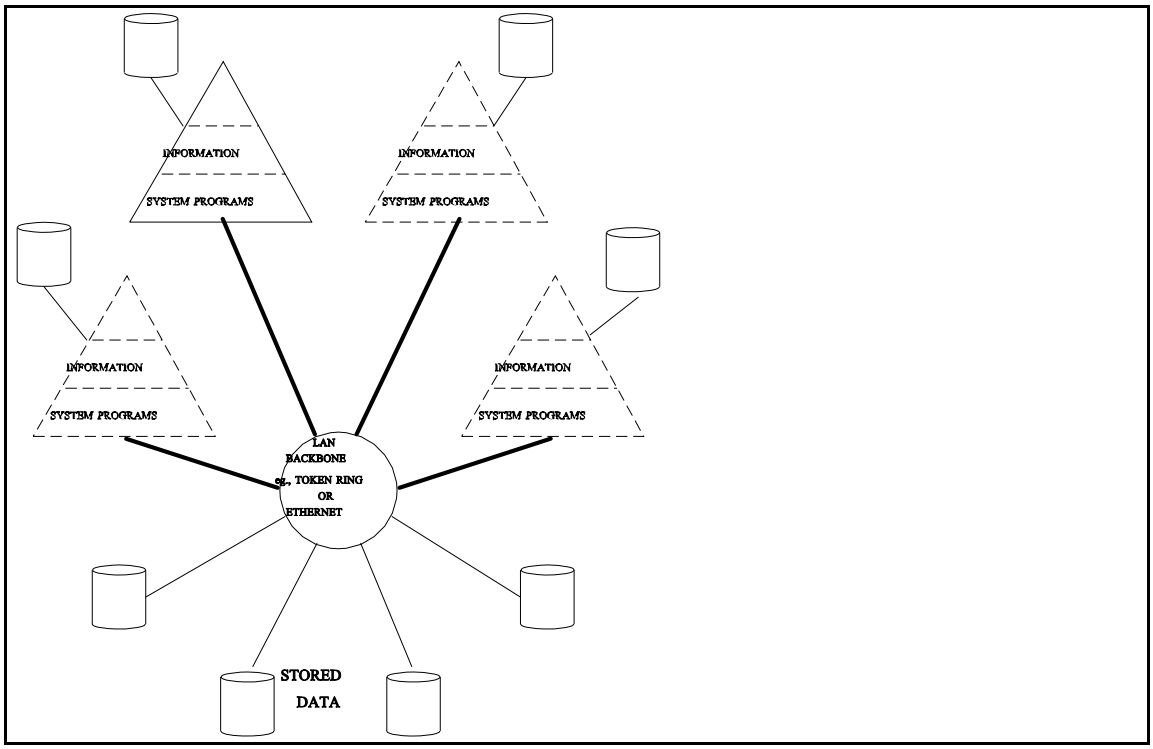

Fig 9.1: Metasystem of functional area information systems

The multiple systems approach, as illustrated in Fig 9.1, may be parallelled with the "schematic diagram" of our own brain and nervous system (*cf.*, Wooldridge, 1963). Ergo, it is a metasystem of related but independent information systems 'building blocks' that interface with each other, yet operate separately. These independent systems are often, however, organised into databases that are controlled to best meet all user requirements. This provides a core of data that can be used by each of the functional area systems within the metasystem.

The adoption of this approach facilitates the use of information stored in existing systems and the flexibility to accommodate changes. In addition the continual flow of information between departments and units makes it possible to coordinate and control the activities that occur in each one.

The conceptual structure of the proposed system, as represented in Fig 9.2 is based on such a multiple systems philosophy.

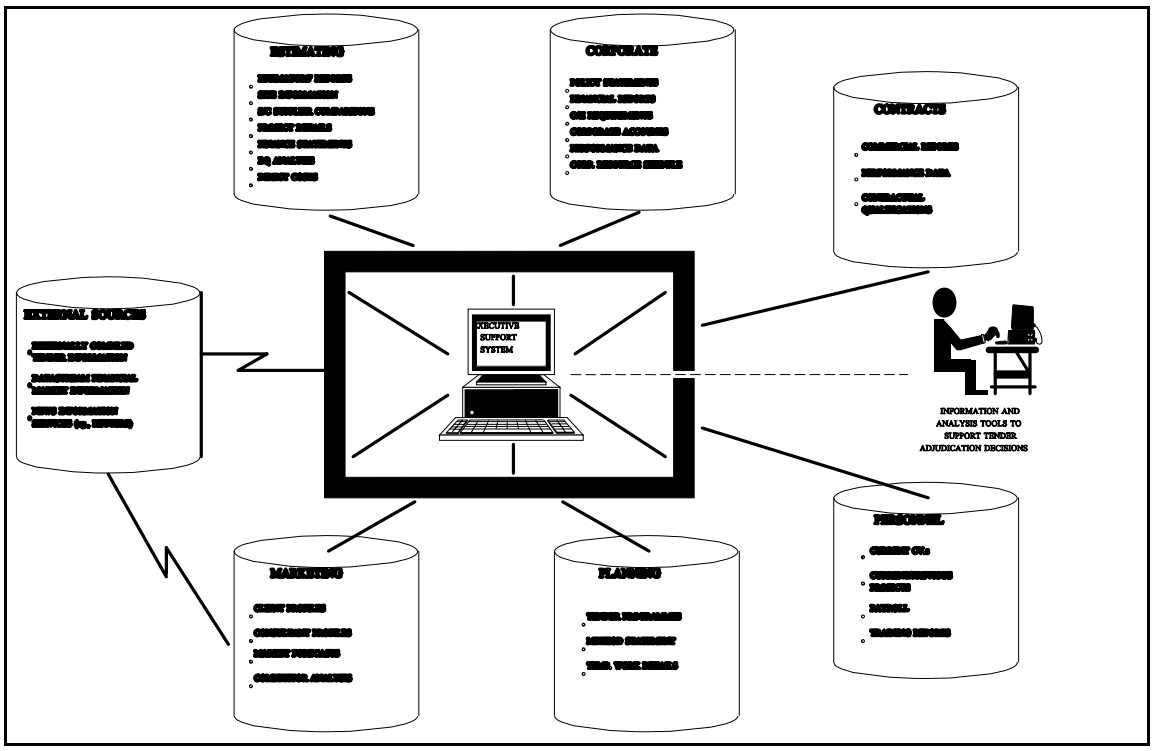

Fig 9.2: ESSTA - Conceptual system structure

DEVELOPMENT ENVIRONMENT

LIGHTSHIP 3.0 (Pilot Executive Software) was selected as the controlling development environment, running under WINDOWS 3.0 for IBM DOS on a PC 386 platform with additional XGA graphic capabilities.

This shell is one of the only development packages designed to build and run EIS/ESS applications specifically for PCs and Local Area Network (LAN) based architectures. LIGHTSHIP is a relatively inexpensive tool for building such applications, normally associated with elaborate and expensive host based systems. Running under WINDOWS 3.0, it provides an 'object oriented' development approach utilising the WINDOWS Dynamic Data Exchange (DDE) protocol, multitasking capabilities and other WINDOWS features to draw data from workstations and servers on a LAN, as well as external on-line data. Such features also allow LIGHTSHIP to interface to other software applications. These features are employed to develop

the system structure, described in Fig 9.2. For development of the prototype system, however, the connectivity problems of the LAN architecture are removed by the encapsulation of the whole LAN environment on a single PC. This is achieved by the use of a series of 'dummy' databases representing the various distributed functional area systems.

ESS CORE

LIGHTSHIP, operating as the ESS core, assumes the role of the central processor, or brain, of the metasystem. This core, utilising the techniques discussed above, 'sucks in' the relevant data, using either the WINDOWS DDE function or through an SQL request (flat files may also be used). The data may then be viewed from a variety of perspectives, defined by the decision maker, using the 'drill-down', 'slice and dice' and 'multidimensional', characteristics of ESSs. In addition the information can be analyzed using the core's integral analysis tool set or by paging out to subroutines for more sophisticated modelling functions.

Information is presented in pre-defined 'data-driven' screens, incorporating the use of icons and 'hot-spot' keys, with mouse driven selection, for user requests. Although the flexibility of information retrieval and analysis is bounded, a tradeoff has been made in favour of icon driven use and instant graphical display of the information.

DATABASES

For the present prototype study, as previously suggested, it is necessary to artificially represent the LAN, or other, distributed environment by developing a series of 'dummy' databases representing the functional area information systems. SUPERBASE 4 (SPC Software Publishing) was selected to develop these databases, being one of the best-selling WINDOWS compatible relational databases. For the operational system data will be drawn, where possible, from existing information systems.

Databases will be constructed for each of the following functional area information systems using sample data taken from the two participating firms and other suitable external sources for:

- cost estimating
- planning
- corporate (accounts etc.)
- personnel
- contracts
- marketing
- external sources

STOCHASTIC SIMULATION

The principal simulation and modelling functions supported by the system are:

- cash flow forecasting
- risk and sensitivity analysis
- probable profit contribution and optimum bid modelling
- simulation of project/corporate overhead requirements

• simulation of construction output trends (future workload)

These functions, together with other text and data related information available from the system, serve to support and enhance the adjudication decision makers own cognitive abilities.

SYSTEM VALIDATION

The prototype system will be validated against live projects within the participating firms. A qualitative evaluation of the utility of the system will be made, based on a comparison with the existing adjudication process.

IMPLEMENTATION STRATEGY

The operational system will be implemented within the context of the contracting firms' own LAN, or similar, distributed environment. Continuing the analogy of the ESS core to the mechanics of the brain, then the distributed network may be seen as the spinal cord of the metasystem.

Requests made from the core system will gather data, via this 'spinal cord', from the various internal and external information sources, as illustrated in Fig 9.2.

SUMMARY

Using the information from the empirical study a conceptual system structure has been proposed. This system is based on a 'collective system' approach. In this approach the system core serves as a junction for the firms information systems, collating the infirmation and translating it to user friendly graphical output. This information is then used by the adjudication decision maker, together with simple analytical tools, to enhance and support his bid adjudication decisions.

10Summary and Conclusions

SUMMARY AND PRINCIPAL CONCLUSIONS

The analysis conducted in the first phase of this research project has clearly identified the complex nature of strategic bidding decisions. Such decisions can be related to two principal strategic functions, the decision to bid and adjudication/mark-up decisions. Despite (or perhaps because of) the complexity and wide variety of factors involved in such decisions, they are still made largely on the basis of intuitive heuristic techniques. Contractors rely on 'gut-feeling' and judgement to make decisions which ultimately affect the short and long term performance of the organisation. The need for a more structured approaches to making both types of strategic bidding decision has been identified.

A study has been described involving interviews with two major construction companies and observations in four 'live' adjudication meetings. A form of structure analysis was applied to the empirical study. A form of structure analysis, based on information strategy principles, was applied and found to be more suitable than other, more inflexible, systems of structured analysis. This analysis resulted in the production of a series of models describing the strategic information requirements of the adjudication decision maker. From these basic models of the adjudication process and the information attributes used in support of adjudication decisions, a conceptual model of the required system was developed.

The methodology and development of a system aimed at supporting the decision maker in the contracting firms' bid adjudication decisions has been proposed in this report. An ESS approach has been used to integrate and centralise the information and tools required to support such decisions. This information is presented graphically via icon driven screens utilising user driven 'hot-spot' keys. The proposed system is aimed at supporting the information gathering and analysis stage of adjudication decisions. The system is not, however aimed at replacing human judgement, its role is principally seen as information support.

FURTHER RESEARCH

Having developed a conceptual system architecture the second phase of the research is initiated. Phase 2 involves the development of the prototype system, based on the findings and strategic information model developed in the analysis stages of the phase 1 research. Once at a suitable stage this system, together with its artificial microsystem representing the contracting firms' distributed information metasystem, will be introduced to the participating firms for iterative development. In addition to the continued development of this particular research project several areas of potential research have been identified. These areas have generally been considered within this research, however, as with most research, several of these topics have warranted much more attention than it was possible to give them.

This project has focused on one single aspect of one specific problem area, namely contract bidding. The principles of information engineering, particularly in the early stage of information strategy planning, could be applied to the generic scenario of the construction firm. The techniques described could be used to develop a strategic model of the aims, objectives,

functional areas, critical success factors, critical decisions and critical information relating to strategic management of the construction organisation. In short a structured analysis of what makes the firm 'tick', in terms of information feedback. Such models could be used to examine the nature of strategic information use by management with a view to creating a more generic executive information system. This system could provide strategic decision makers with information critical to the strength of the firm.

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Appendix I
Adjudication Meeting Notes

SUMMARY OF TENDER ADJUDICATION PROCEEDINGS

Contractor 1

C1-TA1

JOB DESCRIPTION:Extension of existing hospital building.
CLIENT: Regional Health Authority.
APPROX. VALUE: £12 Million.
TENDER SUBMISSION:Originally 17 September 1991, extended to 23 September 1991.

16 September 1991 10.30 HRS
PRESENT: CHIEF ESTIMATOR
PROJECT PLANNING ENGINEER

•The meeting started with an informal presentation, by the project planner, outlining the general nature of the project. This included analysis of the tender drawings and site photographs and surveys, assessing the nature of the site conditions and analysis of access and logistical points of interest.

•Analysis of programme for the works. Assess scope for reduction in programme, ie., increased manpower and resources. Also potential for reduction of supervisory personnel.

•Plant requirements, in particular lifting plant restrictions and risks, unsure of M&E weights and associated lifting requirements. General discussion of small plant requirements and logistical problems.

11.15 HRS
PRESENT: CHIEF ESTIMATOR
PROJECT ESTIMATOR

•Looked at nominated and domestic subcontractor trades in general, ie., what subcontract packages have been sent out for inquiry. Subcontractor comparisons not complete at this stage, a sufficient number of quotes had not been received on some of the packages.

•Commenced completion of the subcontractor quotes comparison sheets for each package in turn. Quotes compared against in house estimate. Initial task involved balancing of the quotes so that like is compared with like. Difficult at this stage as many of the quotes had not been received.

•Looked at possible ways of reducing quoted figures such as potential discounts, using labour only with a cheaper materials supplier. Estimator spent a lot of time in telephone negotiations and clarifications with the subcontractors.

•Much subjective evaluation of individual subcontractors based on previous experience and intuition was observed. No use was made of stored historical information.

13.00 HRS

•Break for lunch.

14.00 HRS
PRESENT: CHIEF ESTIMATOR
PROJECT ESTIMATOR

•Continued evaluation of available subcontractor quotes.

14.45 HRS
PRESENT: CHIEF ESTIMATOR
PROJECT ESTIMATOR
PROJECT CONTRACTS MANAGER

•Analysis of preliminaries and supervisory requirements, scope for reduction. Ensure that supervisory personnel only on site for as long as required.

•General discussion of potential for saving within the preliminaries section, eg., use of Portakabins from existing sites, alternative temporary works and electrics, metering electricity and water rather than percentage cost.

•Other possible alternative for reduction in nett costs, eg., allocation of some preliminary items to the subcontractors responsibility such as groundwater pumping.

•Logistics and maximisation of flexibility of plant requirements, mobile vs. fixed craneage.

16.30 HRS

•Decided to postpone rest of adjudication meeting until 18 September 1991 due to lack of response from subcontractors due to extension.

18 September 1991
09.30 HRS
PRESENT: CHIEF ESTIMATOR
PROJECT ESTIMATOR

•Analysis of late quotes received and completion of the subcontractor comparisons for each package. Again the major problem is in normalising the wide variation of quotes received to compare like with like. Quotes broken down to labour, plant and materials and compared with in house estimate to try to get a clearer picture.

•Chief estimator, with advice of project estimator, selects a suitable subcontractor for each package from the quotes received. Not always the cheapest subcontractor was selected, estimators use heuristic judgement to assess the risks and uncertainties of the various subcontractors. Chief estimator may allocate a capital percentage sum for risk in some circumstances.

•Subcontractor summary sheet and preliminaries analysis are completed together with the adjustments to nett cost summary sheet. A finance sheet is prepare which summarises the nett cost of the project as perceived by the estimators.

11.50 HRS
PRESENT: CONTRACTS DIRECTOR
ESTIMATING DIRECTOR
CHIEF ESTIMATOR
PROJECT ESTIMATOR
PROJECT CONTRACTS MANAGER

•Brief introduction of project.

•General synopsis of possible competitors compiled from a combination of sources.

•Outlined changes to specification on specific packages where risk elements identified. Ensure subcontractor quotes in compliance with specified requirements.

•Chief estimator outlined subcontractor responses in general and outlined major risk elements. Detailed analysis of subcontractors selected, reasons for selection and confidence in quote. Risk analysis based on the spread and soundness of the quotes submitted. Also relationship with subcontractor on historical and current projects.

•Contract manager raises personal objection to individual subcontractor as being unreliable on a previous project. Generally, there was a continued emphasis on the relationship and experience with individual subcontractors.

•Analysis of the preliminaries and outlined principal project peculiarities affecting the preliminaries. Contracts director focuses on preliminaries and makes strategic adjustment on the basis of gut feeling and experience.

•General discussion on possible savings based on current project performance levels and personal knowledge of how much competitors are paying for subcontractors and materials.

•Proactive judgement as to possible buying savings and discounts. Guaranteed payment terms offered to low risk subcontractors to attract higher discounts.

•General tradeoff of risk allocation between preliminaries, subcontract packages and potential buying savings.

•Assessment of markup for overheads and profit. Collective decision ratified by contracts director and estimating director. No formal analysis for selection of a suitable markup, however heuristic judgement and experience was used to assess a suitable addition in consideration of a variety of factors.

•Adjustments to nett cost and completion of finance statement are continually updated by the project estimator for final preparation of the tender documents.

14.30 HRS

•Conclusion of adjudication meeting.

Comments.

It is usual for the adjudication meeting to take place 1 or 2 days prior to final date for submission of tenders. It was decided to go ahead with the adjudication, despite the weeks extension. In retrospect it was concluded that insufficient information was available to do this. The adjudication meeting, in general, was relatively informal. Co-ordinated by the chief estimator the various participants were called upon as necessary, and when available. Summary documents were poorly prepared in the early stages, mainly due to the lack of submitted quotes as a result of the extension. Much of the information presented, even at the later stages, was presented informally and 'on the fly'.

C1-TA2

JOB DESCRIPTION: Six storey extension
CLIENT: Building Society
APPROX. VALUE: £11 Million.
TENDER SUBMISSION: 20 September 1991.

19 September 1991
10.30 HRS
PRESENT: CHIEF ESTIMATOR
PROJECT PLANNING ENGINEER

•Planning engineer gave a general overview of the project peculiarities, groundworks, site access and restrictions, landscaping and specific peculiarities, such as the complexity of the brickwork and an excessive overmeasure of concrete in the foundations.
•Analysis of programme requirements, sectional completion on tender drawings, but not in contract documents.

11.20 HRS
PRESENT: CHIEF ESTIMATOR
PROJECT PLANNING ENGINEER
PROJECT ESTIMATOR

•General discussion of completed subcontractor comparisons and outlined general areas of risk or pricing difficulties.

•Detailed analysis of quotes for the various subcontract packages, assessing particular risks elements and pricing peculiarities. Particular emphasis on the major subcontract packages. The brickwork labour and materials quote was given particular attention due to the variation in quotes received. Estimator aware, from experience, that lowest subcontractor had carried out the similar brickwork 'specials' on the existing building.

13.00 HRS

•Break for lunch

14.00 HRS
PRESENT: CHIEF ESTIMATOR
PROJECT ESTIMATOR

•Continued analysis of subcontractor comparisons. Much of time spent in negotiation with subcontractors and suppliers to obtain the cheapest possible combination of labour, plant and materials.

•Analysis of preliminaries breakdown, no amendments made at this stage.

•Selection of suitable subcontractor from comparisons, completion of subcontractor summary and nett cost estimate for finance statement.

16.00 HRS
PRESENT: CONTRACTS DIRECTOR
ESTIMATING DIRECTOR
CHIEF ESTIMATOR
PROJECT ESTIMATOR
PROJECT CONTRACTS MANAGER

•Brief assessment of competitors, based on information primarily from subcontractors.

•Brief analysis of contractual liabilities and onerous additions to the standard contract form for inclusion in the qualifying letter.

•Looked in detail at two major subcontract packages, groundworks and brickwork. Examined possible alternative methods for basement retention. Estimator outlines risk elements and how reductions and savings on the quotation were made. Looked at various labour/plant and labour/plant/materials options.

•Brickwork package subcontractor appreciably lower than other quotes, risk allowance made by not pricing any possible discount. Considered possible alternatives for the price submitted.

•Analysis of preliminaries breakdown. Lengthy examination of the preliminaries breakdown, with particular emphasis on the supervisory requirements and site buildings. Historical and current projects were used to assess preliminary costs. Despite the detailed analysis, the final reduction to the preliminaries only amounted to some £2000.

•Strategic adjustments made to the nett cost based on experience and knowledge of savings achieved on historical and current projects.

•Discussion of a suitable markup for overheads and profit based on risks and current market decisions. Final decision on the level of markup decided by contracts director and estimating director based on the need to sustain overhead costs for the following year in the face of a shortage of 1992-93 jobs.

•Adjustment to nett cost estimate made, completion of finance statement, including an for non fixed price fluctuations and preparation of tender documents.

22.00 HRS

Conclusion of tender adjudication meeting.

Comments

In general this adjudication meeting had a greater degree of structure than C1-TA1, however much of the information was still presented 'on the fly'.

Contractor 2

C2-TA1

JOB DESCRIPTION: Supermarket Distribution Depot. Design and build project using external architect.
APPROX. VALUE: £12 Million.
TENDER SUBMISSION: 23 August 1991.

22 August 1991
14.00 HRS
PRESENT: MANAGING DIRECTOR
ESTIMATING DIRECTOR
DESIGN SERVICES MANAGER
PROJECT ESTIMATOR

•Initial overview of nature and peculiarities of the project, presentation of site photographs and schematic plans. Access and logistics of site.

•Brief discussion of confidence in nett cost estimate and possible areas of risk. Information presented in estimator's summary documents which included the following:

- Estimator's overview including percentage returns subcontractor enquiries, profit statement and tender breakdown summary, analysis of key tender factors, preliminaries breakdown and adjustments to quotes.

- Subcontractor comparison summaries

- Contractors proposals/options

- Programme for the works

- Cash flow analysis

- Contactual and legal factors for qualification

•Analysis of competitors and their current performance, and identification of competition risks.

•Assessed clients non price criteria, eg., landscaping the quarry face, rock fall risks etc.

•Evaluation of subcontractors, looked at percentage return on quotes for each package. Discussion of pre-emptive buying savings achievable. Location of concrete plant in relation to site.

• Brief analysis of preliminaries summary.

•Strategic adjustment to nett cost estimate, omitted design services profit.

•Discussion of general risks, security, weather etc.. Analysis of contract conditions.

•Allocation of markup for overheads and profit made solely by managing director based on information assimilated in the adjudication meeting and in consideration of subjective analysis of market conditions and the requirements of the firm.

•Completion of the adjustments to the nett cost estimate and finance statement.

15.15 Hrs

•Conclusion of tender adjudication meeting.

Comments

The adjudication meeting was held in the managing directors office, and loosely followed a prespecified agenda. The information was generally well summarised and the managing director had a comparatively high degree of confidence in the summary documents. Very few adjustments to the nett cost estimate were made in the adjudication meeting.

C2-TA2

JOB DESCRIPTION: General Hospital, renewal of windows and roof coverings.
APPROX. VALUE: £3 Million.
TENDER SUBMISSION: 23 October 1991, extended to 28 October 1991.

21 October 1991
09.30 HRS
PRESENT: MANAGING DIRECTOR
ESTIMATING DIRECTOR
PROJECT ESTIMATOR

•Estimator presents general synopsis of project, site photographs and schematics. Phasing of work and working restrictions.

•Managing director requested information on Q.S., but none available, unknown.

•Estimator outlines major risks as presented in the tender summary documents (see C2-TA1). Principal risk element discussed, restrictive scaffolding requirements and temporary roof design in consideration of location and time of project ie., winter. Analyzed in conjunction with programme.

•Risks involved with restrictive working specifications analyzed, also associated risks of replacing windows in an 18 year old building.

•All nominated subcontractors so very little scope for discussion on subcontractors.

•Brief analysis of competition, mainly small contractors and special works division of a large contractor.

•Examination of preliminaries breakdown, analyzed scope for reduction of relatively high preliminaries estimate. Attempt to reduce preliminaries management costs. Looked at plant requirements and contractors site office requirements, suggested use of faxes etc. from existing sites.

•Possible savings noted on hoisting equipment, plant hire companies currently seeking work.

•Markup for overheads and profit set at a relatively high level, little incentive to win job, high risk, low potential for profit, little chance of winning as more suited to smaller contractor.

•Complete adjustment to nett cost estimate and information summary and profit statement.

10.30 HRS

•Conclude tender adjudication meeting.

Comments

Although the tender submission date was postponed it was decided to continue with the adjudication as all the relevant information had been prepared. There was little incentive to win this project other than the possibility of inclusion on the tender list of an eye hospital development on the same site. The adjudication was observed to be just 'going through the motions', effectively this was a strategic cover bid.

Appendix II
Bid Adjudication Data Flow Diagrams

Appendix III
Bid Adjudication Information Entities and Attributes with Principal Sources

Appendix IV
Entity/Process Matrices

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