ORGANIZATIONAL ANALYSIS OF BUILDING PROJECTS

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Abstract:

The principles of organization theory are applied to the organization of construction projects. This is done by proposing a framework for modelling the whole process of building procurement. This consists of a framework for describing the environments within which construction projects take place. This is followed by the development of a series of hypotheses about the organizational structure of construction projects. Four case studies are undertaken, and the extent to which their organizational structure matches the model is compared to the level of success achieved by each project. To this end there is a systematic method for evaluating the success of building project organizations, because any conclusions about the adequacy of a particular organization must be related to the degree of success achieved by that organization.

In order to test these hypotheses, a mapping technique is developed. The technique offered is a development of a technique known as Linear Responsibility Analysis, and is called "3R analysis", as it deals with roles, responsibilities and relationships.

The analysis of the case studies shows that they tended to suffer due to inappropriate organizational structure. One of the prevailing problems of public sector organization is that organizational structures are inadequately defined, and too cumbersome to respond to environmental demands on the project. The projects tended to be organized as rigid hierarchies, particularly at decision points, when what was required was a more flexible, dynamic and responsive organization.

The study concludes with a series of recommendations; including suggestions for increasing the responsiveness of construction project organizations, and reducing the lead-in times for the inception periods.

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CHAPTER ONE: THE CONTEXT OF THE STUDY

This chapter establishes the context of the thesis by considering firstly the historical perspective of construction projects. The way in which the construction industry organizes itself is then examined, and the distinguishing features of construction identified. Organizational theory is studied to look for ways in which other sectors of industry have approached organizational issues. The problem of relating organizational effectiveness to project outcome is discussed. The chapter concludes with the purposes of the study, stating the problems to be addressed.

1.1 HISTORICAL PERSPECTIVE

Building projects have their antecedents in jobs where a master mason was totally in control of a craft-based building project (Shand, 1954). In traditional construction projects, before the Industrial Revolution, the architect was in complete control of the job. It was the architect who hired individual craftsmen and labourers, and organized the work on site. It was also the architect who ultimately decided upon the content and form of the project. This situation is now rarely the case, as clients are taking more responsibility for their own decisions. Forms of procurement have emerged where risk has become a matter of business policy, and is distributed according to who is willing to charge a premium for accepting it. The involvement of a wider range of construction professionals and their institutions has also had an impact upon the development of the construction industry.

Since the Industrial Revolution, the technologies of building components have increased in complexity, not only individually, but also in combination. Before industrialization it was usual for large buildings to be formed from

one technological component which would perform a range of structural, environmental and functional needs. Since industrialization the various functions are served by different technological components. In this way, not only has each component become technologically more complex, but also the interactions between them have multiplied (Turner, 1986). The urge to innovate technically, and the readiness of the industry to accept novel solutions to design and technical problems was noted in the Banwell report (1964).

1.2 ORGANIZATION OF THE CONSTRUCTION INDUSTRY

The first step in understanding the organization of the construction industry is to identify its key features, and to compare this industry with others.

1.2.1 The increasing complexity of organizations

The increased fragmentation and division of specialized skills resulting from the Industrial Revolution created fundamental divisions of responsibility within construction project teams. One of the clearest divisions is that between design and construction. This split has long been clearly recognized, particularly in the Emmerson report (1962), and more recently in BRE studies (e.g. Daltry & Crawshaw, 1973). There are also indications that there has been for some time an equally important split between the pre-design (planning) stages and the design itself (Drage, 1970; DHSS, 1986). This is particularly evident in the public sector where it is not unusual for building projects to becomes the responsibility of another department, once included as a capital expenditure item (Hughes & Walker, 1988). A further division of responsibility lies between the functions of designing and costing. In the United Kingdom it has long been the practice for the architect to engage professional quantity surveyors to be responsible for planning and monitoring costs on construction projects. Other functional divisions arise from the increasing technical complexity of projects; structural and mechanical

services engineers are two of the professions which have developed as specialist fields of expertise. Professional institutions in construction dominate the working practices and organizational form of projects. Each institution lays down its own fee scales and conditions of engagement, producing a far from ideal situation;

> "As specialized institutions proliferate, institutional survival matters more than the appropriateness to changing circumstances of fiercely protected roles" (Andrews, 1983).

The involvement of several different professional practices, each working for their own firm and brought together for the purposes of a building project, creates a temporary organizational structure. Within this "temporary multi-organization" (Cherns & Bryant, 1984) there will be people working on different parts of the project, at different times, in offices which are geographically separated, and utilizing skills of varying types. This phenomenon, known as differentiation (Thompson, 1967), is typical of the organizational issues inherent in the construction industry.

1.2.2 Changing nature of the construction industry

The development of today's project-based industry is well documented (Shand, 1954; Bowley, 1966), and it is not intended to reiterate those discussions here. Suffice to say that the traditional structure of the industry has become outmoded. This is because of a huge increase in the use of new technology in building components and of novel design solutions, without any concomitant changes to the organization of the process of building provision (NEDO, 1985).

There are signs that the industry is responding to change, and that new management strategies are emerging to control the new processes more effectively, for example, "management contracting" (McKinney, 1983; Moore, 1984). However, in many cases these new forms of contractual procedure contain only slight modifications to a system which has become inappropriate, and may not always be in the best interests of the client (Andrews, 1983). Fee structures, for example,

are often still based on a percentage of the final cost of the project. In this way, the more expensive the contract becomes, the more money it will make for the management contractor. The arbitrary introduction of an extra level of management at the construction stage will not solve all of the problems that seem to be inherent in construction. The emergence of a variety of procurement methods suggests that each addresses only one of the problems associated with the organization of construction projects.

The overwhelming impression of organization in the construction industry is not one of inflexibility, so much as inappropriateness (Carpenter, 1981). Indeed, text books on construction management are increasingly stressing the need for organizational structures to be tailored to meet particular project needs (Barrie & Paulson, 1978; Burgess, 1979; Walker, 1984; Bennett, 1985). This would indicate that the problem has been perceived and its solution is being developed. In practice, however, the construction industry falls into the trap of categorizing and classifying procurement methods to such an extent that people develop their own particular favourite methods of organization which they stick to. This leads to the situation described by Carpenter (1981) who states that

> "projects go wrong because the actual tasks peculiar to the project are not identified. This failure prevents appropriate procedures being developed for the project."

Similarly, Neale (1984) comments that

> "it is not unusual to find well qualified and competent people who have become powerless prisoners of ill-conceived management structures and control procedures"

This may imply that practitioners assume that there is one solution to all management problems, just waiting to be found. However, there are clear indications that there is a trend towards appropriateness of management structures (Sidwell, 1982; Finniston, 1986). It is apparent that the industry can accept different organizational forms for different projects, because there are significant differences between types of contract.

The range of organizational options available to clients of construction is increasing. Because of this a variety of approaches exist to choose between procurement methods. This is exemplified by Tatum and Fawcett (1986) who outline a technique for identifying the major variables of a construction project, and select from one of five procurement patterns. This technique suffers from two major drawbacks. One is that the five options from which the technique can choose are fixed and pre-defined. The second is that it is only deemed suitable for large projects. The pre-definition of such a procurement pattern implies that if their system of selection were to become the norm, then no more new procurement patterns would emerge in the future. This is clearly not an end to be pursued. However, unlike some other writers who take this approach, Tatum and Fawcett describe their organizational options only in the most general terms, more as organizational objectives than as a procurement pattern.

Although the organizational approaches to construction projects are adapting fairly slowly, the technical solutions employed are developing rapidly. The modern construction project often takes place in an environment which can be subject to drastic changes within a short time span, often within the life of the construction project. Additionally, as projects become more complex, both technically and economically, their time span can increase relative to the environmental changes taking place. This situation can sometimes result in the client being supplied with an obsolete building (Brauer & Preiser, 1976; Turner, 1986).

1.2.3 Client perceptions of the construction industry

The construction industry has terminologies, methods of working and patterns of doing things which are different to those of many of its clients. It is estimated by NEDO (1974) that over half of the 20,000 or so clients who each year obtain industrial or commercial buildings have had no previous experience of the construction industry during the preceding five years.

Proposals from the British Property Federation (1983), which represents the thoughts of a major group of clients, demonstrate that clients sometimes feel that the industry does not conduct itself in an acceptable manner, and particularly that more flexibility is needed. These proposals demonstrate the dissatisfaction of certain clients of the industry. The view that clients are unhappy with the industry is supported by NEDO (1983).

Moore (1984) reports that some clients have difficulty understanding the nature and complexity of the construction industry and its processes. Contractual procedures are complex despite the existence of standard forms of contract, and the emergence of novel and non-standard forms of contract serves to complicate the client's view of the process of procurement.

Clients of the industry are often berating the building professionals for poor quality work, and unprofessional conduct (NEDO, 1985). The construction industry is different from the industries of most of the clients it serves, being described by one government report (Engineering Construction EDC, 1982) as a "unique and complex business". The construction industry invests little time and resources in ensuring that its clients get "value for money" (Burt, 1978; Building & Civil Engineering EDCs, 1985). This concept of value for money usually refers to the success of a project as perceived by the project team in terms of time, quality & cost (NEDO, 1976). Added to these should be the client's perceptions of project success, in terms of achievement of their stated objectives (Nahapiet & Nahapiet, 1985).

1.2.4 The importance of public sector building

Whilst the problems of the construction industry are present in both public and private sectors, they are more acute in the public sector. This is because the decision-making patterns are surrounded with the need for public accountability. This need is usually manifested through the existence of multiple committee stages for approvals on

expenditure of finance. If public accountability is given high priority, the planning stages of a project can be longer than the execution and commissioning stages. In this way, the problems of organizational structure in construction projects are accentuated and compounded. The excessive bureaucracy and accountability are commented upon in a variety of reports (for example NEDO, 1975).

Important differences between the public and private sectors can be described under the three headings of "Goals, Means and Orchestration" (Paul, 1983). The goals to be achieved within any public sector organization are largely prescribed by policy makers and political constraints, whereas a private enterprise would be freer to choose its own goals. The means by which the goals can be achieved are often more constrained in the public sector; the orchestration (or implementation) of goals and means is even more constrained. It is difficult to adapt to change during a public sector project because those responsible for policy are removed from those responsible for implementation.

The industry must consider both public administration generally, and particular aspects such as public accountability to discover the reasons for the differences between the private and public sectors. Even within the public sector, the professions of the construction industry work as if they were in the private sector, adopting the usual fee scales and conditions of engagement internally between departments. This indicates that the construction professions perceive little need to differentiate between working in the public and private sectors.

The public sector is organized as a multi-disciplinary rigidly hierarchical structure. This has been shown by writers on organizations to be ideally suited to a stable environment (Weber, 1947; Burns & Stalker, 1966). It equates to Weber's "Bureaucratic" type and to Burns & Stalker's "Mechanistic" type. However, the environment of the public sector, particularly in respect to building projects, is far from stable. A general increase in environmental complexity surrounds all contemporary systems of

organization because of an increase in the rate of change within society (Beer, 1972). The longer a project, the less stable is its environment; and public sector projects often have phenomenally long lead times. Therefore, the way in which public sector projects are currently organized is inappropriate.

The current trend towards organizing according to the demands of the environment, rather than according to an idealized pattern, is noted by Toffler (1970). He describes it as a move from bureaucracy to "ad-hocracy".

Both Toffler (1970) and Beer (1972) typify a large number of writers who comment on the enormous increase in the rates of change in society. Since public sector projects tend to have longer durations than private sector projects, this rate of change has a more marked effect on public sector projects. It is because of this rapid change in the environment of large projects that the identification and description of particular "procurement methods" for general types of project is inappropriate. By the time that such a system has been developed, tried, tested, disseminated and accepted, the environment of projects may have changed too much for it still to be appropriate.

The scale of public sector building in the United Kingdom can be assessed from the statistics issued by the Central Statistical Office (1988). Table I shows the scale of construction work in the public and private sectors for the ten years 1977-86. The marked decline in public sector work is clear. However, it still forms a significant proportion of total new construction work. The reduced activity is not because of reduced demand from public sector agencies, but because of government restrictions on spending. This illustrates that the public sector, more than ever, needs to be sure of getting "value for money" from building programmes. As this trend continues, the importance of each project as a proportion of the whole of public sector work increases. Thus it becomes more important to ensure that the output of public sector construction projects is acceptable. The current political climate is such that the public sector

must be able to justify its continued existence by reference to performance in the private sector. If success cannot be assured, then work may be moved to the private sector.

Table I: The importance of UK public sector building

	New Construction Work (x £1000)		
Year	Public Sector	Total Output	%
1977	4,320	8,972	48
1978	4,513	10,313	44
1979	4,779	11,722	41
1980	5,235	13,055	40
1981	4,794	12,354	39
1982	4,092	12,629	32
1983	4,849	13,396	36
1984	4,910	14,192	35
1985	4,704	14,921	32
1986	4,730	16,286	29
10yrs	51,254	135,687	38

(Source: Central Statistical Office,1988)

1.2.5 Construction industry compared to other industries

Economically, the characteristics of the industry are seen by Hillebrandt (1985) as being the physical nature of the product, the structure of the industry, the organization of the construction process, the determinants of demand and the method of price determination.

The economic and technological constraints on construction projects produce a complex and dynamic environment. The organizational characteristics of the construction industry are the separation of design from costing (i.e. distinct roles of architect and quantity surveyor), the separation of design from production, the exclusive specialization of the contributing professions, and the frequent phenomenon of the client not being the end user of the product (e.g. property developers, government projects etc.). The fact that construction projects are frequently unique results in the temporary nature of the organizational structures used. These factors combine to create the characteristic "stages of work" which are recognized by so

many analysts (for example RIBA, 1980). Single projects involve large numbers of people over several years, usually on a temporary basis (Engineering Construction EDC, 1982; Cherns & Bryant, 1984).

The construction industry has attracted a lot of criticism about the difficulties it has in organizing itself; especially by comparison with other industries (see section 1.2.3 on page 5). It has parallels in other project-based industries (Morris, 1983). Together, these industries constitute a large proportion of organizational knowledge and experience. It is this body of knowledge which the construction industry needs to tap. Although an analytical model has been developed on private sector construction projects (Walker, 1980) it does not yet seem to have been taken up by the industry. This model is described further in the next chapter. Section 1.2.4 (page 6) makes it clear that the problems of the construction industry are more acute in the public sector than in the private sector.

1.3 ORGANIZATION THEORY

It is tempting when studying organizational structure in the construction industry to use literature sources solely based around the topic area of construction project management. However, this is too narrow a definition for an effective background. The field of study must be expanded to encompass organizational theory (both in terms of antecedents and in terms of the application of theory to the construction industry), thus providing a broader and more thorough background to the work. Organization theory is based on the premise that one body of knowledge can explain the structure and functioning of all types of organizations, and that it is not necessary to have different theories for different types of organizations (Khandwalla, 1977).

The construction industry seems very reluctant to learn from other industries (Bryant, 1986). It seems to believe that it is always a "special case" and that it therefore needs its own set of organizational and behavioural

theories. For example, it is often considered unusual for a project to consume 100% of a contributor's time. Thus each of the professionals on a construction project team is often active on other projects within the practice. This is highlighted as being somehow extremely important and distinctive. However, as Scott (1981) points out, the people who participate in organizations do not do so to the exclusion of everything else. They will also be involved with activities outside the organization. Thus the partial involvement of people in an organization is one of the fundamental characteristics of all organizations.

As Hillebrandt (1985) states, the distinguishing features of construction are not individually unique. Each one has some similarity or parallel in other industries. It is only their combined effects which make construction unique. The specific tasks of each contributor to the process may be unique to construction; but the fact that people are co-ordinated so that their several contributions may collectively achieve a pre-determined aim, is sufficient in itself to draw upon organizational theory. Thus it is entirely valid to apply organization theory to construction projects.

A useful starting point is to examine studies which concentrate on the project type of organization. As Morris (1983) shows, projects occur across a variety of industries such as film production, aid programmes, Research & Development management, computer software writing etc. There is already an expansive body of knowledge about projects as being "processes for achieving defined change" (Morris's definition), and this is reviewed in the next chapter.

Organization theory is a field which has been reviewed by many writers. A useful approach to adopt is one of looking at the field from the points of view of the various schools of thought on the topic. These are often bracketed into four main groups (Bowey, 1980): the Classical school, Human Relations, Systems Analysis and Contingency Theory. The analysis of organizational structures has its roots in the ground work done in the first two of these categories. Since the main thrust of those studies was the investigation

of people's roles within organizations, and the nature of their interactions, the structural aspects of organizations were secondary. The work in this area has already been extensively reviewed many times, and there is little to be gained in reviewing it again. A good review is given by O'Shaugnessy (1976) who concludes that "the implications for organizational structure are sparse and vague".

1.3.1 Systems Analysis

The Systems view has become very popular in recent years and its use as a theoretical framework is well documented, for example see Buckley (1980). The context within which systems analysis is brought to bear on the topic under discussion is best described by Leavitt, Dill & Eyring (1973), when they state that systems analysis;

> "... provides tools that enable us to talk to one another about models designed to handle complex and messy problems. These tools discipline our efforts to describe, to analyse, and to speculate, and they are designed to add precision and depth to managerial judgment."

Systems thinking originally developed along the lines of considering all systems as organic (von Bertalanffy, 1969), and much progress was made by considering the nature of the relationships between parts of the systems. To paraphrase Buckley (1980), the relationships in organic systems are physiological, involving physical and chemical energy interchanges, whereas the relationships between parts of society are primarily psychic, involving complex communicative processes of information exchange. This provides a firm basis for examining organizations as systems because the whole study of building project organization is one of information exchange. This principle of the exchange of information characterizing the relationships in complex human systems is fundamental to modern complex systems analysis. As Buckley points out, it is the nature of the information that is important, not the media by which it is transmitted. Thus information is not a substance, but a relationship between "sets of ensembles of structured

variety". In this way the systems under consideration may be viewed as information-processing systems.

The advantage of the systems approach is that it involves looking at each of the component parts of the system in terms of their relationships to each other, and to the whole. The most useful models for the analysis of project organizations are those which were developed specifically for temporary organizational structures. Cleland & King (1975) proposed an approach based upon systems analysis which models the organization as a dynamic open system. This produces a very useful conceptual model for defining the structural relationships within an organization, whether temporary or permanent. Thus the system under consideration can be seen as a set of interrelated sub-systems, each with its own objective. The systems view requires that each sub-system is managed in terms of the overall system, and further, in terms of the interaction of the system with its environment. The systems under consideration are engaged in producing some sort of change in their environment. Therefore they have a purpose. The concept of purpose is the thing which distinguishes the organizational system from the physical, or organic systems. Purpose provides a framework and an orientation for objectives. A system can only function effectively if it has feedback about its own performance, therefore, the feedback mechanisms must be linked to the objectives of systems and sub-systems.

The environment of building projects is generally unstable. Therefore the systems of building project organizations must be adaptive. If they cannot respond to changes in the environment then they will not produce output suitable to their purpose.

As Kreitzner (1977) points out, the open systems view is more useful than the closed systems view because it takes account of the interactions between the system and its environment. The environment of a system must be understood when considering open systems, because the interchange is an essential factor underlying the system's viability, and its ability to change (Buckley, 1980).

To view any organization as a system, it is necessary to identify what each of the component parts are. These parts can be seen as sub-systems in their own right, and are defined in a similar manner to the whole system. In order to analyse what lies within any particular system the boundary must be identified. This boundary, in organizational terms, is seen by Walker (1980) as being made up of environmental constraints. It is as a response to this environment that construction projects originate. This response constitutes the first decision point and marks the start of a project. A further decision about the project's completion marks the end of it. Within this environment the construction project exists with the primary aim of fulfilling the requirements of the client. The events that join the two decision points can then be defined as the sub-systems which interact to produce the system.

1.3.2 Contingency Theory

As Woodward (1958) said; "there can be no one best way of organizing a business". Accepting this, it must then be true that different circumstances call for different organizational structures. It would be very useful to identify the most significant variables in the circumstances of construction projects. This could be done by looking at the "causal relationships" in project organization. This approach consists of proposing hypotheses about causes and effects and then conducting statistical analyses on data to ascertain the verity of the hypotheses. It has been criticized (O'Shaugnessy, 1976) because it does not produce explanations, but generalizations which still require explaining. In any case, simply identifying significant variables is not enough to solve organizational problems. It is also necessary to identify those features of organizational structure which contribute to effective project management, thence to develop techniques for designing organizational structures tailored to suit the demands of particular projects.

It was precisely this need in industrial organizations which Woodward (1965) identified:

> "Analytically the central problem in the development of a comprehensive theory of organization is to determine the conditions under which behaviour inside organizations becomes standardized and predictable. Techniques have to be found to describe systematically, and evaluate quantitatively, complex and intricate manufacturing situations. Such techniques would provide not only a tool for the student of organization but also a method of tackling concrete organizational problems. They would provide an answer to a question so often in the minds of those responsible for organizational planning: how can an assessment be made of the appropriateness of a firm's existing organizational pattern to its needs?"

Although Woodward was writing some time ago, techniques for systematic description, and quantitative evaluation of organizational structures have yet to be firmly established.

It may be contended that there is a "typical" project management structure that could usefully be identified for construction projects. However, as Brech (1975) points out, although there may be some groups of organizations which display outward signs said to be generally typical for a type of organization, within every organization the distribution of management and executive responsibility is unique. He states:

> "it may be broadly said that there is no general pattern for the distribution of executive responsibilities; there would appear to be certain basic maxims of organization structure commonly applicable, but with considerable differences in actual application."

Brech and Woodward were discussing organizations generally, with particular reference to industrial and manufacturing organizations. As has already been shown, the fact that they were not referring directly to construction is not sufficient reason for rejecting their work.

The idea that there was one ideal organizational form was the motivation for much of the early work: if this ideal form could be put into practice then problems would evaporate! However, Lawrence & Lorsch (1967) demonstrated that

appropriate organizational structure will depend upon the environmental demands upon the organization. Thus it is the appropriateness that is the key. This is known as the Contingency Approach. Accepting the ideas of this theory, the current study will attempt to provide the tools for describing and analysing organizational structures based upon the foundations laid by such writers.

1.3.3 Classifying and modelling organizations

This study is fundamentally about comparisons between different forms of organization and their effectiveness. This may lead to a scheme whereby certain characteristics may be classified. Burns (1967) proposes a comprehensive classification scheme into which data from different organizations may be fitted and suggests that the most appropriate scheme would be a comprehensive list similar to a thesaurus in nature. He states that the objective of such a scheme would be to answer the question, "What is this organization?", to provide answers that are more comprehensive and meaningful than is currently the case.

Many models have been proposed for organizations, each with a complexity to suit their purpose. A common theme amongst the earlier (and some recent) writers is the "polaristic" style of model. This takes the organization as a whole as the unit for analysis. In this type of model, a few idealized extremes are defined: An organization can then be said to tend toward one or other of the idealized extremes. Examples are provided by Weber (1947) who describes three types of power or authority - Bureaucratic, Rational/Legal and Charismatic; Burns & Stalker (1966) who describe the two extremes of Mechanistic and Organismic; and Perrow (1967) who describes a series of two-by-two matrices, each defining a different aspect of organizations. These approaches serve to define an organization by its type, but they do not serve as conceptual models for a detailed analysis of the performance of an organization.

Organizations can be studied from a sociological perspective such as that proposed by Silverman (1970), with what

he calls the "Action Frame of Reference". Although this is concerned with understanding individual action, rather than observing general patterns of behaviour, it concentrates on the individual actors as the unit of analysis and as such is not very informative about the structure of organizations.

An alternative approach is to study the organization's objectives. There is often great store set by analysing goals and objectives, and researchers in this field often assume that this is the key to effective organization; harmonize the goals, and all work on the project will be easily co-ordinated towards the unified aim. This scenario would fit in with the views of Etzioni (1961) who is interested in the way organizations obtain compliance to their goals. On the other hand, Cyert & March (1963) have found it necessary to discard the idea that organizations have clear, fixed and characteristic goals. It is apparent that there is considerable disagreement within any organization about goals, and evidence from empirical studies confirms this (Walker, 1984).

Armandi (1981) typifies an approach known as causal analysis. This consists of identifying relationships between important variables using statistical analysis of a large number of representative cases. Sidwell (1982) also took this approach and concentrated on the construction industry. The problem with this approach is that it does not produce explanations, merely observations. Therefore, it does not provide the techniques for identifying causes of organizational inefficiency.

The concept of organizational form is useful for describing organizations. The simplest form of organization must be an individual with no self-doubt whose activities are shielded from any extra-organizational effects. The problem of assessing effectiveness for such an individual will be a question of assessing the quality of work produced. An example of this level of simplicity would be an individual building a garden shed. Obviously, society is involved in tasks of far greater complexity than this, and thus the work has to be split up amongst a number of individuals. The way

in which people act together to fulfil a common goal is complex and difficult to understand. The formal structure of their relationships can be mapped out on an organization chart, but that does not give a total picture of the way in which people work together. In addition to the formal relationships, there are informal relationships which take place within an organization and have a tremendous impact upon the way in which work is done. Thus, any model that is to prove useful must provide detailed information at a variety of levels.

1.4 EVALUATION

If the effectiveness of an organizational structure is to be analysed, then some measure is needed of project success in order that any sense can be made of an analysis. An example would be to assess the extent to which the client is satisfied with the completed building.

1.4.1 Building Product Evaluation

One of the problems in ensuring client satisfaction is that no widely accepted method of evaluating the success of a project is readily available. This was evident from the proceedings of a conference concerned with assessing the processes involved in achieving good quality building within acceptable cost margins, whilst still making a profit for the parties to the project (Brandon & Powell, 1984). It was clear from that conference that there is little formal evaluation of the products of the industry. Quality control and performance evaluation were shown to be of great importance, but of inconsistent application. It is apparent from the conference that there is a need for a formal method for evaluating buildings.

It is also apparent that just as there is little historical information on the way in which building projects were managed in the centuries preceding the Industrial Revolution, there is also little recorded information about the organization of current projects. Although every letter is

filed (on well run projects) and meetings are minuted, it is difficult to analyse a building project retrospectively because the purposes behind recording such information are diverse, and often obscure.

There is much evidence that the industry acknowledges the need to evaluate building projects, but little evidence that evaluation is actually undertaken; for example the RIBA Plan of Work (RIBA, 1980) includes a Stage for this to take place (Stage M: Evaluation). Cooper (1983) claims that it is doubtful whether many architectural practices have ever attempted to undertake stage M of the plan of work. The problem may be that in the case of the RIBA, their fee scales do not include an element to cover this stage of work. Not only are clients not charged for it, but once a project reaches this stage, many architects tend to move instead to fee-paying work on a project which is at an earlier, and therefore more lucrative stage.

1.4.2 Building Project Evaluation

If progress is to be made in the development of "ideal" project organization strategies, it is essential that progress takes place in the evaluation of completed building projects. The current "state of the art" of building evaluation techniques needs developing to the point where it is not just the actual product that is examined, but the process which produced it. In addition to this, there is a desperate need for an effective method of documenting all communications and decisions on a project.

It is one thing to critically evaluate an artefact, but quite another to propose ways in which a better artefact may be produced. If the construction industry is going to learn from its mistakes, then it must analyse the way in which decisions are taken, and the way that the several different specialist consultants are co-ordinated and their work unified. A detailed study of the roles, responsibilities and relationships of people and tasks would highlight both the good and bad features of the organizational strategy adopted on a particular project. By referring back to the

evaluation of the product, the process can then be modified so that future projects would have a better chance of success. It will not necessarily follow that a well structured project organization will produce a perfect building, but it is certain that it will encourage better practices and increase the chances of success. Work in this area has already been undertaken by Walker (1980) who developed an analytical model for private sector construction projects. It is clear from the literature that Walker provides the most comprehensive working model for analysing and describing the organizational structure of building projects. Thus it will be used as the basis for analysis in the current work. Walker's model is described in detail in section 2.4, in the context of other approaches.

To summarize the main points so far, construction projects are open, purposive, complex and adaptive systems; organizational structure should be contingent upon project environments; there is a great need for systematic descriptions and quantitative comparisons of organizational structures.

1.5 PURPOSES OF THE STUDY

This study is concerned with the application of organizational theory to building projects, in general; and with the development of an analytical method in particular. This entails establishing whether the principles developed and tested in the private sector of the construction industry still hold true for the public sector.

To this end, the objectives of the study are:

(a) To analyse the way in which the public sector of the construction industry organizes itself to produce buildings, from inception to occupation.

(b) To use a systems approach to model the organizational structures used in public sector construction.

(c) To seek relationships between the structure of an organization, and the outcome of a project.

(d) To make recommendations about how to modify organizational structures to optimize project outcomes.

CHAPTER TWO: THE PROCESS OF CONSTRUCTION

This chapter examines the established views of organization in the construction industry and from there identifies the essential elements of construction project management. The importance of the environment is then discussed, and a new framework for environmental analysis is suggested. A new model of the construction process is proposed along with a technique for validating it.

2.1 COMPARISON OF ESTABLISHED ORGANIZATIONAL APPROACHES

The previous chapter established the inappropriateness of many of the management structures used for construction projects. This is supported by another quotation,

> "We need a flexible organization that can be tailored to suit the project as it develops ... to give full and flexible attention where it is needed ... I don't think traditional methods of managing have the required information handling characteristics." (Bennett, 1984)

Such statements clearly demonstrate the need for a flexible, adaptable organizational structure for building projects. It is clear that the current economic, political and technological changes that are taking place create an unstable environment for the industry. Thus, as Biggs states, the organizational forms that are now required cannot be styled on status quo and tradition as they often have been in the past (Biggs, 1985). The RIBA Plan of Work is very well known in the building industry generally, and is often taken as the baseline against which all others are compared; yet commentators readily acknowledge the limitations of plans of work, particularly the RIBA Plan of Work. One of the main criticisms levelled at them is that they are inflexible and only suited to a limited range of jobs.

If systematic descriptions and quantitative comparisons are to be meaningful, they must be done from a common base.

This will require some common points of reference between different projects, in order that comparisons may be made. For example, Walker's (1980) key decisions and sub-systems of activity were uniquely identified for each of the case studies that he undertook. It is difficult to compare different projects when the decision points, task structure and analysis are dependent entirely on the particular circumstances of the project. With such a wide definition of project structure, it becomes unusual to find points of comparison between different projects. In order to be able to make comparisons, some order should be imposed on the data. Cleland & King (1975) achieve this in their process of organizational analysis by identifying a "normative" model, against which their observations may be compared. This normative model holds only for the particular organization being analysed. For the purposes of analysing a variety of construction projects, this approach is not appropriate. A more general approach is needed which will provide the frame of reference within which comparisons can be made. This can be done by using a regular pattern based upon the plans of work recognized by the industry.

Although the work to be undertaken can vary greatly between projects, there have been several attempts in the past to group tasks together into discrete stages of work. People within the industry are familiar with plans of work, so these form a useful starting point for analysing the organizational structure. Every project goes through similar steps in its evolution in terms of these stages of work. The stages vary in their intensity or importance depending upon the project.

There follows an analysis of seven plans of work. These are compared to each other, to see what they have in common, and where they differ. They have been chosen to typify the variety of such plans of work. Some of the sources examined are not plans of work as such, but are basic text books about how construction projects should be managed. The seven sources are each described briefly below, and summarized in the seven columns of Table II.

Table II: Summary of plans of work compared

G. Peters	CAPRICODE	Austen & Neale	BPF	PSA	N.D. Finn	RIBA Plan of Work
IDEA	-	-	-	-	-	A Inception
IDENTIFICATION	APPRO IN PRINCIPLE	-	-	-	-	-
-	Inception	-	CONCEPT	PRE-DESIGN	-	-
-	Define objectives	-	-	-	-	-
-	-	-	Appt of Client's rep	-	-	-
-	Consider options	-	Devel of concept	-	-	-
Select prefd option	Select prefd option	-	Outline brief	-	Client's init brief	-
Examine need	-	-	-	Need definition	Nature of the devel	-
ID corporate plan	-	-	-	-	-	-
ID funding limits	-	-	Outline cost plan	-	-	-
-	Appro in principle	-	-	Need evaluation	-	-
FEASIBILITY	-	-	-	-	Feasibility study	B Feasibility
CONCEPTUAL ENG'G	BUDGET COST	-	-	-	-	-
Prelim process design	-	-	-	-	-	-
Preliminary layouts	-	-	-	-	-	-
Invsgt std designs	-	-	-	-	-	-
Design brief	Scheme brief	BRIEFING STAGE	PREPARATION OF BRIEF	-	Confirm instns	-
PROJECT STRATEGY	Proceed to design	Work plan	Appt of design leader	-	Appt project manager	-
Choose designers	-	Appoint designers	Appoint consultants	-	-	-
-	-	User requirements	The Brief	Site & brief	Site identification	C Outline proposals
-	Sketch design	(Sketch scheme)	-	-	-	D Scheme design
Resource examination	-	-	-	(Resource planning)	Financing	-
Plan phasing	Devel control plan	(Planning)	-	-	-	-
-	-	-	-	-	Acquire interests	-
Project programme	-	Programme the work	Master programme	-	-	-
Scope of project	-	-	-	-	-	-
ESTIMATE	-	-	-	-	-	-
Decide accuracy	-	-	-	-	-	-
ID work packages	-	-	-	-	-	-
Establish data base	-	-	-	-	-	-
Cost packages	-	-	-	-	-	-
APPROVAL	-	-	-	-	-	-
Financial evaluation	Budget cost	Cost estimates	Master cost plan	-	-	-
Details of funding	Procurement method	-	-	-	-	-
Evaluate options	Scheme validation	-	-	-	-	-
Select prefd option	Budget cost approval	-	-	-	-	-
EXECUTION	-	-	-	-	-	-
DETAIL ENG'G DESIGN	DESIGN	DESIGNING STAGE	DESIGN DEVELOPMENT	DESIGN	-	-
Detail design spec	Design brief	Finalise brief	-	Outline design	-	-
-	Proceed to design	-	Appoint consultants	-	Appt design team	-
-	-	Tech investigations	-	-	Statutory consents	-
-	Design development	Scheme design	Priced programme	Final sketch design	Design phase	-
Perform design	Detail design	Detail design	Devel of scheme desn	Detail design	-	E Detail design
..	..	..	..	..	..	..

(continued.)

Table II continued

G. Peters	CAPRICODE	Austen & Neale	BPF	PSA	M.D. Finn	RIBA Plan of Work
..	..	..	..	..	..	..
-	-	-	TENDERING & DOCN	Contract preparation	-	-
-	-	-	Tender documents	-	-	F Production Info
Prepare tender drwgs	Production info	Wkg dwgs specs & BQs	Prep of drawings	-	-	G Bills of Quantity
Record changes	-	-	-	-	-	-
Design review mtgs	Pre-tender checks	-	-	-	-	-
TENDER PREP & EVAL	Proceed to tender	-	-	-	-	-
Contracts Spec	-	-	-	-	-	-
Bills of Quants	-	-	-	-	-	-
Contract estimate	-	Final cost estimate	-	-	-	-
-	-	Production programme	-	-	-	-
-	TENDER & CONTRACT	TENDERING STAGE	-	-	Tendering/Cont negn	H Tender action
-	Select tenderers	Pre-selection	-	-	Tender package	-
Issue tenders	Invite tenders	Invitation	Tender invitations	-	-	-
-	Receive tenders	-	-	-	Tender results	-
EXPENDITURE APPROVAL	-	-	-	-	-	-
Recommend contractor	-	Selection	Select contractor	-	-	-
Eval contract price	-	-	-	-	-	-
Appro expenditure	Contract programme	-	-	-	-	-
Issue drwgs contract	Award contract	Contr documentation	-	-	-	-
-	CONSTRUCTION	CONSTRUCTION STAGE	CONSTRUCTION	CONSTRUCTION	Construction phase	-
ADMINISTRATION	Constsn preparations	Production planning	-	Constn planning	-	J Project planning
Mon'r cost time & qly	Exec & control wks	Site operations	All construction	-	-	-
Record variations	-	-	-	-	-	-
Regular valuations	-	-	-	-	-	-
Cont progress mtgs	-	-	-	Constn control	-	-
COMPLETION	Completion of works	-	-	Constn completion	-	K Completion
Commission	-	COMMISSIONING STAGE	Takeover com & maint	-	-	-
-	-	Record drawings	-	-	-	-
Approval of work	-	Inspection of bldg	-	-	-	-
Completion cert'cate	Final account	-	-	Contract completion	Final account	-
-	COMMISSIONING	-	-	-	-	-
-	Commissioning brief	-	-	-	-	-
-	Commissioning preps	Op instns & maint man	-	-	-	-
-	Building handover	-	-	-	-	-
-	Building opening	-	-	-	-	-
-	-	-	-	POST-CONSTRUCTION	-	-
-	EVALUATION	-	-	-	-	M Evaluation
-	Eval scheme devel	-	-	Building operation	-	-
-	-	-	-	Maintenance	-	-
Monitor performance	Eval scheme operation	-	-	Performance appraisal	-	-
-	-	Train staff	-	-	Appt letting agents	-
-	-	-	-	-	Managing the devel	-
-	-	-	-	Improve/dispose	Disposal	-

2.1.1 "Project Management & Construction Control"

Peters' text book, Project Management & Construction Control (1981) explains in detail the procedures that should be adopted when managing a project. He embraces the idea of the project being a "dynamic and ever-changing system". He also introduces the idea that the Project Manager should be involved as early as possible in the project, and should remain involved right through to its conclusion. His stages of work are summarized in column 1 of Table II. Overall, Peters describes the widest range of tasks of all of the plans of work.

2.1.2 "Capricode"

The second plan of work examined is that published by the DHSS (1986). Entitled Capricode, it is described as a "mandatory procedural framework for managing and processing NHS capital building schemes". The framework is independent of monitoring and control systems, which are expected to vary appropriately according to circumstance. This distinction between activity and control will be discussed later. One of the underlying principles of the code is accountability, and to that end it makes the project manager individually responsible for the management of a project. It does not set out the responsibilities of individual consultants for schemes, preferring instead to leave such detail to be decided as appropriate for each project. It is expected that such detail will vary. It is also expected that the management pattern and project team membership will change from one stage to another. Capricode is summarized in column 2 of Table II.

2.1.3 "Managing Construction Projects"

Austen & Neale (1984) are the editors of a guide to project management. The contributors to the guide collectively have a very wide range of experience of construction projects in developing countries. It emphasizes the essential nature of good project management and the need for careful planning in the early stages. The authors are

confident that although projects vary a great deal there are still general principles and internationally accepted practice with regard to project management. Thus they describe basic guidelines which may be construed as a plan of work. Column 3 of Table II shows their perception of the development process. Strangely, they do not consider that the construction professionals should have any involvement until the project is definitely going ahead. They make it clear at the beginning of their guide that it does not cover the social, economic and engineering analyses which result in the decision to build.

2.1.4 The British Property Federation

The British Property Federation (BPF) is an affiliation of organizations who build regularly. They see themselves as being uniquely affected by what they term the "usual" problems in construction; i.e. poor design, inadequate supervision and little choice of materials. For this reason they commissioned a research study which resulted in their "Manual of the BPF System" (British Property Federation, 1983). This is an advisory document containing recommendations for a more effective method of organizing the whole building process.

The BPF system splits the process into five major stages (see column 4 of Table II). Flexibility is intended, so the system does not try to prescribe the exact organizational structure. One of their suggestions is that some of the stages may be merged on some projects. Each stage is definitely punctuated by a client decision about whether or not to proceed with the project.

2.1.5 Property Services Agency Project Management Guide

The PSA Plan of Work (Property Services Agency, 1984) is intended to be the framework for all project management structures in the government building programme. It is a guide, and not mandatory. In conjunction with the Plan of Work are guides for each of the professional and technical consultants. The purpose of the Project Management Guide is

to outline the management procedures only, and not the technical steps that have to be undertaken. The majority of the guide is intended to be applicable to all types of project. The start point comes before the decision to build has taken place. However, it is envisaged by the PSA that the project manager, or indeed any construction professional, may not be appointed until after the decision to build has been taken. Stages and sub-stages are punctuated by decision points. Column 5 of Table II summarizes this plan of work.

2.1.6 "Project Management in Development"

Finn (1984) has summarized his experiences of managing property development projects in the form of a checklist. To quote his own introduction, "project management can be defined as the assumption of responsibility for a development scheme from inception to final completion in such a way that the client's aim to have a satisfactory building constructed on time, within an agreed cost limit and producing a satisfactory income is met". His list draws together 237 separate activities which have to be done for the successful management of the project. Priorities and dependencies are not considered as the whole is only intended as a checklist. It is summarized in Table II, column 6.

2.1.7 RIBA Plan of Work

The RIBA Plan of Work is the best known and most comprehensive set of documentation (RIBA, 1980). It is not intended to be specific to any one kind of project, neither is it intended to be immutable. It is the intention that by following the plan of work, "an architect may concentrate on architecture, rather than on management". The inception stage begins with the client considering the need to build, and setting up an organization with a chairman to manage the project from the client's side. There is a great deal of detail allocating responsibilities to particular consultants at every stage. The stages are shown in Table II, column 7.

2.1.8 Comparison of Plans of work

The seven plans of work summarized in Table II clearly have much in common. To highlight their commonality, horizontal lines are drawn across Table II, grouping together similar tasks. These lines approximate to major decision points, loosely fitting all of the plans of work. In essence, the plans of work have several abstract concepts in common; packages of work need to be undertaken, the work has to be managed, decisions have to be made, and individuals' relationships to projects are variable. It is the variation between projects that is the cause of confusion and poor definition of management structures. These are exactly the problems which the plans of work seek, and fail, to overcome.

Returning to the concept of open systems, introduced in chapter one, it is difficult to see how some of the plans of work fit a systems view. The two key features which seem to be underplayed are control, and boundaries. Control is in most cases interwoven with the defined activities to such an extent that it is hard to distinguish it. The boundaries to the system and its sub-systems are not explicitly defined, as such: But Capricode, PSA and RIBA plans of work take decision points as being the boundaries to sub-systems. As Walker described, these decision points serve to punctuate stages of work. The extent of commonality amongst the plans of work is clear when these major decision points are examined. Plans of work with no overt identification of such decision points still exhibit patterns which are common to all projects. Accordingly, the lines drawn across the columns of Table II show the occurrence of these decisions punctuating the lists of tasks.

Table II leads to the identification of eight major decision points which will be common to all construction projects, and these have been extracted on to Table III.

The stages in Table III may take place in a variety of sequences; indeed, some stages may overlap. However, although the sequence may vary, the stages of work remain sequential. Examples of two common procurement methods are

Table III: Decisions and stages of work

Inception: Define need & determine financial implications and sources.
Feasibility: Preliminary designs, costings & investigation of alternatives.
Scheme Design: Programming, budgeting, briefing, outline design etc.
Detail Design: Development of all sub-systems within the design, detailed cost control, technical details etc.
Contract: Contract specification, pricing mechanism, sufficient documentation for selection of contractor etc.
Construction: Execution and control of all site work & associated activities, further contract documentation.
Commissioning: Snagging, operating instructions, maintenance manuals, opening ceremonies, occupation, evaluation, managing the facility, staff training etc.

given in Figure 1. This shows stages of work in relation to decisions which punctuate them.

The top example, the traditional method of procurement, shows a typical pattern of decisions. The first of these decisions is based on the first in Walker's work, the decision to adapt to external influences. As Walker described, this decision will trigger activity which may or may not lead to the procurement of a building. It is during this stage that the need for the project is identified. If relevant, its position in the corporate plan is decided, the sources of funding, and possibly the maximum funding limit could also take place during the first stage. The result of this stage is that the need is identified, and the resources required are approximately quantified.

This leads to the second decision point, that there is a need for a construction project. This triggers the Feasibility stage of work, consisting of preliminary designs, investigations of alternatives and preliminary costings of the possible solutions. The result of this stage enables the client to take the third decision; that the preferred solution, is feasible and the project can go ahead.

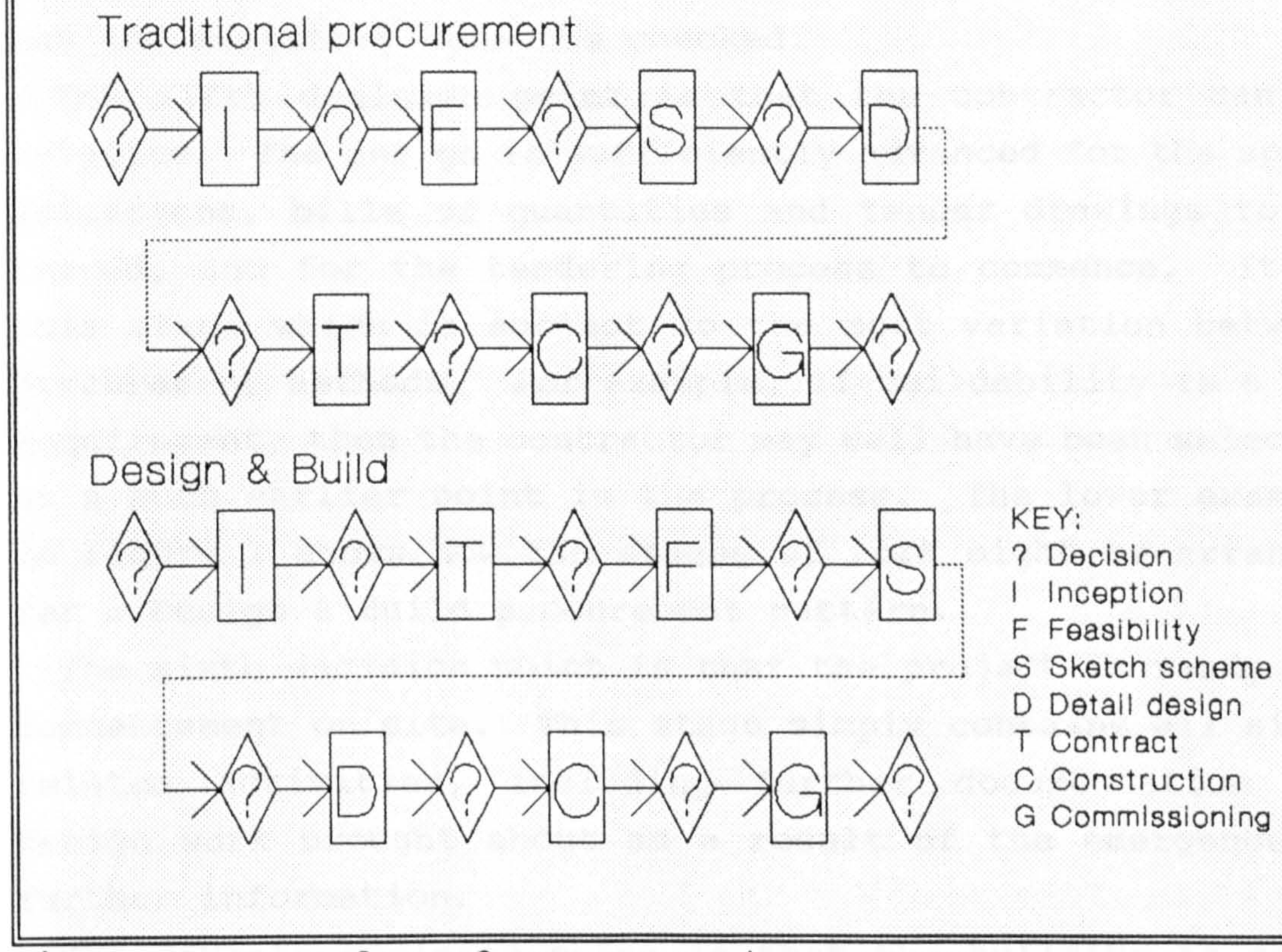

Figure 1: Examples of procurement processes

The third stage of work is the Scheme Design. During this stage, the client will be interacting with the designers, briefing and identifying user needs, approving sketch designs and commenting upon them. The designers will be interpreting in detail the client's requirements. At the end of this stage, it is usual for the design team to wish to freeze the brief, and the client should be prepared to do this as far as possible. (However, at the same time the project team must be willing to acknowledge that as the project progresses the circumstance of the client will be subject to environmental influence, and thus the client's requirements will be subject to unavoidable change.) The decision at this point is that the design is acceptable, within cost limits and is a satisfactory interpretation of the client's requirements.

The fourth decision point triggers the Detail Design stage of work. This is where the consultants develop the design and achieve integration of all of the various sub-systems of

the building (structural, services, circulation etc.). The technical problems of the design have all to be fully worked out and statutory consents checked.

The fifth decision point is that the contractor can be selected. The design is sufficiently advanced for the specifications, bills of quantities and tender drawings to be issued, and for the tendering process to commence. It is this stage which is subject to the most variation between procurement methods. For example, if buildability is a key requirement, then the contractor may well have been selected at a much earlier point in the process. The lower example in Figure 1 shows how the stages of work might be arranged for a Design & Build procurement pattern.

The sixth decision point is that the project is ready for commencement on site. This stage simply contains all site-related activities, including further documentation and design work brought about as a result of the emergence of further information.

The seventh decision point is that the building is ready for commissioning. The identification of this particular decision point removes the problem of identifying the completion date, with the associated problems of final account which can drag on for years. The involvement of construction professionals in the commissioning stage will vary greatly between projects, but ought to be clear from the outset. The final decision point, that the project is complete and all contractual obligations discharged is occasionally difficult to pin down to an exact point. This is because there are often several different contracts which have to be discharged. Usually contractual completion may be taken as the finish point to the building project. In the cases where it may take several years to fully discharge a contract (in terms of liabilities and remedies) this decision point is defined as the decision by the client that the project is concluded. Thus it is dependent on the particular client and the particular project.

2.2 ANALYTICAL MODELS OF THE PROCESS OF BUILDING

The plans of work are lists of activities and roles, and as such are descriptive models of the process of building. They do not provide a model of the organizational structure of building projects. There have been several analytical models developed in the literature, the most significant are discussed below.

Von Scifers (1972) developed a model for the analysis of building project responsibilities which he called Transformed Relationships Evolved from Network Diagrams (T.R.E.N.D.). This involved drawing a network diagram of a building project and analysing the links between each task to identify the pattern and intensity of relationships between the contributors. Whilst providing a rich source of data about the relationships, it does not provide an analytical picture of the whole process of building procurement. In terms of proving that interdependence and uncertainty are linked it works very well, but for the detailed analysis of building projects, it involves too much detail about interdependence, to the exclusion of any analysis of organizational structure.

Morris (1972) proposed that the construction process could be analysed in terms of one or two "tracer" activities observed across a particular boundary in the system. His chosen boundary was that between design and construction and he looked at the flow of information. This model of the process demands an immense amount of detailed information. It is difficult to draw general conclusions from such an analysis, because the organizational pattern within a project changes as the project progresses from one stage to another. By concentrating on one interface, a very narrow view must result, excluding much of potential interest.

A further analytical approach is illustrative of approaches which concentrate on dealing with various facets of Differentiation. The "Task-Field" model of Stoelwinder and Charns (1981) is an approach which classifies contributors as being primary, secondary or tertiary, depending on their relationship to the Operation under

consideration. It is a very useful tool for closely examining a few continuous Operations (for example, running a restaurant) but it does not give sufficient information about dynamic, project-based situations.

Walker (1980) originated an approach which brought together a number of organization theories. He tested his model on a series of construction projects. His was an open systems model based upon the tenets of some of the more important contributors to organizational theory. By analysing the way in which particular construction projects had been run he could link the success of a project to the extent to which the organization structure matched the theory. Because of this, his is the most appropriate model from which to commence the current analysis.

2.3 WALKER'S MODEL OF THE CONSTRUCTION PROCESS

No model currently exists which can adequately relate a project's organizational structure to its environment. The starting point for developing the new model is a summary of Walker's model.

Linear Responsibility Analysis (LRA) was developed by Walker (1980) from the works of Burns & Stalker (1966), Lawrence & Lorsch (1967), Thompson (1967), Cleland & King (1975), and others. The following description is taken from Walker & Hughes (1986).

Walker's model contains the following propositions:

(a) The building process is divided into the systems of "Conception", "Inception" and "Realization" at "Primary Decision" points; and into sub-systems at the "Key Decision" and "Operational Decision" points.

(b) The Differentiation of the system should be matched by a corresponding level of Integration effort.

(c) The Managing System and the Operating System should be Differentiated.

(d) The Managing System itself should be undifferentiated.

(e) The client and the building process should be Integrated.

These propositions are expanded below.

2.3.1 Decision points

According to Walker, decisions on a project are ranked, according to the degree to which they commit the client to given courses of action or commitment of finance. The highest ranked decisions are called Primary Decisions. In the context of building projects Primary Decisions are common to all projects, namely;

(a) the decision to adapt to external influences;
(b) the decision that the client needs to acquire real property to achieve objectives;
(c) deciding the form that the real property should take;
(d) the decision that the project is complete.

These Primary Decisions form the boundaries to the three major systems of activity on any building project as shown in Table IV, i.e. the systems of Project Conception, Project Inception and Project Realization. The system of Project Realization contains the majority of design decisions as well as the construction of the project. Referring back to Table III, it is clear that the systems in Table IV are at different levels of detail to each other. The systems of Conception and Inception are each at a similar level of detail, but the system of Realization contains the whole of the remainder of the project.

The next level of decision-making is the Key Decision level. Key Decisions are determined by the client as a result of the client's internal procedures for expenditure and similar approvals, and will be strongly affected by environmental influences upon the client's activities. They range from, for example, approval of design and budget proposals and decisions to delay the project, to decisions to change the nature of the project. If the client's organization is not responsive to environmental forces, Key Decision points may be inappropriately identified to the detriment of project outcome. They act as major feedback opportunities within the client's firm and also for the process of building provision.

Table IV: Primary decisions versus systems of activity

Primary decision:	System:
Adaptation to external influences	
	Conception
Provision of a performance through the acquisition of real property	
	Inception
Identification and construction of a new building	
	Realization
Final completion	

The third level of decision-making lies at the Operational level. Operational Decisions contribute to Key Decisions and are constrained by them. They are mainly concerned with implementation of procedural aspects of building project organization and move the project incrementally towards a Key Decision, also providing secondary feedback opportunities.

Walker's analytical method is based on the premise that Key and Operational Decision points cannot be universally prescribed for all projects and need to be uniquely identified for each project analysed.

Thus, the systems created by Primary Decisions consist of a number of sub-systems of activity created by Key Decisions, which in turn consist of a number of Task sub-systems created by Operational Decisions.

Sub-systems of activity are Sequential, that is, each sub-system relies upon output from preceding sub-systems, and the order of precedence can be identified. Task sub-systems may be Sequential or Reciprocally Interdependent. Reciprocal Interdependency occurs when two task sub-systems are mutually dependent on each other, for example, the architectural proposals for the external envelope for the

building rely heavily upon the structural solution adopted, and vice versa. Thus, task sub-systems may be linked to one another in a variety of ways.

2.3.2 Differentiation and Integration

Whilst the systems and sub-systems at Primary and Key Decision level are Differentiated by virtue of the decision points, task sub-systems are not only Differentiated by Operational Decisions, but also on the basis of the personnel involved in them. They may be Differentiated from each other on the basis of:

(a) the type of skill demanded by the task (Technology);
(b) geographical separation of the contributors (Territory); and
(c) the sequence of the tasks (Time) (Thompson, 1967).

Differentiation on any of these bases can be reinforced by the concept of Sentience (Miller & Rice, 1967). A Sentient group is a group to which individuals are prepared to commit themselves and upon which they depend for support. In the building context, with substantial autonomy of contributing consultants, firms and professions, Sentience can arise as allegiance to a firm, and/or allegiance to a profession.

2.3.3 Managing system and Operating system

The description so far constitutes the Operating System for actually carrying out the work required to progress the project. This is maintained, co-ordinated and kept going by the Managing System, which is the source of the activities required to Integrate the Differentiation present in the Operating System, including the supervising and decision making activities. It should be Differentiated from the Operating System on the basis of Technolgy.

2.3.4 LRA chart

The term "LRA chart" refers to the process of graphically presenting the organizational structure as a dynamic system. The chart thus produced is then used to analyse the project

in terms of the abstract model described above. (The graphical technique will be discussed in detail in chapter 4.)

The strength of Walker's approach lies in its diverse origins. Its value is that it brings together a wide range of work based outside of construction industry and applies it, successfully, to private sector building projects. For these reasons it is a very useful base from which to begin a study of public sector building project organizations.

2.4 THE ELEMENTS OF CONSTRUCTION PROJECT MANAGEMENT

The foregoing analysis of the established approaches to organization in the construction industry provides the basis for identifying the common elements of construction project management.

2.4.1 Activity

Activity, in the sense of construction projects, refers to the systems of work which have to be done in order to transform input into output and to incrementally produce a building. For the purposes of this analysis, it is the generic term used to encompass work packages which take place between decision points. The detail of the activities needed to be done vary from one building project to another, but in general the overall pattern remains the same. This is clear from the analysis of the plans of work.

Different analysts perceive differing needs for the organizational structure. This is not simply because of their differing perceptions or perspectives; but it is a result of the genuine need for a large amount of variation in organizational structures.

Walker acknowledged the requirement for diversity to the extent that he identified only four things that different building projects must have in common; the Primary Decision points which divide the process of construction into three systems, as in Table IV; viz.: the Process of Conception; the Process of Inception; and the Process of Realization.

The analysis of plans of work shows that it is reasonable to conclude that building projects have more commonality than Walker acknowledges. This is confirmed by the guidance of the British Standard on Quality Assurance (British Standards Institute, 1981) which uses a project model based upon industries other than construction. The analysis has shown that there are systems of activity which are common to all of the plans of work.

2.4.2 Decisions

Decision points form the major boundaries to activities. They have been classified by Walker (1980) as Primary, Key and Operational decisions. The levels of decision making that can be observed on large projects can be more complex than this three tier structure suggests. It is felt that if a hierarchical distinction is to be made amongst types of decisions, then a more comprehensive scheme is needed. The feature of decision points is that they punctuate the work and offer opportunities to higher levels of the management structure to control the project. If an activity orientated approach is undertaken then the work lying between decision points is the significant information, rather than the level at which the decision is taken. Walker's technique involved leaving the entire identification of sub-systems to be dependent upon each particular project. This resulted in the need for specific levels of decisions from which the sub-systems could be identified for each project. If the sub-systems are prescribed, as suggested by the analysis in section 2.1, then this need is no longer present and the level of decision-making takes on a different significance (also see section 3.1.5, page 52).

2.4.3 Interdependence

It has been established that construction projects have a high technical complexity. It is this, coupled with a dynamic environment which produces the inherent uncertainty in construction projects. As has been described in the past (Crichton et al, 1967), the uncertainty produces a demand

for interdependence in the organizational structure. Thompson (1967) defined three types of interdependence; Sequential, Reciprocal and Pooled: and Walker showed that only the first two types exist in construction projects. Some of the plans of work go to sufficient detail to look at the way in which individual items of work and contributors interact with each other, but the amount of variability in projects means that this cannot be universally prescribed. It is clear from chapter one that the level of interdependence is contingent on the environment within which the construction project takes place, and the identification and control of this is one of the elements of construction project management.

2.4.4 Differentiation and Integration

Differentiation is defined as the differences in cognitive and emotional orientation among contributors to projects who offer specialist skills (Walker, 1984). It is clear that varieties of skills are combined in unique ways to produce buildings. Each of the contributors to a building project has their own personality and orientation which gives them their own set of unique predispositions. This variety is necessary in terms of providing the range of skills demanded by the environmental complexity (Lawrence & Lorsch, 1967). All Differentiation needs to be co-ordinated and directed to ensure that the aggregated effort remains orientated towards the client's objectives. This concept is termed Integration and is the corollary of Differentiation.

Some studies concentrate almost exclusively on aspects of Differentiation. When various groups combine on a temporary basis to form a project team, the nature of the Differentiation is complex. It is this situation which has been described by Cherns and Bryant (1984) as Temporary Multi-Organizations. The "transactions" between the constituent organizations within a project have been studied by Williamson (1981). These studies are concerned with the "Human Relations" problems brought about by complex Differentiations and the need for different qualities of Integ-

ration.' The current study, however, is only concerned with organizational structure, i.e. the formal system of roles, responsibilities and relationships within the management of the project. Thus it is valid to state that the "behavioural approaches" mentioned are outside the scope of this study. However, once the organizational structure can be defined in a rational and systematic way, the behavioural studies will be able to fill in the gaps brought about by concentrating purely on structural aspects.

In previous studies of organizational structure (Lawrence & Lorsch, 1967; Walker, 1980), much was made of the determinants of Differentiation, viz.: Technology, Territory, Time and Sentience. This provides a great deal of data about the range and intensity of different combinations of differentiation. However, these studies do not relate the varieties of Differentiation to Integration: They only look at the presence or absence of Integration. This would imply that it is unnecessary to examine all types of Differentiation. Differentiation in terms of skills (Technology) is needed according to the complexity of the environment. Along with their Differentiated skills people bring with them the other types of Differentiation. These other types of Differentiation may reinforce and highlight the Differentiation which is due to Technology, but they cannot mitigate it. Since it is sufficient to examine only the presence or absence of Integration, then for the purposes of this study, all types of Differentiation other than skill can be aggregated and simply referred to as secondary Differentiation. Skill Differentiation is primary and refers to the particular type of Differentiation which is required as a consequence of environmental complexity.

2.5 IDENTIFYING THE ENVIRONMENTS OF CONSTRUCTION PROJECTS

In order to adequately relate the organizational structure to the environment, it is first necessary to describe the environment of building project organizations at a

greater level of detail than has been the case in the past (Napier 1970; Morris, 1972; Walker, 1980; Sidwell 1982).

2.5.1 Types of environmental influence on projects

The environmental influences on construction projects are various. Walker (1980) states that environmental influences can be classed in a variety of ways, and can be identified and analysed for each project. However, this approach seems altogether too loose for comparative analyses, because the way in which environmental influences are classed depends on the project being analysed. Walker's work has shown that by leaving the definition of the environment to be dependent entirely upon the merits of each case gives little scope for making systematic connections between the environment and the organizational form.

The environment should be defined in a more structured way, and the list of criteria should be examined to ensure that any observable environmental phenomena may be classified into one or more generic groups of environmental forces. The groups offered below are based upon five earlier views of environmental influences on projects (Hodge & Johnson, 1970; Hall, 1972; Walker, 1980; Farzad, 1984; Kast & Rosenweig, 1985).

(a) Political: This is mainly concerned with government policy and the effect of national and international political decisions upon the environment of a project. It also covers the occasionally large influence that strong individuals can have over a project.

(b) Legal: Legislation can affect the client's activities directly, through factors such as safety, planning law, building regulations, tax laws etc. It also directly impinges upon the contractual relationships within a project.

(c) Institutional: This covers the influence that professional institutions can have over the conduct of the professional consultants. It affects conditions of engagement, fee scales etc. Institutional forces are also brought about by the influence of the head office or parent company over the client.

(d) Cultural: This describes the acceptability of certain modes of behaviour by society as a whole. It is expected that people will behave in

a manner appropriate to the society in which they live. It covers such phenomena as "peer group pressure". It can have a great effect upon the industrial relations scene within a project, and on the "informal systems" which are often acknowledged to exist within formal organizations. It will also include historical background and idealogies.

(e) Social: This differs from Walker's "Sociological" aspect. The term describes the social environment within which the project is operating. There may be a specific social need for a project, or conversely, a building may have adverse social consequences, such as the use of tower blocks for housing families. In addition to this, social class structures, and the development of social institutions also influence the environment.

(f) Technological: This aspect relates to the technology which is available to do the work, both in terms of design and construction.

(g) Economic: This includes the level of general economic activity, as well as the question of the economic resources available to carry out the work. It includes the structure of the economic system, supply and demand, government economic policies etc. It also covers the fact that economic competition exists around the appointment of all of the parties to the building project, as well as the fact that any building project is an economic response to a perceived problem.

(h) Financial: Financial limits usually exist on building projects. They are often clearly specified, but they can be based on totally inadequate information.

(i) Physical: This relates to the physical circumstances within which the project takes place. At a simple level there may be difficulties associated with the site, or the climate may be bad; adverse or inclement weather is included in this category. On a wider view, the physical environment dictates the materials and techniques that are available.

(j) Aesthetic: There will be some sort of aesthetic influence around a project; whether it is through "fashion" in building design, or whether it arises through the conscious choice by a client of a particular designer.

(k) Policy: The translation of these total environmental influences will be initially undertaken by the client. When a decision to provide a building is taken, steps will be taken to translate the interpretation of the environment into a policy for a project. This decision

will have been based upon some consideration of the environmental influences on the client's organization; possibly even some consideration of the project's effect upon the environment. These decisions form the immediate boundary to the building project as a system.

2.5.2 Levels of environmental influence

It is clear that some of these environmental facets work at different levels. One solution to this problem is to distinguish between the immediate environment of a project and its wider environment. This distinction has been made in the past by Hall (1972), Osborn & Hunt (1974) and Farzad (1984). In the past, these two levels have been termed the general (societal) environment, affecting all organizations within a society, and the specific (task) environment, affecting individual organizations more directly. Kast & Rosenweig (1985) add that the distinction between the two is not always definite, and that the general environment can impinge directly on the project. In this study it is preferred to adopt the terms "Micro-environment" and "Macro-environment" to describe the two levels of environmental influence.

On the level of the Macro-environment, there are essentially five categories of interest, viz.: Cultural, Economic, Political, Social and Physical. Each of these can be viewed in a world context as being generally prescriptive and widely applicable. They each have a 'soft' effect upon the construction project and often may not be perceived as problem areas simply because they are so familiar.

At the level of the Micro-environment, the remaining environmental factors surround and define the project. The legal aspects can be grouped together with the institutional aspects, because the law of the land is the mechanism by which society's requirements are institutionalized. Similarly, professional institutions are legal identities within which people undertake work. This then produces a list of Micro-environmental factors, each of which acts as a buffer between the project and a corresponding Macro-environmental factor. These are summarized in Table V. This shows a

scheme where each Micro-environmental factor can be viewed as existing predominantly as a consequence of its Macro-environmental counterpart. This is not an exclusive relationship because there are many interdependencies at work in the environment. Also, there will be much overlap between types of environmental factor: hence it will not be possible to describe or analyse one factor in isolation from the others.

Table V: Macro versus micro-environment

Macro-Environment:		**Micro-Environment:**
Cultural	◄—►	Aesthetic
Economic	◄—►	Financial
Political	◄—►	Policy
Social	◄—►	Legal/Institutional
Physical	◄—►	Technological

Table V only indicates predominant relationships between the factors, not exclusive ones. Thus the culture of the society under scrutiny is translated into material things through the action of aesthetic realization. Similarly, the economic background to a project dictates its financial limits; the political situation is manifested in the policies of the client for the project; the social conventions and restrictions are realized through the mechanisms of legal and institutional traditions; and finally the physical reality of the world dictates the materials and techniques which are available to undertake the work.

In this way, the immediate environment of the project can be seen as consisting of five variables, each of which acts as a buffer, or an interpretive mechanism, to the five variables in the Macro-environment. Thus, influences from the Macro-environment place demands upon the project. These have to be mitigated through the utilization of expertise in the Micro-environment.

For the purposes of analysis, each of the five facets of the Micro-environment can interact with the other. This

means that wherever a problem occurs in one of the facets, it has consequences for each of the others. Thus, any quantification of the environmental complexity will have to take this into account in its scoring system.

2.6 THE BASIS OF THE NEW MODEL

The analysis of the plans of work has shown that there are stages of work common to all projects, and that these stages are punctuated by decision points. Walker's model is the most appropriate departure point for developing an analytical method for public sector projects, but it needs refining. The new model will encompass the elements of construction project management, i.e. the concepts of Activity, Decisions, Interdependence, Differentiation and Integration; and relate these to the environment of the project. The new model is developed in the next chapter.

CHAPTER THREE: HYPOTHESES AND MODEL OF THE CONSTRUCTION PROCESS

It is central to this thesis that the organizational structure of construction projects can be modelled using theoretical principles developed outside the construction industry. Such a model is developed in this chapter, along with a set of organizational principles, expressed as hypotheses, which can be used for testing the model.

3.1 THE ELEMENTS OF THE NEW MODEL

The starting point for the development of the new model is an examination of objectives and their relationship to the environment.

3.1.1 Objectives

Objectives are defined as the purpose behind the existence of any system or sub-system.

The advantage of the systems approach is that it involves looking at each of the component parts of the system in terms of their relationships to each other, and their relationships to the whole. Thus the system under consideration can be seen as a set of inter-related sub-systems, each with its own objective. The open systems viewpoint requires that each sub-system is managed in terms of the overall system, and in terms of how that system interacts with its environment.

In view of the foregoing, there are several levels of objectives to take account of. At the most general level, that of the system as a whole, the project must be orientated towards an overall objective which will help the client organization react to its environment more effectively. As the environment is subject to change, so this objective will be subject to change. In this respect the duration of a project is important in terms of the timing of changes in

the environment. Objectives at this level ought to form the basis of any review of project success.

Bengtsson (1984), in his study of project objectives, shows that for most people in construction projects, objectives are focused upon their own area of responsibility, and they are less interested in the "whole". This is a result of traditional organization structure of projects and the orientation they impose on the individual.

The general view of objectives in construction is that clients want a building on time, within cost limits, to a specific quality (Chartered Institute of Building, 1982; Draper, 1984; Finn, 1984).

The project objectives become the major determining factor of the objectives for each of the sub-systems within the project. Each sub-system must have its own objectives which are orientated to the overall project objective.

In order for the project to progress in a meaningful way, these objectives, and their achievement, must be closely allied to the decision structure. In line with this, the project can be said to have been initiated at a particular decision point. This would be the client's decision to explore the extent to which organizational objectives can be met by the procurement of a building. Similarly, the completion of the building project is a decision which rests with the client. These two decisions concern matters of client policy, and thus they will be termed "Policy Decisions". Although the client's policy will probably vary during the project, this will be a gradual evolution rather than a series of discrete events. Thus, only two Policy Decisions are identified.

3.1.2 Control

Since an "Open Systems" view is being taken of project organizations, it is essential that some sort of mechanism is provided to regulate the transactions between the system and its environment. This is the purpose of Control Systems. Essentially, it is the systems view which provides the abstract model of a Control System in terms of

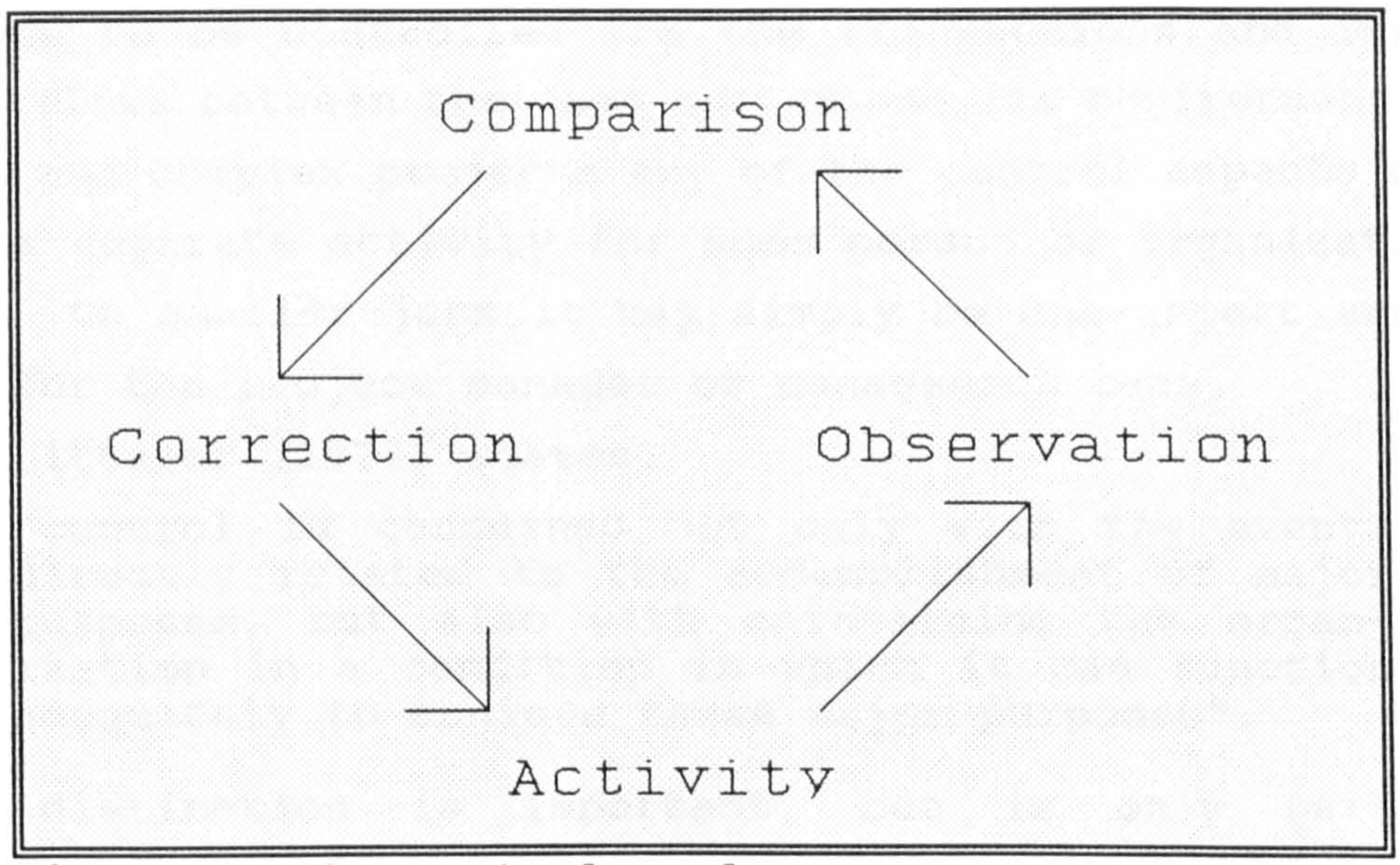

Figure 2: The control cycle

observing, comparing and correcting. The Control System involves comparing progress to pre-determined targets, or plans, and taking some sort of corrective action (Kast & Rosenweig, 1985). This is shown diagrammatically in Figure 2. The corrective action may take two forms. Firstly, taking steps to change the performance of the activity to bring it closer to that which was planned; or secondly, changing the plan so that it more closely reflects the changed situation brought about by the departure from the plan. In this study, in order to distinguish these two forms, the former will be termed Forward Control and the latter will be termed Feedback. Both types of Control System will require decisions to be taken at a level more senior than that under consideration. These decisions are termed "Strategic Decisions". They create the boundaries to the stages of work already described.

Control Systems are required in several respects. All of the plans of work reveal that different types of Control System need to be exerted over a building project. A certain amount of control will be needed irrespective of project variables. But different types of Control System will vary in importance from one project to another, just as the environment varies from one project to another. The variations in the needs for control arise because the major

aspects to be controlled are the transactions and information flows between the open system and its environment. On large and complex projects any of the control aspects could form a separate activity for some person or organizational unit. On smaller jobs it may simply be one aspect amongst many for the project manager or management team.

As Litterer (1973) states,

> "control is concerned not only with the events directly related to the accomplishment of major purposes, but also with maintaining the organization in a condition in which it can function adequately to achieve these major purposes".

This distinction is important, but is only partially revealed in previous studies. Burns & Stalker (1966) refer to the maintenance of the organization as the Managing System, and this idea is followed by Walker (1980). This convention will be followed here. In addition, Control Systems will refer to the matching of performances with objectives. The Control System acts as an interface between the Operating System and the Managing System. The Managing System sets the policies and objectives for the project, and the Operating System undertakes work in order to achieve them. The Control System matches activity to objectives in order to ensure that output is orientated towards objectives.

Figure 3 shows how activity, decisions and control are related to each other in the context of project management. The initial decision is termed the "trigger" decision. It is here that the objectives for this particular sub-system are set. The end point is called the "terminal" decision, and this will usually form a trigger for a subsequent sub-system. This pattern occurs in all of the plans of work and is the basic systems model embodied within Walker's work.

Within this basic pattern of work, the Managing System is triggering, regulating and terminating packages of work, at a lower level of sub-system. The issue of control should be separated from pure activities in the model, to clarify the distinction between levels of systems. Control takes up

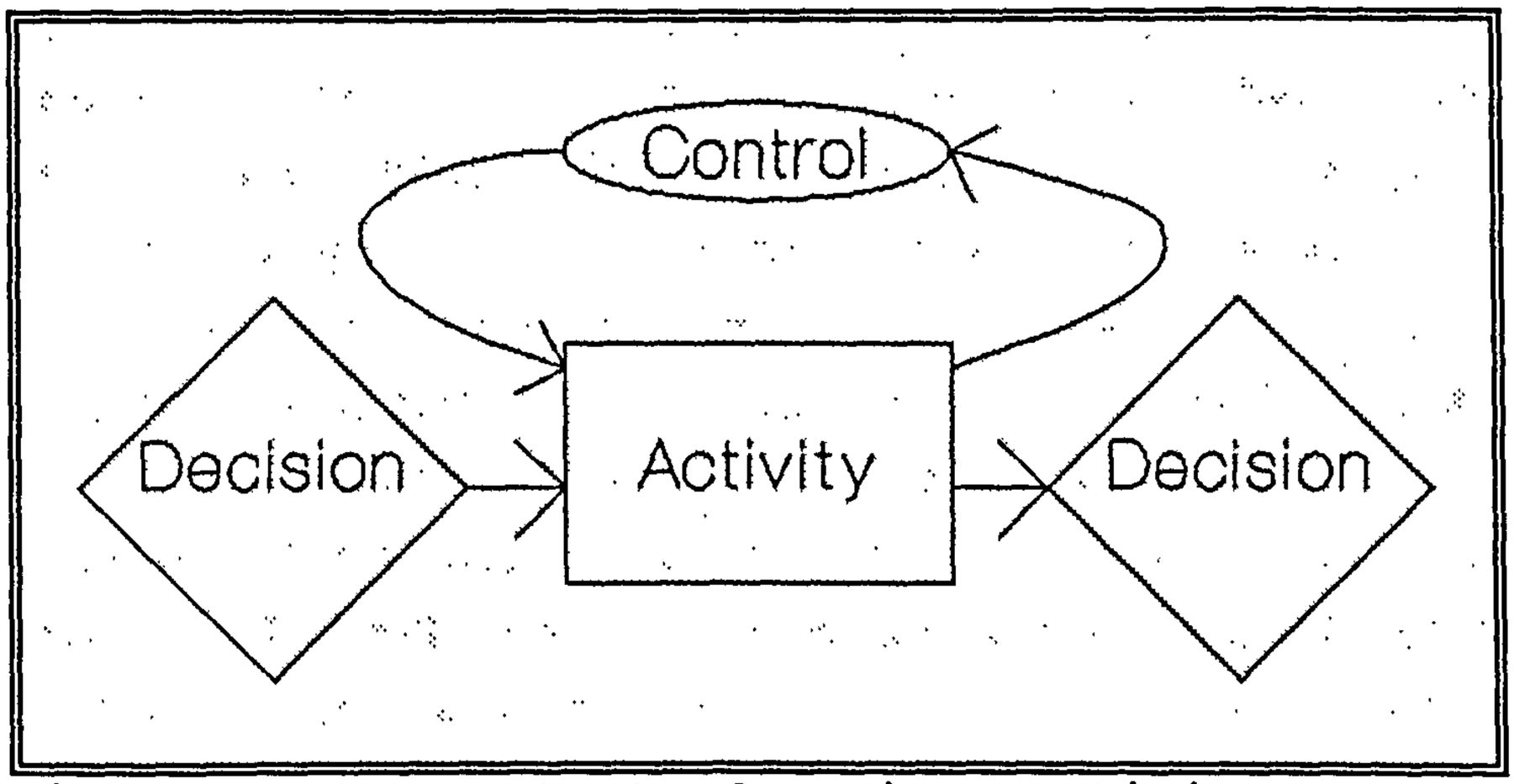

Figure 3: The context of project activity

much of the detail in the plans of work, and accounts for many of the differences between then. Therefore this distinction serves to simplify and clarify the basic stages.

Objectives form the basis of a control plan. Therefore the three objectives regarding time, quality and cost (mentioned in the previous section, page 47) form the basis of the control of construction projects. The term "cost" is rather too narrow to encompass all of the criteria associated with the expenditure of finance. It is felt that in order to include revenue and maintenance budgets the concept of budgetary control is more useful.

Much of the work involved in contract administration and the technical work of professional consultants, is taken up with legal control. Also, the client's briefing is the technique for controlling the functional content of the scheme. These two types of control need to be accounted for in any organizational model of construction projects. Thus the different types of control considered are budgetary, time, quality, function and legal. These aspects of control are present to differing degrees at all stages of the work.

3.1.3 Activity

The seven universal stages of work identified in Table III constitute the activities generally found on construction projects. This pattern will be the basic frame of reference, the "normative model". Although the class-

ification of the work into stages may imply a sequential progress of work, it is not intended that the stages are absolutely sequential because information may be generated in different ways for different projects. These normative stages are merely a generalization and as such much of the detail must be adaptable. This normative model describes the activities taking place in a reasonable pattern. This can be adapted to suit the circumstances of each project. Each stage of work can be broken down into a group of Operations which have to be undertaken with a realistic relationship to each other. Further to this, each stage should have its own uniquely identifiable objective. Some activities identified within plans of work, such as briefing and cost control, take place more or less throughout the life of the project. This is because they form part of the Control Process and are in fact components of the management information system for the project. Figure 4 shows the relationship between activities, the control processes which surround them, and the two levels of environmental factors surrounding the whole.

3.1.4 Operations

Operations are the components of activity. An Operation is defined as that package of work which can be undertaken by one organizational unit without interruption by decision points (adapted from British Standards Institute, 1979). In terms of an "Operating System", Operations are linked in a variety of ways, reciprocally or sequentially (Thompson, 1967). Additionally, within an Operation, different contributors may be providing input, or receiving output. Thus the work to be done in an Operation consists of combining a variety of information inputs, some from previous or concurrent Operations, and some from consulting contributors. These inputs are transformed into information outputs by exercising technical skill. The outputs will be made to other contributors, in other Operations, thus forming the inputs of subsequent Operations. Aspects of control may be so significant as to form discrete Operations in their own

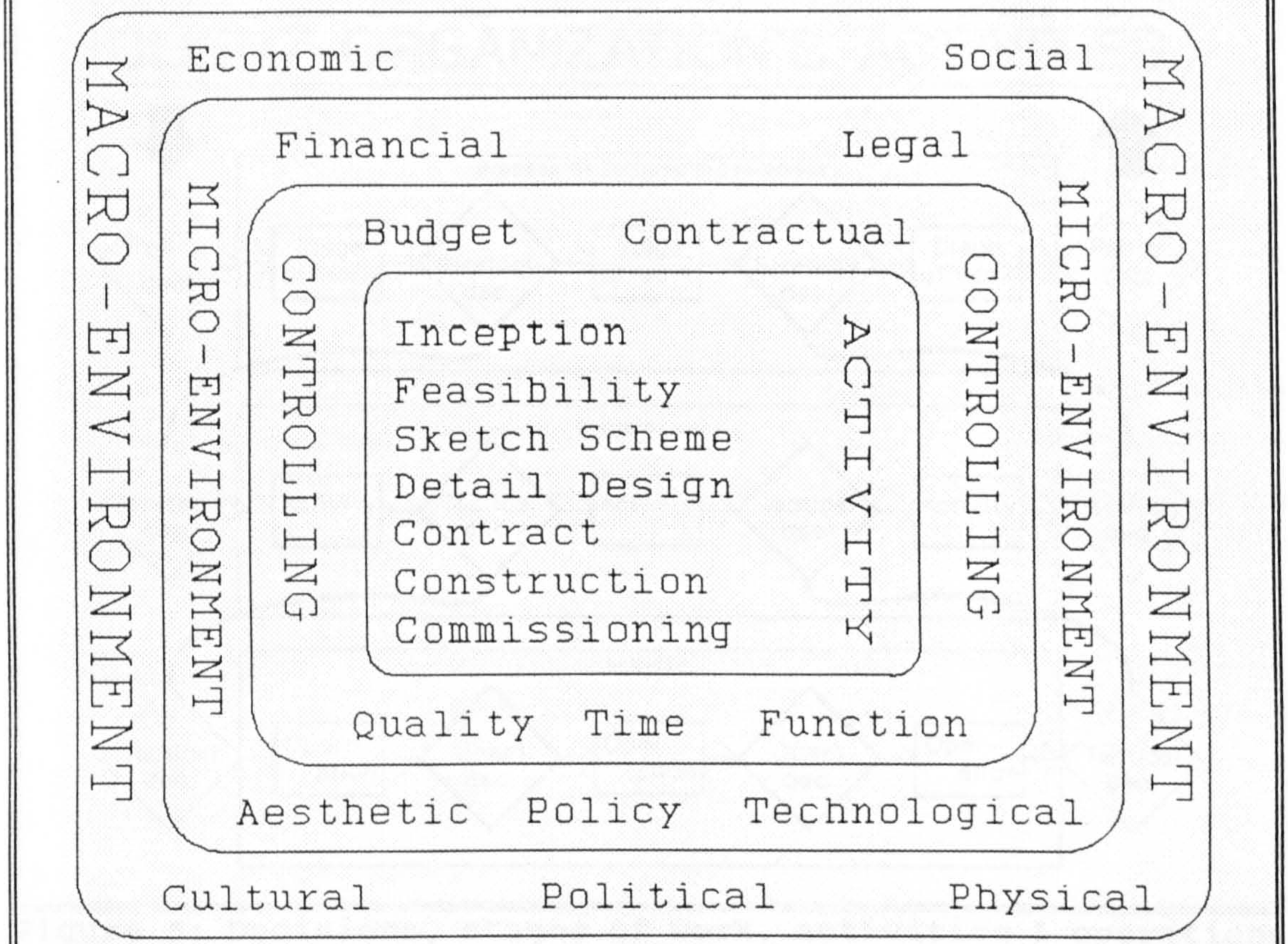

Figure 4: Activities, controls and project environments

right on complex projects; but on simple projects they may be reduced to consultation or management functions within Operations.

3.1.5 Hierarchies of decisions

Decision points form the major boundaries to activities. They can be classed as Policy, Strategic, Tactical and Operational Decisions. The structure of decision points is shown in Figure 5, and the definitions are as follows.

Policy Decisions are the major constraint on any project and determine the framework within which the project takes place. They may be compared to Walker's Primary Decisions, except that there are only two Policy Decisions defined in this study. The trigger Policy Decision sets the objectives for the project, and the terminal Policy Decision terminates the project. Premature termination would be a result of

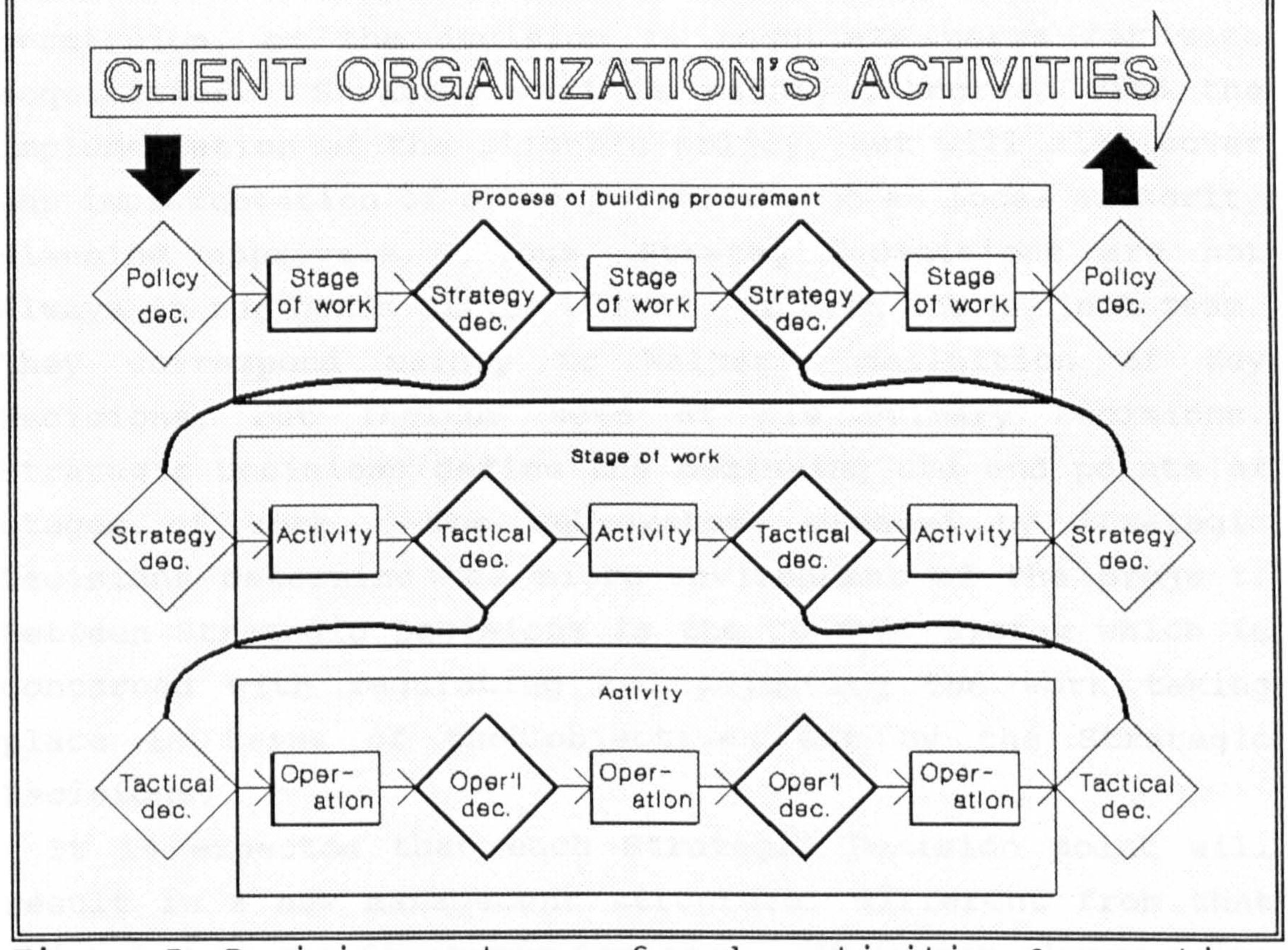

Figure 5: Decisions, stages of work, activities & operations

major change in the client's policy toward the project. It is unclear from Walker's definition whether such changes in policy would be Primary or Key Decisions. Also, because his work was done in the private sector, he did not take account of the effect that policy makers within a public client organization could have upon the project team. Policy Decisions are the highest ranking decisions. They define the beginning and end of the "Process of Building Procurement". As such they are at the interface between the macro-environment and the project. In this sense the project exists as a response to the macro-environment, and with the aim of effecting some sort of change to the macro-environment. This definition results in the Managing System which regulates, maintains and adjusts the process of building procurement in terms of the project's environment.

Within the "Process of Building Procurement", Strategic Decisions are defined as those decisions which deal with matters of the environment impinging on the project

boundary. An example is the decision to apply for planning permission, or the decision to negotiate terms for site acquisition. Strategy will be mainly concerned with the implementation of the client's policy, but will also cover the implementation of other policies such as local authority planning approvals. Thus, Strategic Decisions are not always in the hands of the client, or even the project team. They correspond mainly to Walker's definition of Key Decisions, but include some of his Primary Decisions. Strategic Decisions define the beginning and end points of stages of work. The sub-systems created by Strategic Decisions determine the micro-environment of the project. Between Strategic Decisions is the Control System which is concerned with regulating and adjusting the work taking place in terms of the objectives set by the Strategic Decisions.

It is expected that each Strategic Decision point will result in a new management structure, different from that which led to the Strategic Decision. It is not always going to be the case that decisions are taken at the Strategy level; they may be delegated on some projects. Also, the Decision may not be taken explicitly, but be assumed to have been taken. However, since the nature of the work alters at these milestones, even if they are not explicit, the work progresses as if they had been.

Tactical Decisions are concerned with the deployment of resources and the management of the project on a day-to-day basis. They will be the purview of the project leader, or project manager. Examples of these are the decision to appoint nominated sub-contractors for parts of the work, or the decision to adopt certain forms of contract. A further example is the decision that a project is complete and the contractual obligations can be completed. In practice, 100% completion of a project is unattainable because there comes a time in every project when to do further work entails undoing previous work. Thus completion is not a clearly defined situation, but a Tactical Decision. Tactical

Decisions form the boundaries to sub-systems of activity, and are the means whereby the Control Systems are effected.

Operational Decisions are directly related to Operations as previously defined. By definition, Operations are triggered by decision points and a decision point marks their completion. Therefore, in the absence of a higher rank of decision there will be an Operational Decision. These occur where delegation of authority is high, and where there is autonomy at the Operational level, and thus may not be present on many projects. Activity is the term used to describe the groups of Operations between Tactical Decisions. The Operating System is the term used to signify groups of Operations interacting to incrementally progress the project towards the objectives of the stage of work.

In this way, Operations are sub-systems of activity. Activities are sub-systems of stages of work, and stages of work are sub-systems of the process of building procurement.

3.1.6 Roles and responsibilities

The relationship between a contributor and an Operation is referred to as the contributor's role. There are a variety of such roles, and they may be combined for a particular contributor. They will be determined by the contributor's skill and ability and the purpose of the contribution being made. Analysis of such roles seems mainly confined to behavioural studies, in which sets of roles are studied to analyse job design.

According to Cleland & King (1975), these roles ought to be identified according to the level of detail required of the analysis. Apart from this suggestion, there is no other guidance in the literature about how to choose the total role set for such an analysis. Walker gives no suggestion as to the derivation of his set of roles. The roles used by Walker, and by Cleland & King are the basis for the set used in the current analysis. Since the degree of detail and the classification of roles is dependent on the depth of the analysis and the purpose of the investigation, the role definitions are derived from the discussion up to this

Table VI: Definitions of roles

OPERATING SYSTEM ROLES:	
Operating	The activity of actually carrying out work (i.e. performing an operation) on some aspect of the project.
Co-operating	Membership of a team or committee in which all of the contributors are present at the same time, thus achieving integration.
Consulting	The provision of technical or other information when asked for it. Typically undertaken in the construction industry by professional consultants.
Receiving	A person who is in receipt of information about the project for purposes outside the management of the project; for example the accounts department of a client organization.
CONTROL SYSTEM ROLES:	
Monitoring	The function of recording and filtering information about an operation and communicating it to the right people who may take action.
Supervising	The responsibility for comparing progress with a predetermined plan and for bringing about some sort of response to the situation.
Resourcing	The function which ensures that the people who carry out Operations have sufficient resources (both in terms of skill and economic resources).
MANAGING SYSTEM ROLES:	
Co-ordinating	The function which ensures that information flows successfully between Operational links.
Directing	The executive responsibility for ensuring that the output of Operations is orientated towards the objectives.
Recommending	The function of passing information or the results of an Operation to someone who must take a decision on it.
Approving	The executive function of taking decisions about the output of Operations. This decision will usually form the input of a subsequent Operation, Sub-system or System

point. Three types of system have been introduced, the Operating System, the Control system and the Managing System. Each of these systems consist of sets of roles, and these are summarized in Table VI.

Recommendations may arise at any level in the hierarchy, and will be subject to Approval by the next level in authority. This Approval may become a Recommendation to someone in a higher managing function again, so the chain of Recommendation and Approval passes up the management hierarchy until it reaches the person who has the ultimate authority for the particular decision being taken. The ultimate authority in the project management system is the client, so the final Approval may end up as a client's Policy Decision.

The analysis should be capable of exposing the situation where the integrating mechanism is achieved through meetings and teamwork. Thus the role of "Co-operating" is defined as membership of a team or committee. This can occur at any level in the system, and has to be shown separately because in such a case, even though there may not be an individual whose responsibility is Co-ordination, it may take place by team work and meetings.

These role definitions provide the basis for defining the contribution that each person makes to a project, and they are shown in Figure 6, related to the different levels of systems.

At each of these levels of decision making, will be a different level of detail for analysis. In strict systems terms the Control System described in Figure 2 should be applied at all levels. The practical manifestation of this is the communication patterns that are observed at each of the levels. These form the "glue" which binds the different roles at each level and produce the characteristic pattern shown in Figure 7. This demonstrates the dynamics of communication between the contributors, and shows how the control cycle (from Figure 2) is implemented at all the levels of the management hierarchy. At the Operational level control is achieved through the exercise of three roles. The process of observing is achieved via the role of Monitoring. This gathering of information must include a certain amount of filtering, to make it effective. Thus the Monitor undertakes some comparison of information to objectives. Information is passed to more senior people in

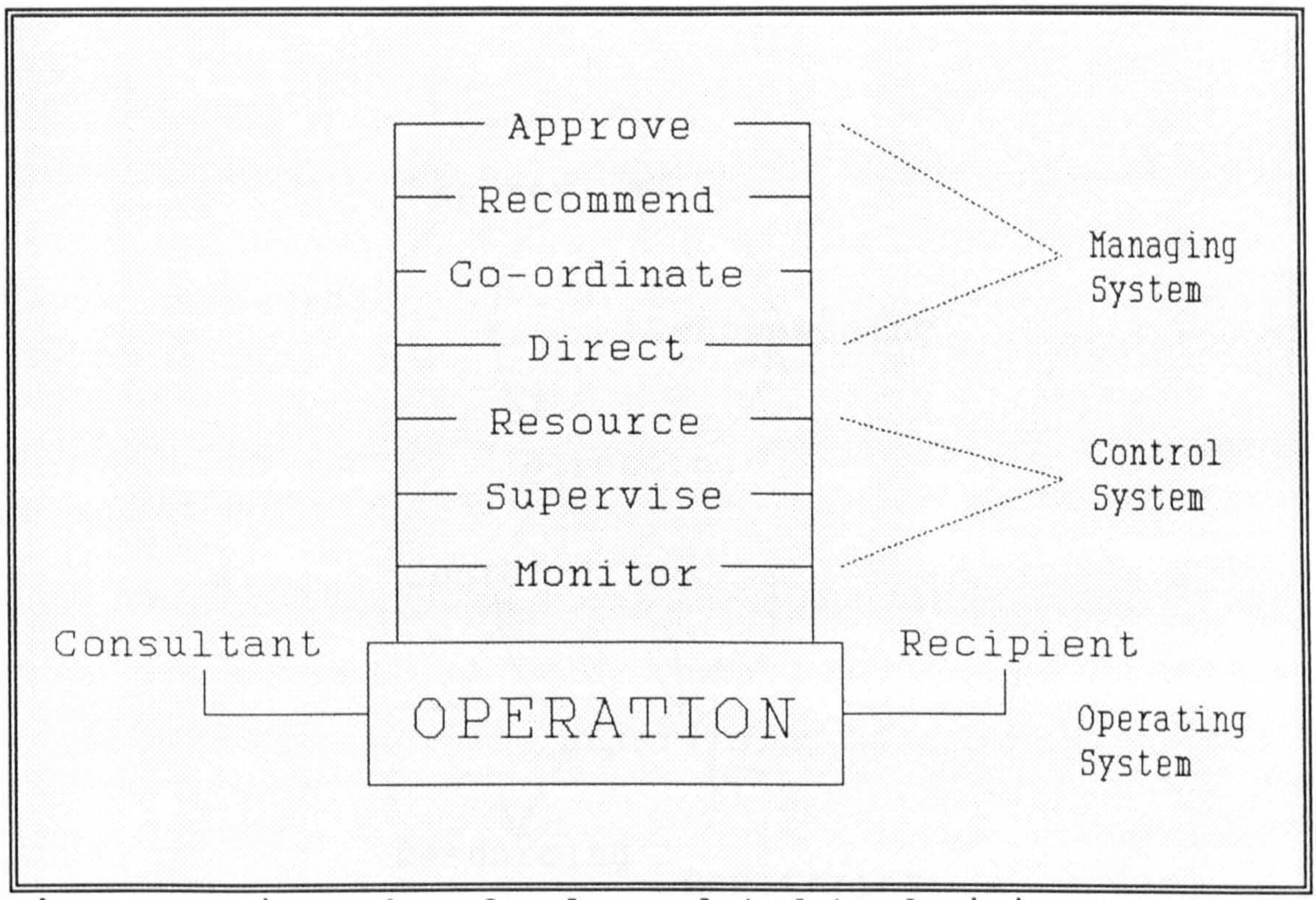

Figure 6: Hierarchy of roles related to decision types

the organization and they also undertake a comparison to the objectives before determining the course of action to take. There are two choices here; Forward Control or Feedback (as defined in section 3.1.2, page 47). Control will be achieved by the exercise of supervisory powers, either to affect the level of resources available to the Operator (thereby achieving Forward Control), or by attempting to change the plan so that the departure from the plan is removed (thereby achieving Feedback). This will mean that the decision is referred to the Managing System for a Strategic Decision. The Control System, then, at the Operational level is achieved through the roles of Monitoring, Supervising and Resourcing (MSR).

At Strategic Decision points, the control process becomes the responsibility of a higher level of the hierarchy, and is manifested through the roles of Directing, Recommending and Approving (DRA). This is a higher level of control which involves the client in the decision making process.

Figure 7 also shows why sometimes decisions from policy makers take a long time to filter down to those who

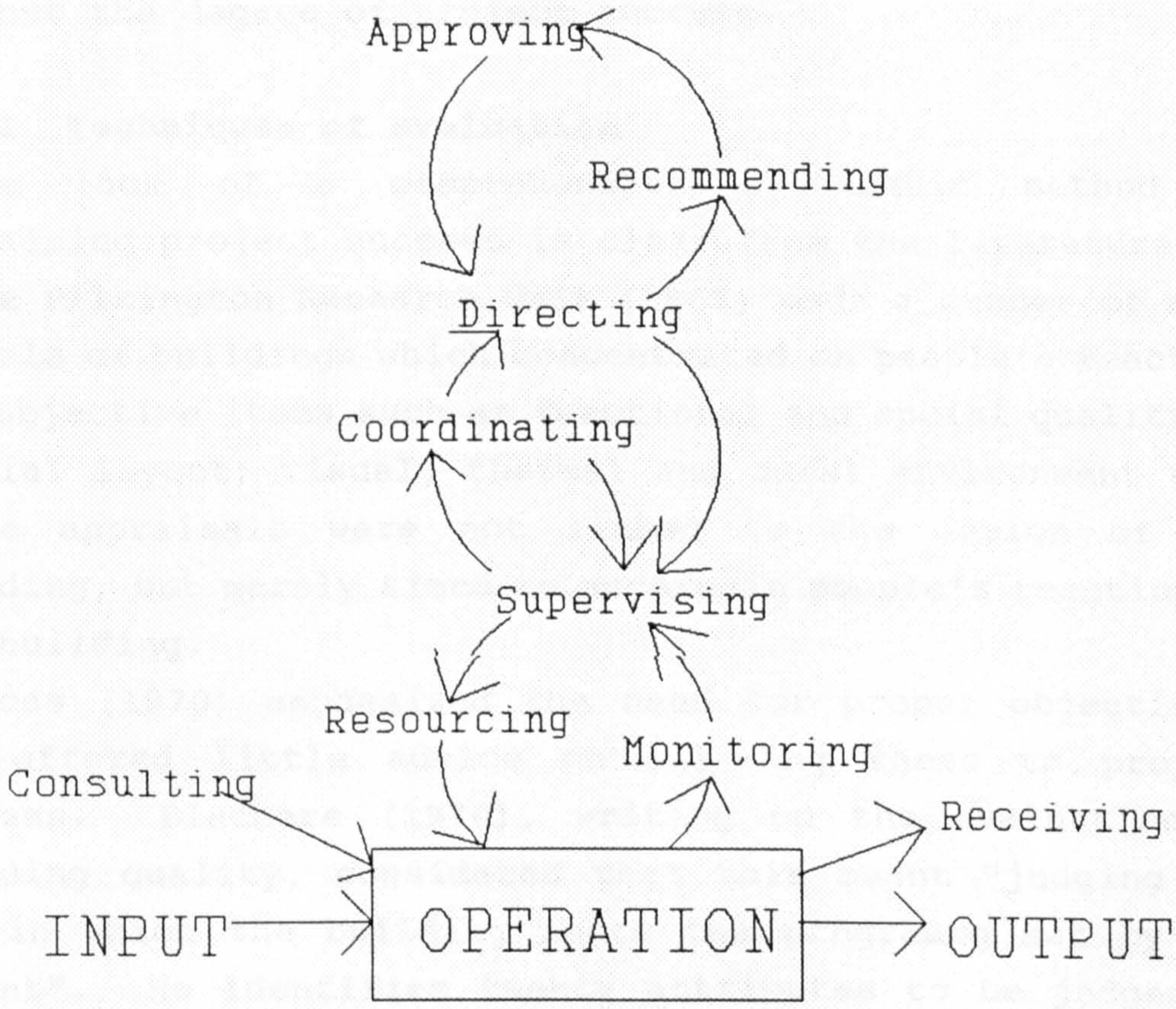

Figure 7: The dynamics of decision making

implement them at the Operating System level; problems may be circulating for many years amongst the cycles in the upper portion of the figure before finally working their way back down to the Operating System. This may be beyond the perception of those on the Operating System who often only perceive the enormous time lag in decision making, with no appreciation of the structure of the system which produces the decision.

3.2 VALIDATING THE MODEL

The purpose of the model is to examine the organizational approaches used in public sector construction. The degree to which a project matches the model is meaningless without

some measure of project success. The only way to test the model is to assess the extent to which the observed organizational structures match the model, and compare that against the degree of project success.

3.2.1 Techniques of evaluation

The lack of a comprehensive systematic method of appraising project success is clear from the literature.

The Pilkington Research Unit (1967) made a number of appraisals of buildings which concentrated on people's reaction to subjective items such as functional and social qualities; spatial layout; visual, thermal and aural environment etc. These appraisals were not linked to the design of the building, but merely aimed to ascertain people's reaction to the building.

Lucas (1970) emphasized the need for proper objectives, but offered little advice on relating these to project success. Blachère (1970), writing on the evaluation of building quality, considered that this meant "judging the way in which the building meets the programme set by the client". He identifies twenty attributes to be judged in assessing housing quality and concludes that it is not possible to summarize them in a single comprehensive assessment.

The Building Performance Research Unit (1972) published a detailed account of their evaluation of the performance of buildings. Whilst they undertook very comprehensive surveys of users' reactions to the buildings, they seem to have based the work on the fact that all buildings are different and therefore demand different types of review. It is difficult to determine the extent of any structure in their reviews, and little reference is made back to the process which produced the building.

A study reported by Dean (1976) found from the literature on this subject that criteria used for making judgments about buildings were almost never linked to the architect's brief. Snowdon (1977) recognized the need for identifying the criteria for success of a project at the time when the

objectives are set. The BRE (Britten, 1977) made a study to ascertain the degree of importance which householders attach to various features of a house and its surroundings. One of their techniques was to rate satisfaction with various criteria on a five-point scale, another was to get respondents to rank 42 attributes.

Draper (1984) described a systematic method of appraisal which was only applied at the design stage, and involved peer group evaluation, by architects, for architects.

To summarize, it seems that the only methods of evaluating buildings which have any rigour or regularity are those which gauge people's psychological reaction to their buildings. It is clear that the measure of success must be related to project objectives. This means that each of the objectives identified from the environmental analysis of the building project should be specified in such a way as to describe the way in which success would be affected by its achievement. When considering projects which have been judged to have failed, reasons for failure, such as poor buildability, illustrate the problem that the degree of success can depend upon whose viewpoint is being sought. This gives two dimensions to the problem of building evaluation; the criteria being judged and the viewpoint of the person judging it. A third dimension arises from the problem that perceptions change with the passage of time. These three dimensions are shown in Figure 8, and discussed in more detail below.

3.2.2 The changing manifestation of a building

One of the problem areas with the evaluation of buildings is the fact that as time progresses, the nature of the building is changing. This change is not merely due to the passage of time; but as time passes, the manifestation of the building changes. In the earliest phases of inception and feasibility, the building only exists as an idea, or a remote possibility. People's reactions to it are reactions to an abstract concept which is only defined in approximate terms. As the project progresses, the subject becomes

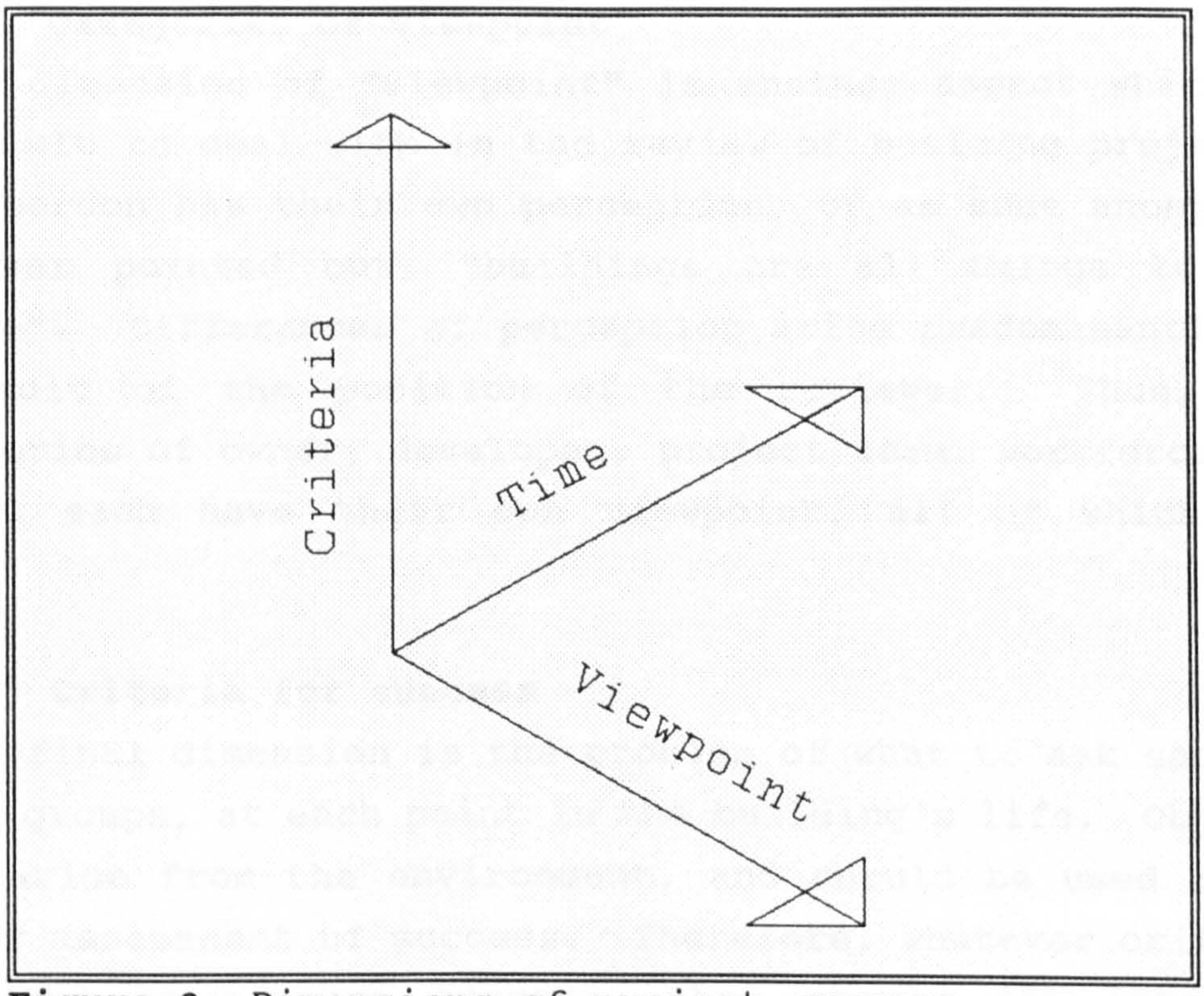

Figure 8: Dimensions of project success

modelled more definitely in terms of drawings, schedules, bills etc. and reactions are more detailed, but still people are reacting to something which only exists as a model. Once on site, the subject is a dynamic production process, noisy, dirty and sometimes dangerous. Reactions will be heavily influenced at this stage by one's perception of the work-place.

Upon completion of the building people are reacting to a new phenomenon, freshly painted and highly conspicuous. Ultimately the building blends in with its background, or it becomes an accepted part of the skyline, part of the environment of people, and again this is a stage which will produce its own perceptions. Eventually, the building will come to the end of its life and perceptions will now be of something which is to be disposed of.

At each stage, the nature of that which is being considered is very different, so it is considered that a comprehensive scheme of evaluation would be hard pressed to relate all of these things together.

3.2.3 Categories of viewpoint

The dimension of "viewpoint" is another aspect which is difficult to deal with in the review of building projects. Each person has their own perception, or as some anonymous observer pointed out, "buildings are all things to all people". Differences of perception arise predominantly as a result of the position of the reviewer. Thus, the categories of owner, developer, project team, workforce and public each have their own viewpoint, all of which are valid.

3.2.4 Criteria for success

The final dimension is the problem of what to ask each of these groups, at each point in the building's life. Objectives arise from the environment, and should be used for a proper assessment of success. Therefore, whatever criteria are used to measure success, they should fit into the categories of legal, financial, policy, technological and aesthetic; i.e. the micro-environmental factors. Within these there are sure to be a myriad of possible sub-divisions, and these should be made for each project, as appropriate, to a depth depending on the relative importance of each of the objectives. It is envisaged that the relative weightings between the five categories will be different for each group of people. Although there will also be variations within any selected group, these should be smoothed out by averaging, otherwise too much detail will be included.

3.2.5 The evaluation of buildings

For a meaningful comparison of different projects, all three dimensions should be taken into account. It is possible to conceive of a system where attributes within each dimension are ranked and given a relative weighting for particular project types. Questionnaires could then be devised which use a few questions for items with little relative importance, and more comprehensive questions for items with a high relative importance. The questionnaires

would be repeated at different stages during the life of the building, and the data generated fed back into client organizations so that their briefing processes would be improved on future projects. The most important feature of such a technique would be the extent to which it provokes criticism and/or praise. This would fill a tremendous shortfall in feedback found in construction projects.

The detail of all three dimensions of the problem of post-occupancy evaluation is summarized in Figure 8.

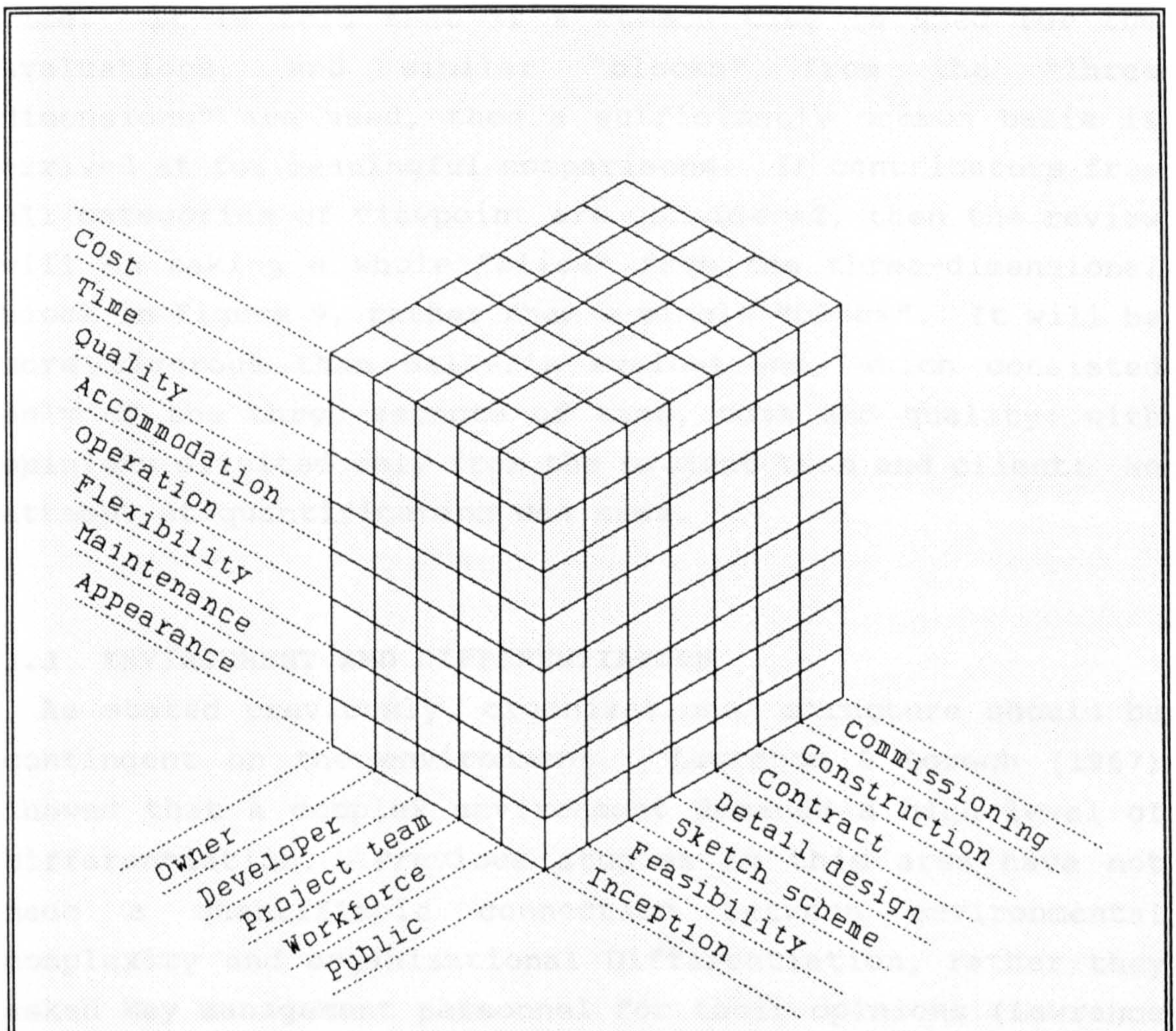

Figure 9: A framework for building evaluation

For the current study, it is sufficient to undertake a more limited view. Clearly, the problem of feedback on construction projects is a huge area of study, much of which is beyond the scope of the current work. For the purposes

of the current study, the evaluation of the project on completion is sufficient to shed light on the relative adequacy of a project's organizational structure. This must exclude the very laudable aim of improving buildings *per se*, because the aims of the current work are solely related to the improvement of organizational structure. Thus, the problem of changing manifestation is discounted since evaluations of relative success can be derived if the reviews are undertaken at the same stage in each project's life. It is felt that if a common base is used for the evaluations, and similar "blocks" from the "three dimensions" are used, then a sufficiently common basis is arrived at for meaningful comparisons. If contributors from all categories of viewpoint are considered, then the review will be taking a whole "slice" from the three-dimensional block in Figure 9, rather than a single "block". It will be more rigorous than Walker's evaluations, which consisted only of the three aspects of time, cost and quality; with opinions elicited only from the project team and client: No attempt at quantification was made.

3.3 ENVIRONMENT AND DIFFERENTIATION

As stated previously, organizational structure should be contingent on the environment. Lawrence & Lorsch (1967) showed that a complex environment demands a high level of Differentiation. Previous studies in this area have not made a quantifiable connection between environmental complexity and organizational Differentiation, rather they asked key management personnel for their opinions (Lawrence & Lorsch, 1967; Walker, 1980). The complexity of the environment must be quantified if the organizational structure is to be related to it. The five Micro-environmental factors identified in section 2.5.2 (page 41) should be analysed for each project. These environmental criteria are subject to variability of three different kinds. This stems from the relative degree of Definition of each

environmental aspect, its Stability, and the ease with which it can be Mitigated. These variables are discussed below.

3.3.1 Definition of the Environment

This variable describes how well-defined a particular environmental influence is. An important feature in identifying the extent of the environmental influences will be to determine the degree of Definition of each type of environmental influence. A test of the Definition of the environment could be to look at the extent to which the contributors perceive the effects of environmental influences upon the project. This perception is the extent to which the contributors to a project acknowledge that there is an influence.

3.3.2 Stability of the Environment

Environmental factors tend towards either stable or unstable. Also, the degree of Stability could change during the life of a long project. Stability may be thought of as a function of duration, since projects of longer duration will be more likely to experience changing environments. It may be useful to explore the relationship between duration and Stability; but this study concentrates on simply judging the degree of Stability of each environmental factor for each project under consideration.

3.3.3 Mitigability[1] of the environment

This variable is concerned with the extent to which environmental factors can be mitigated. This should indicate the extent to which it is in the power of the project team to mitigate adverse influences. Some factors may be unmitigable, and would thus have a far greater adverse effect upon the project (for example; unstable politics of the nation), whereas other factors could be more easy to mitigate (for example; the effect of technological

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[1] It is with reservations that a word like "mitigability" is used in this context, as it is slightly obscure. However, after consulting many dictionaries, two things are clear: Firstly, no other word describes the quality which something has when it is susceptible to mitigation; and secondly, "mitigability" is a correct English word in the Oxford English Dictionary.

complexity could be mitigated by employing suitably experienced consultants).

3.3.4 The ideal environment

The ideal situation in terms of the preceding variables will be an environment which is Defined, Stable and Mitigable. Obviously, this situation would be very rare indeed and projects will suffer difficulties through the varying effects of each environmental variable. It is the task of the project management team to control the "transactions" across the project boundaries. In order to do this there must be a systematic method for providing clear descriptions of the environment.

3.3.5 A new technique of environmental analysis

Each of the variables as described would be impossible to quantify absolutely because of their inherent complexity and the amount of subjectivity involved in their assessment. An enormous multi-variate analysis would be needed to establish definite cause-and-effect links between the environment and the project, and this would call for a massive amount of data. The intention is merely to offer a common framework for descriptions of the environment, and to produce figures which are indicative of complexity in the environment. This will enable project managers, and project teams, to distinguish different project environments and hence differing demands upon the organizational structure.

The framework offered for providing a description of the environment is based upon the Micro-environmental influences described previously, in section 2.5.2; i.e. legal, technological, financial, aesthetic and policy. In the new technique each type of environmental influence is described in terms of both the nature and extent of its influence. These will then be quantified in terms of the variables Definition, Stability and Mitigability.

The intention is to provide a quantitative indication of the distinguishing features of each project's environment. This is done by assigning a score to each of the Micro-

Table VII: Example of an environmental analysis

ENVIRONMENTAL FACTOR:	**Def**	**Sta**	**Mit**	**Tot**
LEGAL/INSTITUTIONAL: English Law applied. Well-known Std Form of Contract was used. Familiar Condns of Engagement for external consultants. Each consultant had a counterpart in the Health Authority for liaison.	1	1	3	5
TECHNOLOGICAL: The solution adopted involved non-traditional materials, some of which had to be imported from the continent. There was a very high services content for specialist equipment.	1	2	3	6
FINANCIAL: Cost limits for the project were clear, but were subject to some changes over the years.	1	3	3	7
AESTHETIC: The design was aesthetically adventurous using large expanses of smoked glass which had to be specially imported from abroad.	1	2	2	5
POLICY: There was conflict between various parts of the client organization which had to be resolved mid-way through the project. The objectives of the project were stable.	1	3	3	7

$$E.C.I. = \frac{(5 \times 6 \times 7 \times 5 \times 7)^{0.2}}{9} \times 100 = 66\%$$

KEY: Def = Definition, Sta = Stability, Mit = Mitigability, Tot = Total.

environmental influences, for each variable. In order to ensure that the information given by this analysis is easily interpreted, it is suggested that the degree of detail should not be excessive. In view of this, only a three point scale is offered for each variable. This is based upon the ideal state scoring one, thus indicating that little attention is needed, and the worst case scoring three, indicating a high level of importance. Intermediate states score two. An example of an environmental analysis is given in Table VII.

Each of the Micro-environmental factors is assessed, and the scores for the three criteria of Definition, Stability and Mitigability are added together. This gives a number out of a maximum of nine points for each factor. It is clear that each environmental factor interacts with all of the others, and it is felt that an arithmetic mean of the five factors would not take account of this complex interaction. If all of the five scores are multiplied together, and their fifth root taken, this gives the geometric mean. This is a better reflection of the inter-dependence of the environmental factors. The geometric mean is then converted into a percentage by dividing by nine (the maximum score per factor), and multiplying by one hundred. This gives the Environmental Complexity Index (ECI).

The resulting figure is not an absolute value from which inferences can be drawn directly, but a relative value to be compared across projects. It will be noticed that the calculation limits the possible range of results to 33-100. Since the results are only intended to be indicative and relative, this is not a problem. Once a large number of projects have been assessed using this measure, then some calibration could result in an absolute scale. This is beyond the scope of the present work wherein the intention is only to compare.

3.3.6 Skill Diversity

If the matching of Differentiation to the environment was taken to an extreme, it could ultimately produce within the

organizational structure a microcosm of the environment within which the project operates. This would be a precise matching of skills to environmental demands. Since technology is the key variable in matching the complexity of the environment to the organizational structure (Woodward, 1965), the diversity of skill types represents the amount of technological Differentiation.

The discussion indicates that the most suitable organizational structure results from this matching of Skill Diversity to environmental complexity. However, the organizational structure is not the only determinant of project success. The ideal organizational structure cannot guarantee success, but can only maximize the potential for success. The hypothesis that follows from this is:

HYPOTHESIS (I) - IN ORDER TO MAXIMIZE THE POTENTIAL SUCCESS OF A PROJECT, THE ORGANIZATIONAL STRUCTURE SHOULD PROVIDE A LEVEL OF SKILL DIVERSITY THAT MATCHES THE ENVIRONMENTAL COMPLEXITY.

The measurement of Skill Diversity will be a count of the number of Operating System "Links" which show a Differentiation of skill. A Link in the Operating System exists when one person executing an Operation has an information transfer with another. However, the result of this is that a finite index (ECI) is being compared to an absolute number (Skill Diversity). This is only going to give a relative measure between projects until a sufficiently large number of case studies have been done to calibrate the analysis. Even so, it will be possible to use the data from this test in a limited way on a small number of case studies.

3.4 DIFFERENTIATION IN THE OPERATING SYSTEM

Although the project Operating System should be subject to Differentiation due to Skill Diversity, it should not suffer from Discontinuity. Accordingly, Discontinuity is defined as Differentiation which is not Integrated. The organizational structure must make provision to overcome this

Discontinuity. "Integrating mechanism" is the phrase used to denote the provision made to do this.

3.4.1 Differentiation

Walker (1980), examined every Link and quantified every possible permutation and combination of the four types of Differentiation. The quantification was a simple count of Operating System Links which were Differentiated; but the quantities were expressed in terms of each possible combination of the four types. This generated a large amount of data which was difficult to interpret. The significant aspect of Differentiation is the extent to which it is present. In terms of environmental complexity (section 3.3.5) the degree of Skill Diversity is required as an appropriate response to the environment. Due to the nature of the construction industry, the provision of diverse skills also results in high levels of secondary Differentiation. The combined effects of primary and secondary Differentiation need to be overcome.

3.4.2 Overcoming the effects of Differentiation

There are many Integrating mechanisms within organizations: Hierarchy is the simplest device, and the most common. By this is meant the placing of interdependent units under one boss. The existence of rules, procedures and policies is another Integrating mechanism; as is participation in group decision making etc. (Khandwalla, 1977). By far the most important aspect from the point of view of organizational structure is hierarchy, which Lawrence and Lorsch (1967) see as an individual approving the output of each contributor. Earlier studies called this Integration, and used the role of "Boundary Control" as the sole Integrating mechanism. This made no allowance for the differing levels of detail which they tried to encompass.

3.4.3 Levels of Differentiation and Integration

One of the distinctions made between levels of Differentiation is that of inter-task Differentiation and intra-

task Differentiation (Walker, 1980). In the terminology of the current study they should be referred to as inter-Operational Differentiation and intra-Operational Differentiation respectively. These aspects are at different levels of detail, since the former is concerned with Links between operations, and the latter with Links between contributors within an operation. In terms of the Operating System, attention must be concentrated on the intra-Operational level. Discontinuities between Operations and the corresponding need for Continuity of the Managing System are dealt with in section 3.7.

Since the focus here is at the Operational level, the Integrating mechanism must be distinguished from an Integrating mechanism at the inter-Operational level. This was not done in earlier studies. It is done here by using the term Co-ordination to describe the Integrating mechanism at this level: This is the Co-ordinating function within an Operation which ensures that each contributor is successfully Integrating, through teamwork and interaction.

In Walker's technique, Integration was also used to describe the involvement of the client with the process of building. This seems to be a confusing use of terminology. The client's involvement with the process should be analysed separately, in order to clarify the items being analysed. Thus it is proposed that Integration should not refer to the involvement of the client with the project team. The client's involvement will be dealt with separately in section 3.9.

3.4.4 Co-ordinating

The Integrating mechanism which is most important in overcoming the adverse effects of intra-Operational Differentiation is Co-ordination. This is achieved either through the provision of a contributor in the role of Co-ordination, or through team-work. The hypothesis that stems from this is as follows:-

HYPOTHESIS (II) - IN ORDER TO MAXIMIZE THE POTENTIAL SUCCESS OF A PROJECT, DIFFERENTIATION OF THE OPERATING SYSTEM SHOULD BE MATCHED BY A CORRESPONDING LEVEL OF CO-ORDINATION.

The test for this hypothesis will consist of identifying all incidences of Differentiation at the Operational level, and then checking to see how many of them are matched by the provision of a role occupant for Co-ordination. "Co-operating" contributors are already Co-ordinated because they are acting as a team, and should be excluded from the test because they need no additional Co-ordination.

3.5 OBJECTIVES

As stated in section 3.1.1 (page 46), it is clear that objectives ought to form the basis for decision points, and that Feedback mechanisms must be provided to ensure that the objectives remain realistic and are being achieved.

3.5.1 Project objectives

It is the initial Policy Decision point at which the objectives for the project are first set. These will be usually vaguely defined in the earliest stages, and refined as more information becomes available to the client and project team. The major purpose of organizational analysis is to examine the extent to which an organization achieves its objectives.

3.5.2 Sub-system goals related to decision points

To quote Walker (1984), an important duty of the project manager is to ensure that the objectives of the client are accurately and clearly stated and that all contributors to a project remain orientated to them. In order to keep the contributors orientated toward the overall project objectives, the trigger decision for each stage of work establishes objectives for the stage.

3.5.3 Feedback

It is clear that objectives must be linked to adequate Feedback mechanisms. As Leavitt & Mueller (1951) demonstrated, performance improves when the results of performance are known. Without Feedback there is little learning. To improve our effectiveness we must have Feedback on the effects of our efforts. Therefore the most important aspect of organizational objectives is the provision of Feedback mechanisms. This will ensure that objectives are relevant and achievable.

The people responsible for setting objectives must not be so remote from the ensuing work that they cannot revise the objectives if necessary. Therefore, they must be present in the Managing System at each Operation. In this way, Feedback will be embodied within the project's control structure as part of the cycle of observation, comparison, correction. The objectives form the yardstick against which progress can be measured, and they form the basis of effective decision-making.

The project organization can only make appropriate changes to objectives if an adequate Feedback structure exists. The hypothesis that arises from this is:

HYPOTHESIS (III) - IN ORDER TO MAXIMIZE THE POTENTIAL SUCCESS OF A PROJECT, THE ORGANIZATIONAL STRUCTURE SHOULD PROVIDE ADEQUATE FEEDBACK LOOPS.

The method of ascertaining the extent to which this condition is being met is to identify the personnel who are responsible for the trigger decision at the start of each stage of work. Within the Operations of that stage of work, the trigger personnel need to retain some sort of participation, in order that objectives can be matched to actual progress, and adjusted where necessary. Thus, the condition to be examined is the incidence of trigger personnel within each Operation.

3.6 CONTROL

Control has been defined in section 3.1.2 (page 47) as the process of observing, comparing and correcting. In combination these three things regulate the performance of work and ensure that Activity remains orientated towards the sub-system's objectives. The application of this principle at the Operational level results in the Control System which consists of the roles of Monitoring, Supervising and Resourcing (MSR).

The control process at Strategic Decision points is achieved through the roles of Directing, Recommending and Approving (DRA). Because of this, it would be unreasonable to expect the incidence of the MSR roles at decision points. It could be argued that in the early stages of the development of a project, and at major decision points, the work is undertaken by senior personnel who are too senior to warrant control. Perhaps this is so, but the provision of control mechanisms would not hinder the work, or prevent it from taking place; it would merely ensure the suitability of the output of each stage by making changes to either the output of the sub-system, or to its objectives. Since there are certainly different levels of control, then for the purposes of measuring the extent of control, the decision points should be analysed in terms of the DRA roles, and the Operations in terms of MSR roles.

3.6.1 Control cycle

The combination of the various roles produces the control cycle, and leads to the fourth hypothesis;

HYPOTHESIS (IV) - IN ORDER TO MAXIMIZE THE POTENTIAL SUCCESS OF A PROJECT, THE ORGANIZATIONAL STRUCTURE SHOULD PROVIDE CONTROL MECHANISMS.

This hypothesis can be tested by counting in each Operation the presence of the MSR roles, and in each decision point the presence of the DRA roles. In each case, each one of the set of three will count as one third of the control. Although this is a crude measure, it is easy to quantify, and can be expressed as a percentage of all Operations.

3.7 CONTINUITY OF THE MANAGING SYSTEM

Walker's hypotheses included a test which he named "Differentiation of the Managing System itself, between tasks". This test was concerned with Discontinuities in the Managing System. A Discontinuity occurs when a change in the Managing System creates Differentiation in the Managing System. Since the Managing System ought to be Continuous (Miller & Rice, 1967), the term "Continuity" is used to express this concept. By avoiding the use of the term "Differentiation" in this hypothesis, confusion with earlier hypotheses is avoided.

3.7.1 Operating System

It is expected that there will be Discontinuity in the Operating System, because Differentiation should be present to a certain extent, contingent upon the environment. These Discontinuities between work packages need to be overcome by the Managing System.

3.7.2 Managing System

The Managing System will be providing the effort to overcome the effects of Discontinuity in the Operating System. However, although advisable, it is rarely possible to sustain a Continuous Managing System over a long period of time: i.e. even though the Managing System may provide mechanisms for combining the Discontinuous Operations, this mechanism may itself be subject to Discontinuity. This may be brought about by the lack of provision for this mechanism at key points in the project. Alternatively it may simply be brought about by a senior member of the project team leaving to work elsewhere.

3.7.3 Directing

In Walker's terminology, "Boundary Control" was the role which was provided by the Managing System to overcome Differentiation either within or between tasks. This approach is inadequate because the data did not provide a distinction between the different demands of inter-task

Integrating mechanisms and intra-task Integrating mechanisms. All Integration was provided by a single role-occupant in "Boundary Control". In the terminology developed in section 3.4, and that in Table VI, the role which overcomes the effect of Discontinuity is Directing. This has already been defined as "the executive responsibility for ensuring that the output of Operations is orientated towards the objectives" (see Table VI, page 56). The Continuous provision of this role is the organizational structure's mechanism for overcoming the adverse effects of Discontinuity. This leads to the next hypothesis:

HYPOTHESIS (V) - IN ORDER TO MAXIMIZE THE POTENTIAL SUCCESS OF A PROJECT, THE ORGANIZATIONAL STRUCTURE SHOULD ENSURE CONTINUITY OF THE MANAGING SYSTEM.

The way to test this hypothesis is to examine each inter-Operational Link for Discontinuity. If the Operating contributor should change, then the Directing contributor should be the same at both ends of the Link. If this is not the case then there should be some higher managing position which is Continuous across the Link. Each Link can be examined in this way and the test can be expressed as the percentage of Links in which the condition is true.

3.8 DUPLICATION

This hypothesis is also based on one of Walker's, which he called "Differentiation of the Managing System itself, within tasks". Since the test for this hypothesis was to look for duplication of Managing System roles, it would aid clarity to name this concept "Duplication". Walker tested this by examining each "control loop" for duplication of roles. (In Walker's model, the "control loop" refers to the Managing System for a particular Operation.) In the new model, the Control System is at a level between the Operating and Managing Systems. There may well be very good reasons for Duplication at the level of Control. For example, during construction, the clerk of works may Monitor progress on behalf of the client and the site agent may

Monitor progress on behalf of the contractor. Although these two roles are similar, they both need to be exercised. In Walker's model there was no allowance for this.

The hypothesis should only be concerned with the roles in the Managing System, i.e. Directing, Approving and Recommending; as well as with Co-ordination, which is the interface between the Control and Managing Systems. The sixth hypothesis then is:

HYPOTHESIS (VI) - IN ORDER TO MAXIMIZE THE POTENTIAL SUCCESS OF A PROJECT, THE ORGANIZATIONAL STRUCTURE SHOULD HAVE NO DUPLICATION OF MANAGING EFFORT AT THE STRATEGY LEVEL OR ABOVE.

To test this hypothesis, each Operation should be examined to see if there is any Duplication of the four roles stated. The other tests are expressed in terms of the proportion of Operations which exhibit the ideal state. In order to be consistent with this, this test will be expressed as the number of Operations without Duplications. Therefore, the test is referred to as "Non-duplication" in the results.

3.9 CLIENT INVOLVEMENT

The concept of "client" was very straightforward in Walker's work because his case studies were all in the private sector. In each case it was possible to identify a single client. The methodology consisted of identifying "Primary Integrators". One of these was drawn from the project team, and the other was drawn from the client's organization. This provides a clear point of contact and offers the client clear opportunities for participating in the management of the project.

In the public sector, the situation is not so clear. It is rare to be able to define one Primary Integrator from a public sector body. Often the client body has "in-house" teams of consultants who each Monitor the work of their counterparts in the project team. The "client" then becomes a project organization in its own right, closely matching Scott's (1981) description of "an opportunistic collection of divergent interest groups temporarily banded together".

There are different ways of describing the client of a construction project. For example, in civil engineering they seem to overcome the problem of loosely defined clients by identifying a "Promoter" of a project, who essentially is the person providing the cash (Thompson, 1981). The BPF proposals envisage a "Client's Representative" as taking this role. Problems arise in the public sector, as we shall see, when there is little definition of roles in the client organization, and complicated controls over expenditure.

3.9.1 Quality of client involvement

Walker's treatment of client involvement was very complex. It required six different conditions to be tested. Whilst this provided detailed data about the quality of client Integration, the detail could be reduced. The quality of information generated by a simpler test would still be useful in the analysis. It is proposed to simply examine each Operation for the presence of client personnel. The Integration of the various client groups is the responsibility of the client's internal organization.

Brauer & Preiser (1976) studied the effect of organizational form on the identification of user requirements. They found that it was typical for buildings to be designed according to the requirements of those who pay for them. In the public sector it is usual for these people to be different from the end users.

3.9.2 Measuring types of client involvement

Because of the problems associated with distinguishing different component parts of the client organization from each other, only one type of client involvement can be measured. That is to examine each Operation for the presence or absence of client personnel. This leads to the final hypothesis:

HYPOTHESIS (VII) - IN ORDER TO MAXIMIZE THE POTENTIAL SUCCESS OF A PROJECT, THE ORGANIZATIONAL STRUCTURE SHOULD PROVIDE OPPORTUNITIES FOR CLIENT INVOLVEMENT AT EVERY STAGE.

3.10 SUMMARY OF THE HYPOTHESES AND THE NEW MODEL OF THE CONSTRUCTION PROCESS

Organizational structure is the factor that relates the project to the environment within which it operates. A description of the organizational structure would consist of identifying and describing the following;

(a) the environment of the project;
(b) the objectives of the project;
(c) the Control Systems to be used;
(d) the incidence of decision points;
(e) the tasks to be undertaken;
(f) the relationships of the tasks to each other;
(g) the relationships of the contributors to their tasks;
(h) the relationships of the contributors to each other.

The research model provides a whole picture of the building process. Basically, the project arises as a response to environmental demands on the client's organization. The aim of the project is to effect some sort of change in the environment. A systematic analysis of the environment of the project will enable correct identification of the objectives of the project. The organizational structure translates the project objectives into work to be done. The effectiveness of the organizational structure can be gauged by assessing the extent to which project objectives have been met.

In order to maximize the potential success of a project, the organizational structure should:-

(a) provide a level of Skill Diversity that matches the environmental complexity.
(b) ensure that Differentiation of the Operating System is matched by a corresponding level of Co-ordination.
(c) provide adequate Feedback loops.
(d) provide proper Control mechanisms.
(e) ensure Continuity of the Managing System.
(f) have no Duplication of the Managing System at the Strategy level or above.
(g) provide opportunities for Client Involvement at every stage.

CHAPTER FOUR: DATA FORMAT

Establishing the appropriate data format is a fundamental aspect of the analysis. The hypotheses have been established, and, in order to test them, the data must be recorded in such a way as to facilitate their analysis. This chapter examines the development of approaches taken to the presentation of data about organizational structures, and a new format of data presentation is proposed. This represents roles, responsibilities and relationships, and is called a "3R" chart.

4.1 CHARTING TECHNIQUES

A variety of charting techniques exist in the literature. They are discussed in turn below.

4.1.1 Traditional organization charts

Traditionally, organizations are described with the use of pyramid organization charts. A typical example is shown in Figure 10 which shows the hierarchical responsibilities within a particular organization. The advantages and disadvantages of their use are discussed in many standard management texts (e.g. Terry, 1964). Details of their preparation and use are given by Allen (1959), and their limitations are summed up concisely by Dale (1973); "the chart ... shows who has authority over whom, but it does not show the extent of that authority or the duties each person in the organization is expected to perform, except insofar as duties are implied by job titles". Thus, the traditional organization chart shows only authority relationships and as such is a graphical portrayal of the traditional school of organization theory (Cleland & King, 1975).

The major drawback with this type of organizational chart is the vast amount of additional text needed to fully describe an organization's structure. This is usually

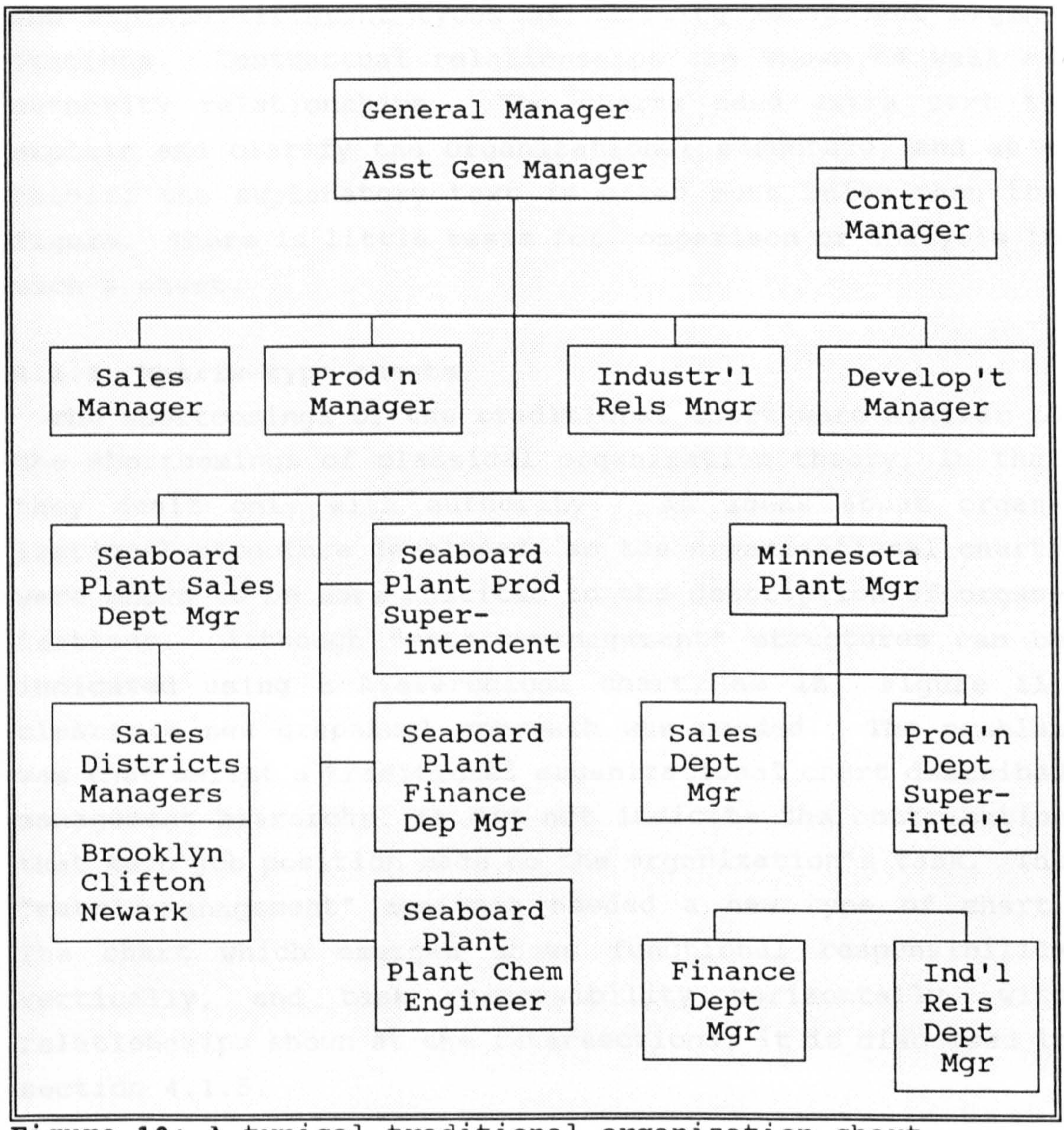


Figure 10: A typical traditional organization chart

(after Allen, 1959)

incorporated in organization manuals which accompany the charts. As Cleland & King (1975) state, this renders it impossible to undertake a meaningful structural analysis due to the problems of semantics in the organizational manuals.

A sign of the acceptance of traditional organization charts, with all of their inherent problems, is the way in which contemporary writers still use them as the main vehicle for expressing organizational relationships. The Chartered Institute of Building (1980) for example, use the traditional style of chart and add various line types to try

and explain different types of building management organizations. Contractual relationships are shown as well as authority relationships. The charts need extra text to explain and clarify the organizational structure, and as a result, the explanatory text is often more bulky than the figure. There is little basis for comparison or analysis in such a chart.

4.1.2 Matrix-type charts

The shortcomings of the traditional chart were similar to the shortcomings of classical organization theory, in that they dealt only with authority. As ideas about organizational structure developed, so the organizational charts were shown to be more unsuited to the description of organizations. Although "matrix-management" structures can be indicated using a hierarchical chart, as in Figure 11, clearly a new graphical approach was needed. The problem was that whilst a traditional organizational chart described management hierarchy, it did not indicate the contribution that each job position made to the organization's task. The "matrix-management" approach needed a new type of chart. The chart which emerged shows functional responsibility vertically, and task responsibility horizontally, with relationships shown at the intersections; it is discussed in section 4.1.5.

4.1.3 Networks and critical path diagrams

One possible model for viewing the work done in temporary organizations is the group of techniques known as PERT and Critical Path Networks. These techniques were developed for the management of large, complex, unique and novel projects. Their development is documented exhaustively in a variety of sources (for example von Scifers, 1972). Whilst they can be very useful for the planning of projects they are of little use in terms of analysing organizational structure. Their purpose is the analysis of operational dependency, resource scheduling and work flow. They deal with the detailed aspects of the operating system at the greatest level of

detail, rather than the interactions between the people doing the work, or the managing and control systems.

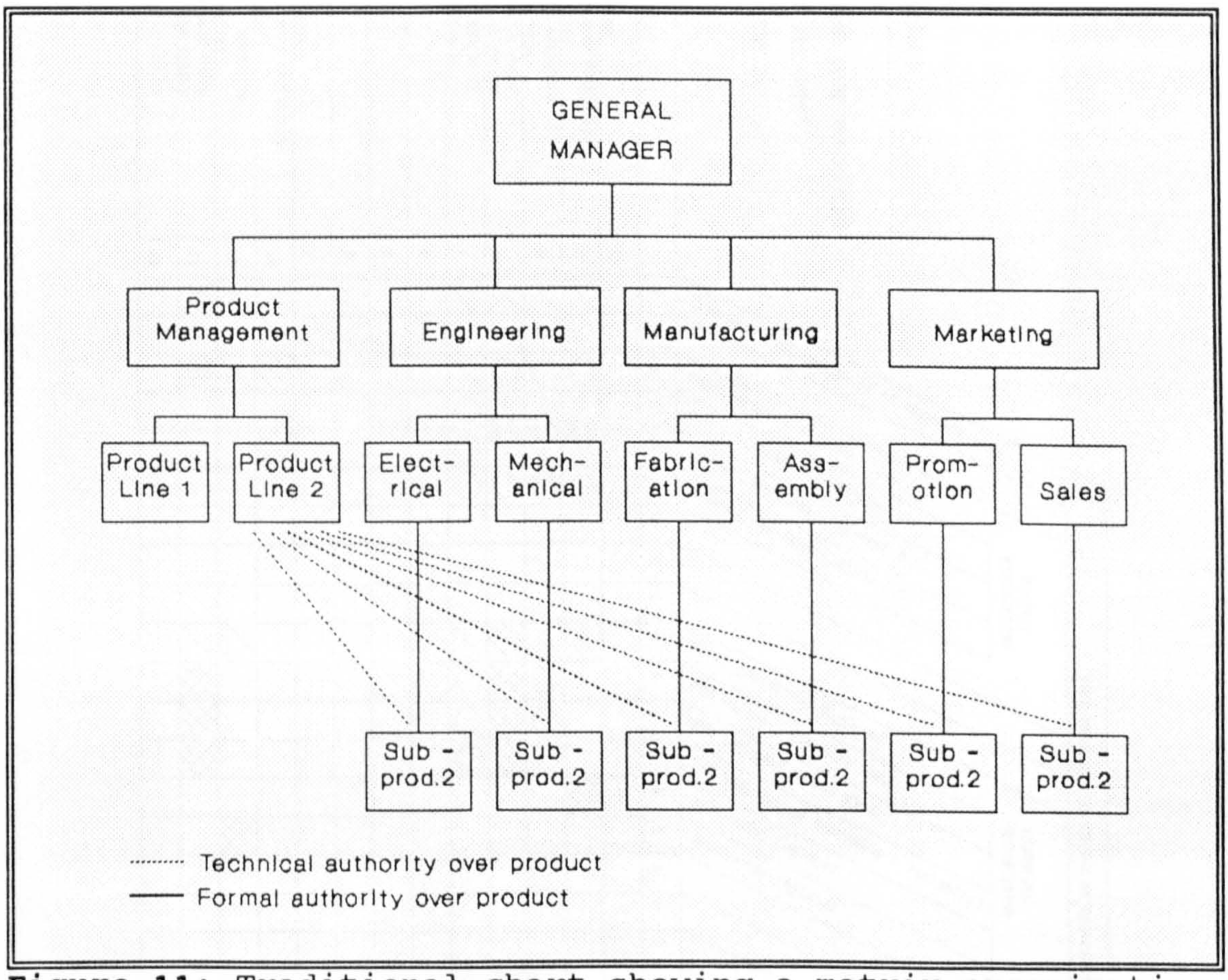


Figure 11: Traditional chart showing a matrix organization
(after Galbraith, 1980)

4.1.4 T.R.E.N.D.

An interesting development of networking techniques was made by von Scifers (1972) who introduced an approach known as TREND (Transformed Relationships Evolved from Network Data). This requires as a necessity a network analysis for any project under consideration. Its major disadvantage is the need for a detailed network diagram from which to analyse the project. The technique does not adequately explore the qualitative aspects of the interactions between the people contributing to the project and their tasks.

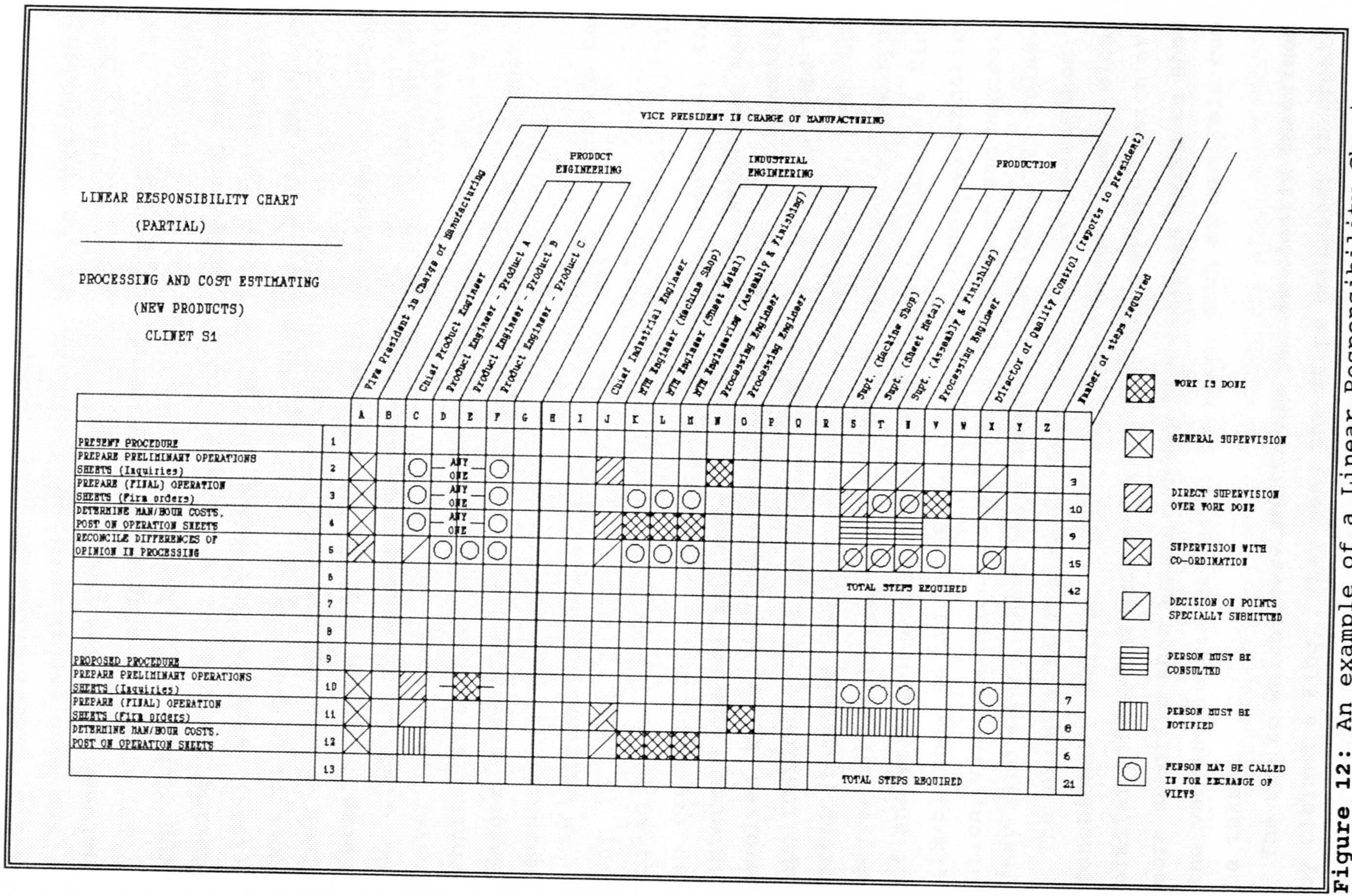


Figure 12: An example of a Linear Responsibility Chart
(Source: Larke, 1954)

4.1.5 Linear responsibility charts

The most useful graphical portrayals of the relationships between tasks and people is the Linear Responsibility Chart (LRC) which is a specific development of the "matrix-type" approach. An example is given in Figure 12. It emerged during the 1950's; for example it was mentioned by Larke (1954), where it was described as a new tool for executive control. Even there, it was described as being developed from a more complex technique that had been originated by Serge A. Birn, a European Management Engineer. It has occurred in various guises since then. Although it has never been used as widely as traditional organization charts, it evokes powerful support from many theorists; e.g. Karger & Murdick (1963), Cleland & King (1975), Dinnat & Murphree (1978), etc.

An extremely important aspect of this type of chart is the way in which different writers categorize the work that takes place (or the roles that contributors assume) within an organization. This is represented by symbols at the intersections of the matrix. Each writer seems to have evolved their own sets of symbols to suit each specific application of the technique. Clearly there is a need to group together various kinds of contributions, and the degree of detail used will be entirely dependent on the type of analysis being undertaken. For example, Cleland & King (1975) show a LRC which only has four types of contribution, viz; execution, consultation, management and control. They also show a chart which has a larger number of roles.

The example in Figure 12 from Larke (1954) describes 8 functions. Melcher (1969) describes seven roles, along similar lines, and Walker (1980) describes eleven, which are more specific than these. These few examples serve to show the varying levels of detail to which such an analysis can be taken.

The use to which these charts are put is clearly described by Cleland & King. They show the steps necessary to create a chart which would reflect the current organizational situation. This they call a "descriptive" LRC. The

analysts then produce a "normative" LRC which would show an idealized picture of what the organization ought to be. These two are then used as vehicles to promote discussion between managers and analysts to produce the "consensus" LRC. This depends on an objective comparison between the descriptive model and the normative model. It must be done by the managers with the aid of analysts. The authors state that the actual codes which represent the relationships in an LRC are decided upon for each analysis by discussion between the analyst and the people whom the chart is intended for. Other than that, no guidance is given on the selection of the role set.

One criticism of LRC is that while it does reveal a task breakdown of the work to be done, and the interrelationships between the people and their tasks, it does not show the precedence of the tasks. Also, it does not purport to show the informal organization, which is often thought to be every bit as important as the formal organization. However, the study of informal organization is not within the purview of a study of organizational structure.

4.1.6 Linear responsibility analysis

The LRC technique was the basis of Walker's analysis (1980). His adaptation rested on stressing the input and output nature of each task, a technique derived from Cleland & King (1975). They transformed the information from an LRC by showing each task as a sub-system in its own right, and superimposing the management structure or control loop on top of it. In this way, they produced what appeared at first glance to be a hybrid between networks and LRCs. This new type of chart was termed Linear Responsibility Analysis (LRA). Walker (1980) developed this further when he added data about differentiation, and feedback loops. Using this approach, Walker analysed three building projects in terms of the extent to which they matched organizational theory, particularly contingency theory and differentiation/integration theory. He was also able to plot the changing management structure throughout each project.

Key: A-Did the work, B-Approved, C-Recommend, D-General oversight, E-Direct oversight, F-Boundary control, G-Monitoring, H-Maintenance, I-Consultation (instructions), J-Consultation (advice), K-Output notification mandatory

Differentiation:
T1-Technology, T2-Territory, T3-Time, S1-Sentience (profession), S2-Sentience (Company)

Interdependence: - - - - Reciprocal, _____ Sequential

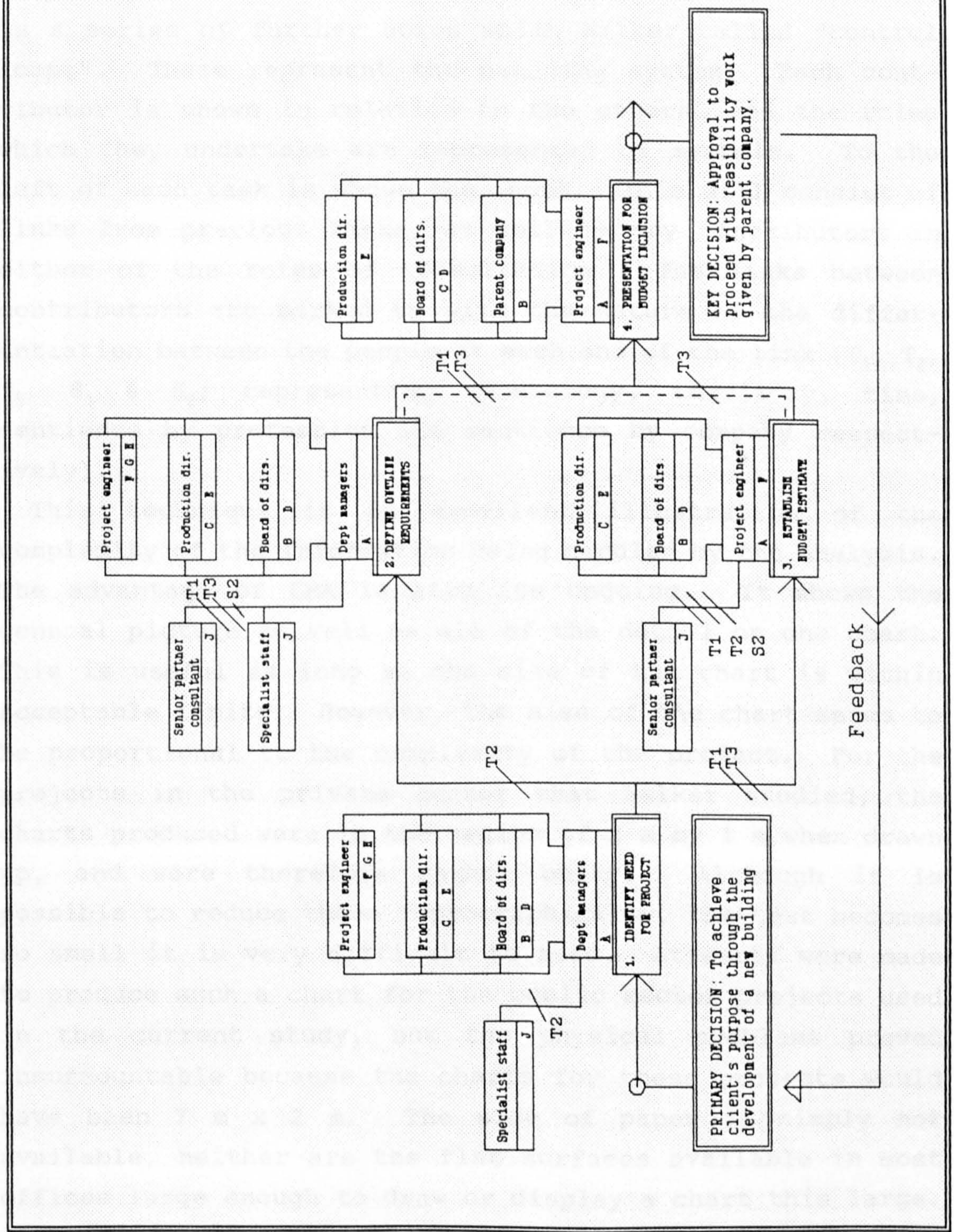


Figure 13: Sample part of a Linear Responsibility Analysis

(Source: Walker & Hughes, 1984)

An example of part of an LRA is shown in Figure 13. The operating system is identified as the series of tasks, connected by the lines with arrow heads showing sequential interdependence, and broken lines showing reciprocal interdependence. Decision points are shown as interrupting the operating system, and each decision point has a feedback loop to previous decisions. Over the top of each task box is a series of further boxes which Walker called "control loops". These represent the managing system. Each contributor is shown in relation to the others, and the roles which they undertake are represented by symbols. To the left of each task is shown the input. This will consist of links from previous tasks, as well as any contributors in either of the roles of consultation. The links between contributors are marked up with the nature of the differentiation between the people at each end of the link (T_1, T_2, T_3, S_1 & S_2; representing technology, territory, time, sentience by profession and sentience by company respectively).

This technique is an excellent illustration of the complexity of the information being handled by the analysis. The advantage of LRA is also its undoing. It shows the general picture as well as all of the detail on one chart. This is useful as long as the size of the chart is within acceptable limits. However, the size of the chart seems to be proportional to the complexity of the project. For the projects in the private sector that Walker studied, the charts produced were in the region of 2 m by 1 m when drawn up, and were therefore rather bulky. Although it is possible to reduce these reprographically, the text becomes so small it is very difficult to read. Attempts were made to produce such a chart for the public sector projects used in the current study, but the physical problems proved insurmountable because the charts for these projects would have been 7 m x 2 m. The size of paper is simply not available, neither are the flat surfaces available in most offices large enough to draw or display a chart this large.

Clearly, if LRA is to be used regularly, the graphical portrayal of the information needs to be reconsidered.

4.1.7 3R charts

The advantages of LRC charts are clearly manifold. It is intended to harness these advantages and at the same time overcome some of the problems inherent in them. Walker attempted to overcome the disadvantages of LRC by adding to the way in which the information was presented. His technique (LRA) is the most comprehensive graphical portrayal of temporary organizational structures. Unfortunately, it is the very comprehensiveness which renders it too unwieldy to use for large projects.

In order to handle the data for a large project, it is necessary to dismantle it into a series of inter-related components. The first step is to separate the general picture from the detail. A "top-down" systems view involves identifying the general picture first in coarse detail, then analysing each of the elements thus identified in further detail. Taking such a view, information at the general level about a project would be the decisions that form the triggers and termini for systems of activity, and the disposition of the operations in relation to each other. With this in mind, the starting point for a graphical portrayal of a project organization should be a schematic which only displays the overall relationships between decisions and operations. An example of such a schematic is shown in Figure 14. This shows the overall disposition of the operations and decisions relative to each other, and represents the same project as Figure 13 for comparison. In this way the information from LRA charts about the relationships between the operations is dealt with.

The model developed in the preceding chapter shows that projects can be split into seven stages common to all projects. Information within each stage can be displayed on its own diagram. This will give a series of charts containing the detailed information, with the overall schematic showing how it all links together. This separation of

levels of detail is the key to overcoming the difficulties with LRA charts.

In this way, techniques of precedence diagrams are added to techniques of LRC diagrams to produce a new approach. Additionally, it is essential that the roles are displayed at the intersections of the matrix, so a system of symbols portraying the roles defined in Table VI (page 56) is required. Many of the writers already mentioned use symbols of one form or another. They all use different symbols, some use graphical icons, others use printer's marks, others use numbers or letters. Generally, these symbolic codes are confusing because the symbols chosen are often totally arbitrary and bear no relationship to the roles which they are intended to represent.

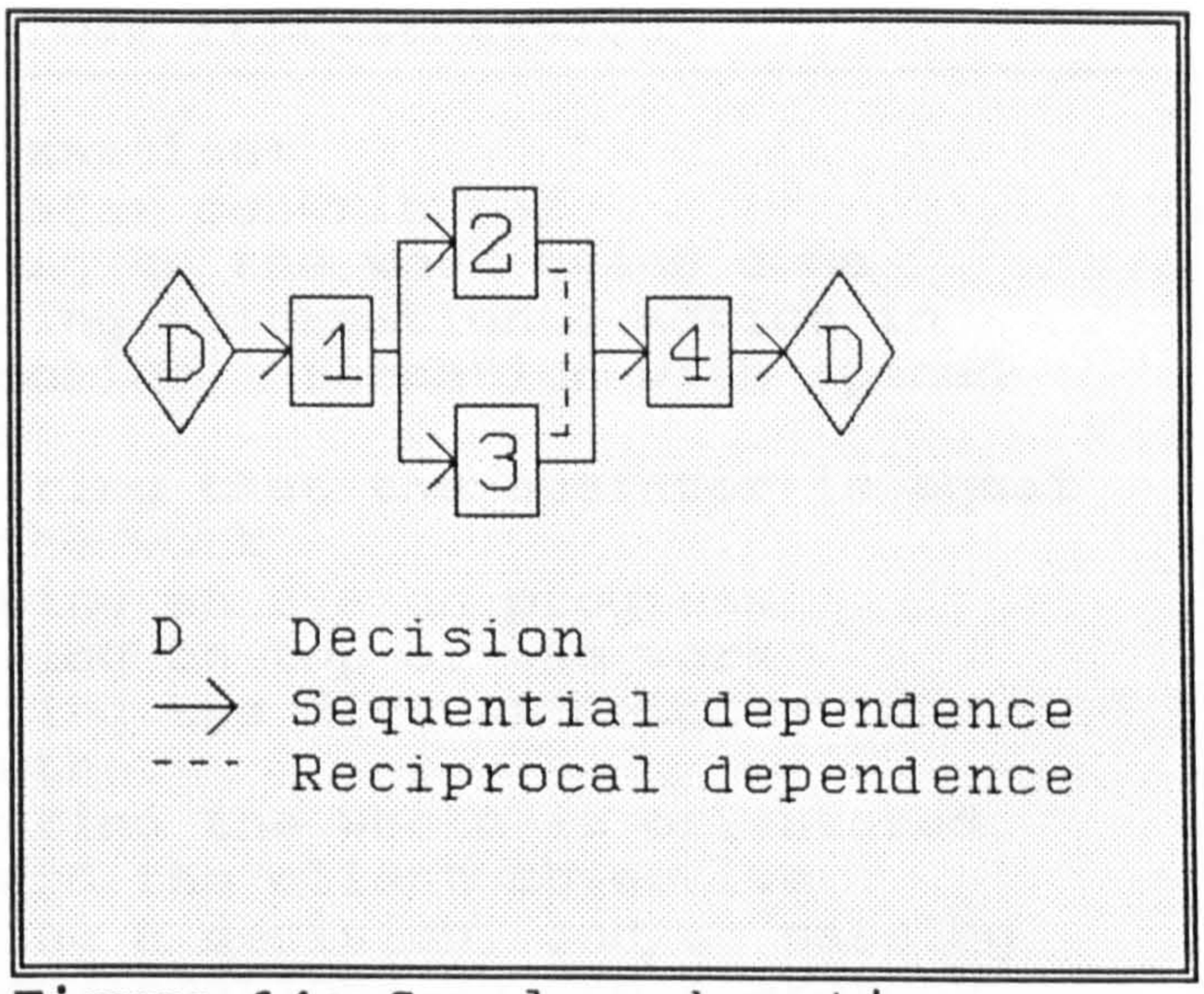


Figure 14: Sample schematic precedence diagram

There is no guidance in the literature on the selection of symbols, and directories of graphical symbols (e.g. Arnstein, 1983) do not consider this to be an issue worth covering. Therefore yet another system of symbols needs to be proposed; but it is hoped that the reasoning behind the choice of these "visual puns" may help to establish some sort of pattern in future studies. At the very least, they are more memorable than the apparently random symbols of previous analysts. The symbols are shown in Table VIII, together with the reasons for their choice.

The proposed charting technique combines information about roles, responsibilities and relationships. Since these words all start with "R" the chart is referred to as a "3R" chart.

Table VIII: Symbols for role representation

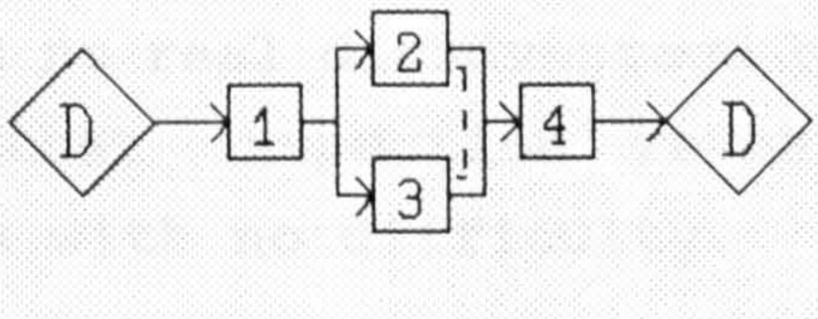
Role:	Symbol:	Explanation:
Operating	*	The star contributor
Co-operating	+	Adding to the work being done
Consulting	→	Putting information & advice in
Receiving	>	Welcoming information with opened arms
Resourcing	=	Ensuring that the operator is equal to the work
Monitoring	⊙	Keeping an eye on progress
Supervising	↓	Staying on top of the work
Co-ordinating	↔	Pulling the diverse orientations together
Directing	○	Ensuring the whole is orientated toward the client objective
Recommending	↑	Making a decision, and/or passing recommendations up the hierarchy
Approving	✓	Approving a recommendation

The most detailed information on Walker's LRA charts was that concerning the various types and mixes of differentiation. The proposed format of 3R charts does not show this information explicitly, but it is easily derived upon observation of the chart. However, the proposed analysis does not examine types of differentiation. Hence the user of the chart is not faced with too much information at once.

To summarize, the form of a 3R chart will be a matrix, with activities down the left hand side, job positions across the top, and role symbols displayed at the intersections. Each activity is related to the others via a precedence diagram at the top left hand corner, and one chart is used for each stage of work. An example of a 3R chart is given and discussed in the next section.

4.1.8 Example of a 3R chart

Figure 15 shows an example of the 3R chart. The example shows one stage of work, the intention being that each stage of work is shown on its own chart. The role symbols are entered at the intersections in the matrix and the key explains their meaning. An additional symbol appears at some of the intersections, the double arrow symbol. This represents the situation where an Operating System Link



	Parent c	Board of	Productio	Departme	Speciali	Project	Senior p
D Develop a new building	✓	○					
1. Identify need for project	⇒	○✓	↓↑	✳	→	◎=↓	
2. Define outline requirements		○✓	↓↑	✳	→	◎=↓	→
3. Establish budget estimate		○✓	↓↑	⇒		✳↔	→
4. Present for budget inclusion		○↑		⇒		✳↔	
D Proceed with feasibility work	✓	↑				⇒	

Key:

✳ Operating	+ Cooperating	→ Consulting	> Receiving ⇒ Input
◎ Monitoring	= Resourcing	↓ Supervising	
↔ Coordinating	○ Directing	↑ Recommending	✓ Approving

Figure 15: Example of a 3R chart

occurs because information is being transmitted from one operation to another. These links can be found by inspecting the precedence diagram, but the interpretation is simplified by the use of this symbol in the matrix.

In the top left hand corner of each 3R chart is the relevant portion of the precedence diagram, showing the stage of work under consideration, to highlight the dependencies between the activities.

By comparison with Figure 13, the 3R chart presents the same information in a more concise format. The responsibility of each contributor in the stage of work is represented in total by each vertical column, and the interactions within each operation are shown on a row. The changing

pattern of management is clear when the patterns of symbols are inspected, and the whole is not cluttered by a high level of detail. Another advantage of this new format over LRA charts is that the contributors from similar interest groups can be grouped together.

The managing system is not as clearly superimposed upon the operating system in 3R charts as it is in LRA charts. This is no real disadvantage because the role symbols are so clear that inspection reveals the control and managing systems with no difficulty.

4.2 DESCRIPTION OF PROJECT DATA

The 3R charts as described provide the basis for the analysis of the hypotheses. The data is collected through case studies. In order to fully describe a construction project so that the charts can be drawn, a range of sources of project information need to be investigated; including project files and interviews with key personnel. The charts do not describe the project in terms of environments and outcomes, therefore certain other items of information are needed. This section describes data sources and the full extent of the information needed to define a project comprehensively.

4.2.1 Project outline

The project outline will describe the purpose and objectives of the project; the nature of the client; the tendering and contractual procedures adopted; and the price and duration of the project. It will be useful to provide an anecdotal description of the management structure adopted on the project as an introduction to each case study.

4.2.2 Environmental analysis

The starting point in the analysis of a construction project will be to analyse the project's environment.

The environmental analyses may be undertaken in two ways. Initially a qualitative description is needed, following the

pattern set down by Walker. This provides a basis for understanding much of what transpires on each project. As an indication of the circumstances surrounding each project it can be invaluable. However, it may not contribute sufficiently to the aim of relating skill diversity to project complexity. For this a quantitative technique is required so that comparisons can be made between different projects. The technique developed in chapter three must be applied to the project so that the environmental complexity can be evaluated.

11.09.73 - Regional Hospital Board seeking committee approval to new cost limit.
26.09.73 - Provisional cost limit of building costs by nominated QS.
16.10.73 - Hospital committee request minor modifications to sketch plans (serving hatch).
20.10.73 - Building & Works Committee on behalf of the regional hospital board approve the suggested appointment of structural engineers.
02.11.73 - Structural engineering consultants appointed by hospital management committee.
17.12.73 - Structural engineering consultants report on trial pit investigations of site calling attention to the need for removal of trees.
05.04.74 - Amendments to room data sheet no. 29 by regional health authority.
16.04.74 - Final room data sheets from regional health authority.
17.04.74 - Commence preparation of revised estimated cost by nominated QS.
11.06.74 - Complete preparation of revised estimated cost by nominated QS.
11.06.74 - Preliminary 1:100 working drwgs submitted to regional health authority by architects.
10.09.74 - Plans submitted to Fire prevention dept.
11.10.74 - Approval of estimated cost by regional health authority.
15.10.74 - Detailed drawings in preparation.
31.10.74 - Clarification of certain details to fire prevention department by architects and request for elucidation by them on their comments.

Figure 16: Example portion of a detailed project diary

4.2.3 Project diary

For each case study a project diary must be compiled. This will be a list of items of communication, showing the

date, who it is from, who it is to, and a brief description of the content. The richest source of data will be the project files in the architects' offices. Events prior to the architect's appointment may be traced in the client's offices. For events after architect's appointment, the clients' files can be used along with those from the consultants' offices for corroboration and further detail. An example of part of a project diary is shown in Figure 16.

In addition to this list will be a list of contributors. Progressing through the correspondence files it should become possible to ascertain, for every contributor, their job position, the company for whom they work, their skill type and the extent and duration of their involvement.

4.2.4 Interviews

The interviews can be conducted after the project team have been identified from the correspondence files. Each of the major contributors should be interviewed, to identify their perceptions of the project and the way it was organized, as well as their view of the success of the final building. This part of the data collection is based on Walker's approach. In all cases, the client's major representative(s) should be interviewed, as well as the project team. In order to ensure that the researcher has correctly interpreted what the interviewee says, the interviews should be recorded on tape and transcribed verbatim. The transcription can then be sent to the interviewee so that they can confirm that it is an accurate record of what they have said. The information from the interviews is important to get an insight into the contributors' perceptions of the project and the way in which it was organized, as well as their view of the success of the final building.

4.2.5 3R charts

Although the interviews are a good source of information, the main source of information for the compilation of the 3R charts is the project diary. From this the involvement

of the contributors in the decisions and operations can be identified and the list of operations drawn up. Initially, each of the operations should be dated, start and finish, to aid in the allocation of roles to contributors and check the chart against the project diary. Since the dates are not needed for the analysis, they need not be presented on the final charts.

4.2.6 Post-occupancy evaluation

The next category of information is that which enables an assessment of the level of success of the project. The level of success is used to put the adequacy of the project organization into perspective. Data about the reactions of people to the building need to be collected using methods appropriate to each group of people. The people to be questioned can be seen as falling into the three categories of Project Team, Workforce and Users. The project team (and client) will be interviewed and asked directly about their reactions to various aspects of the building. The users and workforce can be examined by questionnaire survey, because of the large number of people involved. The questionnaires to be used should be based on the criteria laid down in section 3.2.

4.2.7 Organizational analysis

The final category of information is the quantification of the effectiveness of the project organization according to the hypotheses laid down in chapter three. Each hypothesis must be taken in turn and tested according to the criteria laid down in chapter three. It is intended to seek some sort of rationalization between any observed shortcomings of the project organizational structure, and the achieved outcome of the project. This can be done by examining the project records to try to determine at precisely which stage particular courses of action were chosen, resulting in the observed project deficiencies. This process will give an insight into the effects of organizational structure.

4.3 CASE STUDIES

To test the model, four case studies were undertaken. They were chosen to typify the range of public sector projects in the UK. The case studies are examined in the next four chapters.

CHAPTER FIVE: ANALYSIS - CASE STUDY A

The first case study is described according to the data format outlined in section 4.2, and tested against the hypotheses. To avoid repetition, this chapter contains more detail than the remaining three case studies (in the next three chapters).

5.1 PROJECT DESCRIPTION

5.1.1 Outline

The project was a kitchen/dining room extension for a hospital in Northern England. The site was a piece of land in the grounds of the existing hospital.

The tender sum was £911,000 at 1979 prices. The duration of the contract was 26 months. Being a health authority project, the management of the project was performed in-house, using external professional consultants for architectural, quantity surveying, structural engineering and services engineering work. Each consultant had a counterpart within the health authority.

5.1.2 Objectives

This project suffered from mildly conflicting objectives. Most of the project team included the phrase "provision of a new catering facility" as part of their objectives. Some people saw this as secondary to providing basic health care. Others saw it as instrumental in providing health care. One of the project team saw the objective simply as "to replace existing outdated facilities". These examples show the range of objectives discovered by the interviews.

5.1.3 Project history

The project was first mooted when the existing facility was declared as being inadequate in April 1964. During 1967 various changes of use of certain rooms were brought about to help to relieve the pressure on the catering facility,

taking care not to jeopardize health care services in the hospital. This clearly demonstrated that the catering was a relatively low priority at that time.

In August 1967, various alternatives were being discussed between the catering departments and the architects within the hospital board, and in March 1968 the option to increase and upgrade the existing facility was chosen. The scheme was given a cost limit of £10,000 but the mechanical and electrical engineering services work alone was estimated at £13,600. Therefore, it was agreed that the scheme would be dictated by the amount of finance available and would only be a makeshift arrangement while long term policy for catering in the district was established.

By July 1971, there was a scheme for a new kitchen & dining room costing £121,000 aiming for a site start in 1973. It was put into the small capital works expenditure programme in August 1972 at £133,000. At this time briefing information was being put together by various people and the architects were appointed. The project was repeatedly moved from programme to programme, with increases in its budget each time. It was finally moved to the 76/77 programme but then in January 1976 the scheme was cancelled and the consultants instructed to take no further action.

In March 1977, the rationalization of bed distribution within the region increased the demand on the existing catering facility. Thus the scheme became a feasible proposition once more and was resurrected. The revised estimate of August 1977 was £508,000 and the scheme became extremely urgent with every possibility of it starting on site in the 77/78 financial year. This didn't happen and it next appeared as an item in the programme for 78/79 at a figure of £740,000. The next move was into the 79/80 programme, by which time it had increased to £808,000. This was followed by a tender of £911,000 and a site start in January 1980 actually took place!

The final figure that was suggested at the time of data collection, before the final account came in, was £1,250,000 or thereabouts. However, the increase over the tender was

considered to be within the order of only 5-10% by the time the effects of inflation were considered.

5.2 ENVIRONMENTAL COMPLEXITY ANALYSIS

The environmental analysis was done in two stages. The first stage is a qualitative description of the environment, based on Walker's approach. The second stage is the quantitative analysis from which is derived the Environmental Complexity Index.

5.2.1 Qualitative analysis of environment

The qualitative analysis is executed under the headings of (a) certainty surrounding the project, (b) conflict within the project, and (c) complexity of the project. It is given below.

(a) Certainty/uncertainty surrounding the project

The need for the project arose from a formal review of facilities, which identified that action needed to be taken over the kitchen & restaurant, but it was some years before a formal review of alternatives concluded that a new building was required. This need was never very certain because the political atmosphere within the health service meant that the decision could be overturned at any time. Indeed, during feasibility and sketch scheme stages the project was repeatedly postponed in favour of higher priority projects.

The definition of the scope of this project was subjected to occasional change as the project progressed, because the client's policy was subject to change.

This client was experienced in providing a building of this type.

This project was subjected to unexpected events. During the Contract stage the scheme was dropped from the capital expenditure budget due to the economic climate. At this point the pre-contract design and the contract documentation were substantially complete. Following inclusion in

a subsequent year's budget for capital expenditure, a tree conservation lobby - formed of some hospital staff, patients, and local people - protested about the destruction of trees on the proposed site. The project was delayed while the issue was resolved. During the delays brought about by the combined effects of these issues, the building regulations were revised. The increased requirements for a greater level of thermal insulation resulted in a considerable amount of re-design and hence the preparation of new contract documents.

(b) Conflict identified in the project

The only conflict identified was the tree preservation lobby, which indicated a high level of friction between management in the health authority and some hospital staff, possibly due to a personality clash.

(c) An outline of the complexity of the project

Spatially - the location of the building was the only one suitable to provide the required level of service, although it was not ideal. The constraints due to the layout of the existing buildings coupled with the existing technology for food preparation and meal delivery restricted the range of possible solutions. Areas to be provided were calculated from DHSS guidelines, with advice from client's specialist in-house staff.

Technically - a conventional structural solution was adopted, and the project was heavily serviced for its value. Client specialists were available for advice, much of which was standardized through the use of "Hospital Building Notes".

Aesthetically - demands were quite high as the building became the focus of public awareness after to the issue of the trees. Although the building was an addition to an existing group of buildings, no attempt was made to match the surrounding buildings.

5.2.2 Quantitative analysis of environment

Table IX shows the quantitative analysis of the environment. Each of the five types of environmental factor are scored on a scale of 1-3 for their degree of definition, stability and mitigability. 1 represents the simplest case, 2 represents a normal or average condition and 3 the most complex condition. These three individual scores are added together for each of the five types of environmental force giving scores in the range 1-9. The geometric mean is then taken of these 5 totals. The resulting Environmental Complexity Index of 66% indicates that the environment was of a reasonably high complexity.

5.3 POST-OCCUPANCY EVALUATION

It is clear from section 3.2 that there does not exist a recognized and systematic method for analysing the success of building projects. Therefore, the work undertaken in respect of post-occupancy evaluation was exploratory. The basic approach to surveying building users remained consistent throughout the research, but slight differences had to be developed in the questionnaires because the nature and mix of the user groups varied between projects. These differences are only in terms of individual questions. The results are analysed by groups of questions which are comparable between the different case studies.

A comprehensive questionnaire was given to members of the project team who were asked to comment upon all aspects of the project. This framework was then used to create questionnaires for the remaining groups. The categories of questions were chosen to reflect the knowledge of the people being questioned, for example the general public were not asked about the time taken to complete the building as the initial studies showed that they had little or no knowledge of it. On some of the projects the public have no access to the building and so were not surveyed at all.

The focus of this study is organizational structure, therefore post-occupancy evaluation is not of prime import-

Table IX: Project A quantitative environmental analysis

Hospital Kitchen/Dining Room Extension N. England

ENVIRONMENTAL FACTOR:	Def	Sta	Mit	Tot
LEGAL/INSTITUTIONAL: English Law applied. Well-known Std Form of Contract was used. Familiar Condns of Engagement for external consultants. Each consultant had a counterpart in the Health Authority for liaison.	1	1	3	5
TECHNOLOGICAL: The solution adopted involved non-traditional materials, some of which had to be imported from the continent. There was a very high services content for specialist equipment.	1	2	3	6
FINANCIAL: Cost limits for the project were clear, but were subject to some changes over the years.	1	3	3	7
AESTHETIC: The design was aesthetically adventurous using large expanses of smoked glass which had to be specially imported from abroad.	1	2	2	5
POLICY: There was conflict between various parts of the client organization which had to be resolved mid-way through the project. The objectives of the project were stable.	1	3	3	7

$$E.C.I. = \frac{(5 \times 6 \times 7 \times 5 \times 7)^{0.2}}{9} \times 100 = 66\%$$

KEY: Def = Definition, Sta = Stability, Mit = Mitigability, Tot = Total.

ance in this instance. For this reason, further refinement of the technique of evaluation of buildings should be the subject of future work.

Appendix E contains examples of the questionnaires used. The component parts of an assessment will contain levels of detail relevant to the particular project, for the particular user group, at the particular time. Therefore, some component parts of an assessment will contain more detail than others. In order to reduce the different responses in the data to useable figures, a method of aggregating responses into their respective categories is needed. The resultant figure, called a Weighted Average Satisfaction Level (WASL), is derived as shown below.

Responses for each question were elicited as follows:- 0 = Don't know/No answer; 1 = Unacceptable; 2 = Poor; 3 = Average; 4 = Good; 5 = Excellent. The total scored for each question is derived by weighting the answers given on a scale of 0-100 where the percentage of those answering "Excellent" is multiplied by 100, "Good" by 75, "Average" by 50, "Poor" by 25, and "Unacceptable" by zero. Answers other than these are not counted. The total is then divided by 100 to give the WASL. This is then divided by the number of responses to give a figure which is a percentage of those who answered, rather than a percentage of those who were questioned. For example, consider the following responses;

Response no.	0	1	2	3	4	5
Percentage	11	5	23	30	18	13

the WASL for the question is calculated thus:

$$\frac{(5\times0) + (23\times25) + (30\times50) + (18\times75) + (13\times100)}{89} = 53\%$$

For the purposes of calculating a single overall figure, representing success, an average of the WASLs of the questions within each category can be calculated. This gives a single figure for each group of questions. These figures can then also be averaged to indicate the general level of success of the completed building, giving each category equal weight, rather than each question. This gives a single figure for that survey - a "survey composite". If different questionnaires are used for different

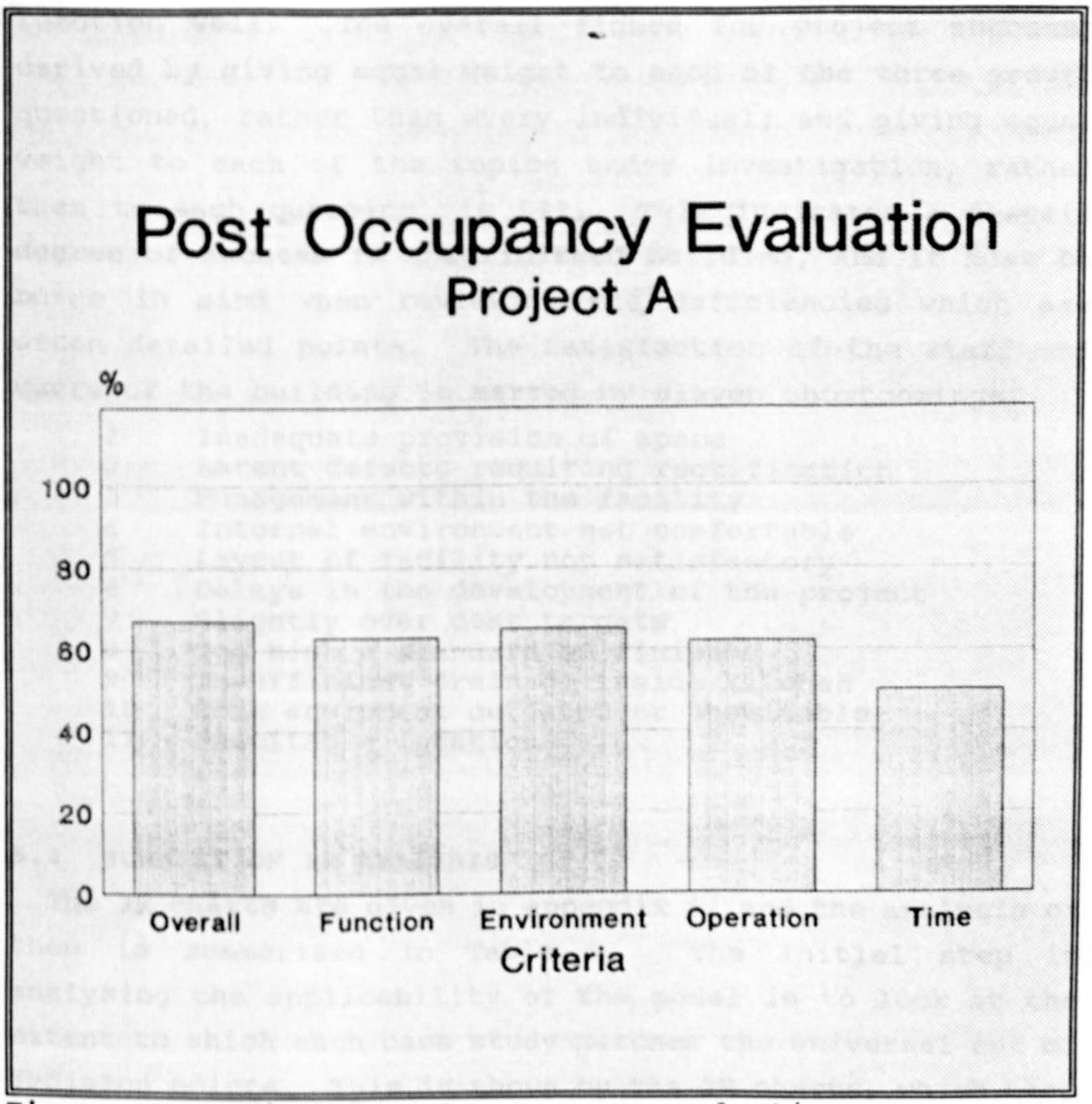


Figure 17: Project A post-occupancy evaluation

categories of user, then for the purposes of deriving a single figure, the survey composites can be averaged.

The P.O.E. for case study A is summarized in Figure 17. This shows the responses given by one of the user groups, the workforce, by way of example. In all categories the outcome was judged as "average" or "good", with most weighted average satisfaction levels being around 60%. The range of responses (WASLs) generally is very small, indicating a fair degree of consistency in peoples' responses.

The surveys show that this building was generally well-liked by the users and the workforce, and performs its

function well. The overall figure for project success, derived by giving equal weight to each of the three groups questioned, rather than every individual; and giving equal weight to each of the topics under investigation, rather then to each question, is 59%. This indicates a certain degree of success in the finished building, and it must be borne in mind when reviewing the deficiencies which are often detailed points. The satisfaction of the staff and users of the building is marred by eleven shortcomings:

1 Inadequate provision of space
2 Latent defects requiring rectification
3 Management within the facility
4 Internal environment not comfortable
5 Layout of facility not satisfactory
6 Delays in the development of the project
7 Slightly over cost targets
8 Too high a standard of finishes
9 Insufficient drainage inside kitchen
10 Some equipment outdated or unsuitable
11 Unsuitable location

5.4 SUMMARY OF 3R ANALYSIS

The 3R charts are given in appendix A, and the analysis of them is summarized in Table X. The initial step in analysing the applicability of the model is to look at the extent to which each case study matches the universal set of decision points. This is shown by the 3R charts, which also indicate the extent to which the work observed on the case studies can be broken down into the Policy, Strategic, Tactical and Operational Decisions; and the identification of Managing, Control and Operating Systems. The two major departures from the model's decision points are the shelving of the scheme as soon as Contract stage was completed the first time around, and the dispute over the trees. These are unexpected decision points brought about as a response to very strong environmental influences.

The shelving of the project, and its subsequent re-commencement, are easily accommodated by the model, because they can be interpreted as the end and beginning of two discrete projects. In this way, the model and the project configuration are compatible with each other.

Table X: Project A summary of 3R analysis

Stg	Op	DIFFERENTIATION Lnk	Agg	Skl	Crd	Feed back	Cont -rol	Integrn Lnk	No	Non Dup	Cli Inv
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
	no	no	%	%	%	%	%	no	%	%	%
a1	4	24	100	79	100	100	50	6	33	25	100
a2	6	51	100	80	75	100	33	14	36	83	100
a3	5	24	100	79	75	100	67	13	92	20	100
a4	16	117	99	92	83	75	79	81	17	81	100
a5	3	14	100	86	14	100	78	3	0	33	100
b1	2	11	100	64	45	100	67	2	0	50	100
b2	2	9	100	67	100	100	67	2	100	50	100
b3	10	90	100	98	100	100	90	73	100	80	100
b4	6	36	100	97	81	100	94	30	83	83	100
b5	6	24	100	96	33	100	94	8	75	33	100
b6	11	119	99	88	72	100	82	59	100	0	100
	71	519	100	89	78	94	76	291	68	54	100

Stages:
1-Inception, 2-Feasibility, 3-Sketch scheme, 4-Detail design, 5-Contract, 6-Construction

Interpretation:

Column:	Meaning:
(a)	Identity of stage of work.
(b)	Number of operations in this stage of work.
(c)	Number of operational links within this stage of work.
(d)	Percentage of operational links with any form of differentiation
(e)	Percentage of operational links which are differentiated by skill.
(f)	Percentage of operational links which are co-ordinated.
(g)	Percentage of operations which exhibit proper feedback loops.
(h)	Percentage of elements of control present within operations.
(i)	Number of inter-operation links within this stage of work.
(j)	Percentage of inter-operation links with continuous directing.
(k)	Percentage of operations with no duplication.
(l)	Percentage of operations with involvement of the client.

5.4.1 Skill diversity

The first hypothesis was that in order to maximize the potential success of a project, the organizational structure should provide a level of Skill Diversity that matches the Environmental Complexity. This is the test of contingency. The technique used to measure complexity in the environment produces an Environmental Complexity Index which has not yet been calibrated. Until a much larger number of projects have been studied, this test gives only speculative results which should indicate whether or not it is going to be worthwhile to develop environmental analysis and contingency testing any further. Because this hypothesis can only be analysed by looking at the results from all four case studies, it will be discussed in chapter nine.

5.4.2 Co-ordination

The second hypothesis was that in order to maximize the potential success of a project, the organizational structure should ensure that Differentiation of the Operating System is matched by a corresponding level of Co-ordination. This was tested by examining all Differentiated Links in the Operating System, and identifying whether or not the Co-ordinating role had been provided to overcome the adverse effects of Differentiation. The count of all Links is required in order to calculate the Skill Diversity. However, if the role of Co-ordination is being exercised in an Operation, then all Links in that Operation are said to be Co-ordinated.

Co-ordination for this case study was 78% overall for the whole project, which although fairly high, is a departure from the model. Table X shows a definite decline in the level of Co-ordination prior to the shelving of the project. It is possible that the lack of Co-ordination was the cause of the project being suspended. Similarly it is also possible that the lack of Co-ordination resulted from knowledge in the project team that the project was not going to proceed.

5.4.3 Feedback

The third hypothesis to be tested was that in order to maximize the potential success of a project, the organizational structure should provide adequate Feedback loops. The test for this was to examine each Operation for the incidence of personnel responsible for the decision which triggered the sub-system. If they were present in some capacity then it would be possible for them to change the objectives of the stage of work should that prove necessary.

Figure 17 shows the overall figure for Feedback is very high, at 94%. This means that the organizational structure was capable of providing opportunities for modifying objectives and project parameters, as the project progressed. The day-to-day management of the project was very closely linked to the client's own management procedures, and this is

reflected in the large amount of written procedures and manuals issued by DHSS for the management of capital expenditure programmes.

In terms of Feedback, project A is compatible with the model, scoring very well in this test. The high level of Feedback is also evident by the complete suspension of work on the project - twice! This shows how completely the project objectives could become modified by Feedback.

5.4.4 Control

The third hypothesis is that in order to maximize the potential success of a project, the organizational structure should provide proper Control mechanisms.

The Control system consists of the three roles of Monitoring, Supervising and Resourcing (MSR) at the Operational level, and Directing, Recommending and Approving (DRA) at the Strategic decision level. This test of this hypothesis consisted of checking each Operation for the presence of the MSR roles, and each decision for the presence of DRA roles.

The overall average for Control is 76%, which is a departure from the model. The incidence of Control is erratic and a problem throughout the project. For this case study it is the worst departure from the model in stages b1 and a2.

Project A is not compatible with this hypothesis because adequate Control mechanisms are not provided consistently throughout the project.

5.4.5 Integration

The fourth hypothesis is that in order to maximize the potential success of a project, the organizational structure should ensure Continuity of the Managing System.

This was tested by examining each Link between Operations and ensuring that the Managing System was Continuous. The hypothesis stated that the role of Integrating should be Continuously exercised wherever there is a Discontinuity in a project's Managing System.

At 68% this test shows that project A displayed a definite departure from the model. It demonstrated that discont-

inuities in the managing system occurred at 32% of the possible opportunities. Continuity was non-existent in stages a5 and b1, the most critical stages of this project. This departure from the model was brought about by the lack of an overall management function in the early stages of the project's development. It is clear from the project diary that the early stages of this project lacked direction and decision, and the results of this particular test confirm this.

5.4.6 Non-duplication

The fifth hypothesis is that in order to maximize the potential success of a project, the organizational structure should have no Duplication of the Managing System at the Strategy level or above. The test for Non-duplication is only concerned with Duplication in the Managing System. There are often very good reasons for duplicating the control system in multi-organizations, and this is rarely to the detriment of project success. However, the Managing System should not be Duplicated, and the test was to examine the roles of Co-ordinating, Integrating, Recommending and Approving. The hypothesis is tested by looking at each Operation for the Duplication of any of these four roles. If any of the roles are present more than once, then that Operation contains Duplication. The result is expressed as the percentage of Operations which are contain no Duplication of the four roles.

At 54%, this test shows the worst departure for any of the tests on this case study. Approval and Recommendation are Duplicated almost continuously across the whole project. If they are being exercised at all, then they are usually Duplicated. This is because of the hierarchical decision making structure within the health service organization, and reflects the concern of the organization for accountability. However, it does not match with the model's proposition because it creates a large, unwieldy decision making process which can slow down progress and prevent the rapid adaptability often required in a changing environment.

5.4.7 Client involvement

The final hypothesis was that in order to maximize the potential success of a project, the organizational structure should provide opportunities for Client Involvement at every stage. The test of this is simply to examine each Operation for the presence of any client personnel in any role. The charts in appendix A show the variety of client personnel involved in this project. These people were constantly in touch with each other throughout the project. This test achieved a measure of 100% throughout the project. This matched the hypothesis, and indicates that no work was done on the project without some member of the client's organization having some input or control over it.

5.5 DISCUSSION

The departures from the model can be summed up as follows:

- Poor co-ordination in stages a5, b1 & b5; mediocre co-ordination in stages a2, a3 & b6; slight lack of co-ordination in stages a4 & b4.
- Mediocre feedback in stage a4.
- Poor Control in stage a2; mediocre control in stages a1, a3, a4, a5, b1 & b2; slight lack of control in stage b6.
- No integration in stages a5 & b1; poor integration in stages a1, a2 & a4; mediocre integration in stages b4 & b5.
- Duplication at every step in stage 6; excessive duplication in stages a1, a3, a5 & b5; mediocre in all other stages.

The project diary has been examined to determine the stages at which particular deficiencies arose. The points where the project organizational structure departs from the model can be attributed to particular stages of work as shown in Table XI. This table also shows how specific deficiencies relate to specific departures.

Since the majority of the pre-construction work was done again after the project was resurrected, it is sometimes difficult to distinguish the two sets of stages and decide where a deficiency originated. There are cases in the table

Table XI: Project A deficiencies related to departures

Stage of Work:	**Deficiency:**	**Departures from the model:**
a1 Inception	6, 7	Mediocre control; poor integration; excessive duplication.
a2 Feasibility	11	Mediocre co-ordination and control; poor integration.
a3 Sketch scheme	1, 5	Mediocre co-ordination; poor control; excessive duplication.
a4 Detail design	4, 9	Slight lack of co-ordination; mediocre feedback and control; poor integration.
a5 Contract	8	Very poor co-ordination; mediocre control; no integration; excessive duplication.
b1 Inception	6, 7	Poor co-ordination; mediocre control; no integration; some duplication.
b2 Feasibility	11	Mediocre control; some duplication.
b3 Sketch scheme	1, 5	Some duplication.
b4 Detail design	4, 9, 10	Slight lack of co-ordination; mediocre integration; some duplication.
b5 Contract	8	Poor co-ordination; mediocre integration; excessive duplication.
b6 Construction	2	Mediocre co-ordination; slight lack of control; duplication at every step.
7 Commissioning	3	No data available

Key to deficiencies:

1 Inadequate provision of space
2 Latent defects requiring rectification
3 Management within the facility
4 Internal environment not comfortable
5 Layout of facility not satisfactory
6 Delays in the development of the project
7 Slightly over cost targets
8 Too high a standard of finishes
9 Insufficient drainage inside the kitchen
10 Some equipment outdated or unsuitable
11 Unsuitable location

where although a deficiency is shown as arising from both the detail Design Stages, there are no marked departures from the model in the second one, therefore it may be assumed that the problems arose from the first one. The reason that problems remained even though the project was almost completely re-designed is that the management structure was so unwieldy and resistant to change once decisions had been taken. Because of this, once the project was committed to a certain course of action, it was almost impossible to alter that decision. This was compounded by the almost continuous Duplication of Approval and Recommendation roles, because so many people were involved when a decision was needed.

The high incidence of Client Involvement and Feedback to Policy and Strategy Decision points created relatively short Feedback loops, for such a long project duration. This helped to reduce uncertainty within the project team.

The decision making pattern observed on this project was created by the nature of the health service and the need for accountability. It slowed down the project and created an enormous "hidden cost". The number of people who contributed to the management and guidance of the project is surprisingly large, and this raises questions about cost-effectiveness in public sector building projects. Clearly the time spent by committees and senior officers will not be allocated to the building costs of this project, but will have to be paid for somewhere. However, this problem is beyond the scope of this study.

CHAPTER SIX: ANALYSIS - CASE STUDY B

The results for the second case study are presented and analysed.

6.1 PROJECT DESCRIPTION

6.1.1 Outline

The project was the conversion of a redundant infants school into a multi-user day care centre for the social services department of a county council in Northern England. It was an innovative project for this county, because they had never tried to integrate so many different groups of people together before. The tender sum was £98,000 at 1984 prices, and the contract duration was 5 months.

The management of the project was a complex affair; firstly because of the innovative nature already referred to, and secondly because of the frequent changes of critical personnel. The client consisted of a large group of people representing several diverse interests. All professional advice came from the construction services department of the county council; but part of the way through the project that department was re-organized and this project became the responsibility of a different part of the department. The picture was further complicated by staff changes.

The contract was let to a small local contractor by selective tendering, with the electrical and mechanical services engineering content let to sub-contractors. This produced three quite distinct tendering processes. The contract used was the county's minor building works contract, and the nominated suppliers/sub-contractors form was used for the electrical and mechanical services engineering work.

6.1.2 Objectives

The objectives of this project were clearly identified at a two day meeting of the various client departments and

specialists. The meeting was a response to the land committee's request for further clarification on details of the proposed new centre. This had to take place before they would agree to transferring ownership of the redundant school to the Social Services Department. As a result of this meeting, the objectives were summarized thus:

> "To provide a flexible range of local supportive services for individuals, either at risk or with special needs, through assessment and educational training programmes, in order to maintain and increase the skills necessary for independent living, and to achieve a reduced level of dependency."

The data for this case study were collected as the project was in progress. Because of this, it was felt that formal interviews would not be appropriate, and the equivalent information was obtained through regular meetings with the project personnel as the project developed. Since formal interviews were not conducted, this is the only knowledge of objectives available.

6.1.3 Project history

The need for the project was established prior to 1978 when it became clear that there was a shortage of places in the district. There was no likelihood that funds would be available for a new building, so this project had to wait for a location for some years.

The infants school suffered falling numbers and in 1980 a rationalization of the provision of primary school places resulted in the closure of this school. Various committees considered using the site but eventually it was declared to be surplus. The County valuation & estates department then offered it to all other council departments and invited bids and proposals for its use. The social services department, in conjunction with construction services, worked up a proposal to use the school as a day centre.

The scheme had two sources of funds; the minor capital works budget of the local authority, and the joint budget provided by the area health authority. This fund is money

from the government to help pay for moving this type of health care into the community.

Before the county council would approve the scheme, they needed a series of approvals: from the personnel committee for staffing costs; from the land committee for the transfer of the land and buildings; and from the finance committee for the costs of building. Each of these committees required additional information from the social services department about their proposals, so by the time the scheme got approval, much of the detail had been worked out.

The initial feasibility study was undertaken by the social services department in very approximate terms and produced a figure of £100,000 for the scheme (£62,000 of which was for building costs). They consulted the county architect for advice at this stage, but an architectural feasibility study was not undertaken until 1982, when a provisional figure had been included in the capital budget. The divisions were then re-organized so this scheme became the responsibility of another division. A project architect then took over the scheme and worked up a sketch scheme. When this was costed, the building costs alone came to £120,000, twice the budgeted figure. This project architect left to work elsewhere, and his scheme was revised by his divisional architect, who got the total costs down to £98,000. He then passed it on to a new project architect who looked after the scheme and developed the detailed design and contract documentation. Briefing was a complex process, due to the multiple client body. The social services department set up a project development steering group to act as a focus for all decisions on the job, but the project architect did not see the meetings of this group as the main form of contact with the client. He dealt with a person from the social services department outside the meetings.

The contract was let on specifications and drawings alone because it was not large enough to warrant bills etc. The contractor was chosen by selective tendering, as were the electrical and mechanical services engineering nominated

sub-contractors. Each of these three tendering processes happened separately, in parallel, and were organized by different people.

The mechanical engineer discovered asbestos in the building and the contract was delayed slightly whilst this was removed by a specialist contractor. There was an additional delay of two weeks to the contract, one of which was due to more preparatory decoration work being necessary than was anticipated. This was given an extension of time. The delays were not seen as important because by this time the client was not in a position to take over the facility, needing time to train staff and get ready.

6.2 ENVIRONMENTAL COMPLEXITY ANALYSIS

6.2.1 Qualitative analysis of environment

As before, the qualitative analysis is executed under three headings.

(a) Certainty/uncertainty surrounding the project

Initially there was a definite need for improved facilities in the area. This need developed into a need for a specific scheme when the building housing the existing nursery facilities was unexpectedly discovered to be unsound. This need was certain, and very pressing, but nothing could be done about it until the reduction in the number of school places meant that buildings would become available for other uses. There was a general shortage of funds for new building development work.

The client was inexperienced in this sort of provision; a day care centre of this type had not been undertaken before by this local authority and had to be accommodated in an existing building.

The project was subjected to unexpected events. During the process of developing the project, the project architect was changed, and the construction services department was re-organized. Asbestos was discovered during stripping out of the existing building and had to be removed.

(b) Conflict identified in the project

There was a small amount of conflict over responsibility for funding some work caused by deterioration of the building whilst it was unoccupied. It was not clear exactly who was responsible for the maintenance of the building whilst it was empty and not in the possession of any department in particular. The construction services department would normally be responsible for the maintenance of all buildings, but since it was not clear whether the council were keeping this one, no maintenance was done.

There was some conflict concerning the design responsibilities of the architect and the interior designer.

Finally, conflict arose as two people both felt responsible for co-ordination. Also, problems of perception often resulted in lack of communication because some contributors did not recognise the validity of each others' inputs.

(c) An outline of the complexity of the project

Spatially - the existing building provided a range of spaces which were considered suitable for the activities to be carried out, although not as satisfactory as a completely new building would have been.

Technically - the existing structure was used without alteration. Conventional simple building services were used without problems.

Aesthetically - existing functional elevations were not altered. Aesthetics were not considered.

6.2.2 Quantitative analysis of environment

Table XII shows the quantitative analysis of the environment. The resulting ECI of 52% indicates that the environment was fairly complex, but less complex than that for project A.

Table XII: Project B quantitative environmental analysis

A Day Care Centre in N. England

ENVIRONMENTAL FACTOR:	Def	Sta	Mit	Tot
LEGAL/INSTITUTIONAL: English Law applied. Well-known Std Form of Contract was used. Familiar Condns of Engagement for external consultants. Each consultant had a counterpart in the County Council for liaison.	1	1	3	5
TECHNOLOGICAL: The solution adopted involved the conversion of an existing system-built school.	1	1	2	4
FINANCIAL: Cost limits for the project were clear, and very strict.	1	3	3	7
AESTHETIC: The design was severely constrained by the appearance of the existing building.	1	1	2	4
POLICY: The client's policy was clearly understood but was difficult to arrive at due to the committee stages of any policy decision. The objectives of the project were stable.	1	1	2	4

$$E.C.I. = \frac{(5 \times 4 \times 7 \times 4 \times 4)^{0.2}}{9} \times 100 = 52\%$$

KEY: Def = Definition, Sta = Stability, Mit = Mitigability.

6.3 POST-OCCUPANCY EVALUATION

As stated earlier, formal interviews were not undertaken for this case study, because the data were collected as the project took place, rather than after it was finished. However, the equivalent information was gained through informal contact and conversations with the major contributors. Notes were taken during these conversations, and checked with the contributors. It was found that although the same quality of information could eventually be

secured by either approach, the structured interviews produced information that was easier to interpret and compare.

The post-occupancy survey revealed that generally, staff and users were very satisfied with the new day centre. All aspects were rated very highly by the staff, except for noise, and heating & ventilation. The users also rated all aspects very highly, the only exceptions being access by foot, noise and safety. Noise is the item that is singled out by both groups. From the individual sundry complaints it would seem that this results from different user groups having different expectations about the use to which the building should be put.

Most of the staff had no clear opinion on the time taken to complete the project, but of those that did, the reaction was favourable. This may seem a positive point, except that most of the staff were not appointed until the building neared completion.

For the majority of the users, their opinion of the building had not changed with time, whereas the staff seemed to be evenly split between increase, unchanged and decreased satisfaction.

Many of the users gave no clear opinion about questions of access, probably because they are brought to the facility in transport provided by the social services department.

If the total weighted aggregate satisfaction levels for both surveys are averaged, the result is 81%. This is extremely high and the detailed criticisms gleaned from the surveys should be tempered by this fact, because no aspects of the building's form or function caused any great dissatisfaction with staff or users. The results of the survey of the users is summarized in Figure 18. The shortcomings derived from the survey are as follows:

1. Inadequate provision of certain areas
2. Lack of storage space
3. Poor security
4. Lack of hand rails and other provisions for the disabled
5. Noise from some users disturbing others

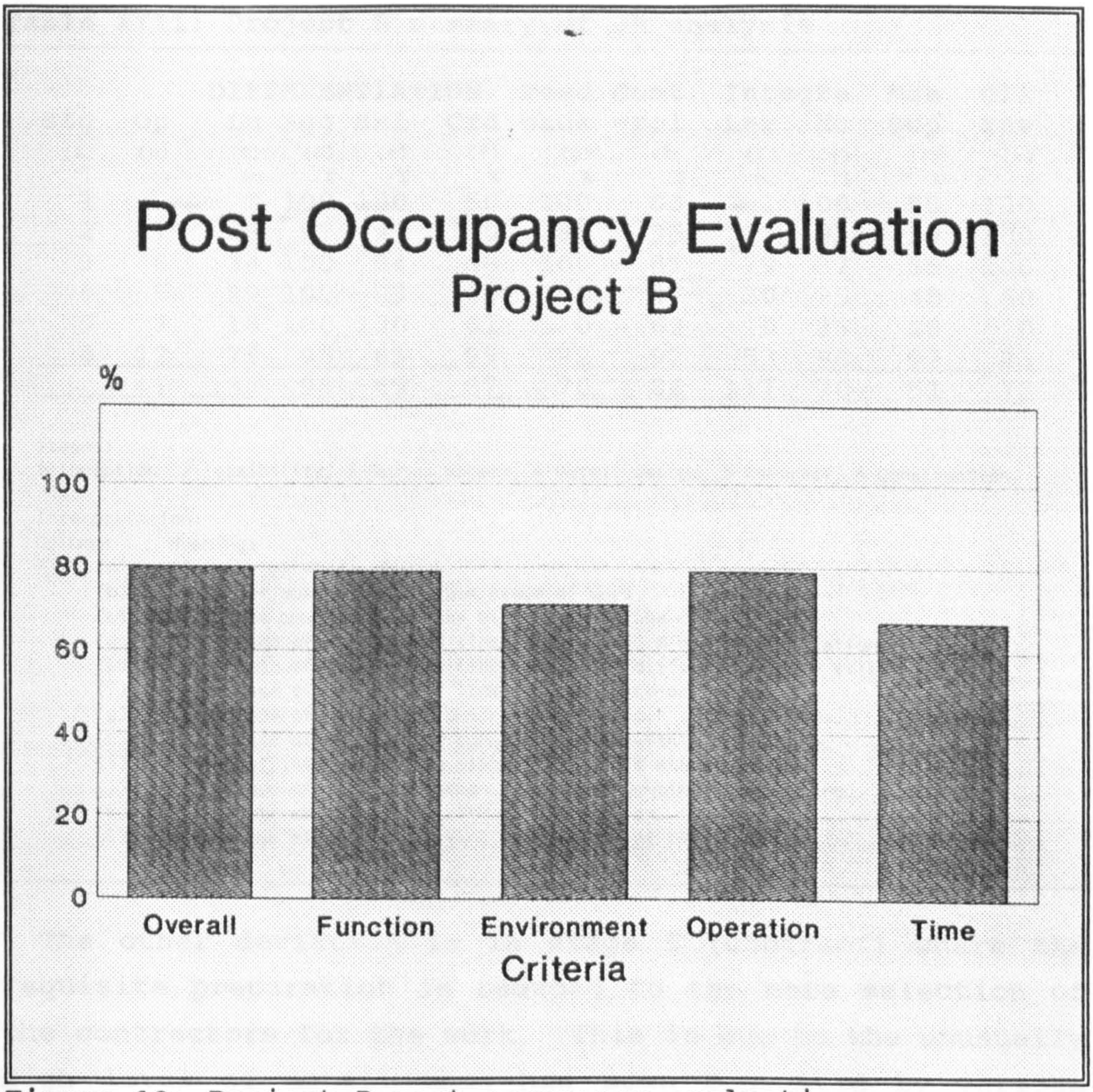


Figure 18: Project B post-occupancy evaluation

6.4 SUMMARY OF 3R ANALYSIS

The 3R charts are given in appendix B, and the analysis is summarized in Table XIII. As the 3R charts show, the decision points for project B demonstrate slight deviations from the model. During stage 3 (scheme design) there is an extra decision point which arises because the scheme was rejected due to it being nearly 100% over budget when it was costed. In this analysis, this is being treated as a lower level decision because it does not effectively punctuate the sub-systems, rather it is the client's opportunity to exercise regulation, in the absence of more usual, and perhaps less drastic techniques.

Table XIII: Project B summary of 3R analysis

Stg	Op	DIFFERENTIATION Ln	Agg	Skl	Crd	Feed back	Cont -rol	Integrn Lnk	No	Non Dup	Cli Inv
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
	no	no	%	%	%	%	%	no	%	%	%
1	2	2	100	100	50	100	83	1	100	50	100
2	7	29	97	97	100	86	95	15	93	29	100
3	8	34	100	94	88	100	81	19	37	38	100
4	5	29	100	93	62	40	87	20	25	40	60
5	7	18	100	100	61	0	62	9	33	29	0
6	12	75	95	69	99	92	92	53	98	92	83
	41	187	98	85	87	70	86	117	70	51	73

Stages:
1-Inception, 2-Feasibility, 3-Sketch scheme, 4-Detail design, 5-Contract, 6-Construction

Interpretation:

Column:	Meaning:
(a)	Identity of stage of work.
(b)	Number of operations in this stage of work.
(c)	Number of operational links within this stage of work.
(d)	Percentage of operational links with any form of differentiation
(e)	Percentage of operational links which are differentiated by skill.
(f)	Percentage of operational links which are co-ordinated.
(g)	Percentage of operations which exhibit proper feedback loops.
(h)	Percentage of elements of control present within operations.
(i)	Number of inter-operation links within this stage of work.
(j)	Percentage of inter-operation links with continuous directing.
(k)	Percentage of operations with no duplication.
(l)	Percentage of operations with involvement of the client.

The other deviation is in stage 5 (contract) where the requisite preparation is reduced to the mere selection of the contractors for the work. This is due to the unusually high level of detail that had been requested by various parts of the client organization in order for approvals to be gained. As a result of this, much of the work normally expected to be contained within stage 5 had already been undertaken in stage 4. As well as this, the small scale of the project meant that the work involved in contract preparation was light. However, these aberrations are not beyond the flexibility of the model, and are described readily.

6.5 DISCUSSION

The project diary has been examined to determine the stages at which particular deficiencies arose. The points where the project organizational structure departs from the

model are also attributed to particular stages of work. Table XIV shows how the specific deficiencies relate to specific departures. From this table it would seem that the severe problems in stages 1 and 5 had no effect; presumably the project team were effective in overcoming the problems caused by these issue. However, it must be remembered that stage 1 only consisted of one operation and one decision, and may not have been perceived as being part of a project at that stage. Also, stage 5 was not the important phase that it often is on some projects because of the low level of documentation being required and its substantial completion in a prior stage.

The stages of work that did produce deficiencies also had organizational departures. Thus the excessive Duplication in stage 2 must be the cause of the facility being too noisy, since it is the only marked departure from the model at that point. Presumably, the excessive Approvals means that the proposal was less than optimal for any one interest group, but the only proposal likely to succeed. The poor Integration and mild Duplication in stage 3 resulted in the inadequate provision of certain areas, and the lack of storage space.

The type of problem that may well be associated with Duplication of Approval powers is the "lowest common denominator" approach where the project team have to attempt to satisfy as many of the executive "Approvers" as possible. The poor security and the lack of hand rails and other provisions for the disabled seem to have arisen from stage 4, and would thus be the result of the poor Feedback, mediocre Co-ordination, poor Integration, mild Duplication and lack of Client Involvement observed in this stage.

The organizational structure on this project produced a building which is very well liked by the users and staff. It performs its function well and is a direct and appropriate response to a high level of need in this district. There are a few small problems with the building which have been observed, but they do not detract from the overall level of satisfaction.

Table XIV: Project B deficiencies related to departures

Stage of Work:	Deficiency:	Departures from the model:
1 Inception		Lack of control; poor co-ordination; mild duplication.
2 Feasibility	5	Excessive duplication.
3 Sketch scheme	1, 2	Poor integration; mild duplication.
4 Detail design	3, 4	Poor feedback; mediocre co-ordination; poor integration; mild duplication; lack of client involvement.
5 Contract		No feedback; slight lack of control; mediocre co-ordination; poor integration; mild duplication; no client involvement.
6 Construction		Slight lack of client involvement.
7 Commissioning		No data available.

Key to deficiencies:

1 Inadequate provision of certain areas
2 Lack of storage space
3 Poor security
4 Lack of hand rails and other provisions for the disabled
5 Noise from some users disturbing others

It is interesting to note that there are so few deficiencies on this project, and this seems to match the general picture from the organizational analysis, which was favourable. There is a fairly consistent pattern which emerges from the analysis, that the organizational structure matches the model, except for a few departures as follows.

There were unusually high demands for information for the purposes of approvals during the early stages of this project. This resulted in a minimal amount of work during

stage five. The total lack of feedback and client involvement during stage five arise as a consequence of this.

The overall indication is that the organizational structure suffered from too many people exercising powers of approval and this may have tended to dilute the solutions being offered. What was produced was a project which aimed to satisfy as many people as possible. Whilst there is always the danger that this aim will produce a solution that is less than satisfactory to everyone, this does not appear to have been the case on this project.

CHAPTER SEVEN: ANALYSIS - CASE STUDY C

The results for the third case study are presented and analysed.

7.1 PROJECT DESCRIPTION

7.1.1 Outline

The project was to build a new divisional and sub-divisional police headquarters in Northern England on a confined town centre site. The tender sum was £3,341,548 at 1979 prices, and the contract duration was 27 months.

The design and management of the project was provided by the newly formed architect's department of a metropolitan county council. The client was essentially the local police force, as represented by the Police Committee of the county council, the Chief Constable of the force and several assistant chief constables, a Police Planning Officer who was in charge of briefing for the project, the Home Office who were paying for half of the scheme and the County Council who were paying the other half. The project team consisted of the chief architect of the county council, several in-house project architects, quantity surveyors and structural engineers, as well as external consultants who were used for the services engineering and taking-off work. The chief architect led the team in the early stages, but handed over project leadership to the project architect once the design stage was reached. The project architect was changed when the project started on site.

The county estates department was heavily involved due to prolonged negotiations about the acquisition of the site. The contractor was a medium sized regional firm, and a contract for preliminary works was let to a different contractor.

7.1.2 Objectives

From the interviews it was clear that most of the contributors to the project acted as if there were specific objectives, but each person's description of the objectives was different. These ranged from "to comply with the brief of the police planning officer" to "providing up-to-date accommodation for police officers in this district and move them out of unsuitable and dilapidated buildings".

7.1.3 Project history

The scheme originated in 1973 when temporary buildings were being provided for the divisional HQ. It coincided with the inception of the metropolitan county councils, which resulted in the creation of a new metropolitan police force, in effect. At that time, the police committee called for a "rolling" return for the 1974-79 five year "rolling" programme. The return showed this project as an essential one and a figure of £700,000 was included. There is no record of how this figure was arrived at. The return was rejected by the Home Office as there was at that time officially no metropolitan county police force in existence. The police authority immediately re-submitted the return under its existing title for the same item at the same price. In January 1974, the Home Office replied that due to economic measures it seemed unlikely that any new starts would be approved for 74/75.

When a site became available, in March 1977, the Home Office agreed to forward planning. The chief constable submitted forms PB1 (persons & unit statement) and PB4 (proposed establishment) in September 1977 to Her Majesty's Inspectorate (HMI) for approval, which was forthcoming within two weeks. After various meetings on "requirements", the chief constable and the county architect provisionally completed form PB3 (accommodation schedule and summary of areas). At this stage, before detailed drawings were prepared, the budget estimate had to be approved by the Home Office through the use of form PB2, as well as what had already been agreed with HMI on forms PB1, PB3 and PB4.

These approvals highlight the tortuous process that almost every decision had to go through before being accepted. The effect of the approval procedures will become clear.

The contract suffered from approximately 42 weeks of delays, including architect's extensions of time of 36 weeks. The biggest single delay was an arbitration on product specification, a cost which had to be borne by the client. The problem was with the specification of some tiles, intended for raked back surfaces on the face of the building. These were intended to match the brickwork, but due to a series of errors, eventually blamed on the architects, the initial delivery of them did not match, and created an effect not unlike a victoria sponge cake! These were replaced through a variation order, and the clients had to pay for new ones.

The site itself was also the source of problems, in that it was bounded by a railway, a major road, and a canal. The ownership of this site was complex, having partly been vested in British Transport, and subsequently split between British Rail and the British Waterways Board. Part of it was also owned by the borough council. Since access was required across the site a new road had to built which would connect the existing road with a proposed new transport interchange on the site. Also, the canal needed extensive strengthening works to its banks, and the ground anchors for this work effectively reduced the site again. Eventually, the site was approximately half of the size that was originally expected. Drainage was difficult, and was resolved by pumping foul and surface water across a bridge into the main sewers.

As personnel changed in the police force from one year to the next, coupled with occasional changes in policy, so the interpretation of what ought to be included in the project changed. Usually, these changes increased the size of the scheme. Originally, it was planned as a £700,000 scheme, and the man-hours for professional work were allocated accordingly. Although the scheme more than doubled in its functional content, no increase in professional resources

was permitted, neither was any delay to the programme. However, under these circumstances some delay was inevitable.

7.2 ENVIRONMENTAL COMPLEXITY ANALYSIS

7.2.1 Qualitative analysis of environment

(a) Certainty/uncertainty surrounding the project

The need for the project was clear at the start point, but this was complicated by the fact that it coincided with the formation of the new metropolitan county council who had just taken over responsibility for the police. There was difficulty associated with funding which was split between the Home Office and the new County Council.

The definition of the scope of the project was subjected to frequent and drastic change. Much of this was due to changes in key personnel; the police briefing officers changed, three different chief constables passed through, and contact people at the Home Office changed. There was uncertainty regarding the year in which it could be funded, aggravated by fluctuating political attitudes to development. Inflation was high during the project.

The client was inexperienced in the provision of this type of building. Similarly, the county architect's department had only just been created, with no previous experience of this type of building.

The project was subjected to numerous unexpected events. Constraints were imposed by the Home Office on ceiling heights, in an attempt to reduce the cost of the project, allowing the extra requirements to be included. The site which was used suffered so many constraints that 25% of it could not be utilized, whilst the accommodation to go on it had been increased. The heating system had to be coal fired for political reasons. A decision was taken that the building had to be able to withstand a five day siege which put further pressure on costs. Rapid changes in communications technology meant that as fast as telecommunications equipment was designed, it went out of date. Changes in

central government during the project altered the availability of funds for police work. Keenes cement manufacturers, the sole source of cement for cell walls, went bankrupt and an alternative was difficult to find. These are just some of the problems which beset this project.

(b) Conflict identified in the project

Conflict was identified between the county council and the Home Office over the amount of information necessary for approvals, over the choice of procurement method and over the programme of work. Also, conflict was identified between the main contractor and the architects about the supply of information. The main contractor refused to attend any sub-contractor's meetings about co-ordination.

(c) An outline of the complexity of the project

Spatially - the location chosen for the building was considered to be the only realistic possibility. The building was complex due to the wide variety of uses that had to be accommodated, relationships between spaces being particularly important in such a building. Designing it to withstand a siege was complicated by the site restrictions. The chosen site was extremely complex; it was in multiple ownership and had development problems to overcome with regard to canal strengthening, access for British Rail to their railway, and a proposed public transport interchange.

Technically - a conventional structural solution was adopted, although low storey heights were insisted upon by the Home Office. The low storey heights resulted in a severe restriction for the ducts in the suspended ceilings, only 100 mm was left for all services to be ducted through. Also, telecommunications equipment was at the forefront of technology. Site services had to be diverted, such as an oxygen main belonging to British Oxygen, and sewage had to be pumped out of the site to get over the waterways.

Aesthetically - a functional building with simple elevations.

7.2.2 Quantitative analysis of environment

Table XV shows the quantitative analysis of the environment. The resulting ECI of 71% indicates that the environment was much more complex than that for projects A or B.

Table XV: Project C quantitative environmental analysis

Police Divisional and Sub-divisional HQ in N. England

ENVIRONMENTAL FACTOR:	Def	Sta	Mit	Tot
LEGAL/INSTITUTIONAL: English Law applied. Well-known Std Form of Contract was used. Familiar Condns of Engagement for external consultants. Some work was split between in-house and external consultants.	1	2	3	6
TECHNOLOGICAL: The solution adopted involved the use of simple materials in conventional manner, but difficulties resulted from storey heights, telecommunications gear, and cement suppliers.	2	2	3	7
FINANCIAL: Cost limits for the project were clear, but subject to change up or down.	2	3	3	8
AESTHETIC: Simple elevations to a functional building.	1	1	2	4
POLICY: The client's policy fluctuated and was open to a variety of interpretations. Client approvals were complex, protracted and extremely detailed.	2	3	3	8

$$E.C.I. = \frac{(6 \times 7 \times 8 \times 4 \times 8)^{0.2}}{9} \times 100 = 71\%$$

KEY: Def = Definition, Sta = Stability, Mit = Mitigability, Tot = Total.

7.3 POST-OCCUPANCY EVALUATION

The general opinion of the workforce is that the HQ is slightly above average. This suggests that none of the HQ's problems are so great as to cause dissatisfaction with the building as a whole.

Satisfaction with the building has not changed over time with most people, even though 60% of then had worked there from within three months of it opening. This is a positive result despite the fact that for 29% of respondents satisfaction had decreased.

The results from specific questions on the function and form of the HQ centre on "average". This is shown by the weighted aggregate satisfaction levels generally coming out around 50% for most questions. However, there are certain points on which the respondents hold strong views.

It is interesting to note that "access by car" scores the highest weighted level of 61%, yet many people complained of a lack of car parking facilities, both for staff and for visitors. These two aspects of access were clearly perceived by many people as two different issues.

Recreational facilities also scored well, yet there were complaints about the gymnasium being consistently out of use, due to problems with the floor.

There is a good deal of complaint about heating and ventilation, and about the constricted widths of the corridors and doors. This is reflected both in the numerical analysis and the specific comments made.

Many people showed no opinion on the duration of the project, or on the maintenance of the building; which is a result to be expected since most people would have little involvement with either of these issues. Other subjects such as form and flexibility prompted little response. In conclusion, the building produces a mediocre level of satisfaction and has some faults. The survey of the workforce is summarized in Figure 19.

Specific comments were invited on the questionnaire forms, and the following comments were made:

1. Project took too long to complete
2. Final cost was over budget
3. Bad heating & ventilation
4. Narrow corridors and floors
5. Lack of parking facilities
6. Lack of interior space
7. Need for a P.A. system
8. Gymnasium consistently out of use
9. Lack of storage/locker space

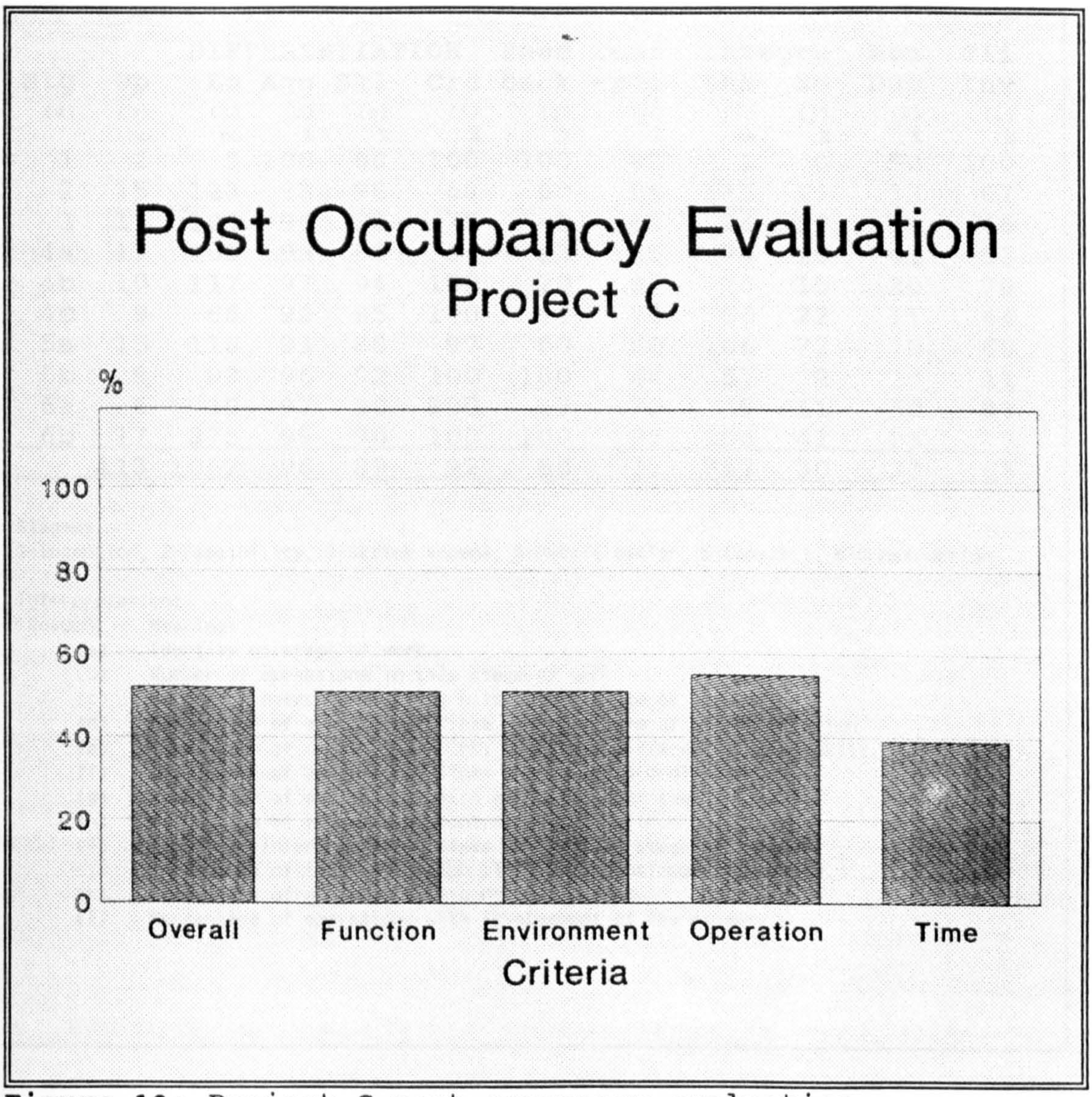


Figure 19: Project C post-occupancy evaluation

7.4 SUMMARY OF 3R ANALYSIS

The 3R charts for this project are given in appendix C, and the analysis is summarized in Table XVI. The main departures from the model may be summarized as follows:

- decision points not clearly identified, particularly at beginning and end of design work (see 3R charts).
- mediocre co-ordination in stage 2.
- almost no feedback in stage 3, poor feedback in stage 4c and mediocre feedback in stages 2, 5a and 6a.
- mediocre control in stages 2, 3, 4a & 5a, and poor control in stage 5b.
- no integration in stage 1; almost no integration in stages 2, 4a, 4b, 5b & 6a; and poor integration in stages 3, 4c, and 6b.

Table XVI: Project C summary of 3R analysis

Stg	Op	DIFFERENTIATION Ln	Agg	Skl	Crd	Feed back	Cont -rol	Integrn Lnk	No	Non Dup	Cli Inv
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
	no	no	%	%	%	%	%	no	%	%	%
1	2	5	100	80	100	100	83	1	0	50	100
2	15	123	98	90	68	60	56	115	17	33	67
3	13	104	96	88	75	8	67	74	24	54	46
4a	17	109	93	83	84	82	65	74	16	41	53
4b	10	117	97	94	100	70	87	73	15	20	70
4c	9	68	92	85	100	44	74	50	22	11	44
5a	15	118	93	88	97	60	60	106	72	20	60
5b	9	93	96	92	100	100	44	57	2	33	11
6a	6	39	97	90	100	67	78	9	11	50	83
6b	17	275	99	90	100	100	92	198	41	24	71
	113	1052	96	89	92	66	71	757	30	33	65

Stages:
1-Inception, 2-Feasibility, 3-Sketch scheme, 4-Detail design, 5-Contract, 6-Construction

Interpretation:

Column:	Meaning:
(a)	Identity of stage of work.
(b)	Number of operations in this stage of work.
(c)	Number of operational links within this stage of work.
(d)	Percentage of operational links with any form of differentiation
(e)	Percentage of operational links which are differentiated by skill.
(f)	Percentage of operational links which are co-ordinated.
(g)	Percentage of operations which exhibit proper feedback loops.
(h)	Percentage of elements of control present within operations.
(i)	Number of inter-operation links within this stage of work.
(j)	Percentage of inter-operation links with continuous directing.
(k)	Percentage of operations with no duplication.
(l)	Percentage of operations with involvement of the client.

- excessive duplication throughout the project.
- almost no client involvement in stage 5b; poor client involvement in stages 3 & 4c; mediocre client involvement in stages 2, 4a, 4b, 5a & 6b.

This project is not at first sight a close match with the model, because of the multiplicity of decision points and stages; and the repetition of operations. Some operations actually take place throughout several stages of work. However, since they do not interact with other parallel activities, they may be treated organizationally as taking place within the stage of work into which they feed information. An example of this is the acquisition of the site, which took many years but is shown as a discrete single operation on the precedence diagrams.

If the detail design stage is viewed as two separate stages (i.e. 4a & 4b), then the project fits the model very closely. The approval system used for this project was so slow that by the time the Home Office approved the basis of the detailed design, the client had altered the requirements. These alterations were so radical as to necessitate the re-commencement of the whole stage of work, and the re-submission of the scheme to the Home Office for approval.

The advance contract also resulted in a certain amount of repetition of decision points, in particular its own detail design, contract preparation and construction stages; but the decisions closely match those identified in the model. In organizational terms, the advance contract became a separate project and had its own discrete stages of work. In this way, the project configuration is expressible in terms of the 3R technique.

7.5 DISCUSSION

The overall figure for project success is 49%. This means that the project is very mediocre from most viewpoints.

Referring to Table XVII, the first two deficiencies seem to have originated from the inception stage; because it was at this point where proper integration mechanisms should have been established and developed for the project. The problems with the duration of the project and its cost were really due to the overall lack of integration throughout the scheme.

The departures from the model in all work on the advance contract do not seem to have caused any problems. However, the sketch scheme and detail design (main contract) seem to have been the sources of most problems with the building.

It seems clear from the interviews that most of the project team did not feel very happy about this project and their dissatisfaction seems to stem from the lack of overall direction given by the organizational structure. In defence of the project team, client and professionals, it must be remembered that the architect's department had only been

Table XVII: Project C deficiencies related to departures

Stage of Work:	**Deficiency:**	**Departures from the model:**
1 Inception	1	Mediocre control; no integration; excessive duplication.
2 Feasibility	2	Mediocre co-ordination feedback, control and client involvement; almost no integration; excessive duplication
3 Sketch scheme	4, 5, 6	Almost no feedback; mediocre control; poor integration & client involvement; excessive duplication
4a Detail design (main)	3, 7, 9	Mediocre control; almost no integration; mediocre client involvement; excessive duplication
4b Detail design (main)	3, 7, 9	Almost no integration; mediocre client involvement; excessive duplication
4c Detail design (adv.)		Poor feedback; poor integration and client involvement; excessive duplication
5a Contract (main)		Mediocre feedback, control & client involvement; excessive duplication
5b Contract (adv.)		Poor control; almost no integration; excessive duplication; almost no client involvement
6a Construction (adv.)		Mediocre feedback; almost no integration excessive duplication
6b Construction (main)	8	Poor integration; excessive duplication; mediocre client involvement
7 Commissioning		No data available.

Key to deficiencies:
1. Project took too long to complete
2. Final cost was over budget
3. Bad heating & ventilation
4. Narrow corridors and floors
5. Lack of parking facilities
6. Lack of interior space
7. Need for a P.A. system
8. Gymnasium consistently out of use
9. Lack of storage/locker space

formed at the outset of this project and found themselves in charge of a job which steadily grew in size year by year, but which had resources assigned to it based on the original size of project. This resulted in a grossly under-resourced project, highlighted by the problems the county architect had in trying to get someone to pay for the design work. He had a design budget of £160,000 for what ended up as a project costing more than £5m. In addition to these problems, the Home Office had developed a new series of approvals which may have suffered from teething troubles on this project.

Considering the severity of the organizational problems, it seems that the project team's efforts must be viewed as successful, since their energies have been directed in many cases at overcoming organizational problems, rather than constructional problems, and the fact that the project is not a complete failure is to their credit.

The organizational structure on this project produced a building which is not very well liked by the staff. It seems that the reaction of most people to the building is that it is mediocre in most respects. It performs its function adequately, and suffers from some specific problems. The project took a long time to complete, and every stage of work suffered delay of one form or another.

The overall indication is that the organizational structure suffered from a lack of direction and co-ordination, erratic feedback and integration, low control and excessive duplication. A mediocre organizational structure has produced a mediocre building, and resulted in an enormous amount of work being undertaken by the project team in trying to mitigate the adverse effects that the organizational structure had on the project. This case study has shown a high degree of correlation between the theory and the practice of organizational structure.

CHAPTER EIGHT: ANALYSIS - CASE STUDY D

The results for the fourth case study are presented and analysed.

8.1 PROJECT DESCRIPTION

8.1.1 Outline

This project was to build a county branch library in Southern England. The contract sum was £356,000 at March 1981 prices, and the contract duration was 25 months, which includes construction delays of six months. Project management, architectural and quantity surveying services were provided by the County Council Architect's Department and external structural and services engineering consultants were appointed. The contract was let by competitive tender to a medium-sized local contractor.

The development was on a site originally purchased for the use of a Health Centre scheme which did not go ahead. Whilst the site was available, it was not ideal for a library, because it was difficult to gain access from the main road. To overcome this problem, a short access path between the main road and the site was provided. This involved lengthy negotiation with existing landowners. This access route now has the potential of becoming a small shopping centre because there is enough land under the control of the council either side of the path. Thus the library development has become a catalyst for future development in the area. The intention is to provide a further series of paths which will provide integration between this site and other nearby sites. Coupled with this will be a further development, possibly housing, which will eventually complete the development of this site which was originally intended for only one public building. These factors combine to make this project fairly complex from a planning point of view.

The library faces the shopping street, and a semi-circular plan creates a cloister-like enclosure. The rear interior wall of the library comprises a large artistic mural depicting the leaves of trees, and the main vertical structural elements of the building are fabricated in timber resembling tree-like structures. These tree symbols are clearly visible through the front of the building, which is predominantly glazing, and therefore act as an attraction to the public, encouraging future development of the site.

The intention of the County Architect was to demonstrate that public expenditure can be used to enhance an area beyond the boundaries of its own site.

8.1.2 Objectives

The interviews revealed that each contributor had specific objectives. However, it was abundantly clear that these conflicted. The County Architect wanted to use the library primarily as a catalyst for development. The County Librarian clearly wanted an "ordinary" branch library. This was a fundamental difference which set the scene for many of the problems on this project.

8.1.3 Project history

The community in this district was rapidly expanding and the library service wanted to increase its local service above the existing small, temporary library which had been provided as a stopgap in the early sixties. The site of the temporary library was originally intended to be the location of the new permanent facility. It was purchased in 1966 and work was due to commence in the 1973/74 programme, for which £85,000 had been included. The original design for this had been undertaken in 1968 by a private practice of architects. Part of this site was due to become an access road for a proposed housing development. By 1971, the planning difficulties with the integration of the library and the housing development became so complex as to prompt the County Architect to suggest an alternative location on a county owned site at the back of the town's main road. A

feasibility study was undertaken for this site in February 1972. The County Planning Officer could then seek release of the first site to enable access through it to land at the rear for the housing development.

The second site was next to land being acquired for a new health centre which was due to commence in 1972/73. It was first thought that the original design for site no. 1 could simply be adapted for site no. 2, but this idea was abandoned in October 1972 because of the changes that had been made in the client's accommodation requirements.

The benefits of the second site were listed in a report for the Libraries and Museums Sub-Committee in March 1972:

(a) The library will interact with the shopping arcade to the advantage of both,

(b) the position is strategically placed to serve a much larger proportion of the catchment area than site no.1;

(c) it would also mean that the new library would be re-sited very near to its original position;

(d) a more useful shape could possibly be achieved in this more rectangular site.

However, in October 1972 it was decided to drop this scheme, due to the severe planning difficulties. In November 1972 there were problems in getting planning permission for site no. 1 because there was no access road. By January 1973 it seemed that planning permission would be granted on the first site, if there was to be no building on the front of the site. The County Librarian had misgivings about the plan but was anxious to get building work started as soon as possible on a permanent facility for the area. However, in the event the scheme missed the 1973/74 programme because of the delays in the planning approval stages. While problems over the access road were tackled other sites were examined.

By July 1973 the plans for the health centre on the second site had been aborted and the focus for the possible site of the library moved back to this site. In April 1974 it was allocated for library use. The scheme then became included for the 1979/80 programme and the scheme lay dormant until 1979 when the client issued their schedule of accommodation. The development proposals were accepted by the client and

the Planning Committee in February 1980 and the scheme proceeded steadily from there.

Work finally started on site in May 1981, at a contract sum of £356,000, and completion was scheduled for September 1982. The work was on programme until August 1981 when it fell behind by one week. By October it was six weeks behind programme, and the delays due to various factors continued to accumulate resulting in a total of six months by the time the contract was over.

One of the delays during the construction stage resulted from the approval given to the County Library Service to install security systems in its larger libraries, including new ones. Such a system, though not in the original design, had to be accommodated. This created several design problems and led to a delay in the completion of the project. The delay was compounded by disagreement between the architect and the client over the type of system to be installed.

The final cost of the project was higher than usual for this client. An example of the factors influencing this is the large area of glazing to the front elevation of the building. At the construction stage the advisors had second thoughts on wind loading, deflection and rocking due to expansion. This resulted in changes, and the incorporation of reinforcing to the glazing support at great cost.

8.2 ENVIRONMENTAL COMPLEXITY ANALYSIS

8.2.1 Qualitative analysis of environment

(a) Certainty/uncertainty surrounding the project

It is unclear when the need for a new building was identified; it was certainly before 1966, and it was clear that a new facility was required. The location and relation of the facility to its surroundings were not clear.

The definition of the scope of the project was clear from the outset.

The client was familiar with the provision of this type of building.

The project was subjected to unexpected events. During the early stages the project was excluded from the intended programme. The planning constraints involved repeated changes of location, resulting in abortive design work. The legal boundaries to the site were not clear, but this did not emerge until the design work was at an advanced stage. The integration of the scheme with existing users of neighbouring sites resulted in the need for third party approvals.

(b) Conflict identified in the project

There was mild conflict between the architect's ideas for aesthetic appearance, and the client's ideas for utility. There was difficulty integrating some of the service ducts with the design of the building. There were conflicting requirements from the library users regarding the ideal location of the site, because the area had more than one identifiable "centre".

(c) An outline of the complexity of the project

Spatially - the location resulted in complex planning issues regarding access to the site, compounded by spatial and functional integration with future developments. The areas provided were to client specification.

Technically - complex timber fabrication was required for the vertical structural supports. There were difficulties complying with the building regulations. The roof tiles do not lie well on the curved roof. Glazing panels were subject to distortion and excessive deflection under wind loadings, and had to be reinforced. Difficulties were experienced integrating heating services with the layout and structure of the building. Electronic security was included at an advanced stage of construction.

Aesthetically - The integration of the scheme with the future development of the site created planning problems and high aesthetic demands.

8.2.2 Quantitative analysis of environment

Table XVIII: Project D quantitative environmental analysis

Branch Library in Southern England

ENVIRONMENTAL FACTOR:	Def	Sta	Mit	Tot
LEGAL/INSTITUTIONAL: English Law applied. Well-known Std Form of Contract was used. Familiar Condns of Engagement for external consultants. A mixture of in-house and external consultants, all of them belonging to their professional institutions. External consultants had counterparts in the County Council for liaison.	1	1	3	5
TECHNOLOGICAL: The solution adopted involved a novel use of structural timber. The unusual shape of the building resulted in innovative glazing and roofing solutions. Location was subject to frequent changes in the early stages. Eventually the site chosen was an urban in-fill site and was not easily accessible from the main road.	1	3	3	7
FINANCIAL: Cost limits for the project were clear, but could be subject to change.	1	3	3	7
AESTHETIC: The design was aesthetically innovative, and became interdependent with the County Architect's policy toward the building.	1	2	3	6
POLICY: The problems of access were overcome by the county architect developing an innovative design which was used as a feature to encourage future development in this area. Unfortunately this very strong policy was sometimes in conflict with the librarians' view of the project.	3	3	3	9

$$E.C.I. = \frac{(5 \times 7 \times 7 \times 6 \times 9)^{0.2}}{9} \times 100 = 74\%$$

KEY: Def = Definition, Sta = Stability, Mit = Mitigability, Tot = Total.

Table XVIII shows the quantitative analysis of the environment. The resulting ECI of 74% indicates that the environment was the most complex of all four case studies.

8.3 POST-OCCUPANCY EVALUATION

The library users are clearly far more satisfied than are the client and project team, who in turn are more satisfied than the staff. However, the only aspect which generates enthusiasm from all three groups is appearance.

The general questions about the environment within the building produce a range of different views. Only the staff are dissatisfied. Likewise, noise scores badly for the staff, but scores well for the others. The biggest difference in opinion is about the heating and ventilation. This draws almost unanimous condemnation from the staff, but a mediocre response from the project team, and a high level of satisfaction from the users. Presumably the staff expend a lot of effort in trying to control the internal environment of the building, overcoming the adverse effects of the thermal performance of the building.

The time taken to complete the building draws opinions from most of the staff. The weighted average satisfaction level of 36% for this aspect is very low. It is not clear if their responses refer to the time taken to find a suitable location and to develop the project, or merely to the construction period. The interviews with the project team indicate that the responses refer only to construction.

The overall satisfaction of the staff has decreased with time, whereas the users' satisfaction is increasing.

The overall picture is that functionally the building is not very good, but aesthetically it is excellent; the three surveys give a combined average satisfaction level of 59%. The reslts for the survey of the users is given in Figure 20, as an example of the responses.

The following are the deficiencies revealed by the surveys and interviews:

1. Poor heating & ventilation
2. Poor access to first floor
3. Poor design in terms of layout and wasted space
4. Lack of car parking spaces
5. Lack of public toilets
6. Lack of seating
7. Inaccessibility to lower shelves
8. Noise and lack of privacy for quiet reading
9. Inadequate lighting

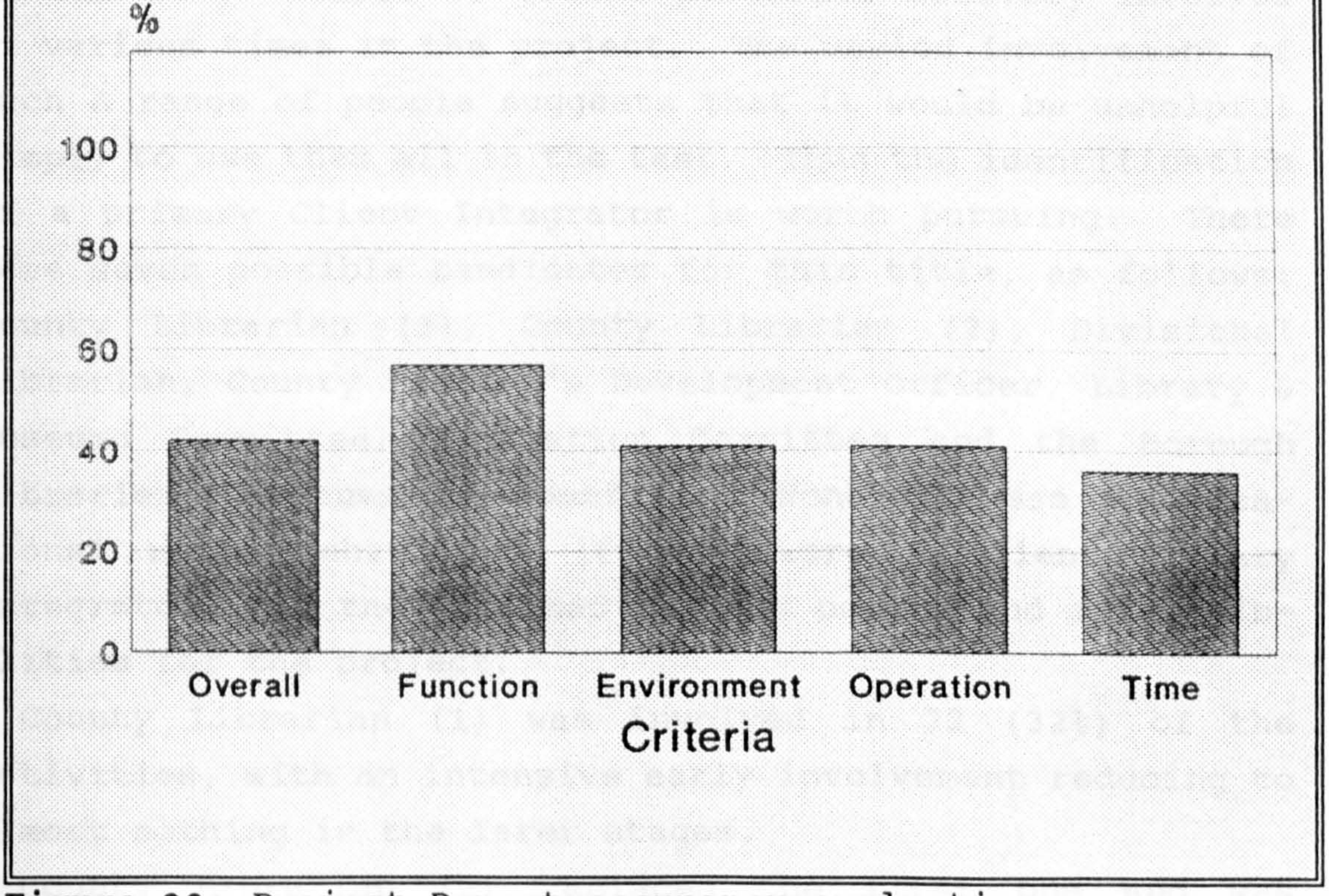


Figure 20: Project D post-occupancy evaluation

10. Incorrectly specified roof tiles
11. Mezzanine floor not performing satisfactorily
12. Unspecified maintenance costs higher than usual
13. Delays in planning and construction stages of project
14. Extra support needed for glazed front wall
15. Higher than usual cost

8.4 SUMMARY OF 3R ANALYSIS

The 3R analysis is summarised in Table XIX, and the main departures from the model are listed below:

- Mediocre Co-ordination in stages a2, a3, b2 & b3.
- Mediocre Feedback in stages a2, a3, b3, and c2; poor Feedback in stages b2, c3 & 4; no Feedback stage 5.
- Mediocre Control in stages 1, a2, a3 b2, b3 & 6; poor Control in stage c2.

- Mediocre Integration in stages a2 and c2; poor Integration in stages a3, b2, b3 and 6.
- Excessive Duplication in stages 1, a2, a3, c2 & 6.
- Mediocre Client Involvement in stage a3 & b3; poor Client Involvement in stages c3, 4 and 6; none in stage 5.

There was a great deal of difficulty in this project applying the test for Client Involvement. This problem lay in the large number of client personnel actively involved at various times in the project. The varied involvement of such a range of people suggests that it would be unhelpful simply to use them all in the test. Thus the identification of a primary Client Integrator is worth pursuing. There were seven possible candidates for this title, as follows: County Librarian (1), County Librarian (2), Divisional Librarian, County Library's Development Officer, Library & Museums Committee, Recreation Committee and the Borough Libraries & Museums Sub-committee. None of these organizational units behaved as if they were a client Primary Integrator, but they all had various powers and responsibilities for the project.

County Librarian (1) was involved in 22 (32%) of the activities, with an intensive early involvement reducing to almost nothing in the later stages.

County Librarian (2) replaced the first one and was involved only in the construction stage, for just 5 (7%) of the activities. If the two are treated as one organizational unit, then their combined involvement spans 38% of the work (they overlapped on one activity).

The Divisional Librarian was involved in 10 of the activities, giving an involvement over 14% of the work, and the County Librarian's Development Officer was involved in 15 (22%) of the activities, always only in a consultative role. With such a job title it would seem that this person may have been the Primary Integrator, but his actual involvement does not bear this out.

Of the three important client committees, the Library & Museums Committee was involved in only one approval and, despite its title, is probably insignificant in involving

the client with the development process. The Recreation Committee was involved in 9 activities (13%) most of which were exercising approval powers at decision points and therefore played an important role. The Borough Libraries & Museums Sub-committee was involved in 3 activities (4%) and was not significant in the decision-making process.

The important Client Integrators, then, are the County Librarian (1 & 2) and the Recreation Committee, whose importance stems from the Approval powers at decision points. The combined effect of these particular integrators, ignoring the others, is a Client Involvement of 45%.

Table XIX: Project D summary of 3R analysis

		DIFFERENTIATION				Feed	Cont	Integrn		Non	Cli
Stg	Op	Ln	Agg	Skl	Crd	back	-rol	Lnk	No	Dup	Inv
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
	no	no	%	%	%	%	%	no	%	%	%
1	2	3	100	67	100	100	50	1	100	50	100
a2	2	6	100	100	67	50	50	2	50	50	50
a3	7	32	100	88	50	57	48	10	30	57	57
b2	5	41	100	90	68	20	40	20	20	80	80
b3	6	48	98	98	50	50	44	30	13	83	67
c2	9	55	100	89	96	44	35	14	50	44	78
c3	9	42	100	86	95	22	74	34	88	100	33
4	6	37	100	95	95	17	72	21	76	100	17
5	11	78	100	92	91	0	73	58	81	91	0
6	12	91	100	92	97	100	64	51	16	42	42
	69	433	100	91	84	43	58	241	50	72	45

Stages:
1-Inception, 2-Feasibility, 3-Sketch scheme, 4-Detail design, 5-Contract, 6-Construction

Interpretation:

Column:	Meaning:
(a)	Identity of stage of work.
(b)	Number of operations in this stage of work.
(c)	Number of operational links within this stage of work.
(d)	Percentage of operational links with any form of differentiation
(e)	Percentage of operational links which are differentiated by skill.
(f)	Percentage of operational links which are co-ordinated.
(g)	Percentage of operations which exhibit proper feedback loops.
(h)	Percentage of elements of control present within operations.
(i)	Number of inter-operation links within this stage of work.
(j)	Percentage of inter-operation links with continuous directing.
(k)	Percentage of operations with no duplication.
(l)	Percentage of operations with involvement of the client.

8.5 DISCUSSION

Table XX shows how the deficiencies in the project are related to departures from the organizational model. The

Inception stage is the time to set up an appropriate organizational structure, thus the delays that plagued the entire project have been attributed to this stage, and the lack of an appropriate organizational structure could be attributed to the poor Control in the first stage.

Although the first two Feasibility and Sketch Scheme stages contributed slightly to the overall problems, the duplication of stages is a result of inadequate organizational structure, rather than the cause of outcome deficiencies. Since most of the work undertaken in those stages was abortive, it would be difficult to justify attaching much importance to their influence on the end result.

The final feasibility stage which resulted in the choice of this location committed the project team to a site which lacked car parking spaces. The adventurous shape of the building may be the reason for some users' perception of a mis-use of interior space, and the level of finishes and complexity of fabrication which also directly arose from this stage produced a higher than usual cost for the building. This extra cost seems to have been absorbed into the budget by reducing the scale of the scheme somehow, but it is not entirely clear. Mediocre Feedback and Integration, and poor Control are the organizational problems at this stage.

The ensuing sketch scheme will have committed the project to the internal arrangement of space. This produced poor access to the first floor, and layout problems such as noisy users conflicting with those who just wish to quietly read. There were also detailed problems with the layout, and continued commitment to higher than usual cost during this stage. Poor Feedback and poor Client Involvement would be the causes of any deficiencies arising from this stage.

At Detail Design stage many of the detailed decisions were taken which resulted in the poor heating and ventilation, lack of public toilets, lack of seating, inaccessibility to lower shelves, inadequate lighting, higher than usual maintenance costs, extra support being needed to withstand

Table XX: Project D deficiencies related to departures

Stage of Work:	Deficiency:	Departures from the model:
1 Inception	13	Poor control.
a2 Feasibility		Mediocre feedback, integration & client involvement; poor control.
a3 Sketch scheme		Mediocre feedback, control, co-ordination & client involvement; poor integration.
b2 Feasibility		Poor feedback & integration; mediocre control.
b3 Sketch scheme		Mediocre feedback & co-ordination; poor integration & control.
c2 Feasibility	4, 15	Mediocre feedback & integration; poor control.
c3 Sketch scheme	2, 3, 8, 15	Poor feedback & client involvement.
4 Detail design	1,5,6,7, 9,13,15	Poor feedback & client involvement.
5 Contract	10,11,12 15	No feedback; no client involvement.
6 Construction	11,13	Poor integration, duplication of co-ordination; poor client involvement.
7 Commissioning		No data available.

Key to deficiencies:

1. Poor heating & ventilation
2. Poor access to first floor
3. Poor layout with wasted space
4. Lack of car parking spaces
5. Lack of public toilets
6. Lack of seating
7. Inaccessibility to lower shelves
8. Noise and lack of privacy for quiet reading
9. Inadequate lighting
10. Incorrectly specified roof tiles
11. Mezzanine floor not performing satisfactorily
12. Maintenance costs higher than usual
13. Delays in planning and construction
14. Extra support needed for glazed front wall
15. Higher than usual cost per square metre

deflection of glazed front wall and again, more commitment to higher than usual cost. These problems seem to be a result of the poor Client Involvement observed at this stage.

The Contract stage includes specification as well as cost checking and estimating. It is considered that in this stage originated the incorrectly specified roof tiles, the structurally unsound mezzanine floor and the problems with the maintenance of carpet. At this stage there is no Feedback and poor Client Involvement.

Finally, the construction stage may also have contributed to the lack of performance of the mezzanine floor. It may also be partly responsible for the higher costs. These deficiencies could be connected to the mediocre Integration, Duplication of Co-ordination and absence of Client Involvement.

The organizational structure for this project produced a building which was very well liked by the users, but not very well liked by the staff. The average weighted satisfaction level for each of these groups is 73% and 44% respectively, giving an average level of 59%.

The overall indication is that the organizational structure was not properly equipped to deal with the complexity of the environment. Many of the organizational problems may have been avoided had the organizational structure been designed adequately in the first instance. The success of the project is due to the commitment and enthusiasm of one or two individuals, and much effort was expended by the project team in trying to mitigate the effects the project's environment, rather than working on the detailed design problems they were appointed to deal with. This wasted effort must be a major contributory factor to the technological difficulties encountered on this project.

CHAPTER NINE: DISCUSSION OF RESULTS

The results are discussed in terms of the compatibility of the model with observations of case studies. The application of the new technique of post-occupancy evaluation is considered, and its relationship with the analysis of organizational effectiveness. Skill diversity is related to environmental complexity, and the results are discussed in terms of their implications for the hypotheses and the model.

9.1 COMPATIBILITY OF THE MODEL WITH OBSERVATIONS

In order to maximize the potential for success of construction projects, their organizational structure should be designed according to the principles expounded in chapter three. The model that has been developed shows stages of work taking place in a flexible sequence, with possibilities of overlaps between some of the stages. Three of the case studies exhibited repeated stages of work. This was not foreseen in the theoretical discussion of the model. On examining the results from the organizational tests, it seems that in all three cases of repetition, the reasons for abortive work lie with deficiencies in the organizational structure used. The flexibility of the model lies in the generalized nature of the definitions used for the stages of work; and this means that it meets the quirks of construction organization without any problems.

The punctuation of the stages of work by decision points was observed, as predicted. In many cases the decision making process was highly tortuous, being subject to long chains of Approval and Recommendation as various committees vetted each other's decisions. The 3R charts show that the organizational unit which was to use the facilities being built was not always involved in the briefing or decision-making process. Decisions were often taken by a variety of

committees and senior officers who were remote from the users. For example, decisions about the location, layout and design philosophy of the fourth case study (the branch library) were taken by the Chief Architect in conjunction with the Planning Authority. The Libraries Committee had little choice in the matter. This produced a building which although not ideal as a library, is architecturally very successful.

All four case studies matched the analytical model closely in terms of the structure of Managing, Control and Operating Systems.

The second step in discussing the detail of the results is to examine the success with which the mapping technique can cope with the actual observations made of the various organizational structures. The mapping technique lends itself well to the expression of projects as a series of linked stages. It also takes account of the situation where some stages overlap.

In the initial stages of this study, Walker's data format was explored. One of the consequences of using Walker's data format was the extent of data manipulation. The case studies used here were so large and complex that the LRA diagrams were up to 7 metres long, and a computer programme had to be developed in order to analyse the projects and count the various items required in the tests. The simplified data format renders this unnecessary because the analysis is much quicker and easier. An example of the speed of analysis is given by case study A which took nearly a week to analyse using Walker's data format, but only a matter of hours to analyse using the new data format.

9.2 POST-OCCUPANCY EVALUATIONS

The results for each of the tests must be considered in relation to the achieved success of each project. Although it is inadvisable to place much credence on a single figure summarizing an evaluation (Blachère, 1970), there is some merit in seeking a single quantity purely for the sake of

indicating comparability between projects. This is always providing that any such single figure must not be allowed to assume more importance than the component parts of the investigation. In terms of relating the success of a project to its organizational structure, it is the individual parts of the assessment which contribute the most useful information, not the final overall figure.

The structure proposed for post-occupancy evaluation in chapter two produces a survey which is tailored to suit each project in terms of details, whilst retaining a pattern which enables comparisons between projects at a more general level. The aggregation of the responses to derive a single quantity indicates the overall success of each project. These scores are summarized in Table XXI.

Table XXI: Summary of P.O.E. results

Project	Success	Description
A	59%	Hospital kitchen/diner
B	81%	Day care centre
C	49%	Police headquarters
D	59%	County branch library

The most important qualitative information from the P.O.E. is the list of perceived deficiencies in the finished building. By examining the project diary it has been possible, for each of the case studies, to determine which stage of work generated each deficiency. This is an important step forward in the evaluation of the effectiveness of building project organization.

9.3 RESULTS FROM THE TESTS

The tests on the case studies are discussed in relation to each other, and observations are given on the organization of public sector building projects.

9.3.1 Skill diversity

The first hypothesis was that in order to maximize the potential success of a project, the organizational structure

should provide a level of skill diversity that matches the environmental complexity. This is the test of contingency. As noted in chapter five, the technique of measuring complexity in the environment produces an ECI which still requires calibrating. The results from the case studies for this particular test cannot be discussed in isolation from each other. But before looking at the results, the problem of relating environmental complexity to project complexity needs to be examined.

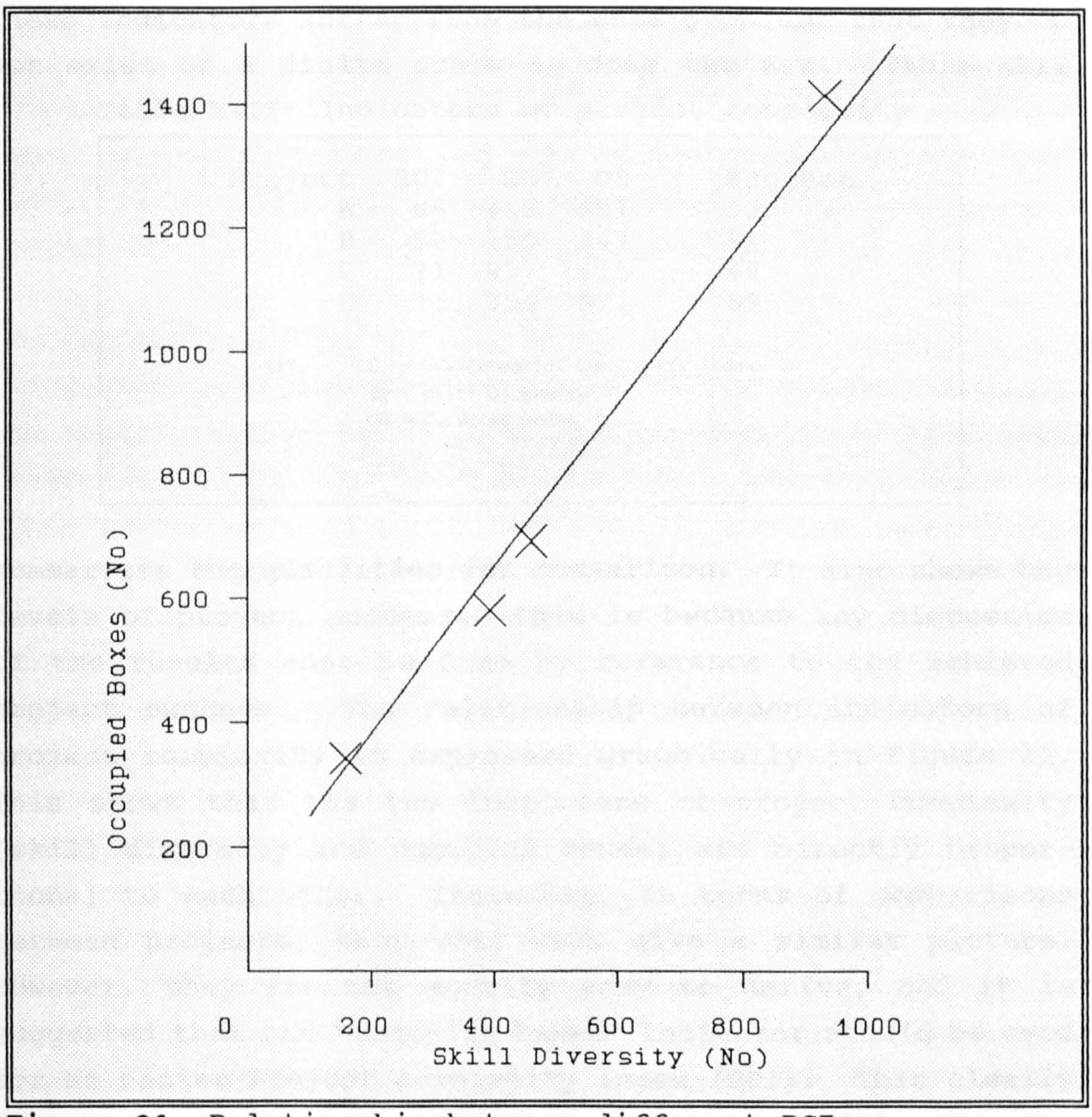


Figure 21: Relationship between different PCIs

9.3.2 Environmental complexity versus project complexity

The ECI is expressed as a percentage, but the minimum possible value it can have is 33%, due to the scoring technique used. If the number of differentiated links is taken to represent skill diversity, then this scale has no theoretical maximum, and is therefore difficult to relate to the ECI which is in the range of 33-100. An alternative indicator of project complexity could be the number of boxes on the charts which have roles entered in them. Both of these indicators suffer from the same problem; that they do not exist on a finite scale as does the ECI. Table XXII

Table XXII: Indicators of project complexity

Project	ECI	SD	OB	Success
A	66	463	691	59
B	52	159	343	81
C	71	937	1415	49
D	74	396	578	59

KEY: ECI = Environmental Complexity Index
SD = Skill Diversity
OB = Occupied Boxes

summarizes the quantities for comparison. It also shows the levels of project success. This is because any discussion of the results must be done by reference to the achieved project success. The relationship between indicators of project complexity is expressed graphically in Figure 21. This shows that the two indicators of project complexity (skill diversity and occupied boxes) are directly proportional to each other. Therefore, in terms of comparisons between projects, they will each give a similar picture. However, they are not equally easy to derive, and it is suggested that the "occupied boxes" indicator should be used for an easier Project Complexity Index (PCI). This clearly shows that it is unnecessary to examine the skills of every person in the operating system in order to arrive at a figure for Skill Diversity. The same comparative assessments can be derived by simply counting up the number of occupied boxes in the 3R chart. This may well be because

most of the operational links display very high levels of differentiation; but it is clear that the two quantities are very closely linked. Therefore it can be concluded that future analyses need only count the number of occupied boxes to assess the project complexity.

With only four case studies it is clearly impossible to statistically analyse the relationships between the variables of ECI, PCI and project success.

9.3.3 ECIs & PCIs from the case studies

Project B had the simplest environment, the simplest organizational structure and the best level of success. As such it may be taken as an approximate datum amongst these four cases, indicating the requisite level of project complexity for an ECI of 52. The ECI for project A is higher than that for project B, at 66, but the PCI is nearly twice the level of project B in terms of occupied boxes. Since the increase in PCI is far greater than the increase in ECI, it may be assumed that the increase in PCI is too much (i.e. there is too much Skill Diversity in project A). This accounts for the reduced level of success on project A compared to project B.

Project D has the same level of success as project A, at 59%. Therefore, for these two projects the relationship between ECI and PCI may be expected to be similar. However, whilst the ECI for project D is the highest, at 74, the Skill Diversity is slightly lower than that for project A. Since the level of success is no better, it may be assumed that the reduction in the level of Skill Diversity is too severe.

Projects C and D had similar ECIs, but project C had a PCI more than double that of project D. Since project C resulted in a lower level of success than D, then it may be assumed that the project organizational structure was too complex. The project organization is so diverse as to be entirely inappropriate to the environment within which it is operating. Thus, the level of success for project C is the worst of all four cases.

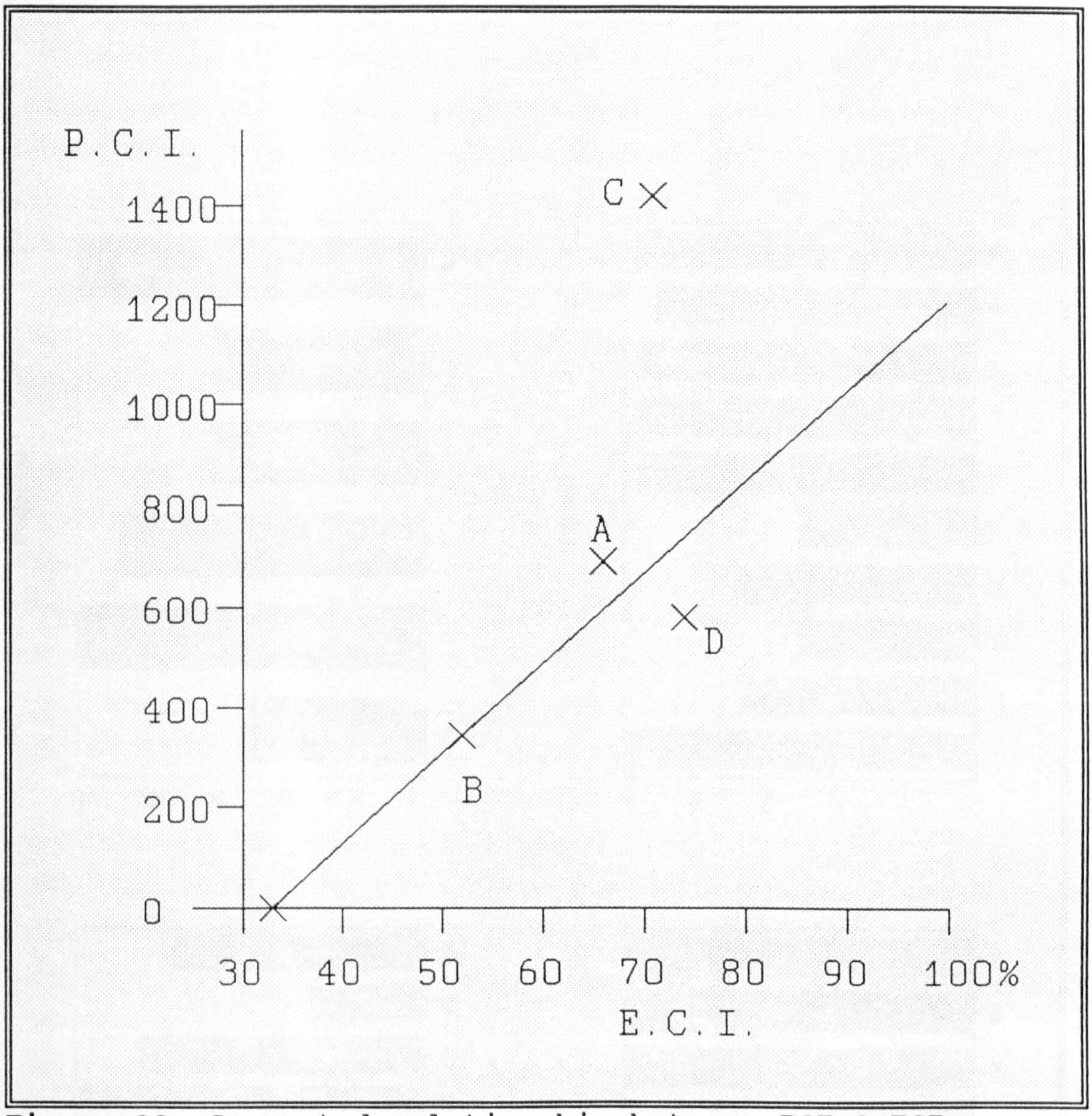


Figure 22: Suggested relationship between PCI & ECI

Despite this, some speculation ought to be offered relating project complexity to environmental complexity. Firstly, an imaginary project of ultimate simplicity would have a PCI of 1 and an ECI of 33 (the calculation for ECI precludes lower figures than this). Also the result for project B established that a PCI of 343 was approximately appropriate for an ECI of 52. This gives us two points from which to construct a relationship. The preceding discussion indicates that the PCI for project A was too high, and the PCI for project C was exceedingly high. Also, the PCI for project D was considered to be lower than appropriate. These deviations could be explained if a straight line is drawn

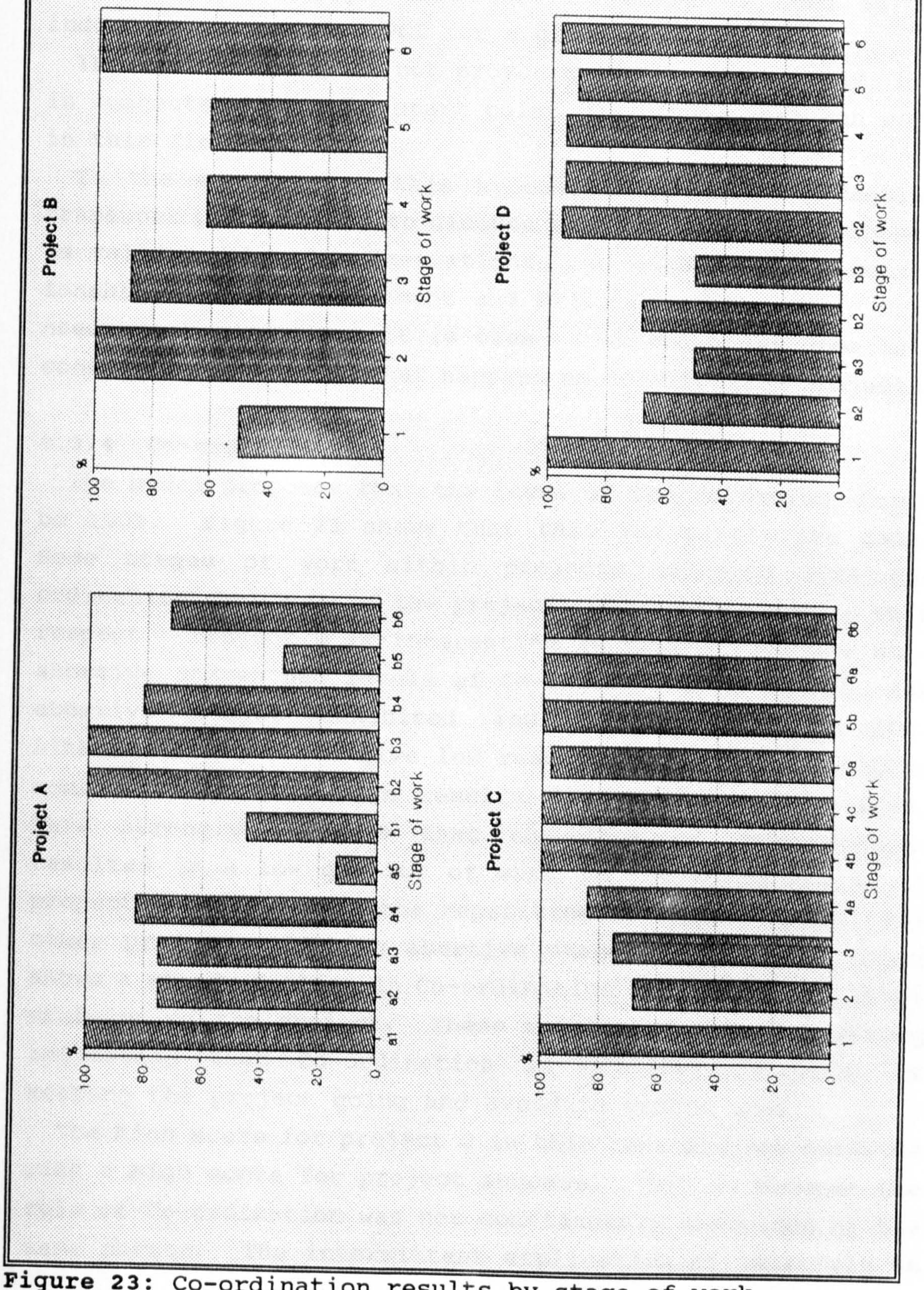


Figure 23: Co-ordination results by stage of work

through a graph of ECI vs PCI, as in Figure 22. This straight line relationship is purely speculative and is an attempt to point the way towards an answer to the question "how complex should a particular organizational structure be?"; i.e. the graph in Figure 22 could be used as an indicator of expected PCI for a given ECI.

This relationship is not proven by the current study, but is suggested here as a start point for future research work in this field.

To the extent that this hypothesis provides a regular framework within which to discuss the issues, the hypothesis is validated by the observations. To ascertain the relationship between environment and Skill Diversity, more work needs to be done; but it is clear that the model creates a consistent picture of what happens on construction projects.

9.3.4 Co-ordination

The model proposes that the level of Co-ordination should be 100%. Figure 23 shows that this was rarely the case. Some stages of work within projects achieved 100% Co-ordination, but none of the projects were consistent in this respect. Project D is interesting in that all of the non-abortive stages had levels of Co-ordination above 90%, and abortive stages exhibited low Co-ordination results. Although other tests give low results for abortive stages, none of them give high results for non-abortive stages. This strongly suggests that the lack of Co-ordination resulted in a low quality of work in the early stages of project D which led to the repetition of those stages. The other project suffering abortive stages (project A) also shows a steady decline in Co-ordination leading to the total shelving of the project. These results give a very strong indication that Co-ordination is critical in terms of keeping the project going and avoiding wasted work.

The high score for project C in this test did not coincide with a high score for project success. This is because the role of Co-ordination was not continuously exercised by the same person. The intermittent application of this role is

not revealed by this test, the focus of which is the Operation. It is the test for Integration which reveals Discontinuities in the Managing System, (i.e. intermittent application such as this).

This hypothesis has been tested by examining each Operational link in the Operating System for the application of the role of Co-ordination. This role is defined for whole Operations only. Because of the distinction now drawn between Co-ordination and Integration, and the preceding conclusion that the number of Operational links need not be examined for Differentiation, it is now feasible to suggest that Co-ordination can be expressed as the percentage of Operations in which the Co-ordinating role is exercised.

The hypothesis has shifted the emphasis away from detailed considerations of types of Differentiation, and their concomitant demands for Integration. This has been done in the interests of streamlining the model. The explanations of organizational deficiency produced by this test are validated by the case studies, thus this simpler approach is justified.

9.3.5 Feedback

The third hypothesis tested the level of Feedback. The model proposes that this should be 100%. Figure 24 shows that project A demonstrated a very high level of Feedback, at 94%, whereas the other projects showed marked departures from the model. Projects C and D were particularly erratic in this respect.

Project D has the worst score for Feedback of all four cases, but the achieved success was not the worst. However, during the P.O.E. survey, there was a lot of dissatisfaction expressed by the client-employees with the extent to which they felt able to influence the design of the building and the finishes and fittings. It was clear that this was always "the architect's building", which the library would use after it was designed. On the other hand, the interviews on project A revealed very little dissatisfaction from the client's project team. These results suggest that the

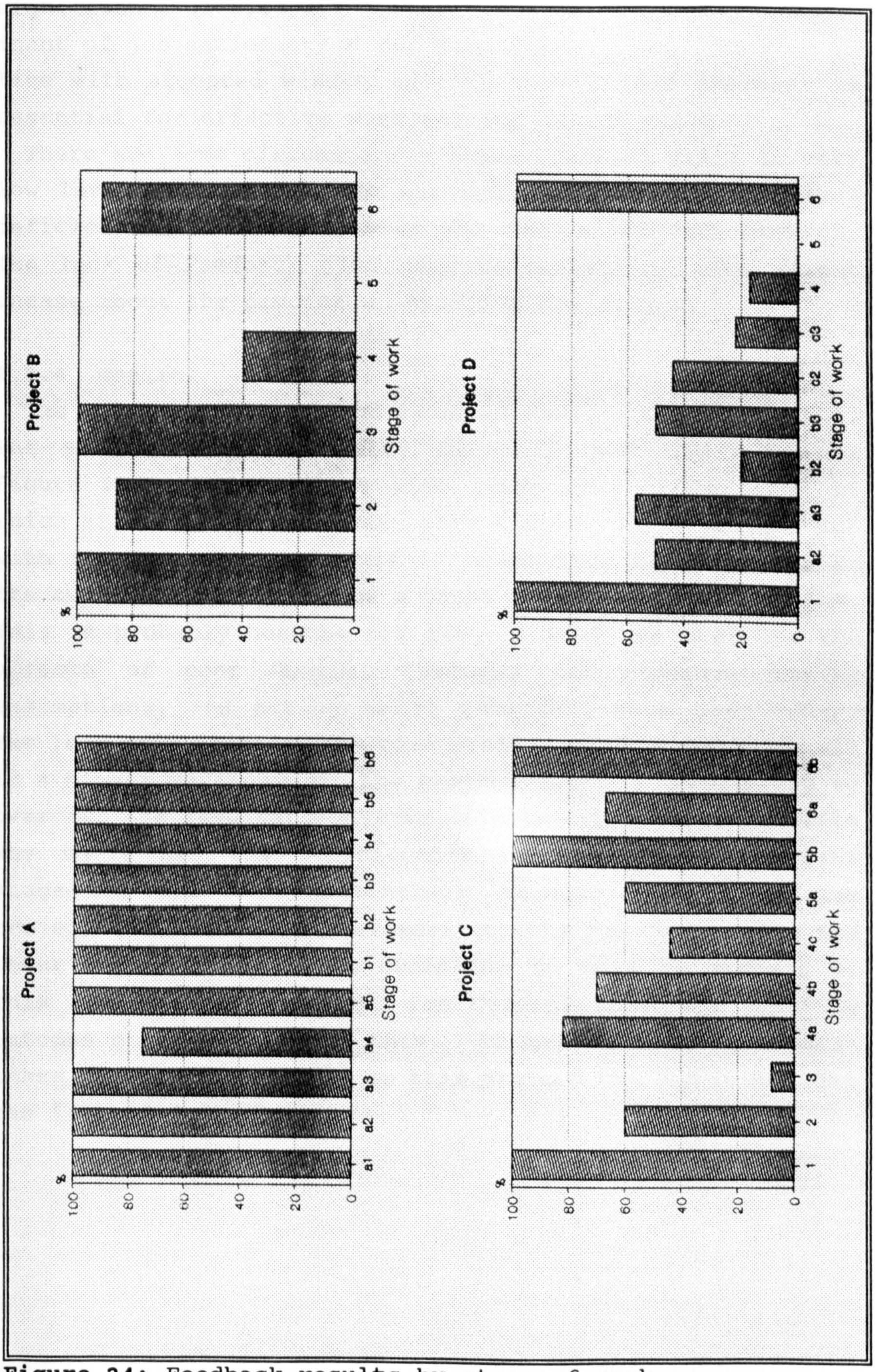


Figure 24: Feedback results by stage of work

significance of Feedback is that it is an important determinant of job satisfaction for the project team. This is in line with accepted wisdom on this topic; that feedback is essential for effective work and job satisfaction.

There are some circumstances where Feedback falls to very low levels, but this does not always result in perceived deficiencies in the review of the success of each project. The lack of Feedback does seem to correspond with client unease about the process of briefing and design.

9.3.6 Control

The model states that the level of Control should be 100%. The summary of the results for this test are given in Figure 25. This shows a wide range of results, some of which are very low. However, when considered in conjunction with the P.O.E. results, it is clear that poor Control on its own does not seem to be a cause of project deficiencies. This is probably because the project team can overcome the effects of poor Control through, for example, making assumptions, and acting as if decisions have been taken. The lack of Control on the case studies will probably result in a higher workload for the project team, in attempting to overcome the resultant adverse effects. This would explain why there are few deficiencies arising from particular stages of work with low Control: It also explains why the projects with the lowest overall results for Control are the least satisfactory. The exception to this is project D. This had the worst result for Control, but the achieved outcome does not reflect this. It may be that the inordinate number of personnel on this project was connected with the lack of Control.

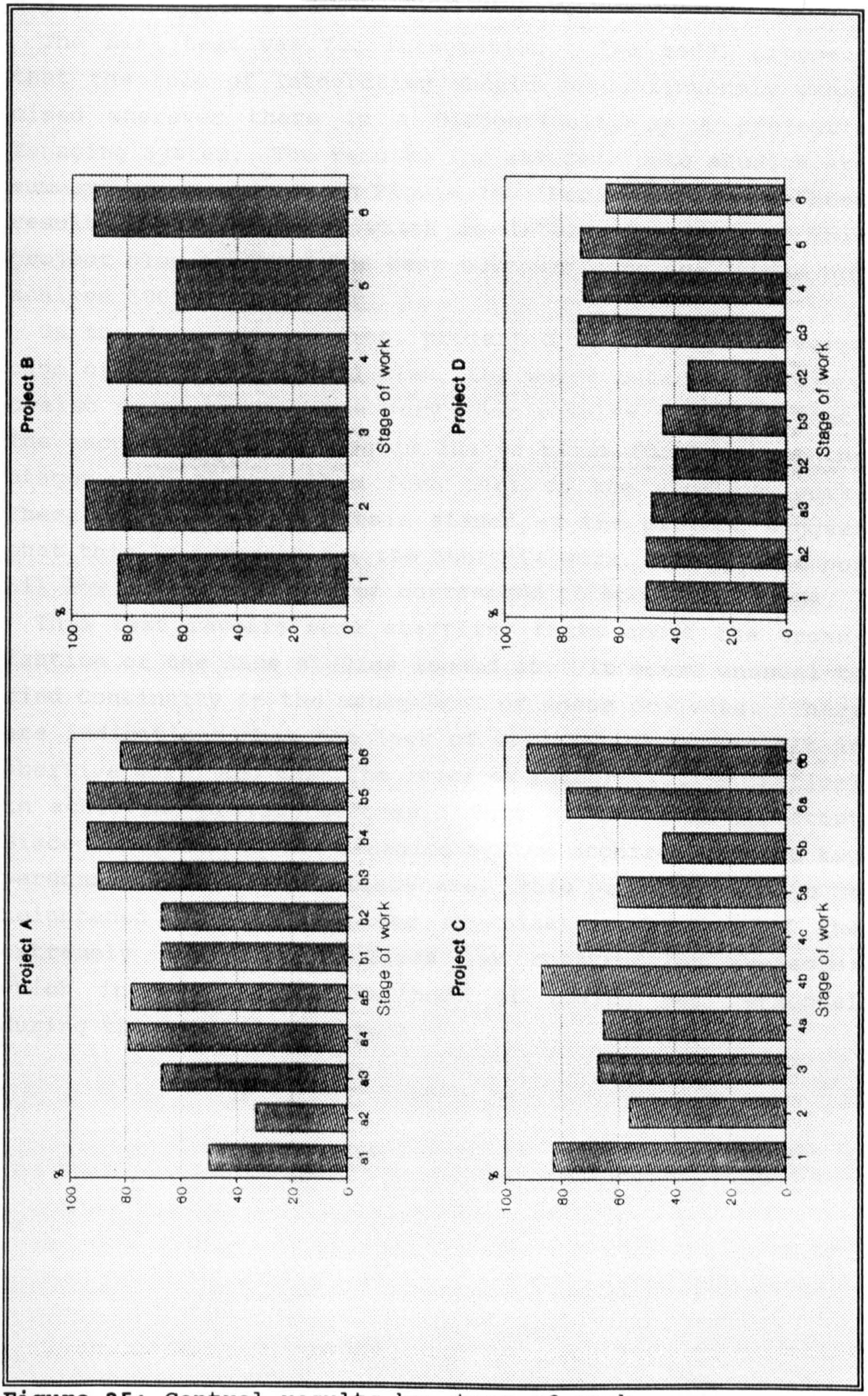


Figure 25: Control results by stage of work

9.3.7 Integration

The next test was for Integration. The model proposes that the role of Integrating should be continuously exercised wherever there is a Discontinuity in a project's Managing System. The results for all four case studies are summarized as a graph in Figure 26. Project B has the best results for this test, which is interesting because this project also produced the best outcome; even so, it did not achieve 100% Integration.

Of the four case studies, project C is clearly the worst case of Integration, and also, the worst outcome. Project D also demonstrates some very poor results for this test. The amount of Integration is 20% or below for three of the stages, and two of them form part of the abortive work. These low scores in certain stages of the project suggest that this is a reason for the abortive work, except that not all low Integration scores correspond to abortive stages.

This test reveals some startling facts about the organization of the case studies looked at. It seems unusual to find Continuity in the management of these projects. There are indications that the lack of Integration can result in abortive work, and that the level of Integration is critical in achieving project success. Some of the most important Discontinuities in the Managing System occurred because key personnel left, to work elsewhere. This problem seems to be heightened in public sector organization because of the extremely long lead-in times for construction projects; which increases the likelihood of losing key personnel during the life of a project.

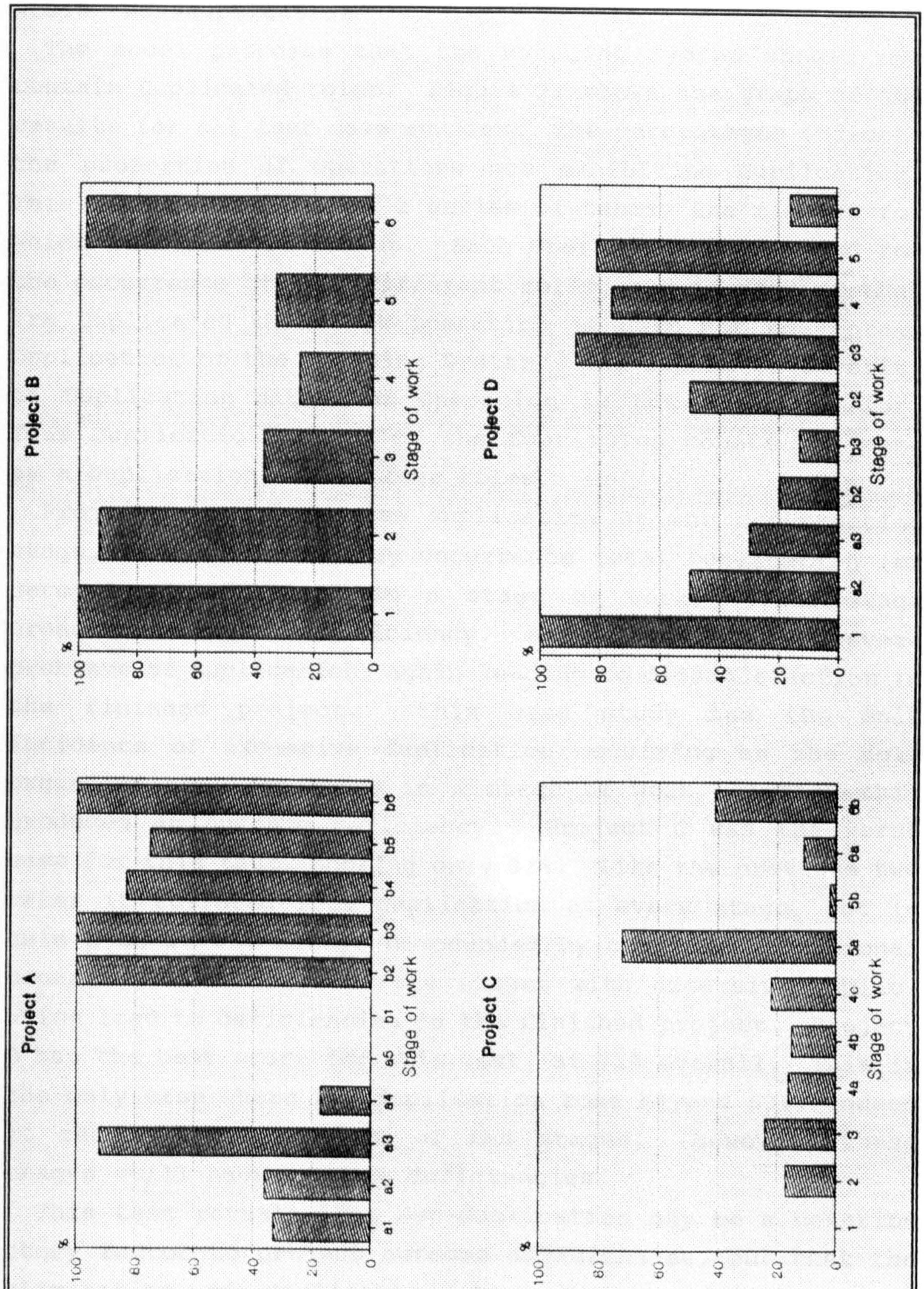


Figure 26: Integration results by stages of work

9.3.8 Non-duplication

The model proposes that the Managing System should not contain Duplicated roles. Figure 27 shows the graph of the results for all four case studies. The percentages indicate the proportion of Operations not exhibiting Duplication. This test is effectively a series of tests, the figures for which have been rolled up. Each Operation is examined for the occurrence of four different roles, and if none of them are Duplicated then that Operation is said not to contain Duplication of the Managing System. The extent or severity of Duplication within an Operation is not accounted for. Thus Duplication of one of the four roles counts the same as a Duplication of all four roles.

Project A has excessive duplication at the construction stage, which was the only occurrence total Duplication (or zero Non-duplication) in a stage of work. This stage produced an outcome deficiency. Project B also had severe problems of duplication, again leading to dissatisfaction in the finished project. This case study had the only incidence of excessive duplication occurring as the sole organizational departure in a stage of work. Again, this produced an outcome deficiency. Project C was the worst case for this test, scoring only 33%. Like the previous two cases it suffered from duplication at every stage, but in this case it was always compounded by other organizational departures. Not all of the stages with excessive Duplication lead to deficiencies in the finished project. Project D had the best score for this test, at 72% overall. This is the only case where Non-duplication rose beyond 83%; indeed it reached 100% for two of the stages. However, these stages still have outcome deficiencies.

This test reveals that Non-duplication may be a contributory factor to project outcome deficiencies, but that the elimination of duplication does not eliminate project deficiencies. The implication is that excessive duplication will produce a sub-optimal result, achieving satisfaction for none of the contributors. There may be good reasons for this to happen, but the case studies suggest that the

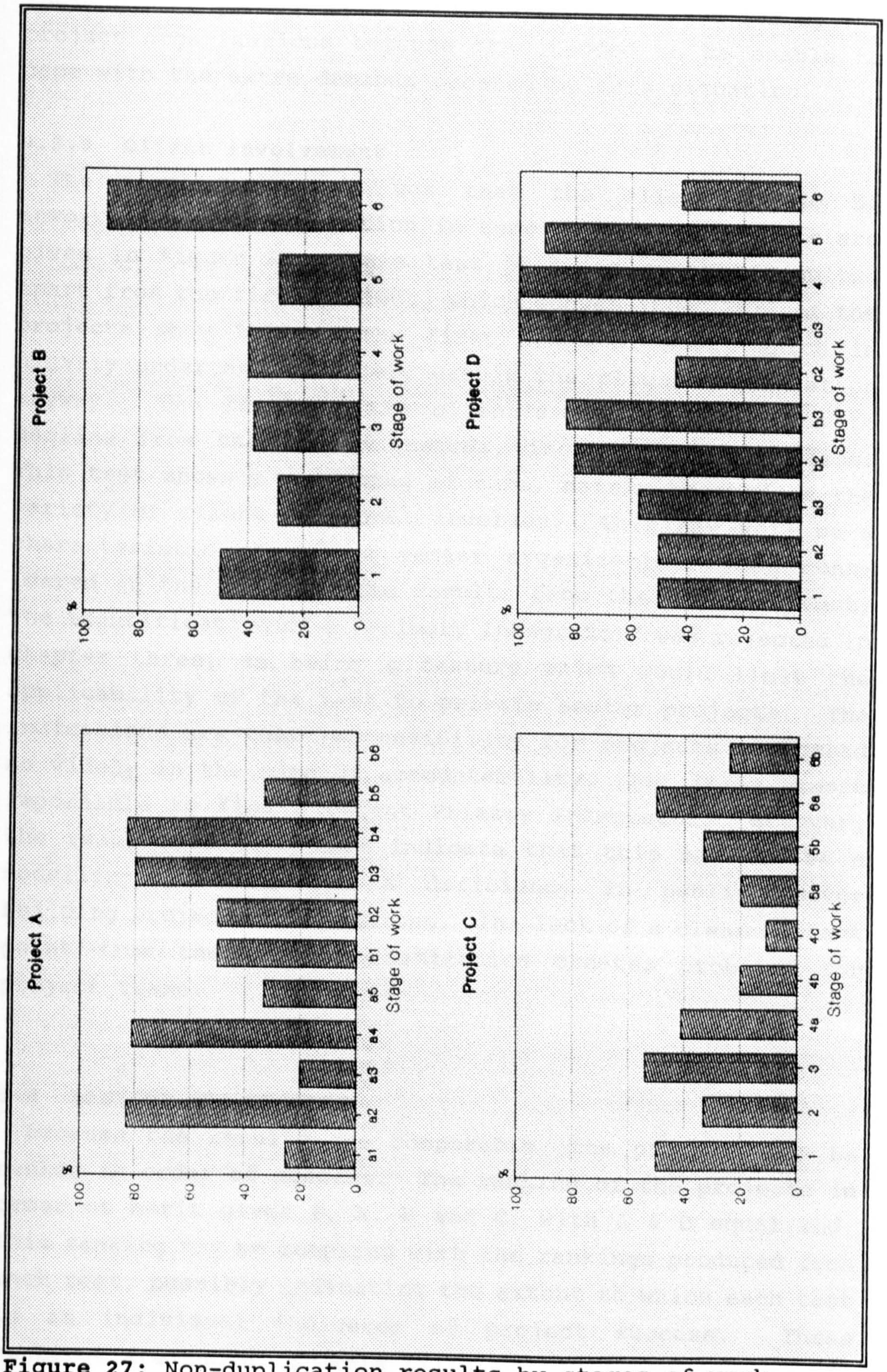


Figure 27: Non-duplication results by stages of work

incidence of intense Duplication was not planned for by the project organizations because they tended to be unable to cope with the extra demands created by this situation.

9.3.9 Client involvement

The final hypothesis was that the client should be involved in every Operation in some role. The results are given in Figure 28. This test produces erratic results, apart from the first project, which scores 100%. All of the projects show 100% in the first stage of work, which is usually undertaken entirely within the client organization anyway. The level of the client's involvement seems to decline from that point onwards, in three of the cases. This test shows a confusing picture, mainly because of the variety of client personnel involved. This may well be a characteristic of public sector organization, when considered in the light of the results from the previous test. The identification of a "Primary Integrator" was rejected in chapter three, as being a feature which would limit the applicability of the test to private sector projects. The indications are that responsibility for projects is spread so widely in the name of accountability, that it is almost impossible to find a client Primary Integrator. However, the results of this test indicate that this may not be a modelling problem, but a deficiency in public sector building project organizations. The lack of a clear contact point from the client organization creates problems for project teams.

9.4 RANKING THE RESULTS

Because the results are comparable, the projects can be ranked in order of success. The ranking of the projects in order of merit gives B, A, D and C, with A & D equal 2nd. This ranking may be compared with the rankings produced from each test, possibly indicating the extent to which each test is an individual indicator of project success. These rankings are shown in Table XXIII.

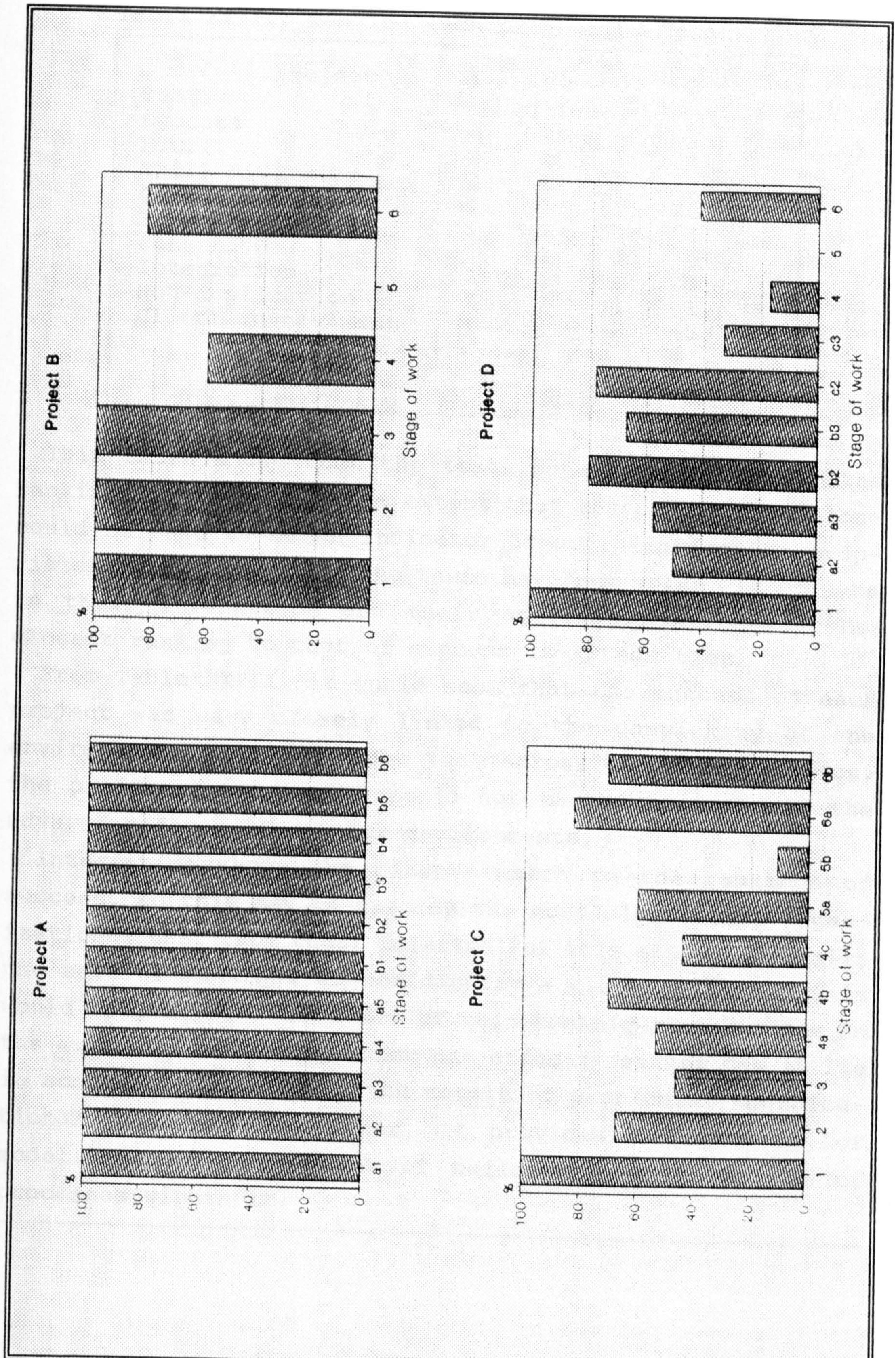


Figure 28: Client involvement results by stages of work

Table XXIII: Ranking each project by test

Project	A	B	C	D
Test:				
Success	2	1	4	2
E.C.I.	2	1	3	4
Skill diversity	2	4	1	3
Co-ordination	4	2	1	3
Feedback	1	2	3	4
Control	2	1	3	4
Integration	2	1	4	3
Non-duplication	2	3	4	1
Client involvement	1	4	2	3

1 = highest score, 4 = lowest score)

This table shows that the tests do not conform with the ranking for success to the extent that any one of them alone could be said to be an indicator of organizational appropriateness. Clearly, if the tests have any value, it will be in their interaction and their aggregated effects. The closest ranking to that of success is Integration.

From Table XXIII, it would seem that the success of each project was very closely linked to the complexity of the environment. This suggests that across all four projects, the project teams simply could not manage to mitigate the adverse effects of complex environments.

Integration shows the closest match to the rankings of success, so this may be seen as the most significant organizational test from those selected for this study. Overall, the sets of rankings do not display a close pattern. This would suggest that the value of this technique cannot lie in the area of identifying cause and effect; neither can it lie in accurately predicting the result of particular organizational departures. Rather, it provides a framework for modelling the procurement of buildings and a variety of processes within it.

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CHAPTER TEN: CONCLUSIONS & RECOMMENDATIONS FOR FURTHER WORK

The extent to which the objectives have been achieved is discussed. The discussion is in six parts; the use of the case studies, the creation of the new model, the use of the new model as an analytical tool, recommendations about public sector construction, limitations of the work, and recommendations for future work.

10.1 THE ANALYSIS OF PUBLIC SECTOR CASE STUDIES

The first objective of this study was to analyse the way in which the public sector of the construction industry is organized. This objective arose from participation in a research project funded by the Science and Engineering Research Council about the performance of building project organizations. The goals of the SERC project were (a) to analyse building projects using the Linear Responsibility Analysis (LRA) technique to identify and measure the organizational features which affect the performance of project organizations; (b) to develop a method of measuring the performance of project organizations in terms of success in meeting project objectives; and (c) to relate the performance of project teams to the project structure adopted, in order to determine the factors which contribute to effectiveness in achieving project objectives.

The pioneering work in this field was undertaken by Walker (1980), who developed the technique of LRA. Walker's case studies were all from the private sector of the UK construction industry, and it was clear that there was much scope for extending the applicability of his technique. In applying LRA to public sector projects, it became apparent that there was much work to be done to develop and refine the techniques. The current study was undertaken in order to do this. When this study was commenced, the aim was simply to apply Walker's model to the public sector of the

construction industry, with the intentions of extending and validating it. One of Walker's recommendations for further research was to undertake a comparative study of different organizational structures. To this end, the four case studies were chosen in order to stretch the analytical technique, and to develop the potential for comparative analyses. In order to achieve this, the case studies, although all from the public sector, were deliberately chosen for their diversity. It was also thought that this would avoid the problem of too much "narrowness" in the applicability of the findings. The approach soon revealed many limitations in the model, and it became necessary to include an additional objective: the development of a new model which was simpler, more robust, and capable of encompassing both private and public sector projects. The complexity of public sector projects, compared with the private sector projects in Walker's study, resulted in a very close scrutiny of the level of detail necessary for an analysis of organizational structure.

The net result of the modifications to the original objectives is that the focus of the study has shifted from the application and validation of a model. It has become a study of the way in which organizational structures for building projects can be analysed, using four case studies from the public sector by way of example. The diversity of the case studies, and the small number of them, has meant that the findings, whilst broadly applicable, cannot be claimed to be definitive for all construction projects. The limitations arising from this approach are discussed in section 10.5.

10.2 THE NEW MODEL OF THE PROCESS OF BUILDING PROCUREMENT

The first objective was closely linked with the second, which was to use a systems approach to model the organizational structures used in public sector construction. This approach has resulted in two distinct strands to the investigation; (a) modelling the process, and (b) hypotheses about

the best strategies to adopt in the management of building projects. The remainder of this section deals with the developments in the model, and section 10.3 deals with the hypotheses which have been tested.

10.2.1 The Model

The analysis undertaken to achieve the first objective provided a thorough basis for the model-building required by the second objective. The new model is capable of describing a wide range of projects in terms of the relationships between tasks, and the roles and responsibilities of the contributors. It provides a robust and consistent picture of the various processes taking place within and around a building project. Briefly, according to the model, the project exists as a mechanism for enabling the client organization to respond to its environment. In this way the building project is a mechanism for change. The client's Policy Decisions form the trigger and terminus to the process of building procurement. This process is sub-divided into Stages of Work, each terminated by a Strategic Decision. Each Stage of Work is further sub-divided into a series of Activities which are punctuated by Tactical Decisions. These Activities are sub-divided into Operations punctuated by Operational Decisions.

10.2.2 Decision points

The new set of decision points at the strategy level provide a useful framework within which to analyse building projects. It is clear from the analysis of plans of work that all building projects pass through similar stages, and the results from the case studies confirm this. Initially, it seemed that three of the projects seemed to depart from the ideal state. However, it is interesting that they could easily be defined in terms of the set of decision points once it was acknowledged that Strategy Decisions, and therefore Stages of Work, are repeated.

10.2.3 Managing, Control and Operating Systems

The Managing System regulates, maintains and adjusts the process of building procurement in terms of the project's environment. This is effected through the Control System, at the Tactical level. The Operations can be linked sequentially and/or reciprocally. The interconnections and flows of information at this level constitute the Operating System. The definition of an intermediate level of system, the Control System, is new in this study. This has produced a more flexible framework for modelling the various processes involved in the organizational structure of the case studies. It has enabled observations of the way in which environmental influences impinged on the case studies.

10.2.4 Role Specifications

The relationship between a contributor and the project can be expressed as one or more roles. The development of a simpler specification of roles in this study signifies another area in which progress has been made. The inconsistencies and ambiguities which hampered earlier models have been eliminated.

10.2.5 Mapping Technique and Analysis

The mapping technique has been successful for all four case studies. It has been based very firmly in previous work, and its antecedents are clear. The 3R charts are very much more straightforward, both in preparation and in interpretation than their predecessors. The symbols used for role representation are much more accessible than those used in previous techniques. In terms of what has been lost by the introduction of a new mapping technique, three items stand out. Firstly, the overall picture of the whole project is not given on one piece of paper. Secondly, the Feedback loops are not drawn as lines relating decisions to each other. Thirdly, the levels of Differentiation are not marked as clearly, and require counting in order to extract them from the data.

The biggest advantages of the 3R charts are the conciseness with which the information can be conveyed, and the interpretation and analysis of the data contained in them. Under the LRA method, aspects such as Feedback, Differentiation and Integration could be seen, but their detailed quantification could only be effected by compiling calculation tables as an intermediate step. The data could be extracted, but only after a considerable amount of data manipulation. Under the new mapping technique, these aspects can be ascertained by inspection, and extracted operation-by-operation for all of the tests. This greatly reduces the time spent on data analysis.

10.2.6 Application of the New Model and Mapping Technique

This study can be placed in the context of earlier works by reference to the works of Woodward (1965) and Brech (1975) as quoted on page 15. The new model meets the needs outlined by Woodward for a technique to systematically describe and quantitatively evaluate complex organizational structures. It also answers her question about the assessment of the appropriateness of an organization to the needs placed upon it. The set of decision points are applicable to all of the case studies, and this confirms Brech's assertion that there are basic maxims applicable to organizations. The model allows for considerable differences in particular applications.

Three of the four case studies were subject to extreme pressures from the environment and from the client to such an extent that stages of work were aborted and repeated. Repetition occurred when the organizational structure departed from the ideal patterns described in chapter three. This repetition, therefore, may be viewed as a consequence of disorganization. These extremes were easily accommodated by the model.

The adequacy of the model is borne out by the following quotation from Leavitt, Dill & Eyring (1973);

> "Perhaps we should measure the worth of a model not only by how well it predicts, but how successfully it modifies human behaviour. If it makes

> people more effective than they were, or helps them learn faster, then it is a good model."

The model given in this thesis is not a predictive model to the extent that all organizational problems can be predicted and overcome before they arise: Rather it is a descriptive model which will allow people successfully to design and communicate their ideas for effective organizational strategies.

One of the key issues revealed by this study is the dissatisfaction of building users (particularly the workforce within a new facility) with the process of building procurement. In the public sector this arises because in many cases the users are not involved in the early stages of the project; instead the funding body is solely responsible for the development of the project. This creates, more than ever, a need for a model of organization which will enable the establishment of opportunities for proper and timely participation of the users of a building in its development. As Brauer & Preiser (1976) state;

> "As organizations grow in size and complexity, the future occupants of facilities become more and more removed from the process that provides the facilities they need. This phenomenon results in misfits between the occupants and the facilities delivered for their use."

This is an area where the model offered in this thesis can have a tremendous effect. The systematic methods which are suggested here provide a framework for ensuring that objectives are related to environments and appropriate control systems are created within the project to ensure that what is being produced is suitable. The discussion below (in section 10.3) on feedback and project evaluation is also important in this context.

10.3 ORGANIZATIONAL STRUCTURE AND PROJECT OUTCOME

The third objective of this study was to seek relationships between the structure of an organization, and the outcome of a project. The study has focussed upon the

structural aspects of organizations, to the exclusion of behavioural aspects. The exclusion of behavioural aspects was made for several reasons. In order to make progress in the development of analytical techniques it has been necessary to be rigorous about which aspects of organizations to model, and to be very specific about the level of detail of the analysis. The study of behaviour in organizations is very important, and the relationship between an individual and the organization is critical in determining the effectiveness of the individual. It is a part of any manager's duty to mitigate the adverse behavioural aspects and harness the positive behavioural aspects of individuals under their responsibility. However, before studying the behaviour of an individual in a particular role, it is first necessary to be able to specify the role accurately. It is only through modelling the organizational structure that an objective picture of a person's role in an organization can be formed. This will then provide a basis against which perceptions of roles may be analysed.

The study of organizational structure in construction projects is essentially a study of professionals. By omitting any analysis of behavioural issues, the analyst is implying an assumption that these people are professionally competent. Clearly, this will not always be the case, but no evidence of professional incompetence was encountered in the case studies.

It is recognized that an ideal organizational structure may not produce an ideal building because of the behavioural aspects which may be affecting the way in which people perform their duties. However, the modifying effects of organizational behaviour are at a different level of detail to the overall picture of organizational structure related to project outcome. In this respect, this study has focussed upon the project organization as the unit for analysis, rather than the individual, and any conclusions drawn from the study have to be drawn with this in mind.

Relating the organizational structure to project outcome has necessitated the development of the new technique of

post-occupancy evaluation. The methods used to evaluate the building projects' outcomes have been shown to produce useful and comparable results. The fact that some structure can be imposed on the evaluations of different projects makes comparative assessments feasible.

It is clear that this framework provides a very useful basis for undertaking the evaluation of completed building projects. Each evaluation takes account only of the factors relevant to the particular building, whilst still producing figures which can be compared with other projects. The surveys also provide a rich source of anecdotal information. The results from the post-occupancy evaluations are capable of being related to the project organizational structure; this is the greatest benefit of the methodology. The weakness of the method is that it is not clear whether the same results would be gained by different researchers. However, this is not thought to cause problems when making comparisons of evaluations undertaken by one researcher. The technique has been used in an exploratory way, and further work is required in order to fully validate it.

The collection of survey data from diverse groups of people has been shown to be worthwhile and contributes much to the understanding of the good points as well as the bad points of particular project outcomes. The three-dimensional matrix given in Figure 9 (page 64) is perhaps too detailed as a basis for producing questionnaire forms, as this level of detail has not been possible to attain in practice. This is mainly because of the small sample sizes involved in the groupings of building owners, occupiers and project teams.

In terms of the relationship between organizational structure and project outcome, the remainder of section 10.3 examines the significance of each of the hypotheses.

10.3.1 Skill diversity & environmental analysis

The first hypothesis states that the in order to maximize the potential success of project, the organizational structure should provide a level of skill diversity that

matches the environmental complexity. It seems strange that several writers have highlighted the need for the organization to be contingent upon the environment, but none has offered a systematic way of analysing the environment. The new method developed herein offers a comparative framework which will be applicable not only at the level of the project, but also at higher levels of detail (for example, it has been applied to a description of the British and Jamaican construction industries; see Hughes, 1989). However, the ECI still requires calibration. The measure provided by the ECI gives a measure of complexity as perceived by the analyst. In this respect, it must be used with care. Its chief benefit is that it provides a framework and a vocabulary with which to discover, discuss and compare the major environmental influences on construction projects.

Skill Diversity is a specific example of Differentiation at the Operational level. As such it is a concept that is more easily identified than Differentiation, with all of its variants and levels. It is important that the principles underlying this study are made more accessible to the industry, and it is felt that the rationalization and simplification of concepts goes a long way towards this. The use of the concept of Skill Diversity, instead of the more complex idea of Differentiation is such a move. The complexities of different types and mixtures of Differentiation have been shown to be unnecessarily complicated. By tightening up the definitions of the terms used, many of the more esoteric problems have been avoided. The recorded values for ECI and for PCI demonstrate a consistent picture when related to project success. In this respect the hypothesis is validated; although more case studies are needed in order to increase the reliability of the relationships between the variables.

10.3.2 Co-ordination

Co-ordination is another case of simplifying and rationalizing difficult concepts. This hypothesis stated that the

Differentiation of the Operating System should be matched by a corresponding level of Co-ordination. The tests have shown that it is not necessary to quantify every link between every possible contributor within an Operation, which was the pattern used in the LRA technique. In that technique, the role of Boundary Control was seen as the sole Integrating mechanism, between tasks and within tasks. The presence of this role was only defined at the level of the task, even though it was deemed to be an Integrating mechanism at the level of the intra-task link. Therefore, the counting of the number of intra-task links for the purposes of assessing the level of Boundary Control is not necessary in either the 3R or the LRA technique.

A further refinement is the distinction now drawn between Integrating mechanisms at inter-operational and intra-operational levels. These Integrating mechanisms are now termed Integration and Co-ordination respectively, and are assigned different role symbols in the mapping technique. The result of this is that they can be analysed separately, and the tests for them can be simplified.

For the level of detail required by this analysis it is sufficient simply to examine an Operation for the presence of the role of Co-ordinating. The presence of the role-occupant, however, does not automatically solve the problems of the organization. It is still necessary to take steps to ensure that the person exercising the role is performing correctly. This is beyond the scope of this work.

Case study A shows a decline in co-ordination prior to the shelving of the project, and case study B shows high levels of co-ordination with no repeated Stages of Work. However, cases C & D have high levels of co-ordination, but also display repeated Stages of Work. The results of this test indicate that whilst low levels of Co-ordination may lead to abortive work, they don't necessarily lead to immediate repetition of Stages of Work.

10.3.3 Feedback

The third hypothesis is that the organizational structure should provide adequate Feedback loops. This is a new development in this type of analysis, and its inclusion has been shown to be valid. Earlier analysts found this aspect difficult to test; it was mentioned in passing, but not tackled as a quantifiable item. The new mapping technique enables the testing of Feedback and it is now an easy aspect to quantify. It is clear that it is not always present. It is not particularly significant as a direct cause of project deficiencies, but it is definitely a contributory factor to unease within the organizational structure. When Feedback was high, such as in case study A, objectives could be modified radically, even to the extent that the project could be shelved altogether. When Feedback was low, as in case study D, there was unease amongst members of the client organization about whether the building being produced was primarily for them or for the architects.

10.3.4 Control

The fourth hypothesis is that the organizational structure should provide proper Control mechanisms. The test for this shows that the results are consistent with the hypothesis. The validity of this finding depends on the assumption that the consequences of low Control will require extra work from the project team. All of the case studies suffered from erratic control. The results show that poor Control on its own does not cause project deficiencies, although it is a contributory factor. In case studies A, C and D, the occurrences of low levels of Control tended to coincide with the repetition of Stages of Work. High levels of Control (as in case study B) did not result in repetition. The adverse effects of poor Control may be easily discerned by the project team when they find that their output is not being related to client objectives for the project, and inadequate information is being supplied to the decision-makers in the organization. This results in repeated changes of mind by the client about what is wanted,

and general confusion amongst the project team about what is being produced. The project team in these circumstances have to try to take steps to rectify and overcome the adverse effects of these phenomena. This means that unnecessary effort is expended, and if this extra effort is not carefully directed, it leads to the need for work to be revised, and Stages of Work repeated. Therefore Control should be applied more uniformly in construction projects. Thus the hypothesis is verified.

It may not be possible to connect specific project deficiencies with particular organizational departures for this test. However, at a less specific level of detail, the overall framework of the analysis reveals some interesting features about the management of projects. The extra work for the project team created by the lack of proper Control mechanisms is an example of this. This may be manifested in over-complicated communication flows in the Operating System, or in over-long project durations. If these consequences are permitted then the project team may still achieve a successful result - often against all expectations. Indeed, the project team for case study D invited the analysis of the library precisely because the project had won architectural awards and they didn't know what features of organizational strategy had produced such a result. The detailed analysis of each hypothesis shows that the organizational structure was not ideal and left much to be desired. The consequences of lack of Control were seen to be a need for more staff and extended project durations. These consequences can be interpreted as having to work against the organizational structure. Where the Managing System mitigated the consequences by revising programmes and increasing staffing, such as case study D, the result was a satisfactory building from an unsatisfactory organizational structure. The importance of this point is that the new model provides a thorough framework for rationalizing and explaining observations of organizational problems in construction.

10.3.5 Continuity of the Managing System

The fifth hypothesis states that the organizational structure should ensure Continuity of the Managing System. This is provided by ensuring that the role of Integration is constantly applied. In case study A the lack of Integration was probably the main cause of the deficiencies in the finished building, because it is the worst departure from the model of all of the tests for that case. In case study B the low Integration in stage 3 resulted in the re-working of that stage, whereas high Integration later on in the project resulted in a successful project. Project C had low Integration and was the least successful project, and project D had mediocre Integration and the result was a reasonably satisfactory project. The correspondence between the results for Integration and the results for project success is very high. This test is probably the most significant indicator of project success, without qualification, because the rankings for the results from this test exactly match the rankings for project success. However, more case studies would need to be undertaken in order to fully validate this claim.

10.3.6 Duplication

The sixth hypothesis is that the organizational structure should have no Duplication of the Managing System at the Strategy level or above. The worst case for Duplication was case study C, but this was not the least successful project. The best case for this test was project D, but this was not the most successful project. There is no correspondence between the results for Duplication and project success. There is only one point where excessive Duplication produces a deficiency in outcome (in project B, stage 2). All other outcome deficiencies are attributable to other causes as well. This test seems inconclusive, and whether the detail of different types of Duplication is looked at, or whether all Duplications are counted as equal, it seems to reveal little helpful information or shed any light on the causes of project deficiencies. Indeed, there are cases of Duplic-

ation which should be present. An example is the Co-ordination of different aspects of site works by different people; another is the approval process for finance in public sector projects; it is clear from these examples that Duplication is a symptom of issues (such as accountability) which are probably beyond the construction project. This produces effects which have to mitigated by the project team, but cannot be eliminated as a principle. This hypothesis, therefore, is not proved, and the recommendation is that Duplication is not necessarily to be eliminated from construction projects. The test for duplication has revealed that most duplication is due to Recommendations and Approvals. During construction there are also Duplications of Co-ordination. However, these are not associated with shortcomings in the finished project. Observation of the 3R charts shows that the Duplications associated with Approvals coincide with the very long lead times observed in the case studies. This phenomenon is perhaps a characteristic of public sector construction projects.

10.3.7 Client involvement

The seventh hypothesis stated that the organizational structure should provide opportunities for Client Involvement at every stage. The best result for project success was also the worst result for Client Involvement (case study B). Case study A scored 100% for Client Involvement, but this did not produce the most successful project. These results show that simplification of the test has not produced a useful or expected result. However, the particular circumstances of case study A are unusual in that a Primary Integrator from the client's organization cannot be identified from the large number of client personnel involved.

The measurement of the level of Client Involvement does not take account of the way in which the client integrates the diverse parts of its own organization which each have an involvement with the project. The test has not succeeded by being simplified. This issue is worthy of further invest-

igation; it is important to be able to observe and understand the interaction between the client and the project team. The model and the techniques offered here provide the capability for observing the processes and interactions, but more comprehensive hypotheses about the relationships between the client and the project team should be examined with this model.

10.3.8 Characteristics of public sector construction

The tests have revealed certain patterns which are here suggested as being characteristic of public sector construction projects. These are:

- erratic Control
- high levels of Duplication in Recommendation/Approval cycles
- extraordinarily long lead times
- difficulties in identifying Primary Integrators from the client's organization

10.4 ORGANIZATION OF PUBLIC SECTOR BUILDING

The fourth and final objective of this thesis was to make recommendations about how to modify organizational structures to optimize project outcomes. This study has shown that for the cases studied, objectives were specifically defined in only one out of four of the projects. The one which had pre-defined objectives was also the most successful in terms of post-occupancy evaluation. This is probably the single most important issue arising from the study; objectives must be set at the beginning of the project. Further to this, objectives must be set for each stage of work so that adequate control systems can be implemented at all points in the progress of the project.

The extraordinarily long durations in the early stages of all of the case studies show that the decision making patterns are slow to respond to the needs of the project.

The research has indicated that there are definite advantages in adhering to the principles of good organization. The lessons learned from the case studies in the public sector, added to the lessons learned from Walker's case studies in the private sector, result in the suggestion of the following steps when setting up a construction project organization:

1. The organizational structure should be designed at the outset of the project, using 3R charts.
2. The objectives of the project should be defined in terms of the effects intended on the environment.
3. Policy decision points should then be identified.
4. Within each Policy system, Strategic Decisions should be identified.
5. Within each Strategy Sub-system, Tactical decisions and Operations should be identified.
6. Responsibilities for Operations should be defined, and opportunities for inputs from the end users of the building identified.
7. The requisite level of control should then be superimposed on to the responsibilities, relating to the achievement of the objectives defined in step 2. The management structure is thus identified.
8. Co-ordination, Integration, Feedback and Client Involvement patterns should be identified, and mapped on to the set of 3R charts which describe the organizational structure for the project.
9. From the columns of the 3R charts, job descriptions for each of the members of the project team can be identified, and used for selection and appointment of the consultants etc.

10.5 LIMITATIONS OF THE STUDY

The choice of case studies has imposed some limitations and constraints on the work undertaken. Firstly, the new model has only been tested in the public sector of the UK construction industry; secondly, it has only been applied to a limited range of projects in terms of complexity and size; and thirdly, the choice of case studies has precluded the use of control variables. This third limitation has meant that critical variables have not been isolated so that their individual effects on project outcome can be examined.

However, it must be expected that projects consist of a wide range of interrelated and interdependent sub-systems. The research has shown that project outcome deficiencies are rarely the result of single organizational departures - a conclusion shared with Walker (1980).

The small number of case studies is a reflection of another constraint on the analytical techniques offered. A large amount of data are required in order to undertake a complete analysis of a project's organizational structure. It took approximately six months (full time) to collect the data and compile the 3R charts for each of the case studies used. This leads to a further limitation; which is that there are insufficient case studies from which to undertake any sort of statistical analysis.

By focussing exclusively on the structural aspects of organizations, little has been learned about the effects of behaviour on organizational effectiveness - although it is acknowledged implicitly throughout the study that behavioural characteristics are present and can be important.

The nature of the data collection is an issue which may impose limitations on the findings of the research. In each case study, data collection commenced with detailed interviews of the major contributors to the project, and then proceeded with the analysis of correspondence files and minutes of meetings in the offices of architects and clients. This approach produced a lot of corroboration for each data item; but it is possible that some facts may be obscured by the way in which they are recorded. However, it is unlikely that this has happened in the case studies used, although it may be an important factor on politically sensitive projects, or projects of national importance.

The techniques of quantifying environmental complexity and post-occupancy evaluation cannot yet be claimed to be reliable. There is no absolute way of ascertaining their validity. However, the techniques have been developed from the theoretical literature, and from earlier studies in practice. It is clear that the results can only be viewed in the light of the four case studies. There is plenty of

scope for refining, or even replacing these two aspects of the analysis, as the analytical technique simply requires that the environmental complexity and the relative level of project success should be evaluated. This does not preclude the use of alternative techniques. In this way, the techniques are offered as a starting point for future developments, not as an end in themselves.

10.6 SUMMARY OF FINDINGS

(a) The 3R technique provides a useful way of modelling the organizational structures of public sector building projects. It meets the need for a technique to systematically describe and quantitatively evaluate the organization of building projects. The time needed to undertake an analysis has been reduced, and many of the concepts have been simplified and rationalized to create a model which is more consistent and whole than previous models.

(b) The process of building procurement is divided into Stages of Work, which are triggered and terminated by Strategic Decisions. The stages are divided into a series of Activities which are punctuated by Tactical Decisions, and these Activities are further sub-divided into Operations punctuated by Operational Decisions.

(c) The analysis of the plans of work shows that all building projects pass through similar Stages of Work, and this is confirmed by the case studies.

(d) The introduction into the model of a Control System between the Managing and Operating Systems has produced a more flexible framework for modelling the organizational processes in construction project management.

(e) The development of a more straightforward set of role specifications has eliminated some of the inconsistencies and ambiguities which hampered earlier models.

(f) The new style of 3R chart is easier to prepare and to interpret, and is more concise than other charting techniques at this level of analysis.

(g) Repetition of work, and abortive work, are direct consequences of disorganization.

(h) The evaluation of buildings is greatly facilitated by the new framework of post-occupancy evaluation. The technique is more structured and directly applicable to building projects than anything which has been proposed in the past. The information thus collected is extremely useful in pin-pointing the good and bad points of a building. Although the results of the post-occupancy evaluation can be used in isolation, when paired with the organizational analysis, the result is that many of the deficiencies in a building can have causes attributed to them. This fills a gap in the overall evaluation of buildings.

(i) The technique for quantifying environmental complexity, whilst not fully validated, provides a framework and a vocabulary with which to discover, discuss and compare the major environmental influences on construction projects.

(j) There are indications that there is a link between environmental complexity, Skill Diversity and project success. This was expected from the literature on the theory, but the practical application of this theory is rare. The fact that the theory is borne out by practical observation is a useful conclusion. The case studies indicate that the complexity of the project organization should be contingent on the environmental complexity.

(k) The project teams were not able to mitigate the adverse effects of complex environments.

(l) The level of Co-ordination is significant in terms of abortive work. Good Co-ordination is essential if these problems are to be avoided.

(m) Feedback and Control are related issues which form indispensable parts of the organizational analysis. Although they cannot be used as direct indicators of project success, they are major contributory factors. The indications are that they are important in ensuring that work is not wasted, and that it is matched to objectives. High levels of Feedback enable project objectives to be modified, if necessary. Low levels of Control can result

in repetition of Stages of Work, and lead to increases in workload and extended project durations.

(n) Continuity of the Managing System is achieved through the provision of the role of Integrating. It is a very significant indicator of project success, and is probably the single most important demand on the organizational structure of a building project. Integration shows the closest match to the rankings of success, so this may be seen as the most significant organizational test from those selected for this study. A consequence of low Integration is that stages of work have to be repeated. The long durations of early stages in public sector construction projects increase the potential for poor Integration.

(o) Duplication in the Managing System is not necessarily to be avoided. There are cases when it is needed for effective Control of the project. Duplication of Approvals seems to be a contributory factor to the long durations of early stages of work.

(p) Objectives should be explicitly defined at the outset of a project.

(q) Recommendation/Approval cycles need to be more dynamic if they are not to prevent the project team from making reasonable progress.

(r) Client Involvement is an important influence on the success of projects, but it is difficult to measure.

(s) Finally, it is clear that insufficient attention is given to organizational issues in public sector building projects. Project organizational structures should be designed in advance of the project. The consequences of disorganization are aborted or repeated stages of work, extended project durations, increased workloads, job dissatisfaction and client unease about the process of building procurement. It is clear that the application of analytical techniques to organizational problems will help to bring the principles of organizational design to construction projects.

10.7 RECOMMENDATIONS FOR FUTURE WORK

(a) The new model of organizational structure and the associated analytical techniques require further rigorous validation and checking. This should be done by further case studies; judiciously chosen to isolate as many variables as possible in order to examine the impact of particular organizational departures on project outcome.

(b) Organization structural analysis can provide an "audit trail" of decisions and actions. As a means of exposing what has been recorded in correspondence and minuted at meetings it is very effective. This means that it is possible to identify the exact nature of an individual's contribution to a project. This in turn can provide a useful starting point for an analysis of the effectiveness of an individual in relation to their position in the organization, and to the influences on the individual within the organization.

(c) In terms of organizational behaviour - once the organization's structure has been accurately mapped - there is tremendous scope for an analysis of the opportunities and mechanisms for mitigating adverse effects and harnessing positive effects of behavioural characteristics.

(d) If post-occupancy evaluation is being undertaken for the purposes of feedback - either to the design team or to the client - then repeat surveys at different points in a building's life may be helpful. The literature survey exposed the lack of a systematic method of evaluating the success of building projects. This has to some extent been filled by the approach offered in this work. It is clear that in some public sector projects, the end users of buildings have very little input into the briefing and design processes. Further research is necessary to bring these post-occupancy evaluation techniques to bear on the feedback of information about buildings-in-use to the briefing and design processes.

(e) The data collection for the case studies indicates that the storage of project data in files is irregular and fortuitous. An interesting area for further research is the

need to analyse the reasons and the methods for the storage and retrieval of construction project information. An aspect related to the collection of data is the use of the technique for examining only one stage of work within the overall process. By choosing the design stage, for example, the period for data collection could be greatly reduced, and the number of cases studied could consequently be increased.

(f) The technique used for assessing environmental complexity needs to be refined and developed. It is essential in future studies that the ECI can be derived with more reliability. Both theory and practice have shown that the project's organizational structure should be contingent upon, and responsive to the project's environment.

(g) Whilst the current study has shown that there is an interesting link between environmental complexity and Skill Diversity, it is clear that more data are needed to test the relationship. It was stated in chapter nine that the results from this test are only speculative, and that they indicate the advisability of pursuing this line of research further. The suggested relationship given in that chapter is a useful way of explaining the observations. The current study has demonstrated that this relationship exists: It is recommended that this work is pursued further, in order to identify the exact nature of the relationship.

(h) It is also recommended that further work be done in identifying the extent of the increases in workload and project duration resulting from lack of Control. The question of workload on a professional consultant is an interesting one, relating behavioural characteristics to the way in which the organizational structure can modify and influence motivational factors.

(i) The test for Duplication has shown that this aspect is not necessarily to be avoided in construction projects. It would be interesting to study the relationship between Duplication of managing roles and issues such as accountability.

(j) The test for Client Involvement has not been successful. It is recommended that in future work a

slightly more comprehensive approach needs to be taken with this test, although it should not go to the complexity of measuring full and partial Integration, both between and within Operations, as did the LRA technique. There needs to be found a point mid-way between the two extremes; perhaps by giving attention to determining the requisite nature of client involvement, as well as its quantification.

(k) More data need to be generated about organizational problems and their consequences. The application of the new model to the analysis of other sectors of the construction industry, and to the construction industries of other countries, would provide valuable sources of information for different sectors to learn from each other.

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APPENDIX A: 3R CHARTS FOR CASE STUDY A

Project A
Stage a1: Inception

{1}→|→[2]=‖
    |→[3]=‖→{4}→

{} - Decision
[] - Operation
→ - Sequential
= - Reciprocal

1964-71		D.H.S.S. 1	Regional Capital Planning Team 5	Regional Catering Adviser 1 6	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Assistant Regional Engineers 11	Regional Administrator 12	Asst. Snr. Admin. Medical Officer 14	Regional Hospital Board 17	Hospital Administrator 19	Group Secretary 20	Group Catering Officer 21	Group Administrator 22	District Catering Adviser 25	Hospital Management Committee 54
1	Shortfall in catering facility identified		✓=	→							→	→	→	→	→	↑⇔
2	Consider alternative solutions		↑=	→⇉	→	→	→		→	✓	→	→	→	→	→	*⇔
3	Define scope of project		↑⊙	*				+		✓	→				+	→⇔ ⇊
4	New building required	✓	↑=	⇊	+					↑						↑⇔ O

KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input › Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ⇔ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage a2: Feasibility

→{4}→[5]→ [→[6]= / →[7]= / →[8]=] →[9]→{10}

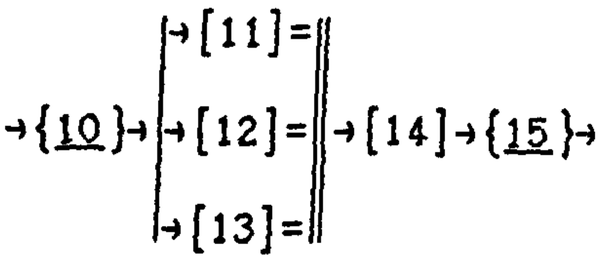
{} - Decision
[] - Operation
→ - Sequential
= - Reciprocal

	1971-73	D.H.S.S. 1	Asst. Reg. Cap. Ser. Officer 4	Regional Capital Planning Team 5	Regional Catering Adviser 1 6	Regional Architect 8	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Assistant Regional Engineers 11	Regional Administrator 12	Principal Assistant Quantity Surveyor 13	Asst. Snr. Admin. Medical Officer 14	Regional Hospital Board 17	Partner Architect 27	Partner Services Engineer 28	Partner Quantity Surveyor 30	Partner Structural Engineer 33	Regional Secretary 46	Regional Treasurer 47	Regional Nursing Officer 48	Project Architect 1 52	Hospital Management Committee 54
4	New building required	✓		↑=	⇉		+						↑									↑Θ O
5	Appointment of consultants					→		→	→				*Θ	→›	→›	→›	→›					⇉›
6	Prepare initial brief	→			→	→	→					→	⇉↑							→	⇉	*Θ O
7	Feasibility study		→⊙ Θ		→		→⊙	→	→				⇉	→↓ =							*	⇉O
8	Consider alternative locations		⊙Θ		→		→	→	→			→	*O								⇉	⇉
9	Presentation for inclusion in capital programme	→		→	→		→			*	→	→	⇉O					→	→	→	⇉	⇉
10	Scheme included in capital programme	✓		↑						⇉			↑									

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input › Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: Θ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage a3: Scheme Design



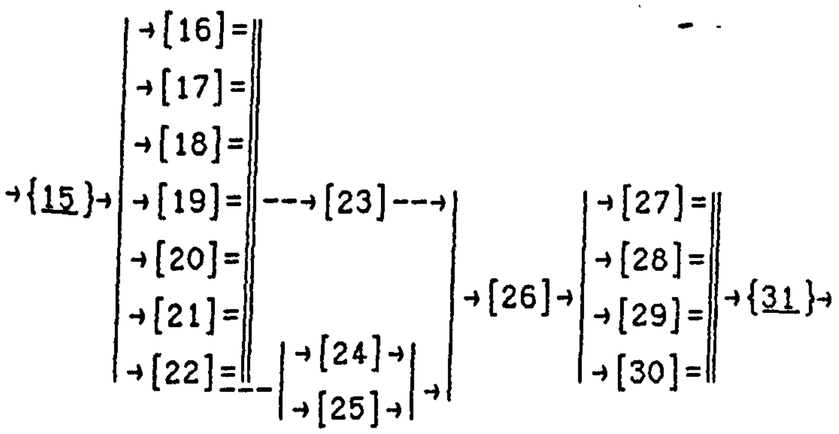
{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1973-74	D.H.S.S. 1	Regional Health Authority 2	Asst. Reg. Cap. Ser. Officer 4	Regional Capital Planning Team 5	Regional Catering Adviser 1 6	Regional Catering Adviser 2 7	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Assistant Regional Engineers 11	Regional Administrator 12	Regional Hospital Board 17	District Catering Adviser 25	Project Architect 2 26	Partner Architect 27	Partner Services Engineer 28	Project Services Engineer 29	Partner Quantity Surveyor 30	Project Quantity Surveyor 31	Project Structural Engineer 32	Hospital Catering Staff 49	Hospital Management Committee 54
10 Scheme included in capital programme	✓			↑						⇒	↥										
11 Architect's sketch scheme		✓O	↔		→	→	⊙				✓O ⇒		*	=↓		+		→⇒	→		
12 Initial cost estimates		O	↔	✓				⊙			O⇒		⇒			+	=↓	*			
13 Prepare detailed brief		O→	↔		→	→					*O		⇒					⇒	→		
14 Presentation for budget cost approval		→O	*	→= ⊙							→ ⇒		⇒					⇒			
15 Budget cost approval	✓	↑	⇒	↥																	

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ↔ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage a4: Detail Design



{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1974-75

	D.H.S.S. 1	Regional Health Authority 2	Asst. Reg. Cap. Ser. Officer 4	Regional Capital Planning Team 5	Regional Catering Adviser 2 7	Regional Architect 8	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Assistant Regional Engineers 11	Regional Administrator 12	Asst. Snr. Admin. Medical Officer 14	Group Administrator 22	District Catering Adviser 25	Project Architect 2 26	Partner Architect 27	Partner Services Engineer 28	Project Services Engineer 29	Partner Quantity Surveyor 30	Project Quantity Surveyor 31	Project Structural Engineer 32	Partner Structural Engineer 33	Regional Secretary 46	Regional Treasurer 47	Regional Nursing Officer 48	Hospital Catering Staff 49	Building Inspector 51	Planning Authority 53	Hospital Management Committee 54	Site Investigation Contractor 58
15 Budget cost approval	✓	↑	>⇉	|↑																									
16 Refinement of brief			=O	⊙⇉	*		⇳	⇉		↴		↴	↴	⇉⇉			⇉	⇉		⇉					↴				
17 Develop sketch scheme			O	⊙⇉	⇉		⊙→	⇉		↴				*⇳ ⇉			⇉	⇉		⇉									
18 Cost estimates				⊙⇉	⇉			⊙⇉					↴	+⊙ ⇉⇉			⇉	*=		⇉									
19 Revise budget cost			O	⊙⇉	⇉	↓	⊖	*		=				⇉⇉			⇉	⇉		⇉									
20 Services engineering proposals				⊙⇉	⇉			⇉	⊙→					→⊖		=↓	*	→		→									
21 Obtain statutory approvals				⊙⇉	⇉			⇉						*⊖	=↓		⇉	⇉		⇉					✓	✓			
22 Structural engineering proposals				⊙⇉	⇉		⊙	⇉						⊖⇉ ⇉			⇉	⇉		*	=↓								
23 Increase budget cost	✓	↑	*⊖	↑	⇉		→	→⇉	→		→			⇉> ⇉			⇉	⇉		⇉		→	→	→					
24 Tree removal specification					→		⊙	→						→⊖			→	→		*	=↓							>	>
25 Site investigation					→		⊙	→						→⊖			→	→		↓⇉									*=
26 Formal planning application			⊖⇉ O	*=										→						⇉						✓			⇉
27 Design cost estimates			O	⊙⇉				→⊙						→⊖ ⇉			⇉	=↓	*	⇉									
28 Architectural detail design			O	⊙⇉	→		⊙							*⊖	=↓		⇉		⇉	⇉									
29 Services engineering detail design				⇉	→		⊙		→⊙					→⊖ ⇉		=↓	*		⇉	⇉									
30 Structural engineering detail design				⇉			⊙							→⊖ ⇉			⇉		⇉	*	=↓								
31 Acceptance of design	✓	↑		↑		↓	↥							⇉			⇉		⇉	⇉									

9/83

KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ⊖ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage a5: Contract

→{31}→[31]→[33]→{34}→

() - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1975-75	D.H.S.S. 1	Regional Health Authority 2	Asst. Reg. Cap. Ser. Officer 4	Regional Capital Planning Team 5	Regional Architect 8	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Project Architect 2 26	Partner Architect 27	Partner Services Engineer 28	Project Services Engineer 29	Partner Quantity Surveyor 30	Project Quantity Surveyor 31	Project Structural Engineer 32
31 Acceptance of design	✓	↑		↑	↓	↑		→						
32 Prepare bills of quantity		O	⊙			⇉	→⊙	↔				=↓	*	
33 Pre-tender information report			O	✓		↑		*	=↓		→		⇉	→
34 Scheme excluded from programme	✓	↑	→	↑		→	→	>⇉	>	>		>		>

9/89

KEY:

Operating system:	* Operating	+ Cooperating	→ Consulting	⇉ Input	> Receiving
Control system:	= Resourcing	⊙ Monitoring	↓ Supervising		
Managing System:	↔ Coordinating	O Directing	↑ Recommending	✓ Approving	

Project A
Stage b1: Inception

→{34}→[35]→{36}→

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1975-77

	D.H.S.S. 1	Regional Health Authority 2	Asst. Reg. Cap. Ser. Officer 4	Regional Capital Planning Team 5	Regional Catering Adviser 2 7	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Asst. Snr. Admin. Medical Officer 14	Group Secretary 20	Group Catering Officer 21	Group Administrator 22	District Catering Adviser 25	Project Architect 2 26	Partner Architect 27	Partner Services Engineer 28	Partner Quantity Surveyor 30	Project Structural Engineer 32	Hospital Management Committee 54
34 Scheme excluded from programme	✓	↑	→	⊥↑		→	→						>⇉	>	>	>	>	
35 Review of hospital facilities			O	⊙⇉	→			↓	✱↔	→	→	→						✓
36 Resurrect previous scheme	✓	↑	→	⊥↑					⇉					>	>	>	>	

9/89

KEY: Operating system: ✱ Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ↔ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage b2: Feasibility

→{36}→[37]→{38}→

{} - Decision
[] - Operation
→ - Sequential
≡ - Reciprocal

1977-77

	D.H.S.S. 1	Regional Health Authority 2	Asst. Reg. Cap. Ser. Officer 4	Regional Capital Planning Team 5	Regional Catering Adviser 2 7	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Assistant Regional Engineers 11	Asst. Snr. Admin. Medical Officer 14	Partner Architect 27	Partner Services Engineer 28	Partner Quantity Surveyor 30	Project Structural Engineer 32	Regional Secretary 46	Regional Treasurer 47	Regional Nursing Officer 48
36 Resurrect previous scheme	✓	↑	→	↑						>	>	>	>			
37 Presentation for inclusion in capital programme			*↔	⊙↓ O⇒	→	→	→	→	→					→	→	→
38 Inclusion in capital programme	✓	↑	↑	⊙↓ ↑												

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ↔ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage b3: Scheme design

→{38}→ ‖ →[39]= / →[40]= / →[41]= / →[42]= / →[43]= / →[44]= / →[45]= / →[46]= ‖ →[47]→{48}→

{} - Decision
[] - Operation
→ - Sequential
= - Reciprocal

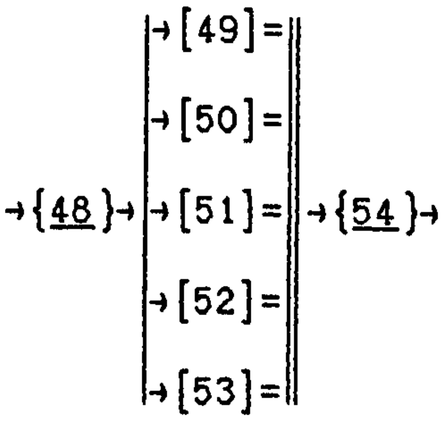
1977-77

		D.H.S.S. 1	Regional Health Authority 2	Minister for Health & Social Security 3	Asst. Reg. Cap. Ser. Officer 4	Regional Capital Planning Team 5	Regional Catering Adviser 2 7	Regional Architect 8	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Assistant Regional Engineers 11	Asst. Snr. Admin. Medical Officer 14	District Capital Works Officer 23	Fire Prevention Officer 24	District Catering Adviser 25	Project Architect 2 26	Partner Architect 27	Partner Services Engineer 28	Project Services Engineer 29	Partner Quantity Surveyor 30	Project Quantity Surveyor 31	Project Structural Engineer 32	Partner Structural Engineer 33	Hospital Catering Staff 49	Building Inspector 51	Project Architect 1 52	Hospital Management Committee 54	Tendering Contractors 55	Action Committee 56	Environmental Health Officer 57
38	Inclusion in capital programme	✓	↑		⊙|→	↑																								
39	Consultants' contractual proposals				O⇉	✓	⇉		→⊙							*Θ	=↓	→	⇉	→	⇉	⇉	→							
40	Check statutory approvals				O⇉	✓	⇉		→⊙					→		*Θ	=↓	→	⇉		⇉	⇉			→	→				→
41	Revise estimates				O⇉	✓	⇉			→⊙						Θ⇉			⇉	=↓	*	⇉						→		
42	Structural re-design				O⇉	✓	⇉	→⊙								Θ⇉			⇉		⇉	*	=↓							
43	Services re-design				O⇉	✓	⇉				→⊙					Θ⇉		=↓	*		⇉	⇉								
44	Architectural re-design				O⇉	✓	⇉	⊙		→⊙						*Θ	=↓		⇉		⇉	⇉								
45	Revise brief				O=⇉	✓⊙	*							→		→Θ⇉			⇉		⇉	⇉								
46	Programme preparation				O⇉	✓	⇉			→⊙		→	→		→	*Θ→	=↓		⇉		⇉	⇉								
47	Resolve tree conflict	↑	↑	✓	*Θ	=⊙↑	+⇉								+	⇉			⇉		⇉	⇉		→			→		→	
48	Scheme acceptable to all parties	✓	↑		↑Θ↑	=⊙								→		>									→					→

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: Θ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage b4: Detail design



{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

	1977-79	D.H.S.S. 1	Regional Health Authority 2	Asst. Reg. Cap. Ser. Officer 4	Regional Capital Planning Team 5	Regional Catering Adviser 2 7	Assistant Regional Architect 9	Assistant Regional Q.S. 10	Assistant Regional Engineers 11	Fire Prevention Officer 24	Project Architect 2 26	Partner Architect 27	Partner Services Engineer 28	Project Services Engineer 29	Partner Quantity Surveyor 30	Project Quantity Surveyor 31	Project Structural Engineer 32	Partner Structural Engineer 33	Building Inspector 51	Project Architect 1 52	Environmental Health Officer 57
48	Scheme acceptable to all parties	✓	↑	↥⊖	↑ ⊙=					→	→								→		→
49	Services engineering detail design			O⇒		→			⊙		⊖⇒		=↓	*		⇒	⇒				→
50	Architectural detail design			O⇒		→	⊙				*⊖	=↓		⇒		⇒	⇒				→
51	Structural detail design			O⇒			⊙				⊖⇒			⇒		⇒	*	=↓			
52	Statutory approvals			O⇒			⊙				*⊖	=↓		⇒		⇒	⇒		→	→	
53	Bills of quantity			O⇒				⊙			⊖⇒			⇒	=↓	*	⇒				
54	Design complete		✓	↑			→			→	↥	=↓		⇒		⇒	⇒		→		→

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input › Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ⊖ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage b5: Contract

→{54}→[55]→ [→[56]-
→[57]-
→[58]-]→[59]→{60}→

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

	1979-79	2 Regional Health Authority	4 Asst. Reg. Cap. Ser. Officer	5 Regional Capital Planning Team	8 Regional Architect	9 Assistant Regional Architect	10 Assistant Regional Q.S.	11 Assistant Regional Engineers	12 Regional Administrator	24 Fire Prevention Officer	26 Project Architect 2	27 Partner Architect	29 Project Services Engineer	30 Partner Quantity Surveyor	31 Project Quantity Surveyor	32 Project Structural Engineer	51 Building Inspector	55 Tendering Contractors	57 Environmental Health Officer	58 Site Investigation Contractor
54	Design complete	✓	↑			→				→	↥	=↓					→	→	→	
55	Pre-tender information report			✓		⊙O			↑		✱Θ	=↓	→		→	→		→		
56	Pre-tender estimate	✓		↑		O	⊙				→Θ ↑⇉			=↓	✱					
57	Programme preparation			✓		⊙			✓		✱Θ	=↓								
58	Ground moisture content tests					O					→Θ ⇉					=⊙ ↓				✱
59	Tender action			✓O	→	→O	→⊙	→			→↑ ⇉		→	=↓	✱	→		→		⇉
60	Successful bidder chosen	✓	↥	↑⊙							>		>		>⇉	>		>		

9/89

KEY: Operating system: ✱ Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: Θ Coordinating O Directing ↑ Recommending ✓ Approving

Project A
Stage b6: Construction

→{60}→ ‖ →[61]= ‖ →[62]= ‖ →[63]= ‖ →[64]= ‖ →[65]= ‖ →[66]= ‖ →[67]= ‖ →[68]→[69]→[70]→{71}

{} - Decision
[] - Operation
→ - Sequential
= - Reciprocal

1979-83

		2 Regional Health Authority	4 Asst. Reg. Cap. Ser. Officer	5 Regional Capital Planning Team	7 Regional Catering Adviser 2	9 Assistant Regional Architect	10 Assistant Regional Q.S.	11 Assistant Regional Engineers	12 Regional Administrator	16 Engineering Clerk of Works	18 Building Clerk of Works	19 Hospital Administrator	20 Group Secretary	21 Group Catering Officer	22 Group Administrator	23 District Capital Works Officer	24 Fire Prevention Officer	26 Project Architect 2	27 Partner Architect	28 Partner Services Engineer	29 Project Services Engineer	30 Partner Quantity Surveyor	31 Project Quantity Surveyor	32 Project Structural Engineer	35 Main Contractor's Site Agent	36 Main Contractor's Contracts Manager 1	37 Main Contractor's Contracts Manager 2	40 Electrical Engineering Sub-contractor	41 Mechanical Engineering Sub-contractor	42 Cladding Sub-contractor	54 Hospital Management Committee	55 Tendering Contractors
60	Successful bidder chosen	✓	⊢→	↑⊙														>			>		>								>
61	Cost statements		O⇉	✓	⇊	O	⊙											⇉⇊			⇊	←=	*	→	⇊		⇊			⇉		
62	Architectural revisions		O⇉		⇊	O⊙						→	→	→	→	→	→	*⇉	=↓		⇊		⇊		⇊		→			⇉	→	
63	Services engineering revisions		O⇉		⇉	O		→⊙	→			→	→	→	→	→	→	⇉		↓	*		⇉		⇉		→			⇉	→	
64	Briefing revisions		O⇉ =	⊙✓	*	O			⊖			→	→	→	→	→	→	⊖⇉			⇉		⇉		⇉		→			⇉	→	
65	Construction - main contractor		O⇉		⇉	O					⊙→							=⊙ ⊖⇉			⇉		⇉	⊙→	*	=⊙ ↓⊖	→			+⇉	→	
66	Cladding		O⇉		⇉	O					⊙→							=⊙ ⊖⇉			⇉		⇉		+⇉ ⇉	=⊙ ↓⊖	=⊙ ↓⊖			*		
67	Services installation		O⇉		⇉	O		⊙→		⊙→								=⊙ ⊖⇉			⊙⇉		⇉		*		=⊙ ↓⊖	+	+	⇉		
68	Testing & commissioning		O		⇉	O		⊙→		⊙→	⊙→							=⊙ ⊖⇉			⇉		⇉		⇉		*= ⊖	+	+	⇉		
69	Final account		O			O	⊙											=⊙ →⊖			→	↓=	*	→	→		⇉					
70	Certificate of final completion	✓	O	↑		O		→										*	↓=				⇉				→	→	→	→		
71	Contractual obligations fulfilled	✓	⇞	↑		O												>⇉	>			>		>			>	>	>	>	>	

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ⊖ Coordinating O Directing ↑ Recommending ✓ Approving

APPENDIX B: 3R CHARTS FOR CASE STUDY B

Project B
Stage 1: Inception

[1]→{2}→

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1978		District Social Services Officer 1	Planning Groups 10	District Management Team 11	Senior District Management Team 12	Social Services Committee 14	County Council 15	District Building Surveyors 66
1	Review of provision of services	⇳	⁑	=⊙ ↓↑	✓O			→
2	Shortfall in services to be accommodated in this district		⇒		↑	↑	✓	

9/83

KEY:
Op. sys: ⁑ Operating + Cooperating → Consulting ⇒ Input > Receiving
Con. sys: = Resourcing ⊙ Monitoring ↓ Supervising
Man. sys: ⇳ Coordinating O Directing ↑ Recommending ✓ Approving

Project B
Stage 2: Feasibility

→{2}→[3]→[4]→[5]→ [6] / [7] / [8] →{9}→

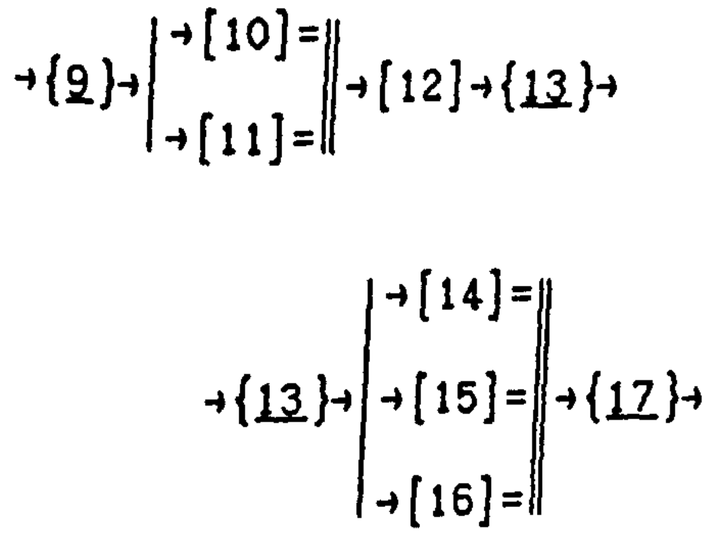
{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1978		District Social Services Officer 1	Principal Officer Administration 2	Principal Officer Day Care 3	Principal Officer Team Services 4	Principal Officer Residential 6	Principal Officer Capital Buildings 7	Planning Groups 10	District Management Team 11	Senior District Management Team 12	District Advisory Committee 13	Social Services Committee 14	County Council 15	Joint District Management Team 16	Divisional Architect Division 'A' 19	Practice Group Management Team 'A' 20	Divisional Q.S. Division 'A' 22	County Valuer 52	Personnel Committee 53	Land Committee 54
2	Shortfall in services to be accommodated in this district							→		⊢↑	↑	✓								
3	Consider alternative locations	⁑⇳ O	→	→	→	→			⊙	=↓ ⇒								→		
4	Feasibility studies	⊙⇳ O⇒	→												⁑	=↓	→			
5	Presentation for inclusion in joint budget	⁑⇳ O	→	→	→	→			⊙	↑ =↓	↑	✓		✓	⇒					
6	Presentation for inclusion in minor capital works budget	⁑⇳ O⇒	→⇒	→	→	→	⇳		⊙	↑ =↓	↑	✓								
7	Establish revenue costs	⇳O ↑⇒	⁑	→	→	→			⊙	↑ =↓	↑	✓							↑	
8	Propose bid for site	⁑O	⇳⇒	→	→	→	⇳		⊙	↑ =↓	↑	✓								↑
9	Scheme is feasible and finance is available	↑→	⇳⇒				⇳		⊙	↑ =↓	↑	↑	✓	✓						

9/83

KEY: Operating system: ⁑ Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ⇳ Coordinating O Directing ↑ Recommending ✓ Approving

Project B
Stage 3: Scheme design



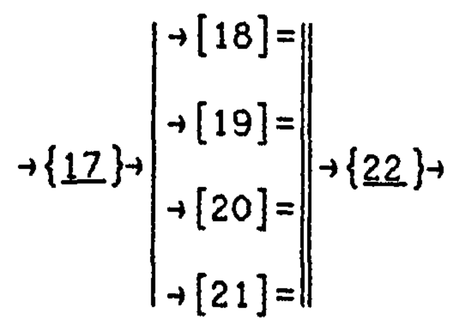
() - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1983		1 District Social Services Officer	2 Principal Officer Administration	7 Principal Officer Capital Buildings	8 Client's Project Development Group	10 Planning Groups	11 District Management Team	12 Senior District Management Team	13 District Advisory Committee	14 Social Services Committee	15 County Council	16 Joint District Management Team	26 1st Project Architect Division 'C'	28 Divisional Architect Division 'C'	29 Project Q.S. Division 'C'	30 Divisional Q.S. Division 'C'	31 Practice Group Management Team 'C'	36 Mechanical Engineer	37 Electrical Engineer	51 Project Architect 1964
9	Scheme is feasible and finance is available	↥→	⇿⇒	⇿			⊙	↑ =↓	↑	↑	✓	✓								
10	Define requirements	O✓ ↑⇒	✱⇿			→	→⊙	=✓ ↓					⇒							
11	Initial sketch scheme	✓⇒	⇒		→								✱⇿	=↓ ↑			⊙	→	→	→
12	Budget estimate	✓	⇒										⇿⇒	⊙	✱	=↓	↓	→	→	
13	Sketch scheme rejected	↥					=⊙	↓↑		✓					⇒					
14	Revise requirements	↑⇒ ↓O	✱⇿		→		→⊙	=✓ ↓						⇒		⇒				
15	Revise sketch scheme	✓O ⇒	→		⇒									✱⇿ =		⇒	⊙↓	→	→	
16	Revise budget estimate	✓⇒	⇒											⇿⇒		✱=	↓	→	→	
17	Scheme accepted	↥	⇒				=⊙	↑ ↓		↑	✓			⇒		⇒				

3/89

KEY: Operating system: ✱ Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ⇿ Coordinating O Directing ↑ Recommending ✓ Approving

Project B
Stage 4: Detail design



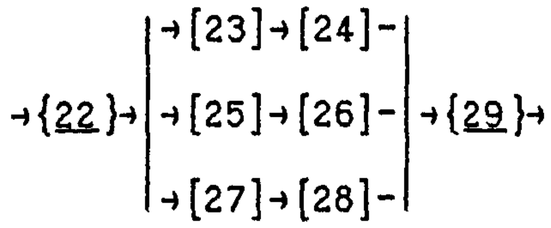
{} - Decision
[] - Operation
→ - Sequential
= - Reciprocal

		1	2	8	11	12	14	15	27	28	30	31	35	36	37	59	60	61	62	63	64	65
	1983-84	District Social Services Officer	Principal Officer Administration	Client's Project Development Group	District Management Team	Senior District Management Team	Social Services Committee	County Council	2nd Project Architect Division 'C'	Divisional Architect Division 'C'	Divisional Q.S. Division 'C'	Practice Group Management Team 'C'	Divisional Engineer	Mechanical Engineer	Electrical Engineer	Mechanical Eng'g Sub-contractors	Electrical Eng'g Sub-contractors	Crime Prevention Officer	Fire Officer	Interior Designer	Building Control Officer	Planning Authority
17	Scheme accepted	↑	⇒		=⊙	↑ ↓	↑	✓		⇒	⇒											
18	Establish detailed requirements	↑ O⇒	*	→	→⊙	✓= ↓			⇒					⇒	⇒					→		
19	Detailed architectural design	⇒	O⇒						*Θ	=⊙ ↓		↓		⇒	⇒			→	→	→	✓	✓
20	Electrical services design	⇒	→⇒						Θ⇒				=↓	⇒	*		→					
21	Mechanical services design	⇒	⇒						Θ⇒				=↓	*	⇒	→						
22	Design is acceptable	↑→	O⇒		↑ ⊙	=✓ ↓			⇒					⇒	⇒							

9/83

KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: Θ Coordinating O Directing ↑ Recommending ✓ Approving

Project B
Stage 5: Contract



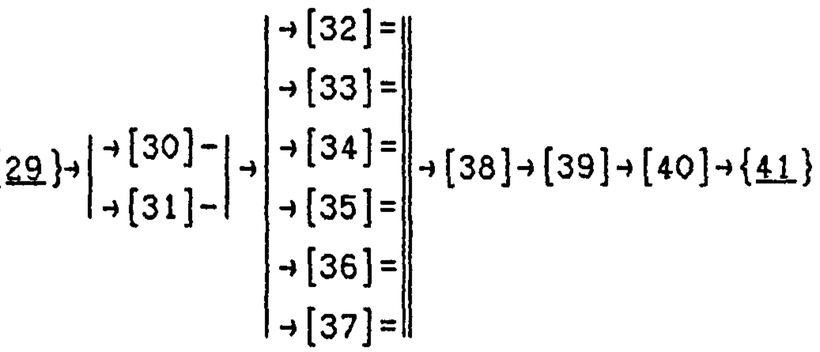
{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1984		1	2	11	12	27	29	30	31	35	36	37	57	58	67
		District Social Services Officer	Principal Officer Administration	District Management Team	Senior District Management Team	2nd Project Architect Division 'C'	Project Q.S. Division 'C'	Divisional Q.S. Division 'C'	Practice Group Management Team 'C'	Divisional Engineer	Mechanical Engineer	Electrical Engineer	County Council Admin Department	County Secretary	Tendering Contractors
22	Design is acceptable	↥	O⇒	↑⊙	=✓ ↓	⇒					⇒	⇒			
23	Compile main contract tender list	⇒				→		*⊖	=↓ O				✓		
24	Tender action main contract					>	+⊙	⊙✓ ⊖⇒	O				*	=✓	+
25	Compile heating cont. tender list	⇒						⊖	↓O	=↓ ↑	*		✓		
26	Tender action heating contract					>	+⊙		O	⊙⊖ ✓	⇒		*	=✓	+
27	Compile electrical ct. tender list	⇒						→	↓O	=↓ ↑		*	✓		
28	Tender action electrical contract					>	+⊙		O			⇒	*	=✓	+
29	Construction can be started							↥	=↓ ⊙				✓⇒	✓	

9/89

KEY: Op. sys: * Operating + Cooperating → Consulting ⇒ Input > Receiving
Con. sys: = Resourcing ⊙ Monitoring ↓ Supervising
Man. sys: ⊖ Coordinating O Directing ↑ Recommending ✓ Approving

Project B
Stage 6: Construction



{} - Decision
[] - Operation
→ - Sequential
= - Reciprocal

1984

		District Social Services Officer	Client's Project Development Group	Clerk of Works	2nd Project Architect Division 'C'	Divisional Architect Division 'C'	Project Q.S. Division 'C'	Divisional Q.S. Division 'C'	Practice Group Management Team 'C'	Mechanical Engineer	Electrical Engineer	Main Contractor's Site Agent 1	Main Contractor's Site Agent 2	Main Contractor's Site Agent 3	Main Contractor's Contract Manager	Heating Contractor's Site Agent	Heating Contractor's Area Manager	Electrical Contractor's Site Agent	Electrical Contractor's Area Manager	Domestic Sub-contractor's Site Agent	Domestic Sub-contractor's Area Mgr	Stripping Out Contractor	Factory Inspector	Chemist	County Council Admin Department	County Secretary
		1	8	17	27	28	29	30	31	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	57	58
29	Construction can be started							⊢	=⊙ ↓																⇊	
30	Stripping out		↓	⊙	=⇕			⇊	O			*			=⊙ ↓								>			
31	Asbestos removal		↓	⊙	=⇕			⇊	O													*	✓	↑		
32	Main construction contract		↓	⊙	=⇕ ⇊		⇊		O			+⇊	*	+	=⊙ ↓	⇊		⇊		⇊		⇊				
33	Heating sub-contract		→	⊙	=⇳ ⇒		⇒		O	✓		⇒	⇒		=⊙ ↓	*	=↓	⇒		⇒		⇒				
34	Electrical sub-contract		→	⊙	=⇳ ⇒		⇒		O		✓	⇒	⇒		=⊙ ↓	⇒		*	=↓	⇒		⇒				
35	Domestic sub-contractors work		→	⊙	=⇳ ⇒		⇒		O			⇒	⇒		=⊙ ↓	⇒		⇒		*	=↓	⇒				
36	Cost statements		→	⊙	=⇳ ⇒		*	=↓	O			⇒	⇒			⇒		⇒		⇒		⇒				
37	Supporting documentation		→		*⇳	=↓ ⊙	⇒		O			⇒	⇒			⇒		⇒		⇒		⇒				
38	Certificate of practical completion	>			*⇳	=↓ ⊙	⇒		O				⇒		→	⇒	→	⇒	→	⇒	→					
39	Snagging		→	⊙	=⇳ ⇒				O				+	*	=⊙ ↓											
40	Certificate of final completion	>			*⇳	=↓ ⊙			O				→	⇒	⇳		→		→		→					
41	Contractual obligations fulfilled	✓	↑		⇒																					

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⇳ Coordinating O Directing ↑ Recommending ✓ Approving

APPENDIX C: 3R CHARTS FOR CASE STUDY C

Project C
Stage 1: Inception

[1]→{2}→

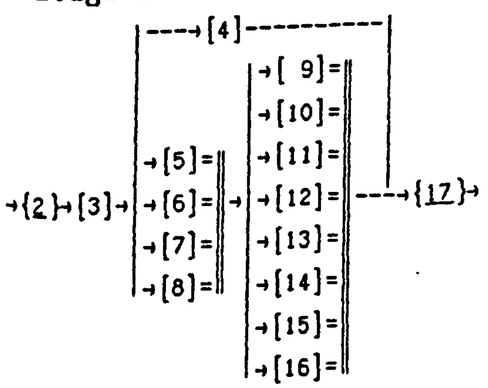
{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1974	4 Her Majesty's Inspectorate	5 County Council	6 Police Committee	7 Police - Forces Policy Review Sub-Ctee	8 Policy Committee	9 Policy - Lands & Buildings Sub-Ctee	64 Chief Constable '1'	66 Asst Chief Constable Management Services	67 Asst Chief Constable Buildings	68 Divisional Commander	69 Chief Superintendent Operations & Traffic	70 Police Planning Officer
1 Review of accommodation	→						⇔↑	↓	O‖	→	→	*
2 New facility is needed		✓	↑	↑	↑	↑	‖↑O ⇔	→				⇒

9/89

KEY: Op. sys: * Operating + Cooperating → Consulting ⇒ Input > Receiving
Con. sys: = Resourcing ⊙ Monitoring ↓ Supervising
Man. sys: ⇔ Coordinating O Directing ↑ Recommending ✓ Approving

Project C
Stage 2: Feasibility



() - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1974-75

	2 Home Office 'G3' Division	4 Her Majesty's Inspectorate	5 County Council	6 Police Committee	7 Police - Forces Policy Review Sub-Ctee	8 Policy Committee	9 Policy - Lands & Buildings Sub-Ctee	10 Policy - Finance & Gen. Purposes Sub-Ctee	11 Policy - Budget Sub-Committee	13 Planning - Area Sub-Committee	14 Passenger Transport Executive	15 Land Use Transportation Study	18 Chief Architect	19 Chief Engineer Major Works Division	20 Chief Executive	21 County Treasurer	22 County Planning Officer	26 County Estates Surveyor	30 Chief Mining Engineer	33 Chief Quantity Surveyor	37 Asst Chief Officer Functional Services	38 Deputy Estates Surveyor	40 Project Architect '1'	50 Neighbouring Divisional Headquarters	51 B.W.B. Area Estates Officer	52 B.W.B. Engineer	53 Water Authority Rivers Division	55 Gas Board	56 Electricity Board	57 Post Office Telephones	59 British Steel	61 B.R. Estates Surveyor & Manager	64 Chief Constable '1'	66 Asst Chief Constable Management Services	67 Asst Chief Constable Buildings	68 Divisional Commander	69 Chief Superintendent Operations & Traffic	70 Police Planning Officer	80 Clerk to the Police Committee	87 Metropolitan Borough Council	88 M.B.C. Planning & Resource Committee	89 M.B.C. Planning & Development Committee	90 M.B.C. Assistant to the Chief Executive	91 M.B.C. Director of Engineering	92 M.B.C. Director of Planning	98 M.B.C. District Estates Officer	99 M.B.C. Legal & Administrative Officer
2 New facility is needed			✓	↑	↑	↑	↑						→‖					→‖																									
3 Identify scope of project	→‖		✓	↑	↑⊙		↑																									↑→‖	‖↓											
4 Major capital works return	→‖	→‖	↑	↑↓		↑		↑	↑			→‖	⊕↑‖				→‖	⊙ =↓				*	→‖		→‖																			
5 Identify possible location			✓										*⊕ =O									‖*																					
6 Site feasibility studies												→‖	*⊕ =O	→‖	→‖		→‖	→‖				‖*					→‖	→‖	→‖	→‖	→‖												
7 Initial layout plans													⊙↓ ⇉ =O					=				*					→‖	→‖	→‖	→‖	→‖												
8 Site services investigation													⇉ =⊙ ⇉					⇉	⇉	⇉			→⊕		⇉									⇉			✓O ⇉						
9 Establish budget estimate	✓	↑											⊙⇉					⇉	⇉	⇉			→⊕		⇉							↓	=	⇉			‖O						
10 Specify requirements	✓	↑											⊕O ⇉	=↓				⇉	*	⇉					⇉									⇉			⇉						
11 Site investigation													*= ⊙↓					⇉	⇉	⇉					⇉									⇉			⇉						
12 Identify consultants			✓	↑		↑	↑						→⇉					⇉	⇉	⇉					⇉							=O		*⊕			→⇉						
13 Pre-contract programme										⊙			*⊕ O			⊙	→⇉	⇉	⇉			→		⇉									⇉			⇉		✓		↑		
14 Outline planning application													✓⇉				→⇉	⇉	⇉	✓		↑ →	→	*									⇉			⇉		→				
15 Canal strengthening scheme										→			=⊕ ⇉		>	→	*⊕	⇉	⇉			→	→✓	⇉							→✓		⇉			⇉						
16 Acquisition of site	✓	↑	↑	↑		↑	↑						⇉				⇉	⇉	⇉					⇉									→⇉			→⇉	→⇉					
17 Scheme included in major capital works budget	↥	→																																									

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⊕ Coordinating O Directing ↑ Recommending ✓ Approving

Project C
Stage 3: Sketch Scheme

→{17}-|→[18]=‖ →[19]=‖ →[20]=‖ →[21]=‖|-|→[22]=‖ →[23]=‖ →[24]=‖ →[25]=‖ →[26]=‖|-|→[27]- →[28]- →[29]-|→{30}→

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

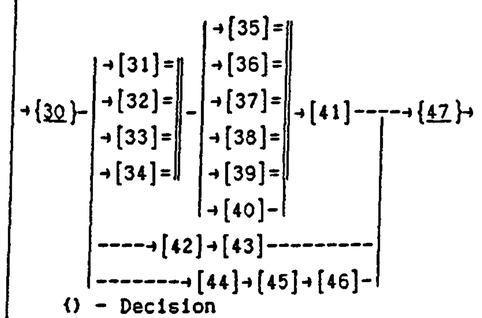
1975-77

	Home Office 'G3' Division 2	Her Majesty's Inspectorate 4	County Council 5	Policy Committee 8	Policy - Lands & Buildings Sub-Ctee 9	Planning Committee 12	Planning - Area Sub-Committee 13	Passenger Transport Executive 14	Land Use Transportation Study 15	Chief Architect 18	Chief Engineer Major Works Division 19	Chief Executive 20	County Treasurer 21	County Planning Officer 22	County Legal Services Officer 23	County Estates Surveyor 26	County Services Engineer 28	Chief Bridge Engineer 32	Chief Quantity Surveyor 33	Asst Chief Officer Functional Services 37	Project Architect '1' 40	Project Architect '2' 41	Neighbouring Divisional Headquarters 50	Chief Constable '1' 64	Asst Chief Constable Management Services 66	Asst Chief Constable Buildings 67	Divisional Commander 68	Chief Superintendent Operations & Traffic 69	Police Planning Officer 70	Communications Officer 71	Transport Manager 72	Catering Officer 73	Firearms Officer 74	Crime Prevention Officer 75	Sports & Social Club Divisional Committee 76	Mounted Police Department 77	Dog Handler's Department 78	Scenes of Crimes Department 79	Clerk to the Police Committee 80	M.B.C. Planning & Development Committee 89	M.B.C. Director of Engineering 91	M.B.C. Director of Planning 92	M.B.C. District Drainage Officer 96	M.B.C. District Estates Officer 98	Hydraulic Pump Suppliers 04
17 Scheme included in major capital works budget	↑	→																								→			→														
18 Sketch scheme	⇉									O=									⇉		✱⇹				⊙	↓=			✱																
19 Initial schedule of accommodation	⇉																		⇉		→O ⇉		→	⊙		↓=			✱⇹															
20 Establish detailed requirements	⇉									=⊙ ⇹O									✱		⇉	⇉							⇉															
21 Budget estimate	⇉									✱	⇉	✓	↑	⇉		⇉			⇉		⇉	⇉		↑		→			⇉														
22 Financing of administrative costs										⊙O ⇉	✱=			⇉		→⇉			⇉		→⇹ ✓⇉	⇉							⇉														
23 Road diversion design & estimate										↓O ⇉	⇉			⇉		⊙⇉		→	⇉		→⇹ ⇉ ✓↓	✱							⇉										→				→
24 Drainage scheme design & estimate						✓	↑	→	→	⊙⇹ ⇉	→⇉			✱	→	⇉	→		⇉	↑	⇉	⇉							⇉										→	→	→	→	
25 Integration with transportation planning requirements										↑= ⇉ ⊙⇹	⇉			→		✱			⇉		⇉	⇉							⇉									✓		↑ ⊙			
26 Re-submission of outline planning application										→= ⇉ ⊙⇹	⇉			⇉		⇉			✱		⇹	⇉																					
27 Revise estimates										⇉	⇉			⇉		⇉					⇉			↑		=↓	→⊙	→	✱⇹	→	→	→	→	→	→	→	→	→				
28 Detailed schedule of accommodation	✓	↑								⇉	⇉			⇉		⇉						⇉				→			→⊙											⊙→		
29 Submission for detailed planning permission			✓	⊙↑						✱				⇉		→⇉						⇉				→			→⊙											↑		
30 Planning approved, proceed to detail design			✓		>					↑= O⇉				>					⇉										⇉									✓		↑		

9/83

KEY: Operating system: ✱ Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⇹ Coordinating O Directing ↑ Recommending ✓ Approving

Project C Stage 4a: Detail design, main contract



() - Decision
[] - Operation
→ - Sequential
= - Reciprocal

1977-79

	Secretary of State 1	Home Office 'G3' Division 2	Home Office Dir. of Telecommunications 3	Her Majesty's Inspectorate 4	County Council 5	Police Committee 6	Policy Committee 8	Policy - Lands & Buildings Sub-Ctee 9	Policy - Finance & Gen. Purposes Sub-Ctee 10	Policy - Budget Sub-Committee 11	Chief Architect 18	Chief Engineer Major Works Division 19	Chief Executive 20	County Treasurer 21	County Planning Officer 22	County Legal Services Officer 23	County Engineer 24	County Fire Officer 25	County Services Engineer 28	Group Engineer 29	Chief Quantity Surveyor 33	Project Architect '1' 40	Project Structural Engineer 43	Electricity Board 56	Post Office Telephones 57	B.R. Estates Surveyor & Manager 61	Neighbouring County Architect 62	Neighbouring City Chief Q.S. 63	Chief Constable '1' 64	Chief Constable '2' 65	Asst Chief Constable Buildings 67	Divisional Commander 68	Chief Superintendent Operations & Traffic 69	Police Planning Officer 70	Communications Officer 71	Transport Manager 72	Firearms Officer 74	Crime Prevention Officer 75	Mounted Police Department 77	Dog Handler's Department 78	Scenes of Crimes Department 79	Consultant Partner Services Engineers 82	Consultant Project Services Engineers 83	Consultant Partner Quantity Surveyor 84	Consultant Project Quantity Surveyor 85	Royal Fine Arts Commission 86	M.B.C. Planning & Development Committee 89	M.B.C. Director of Engineering 91	M.B.C. Director of Planning 92	M.B.C. District Building Control Officer 95	Site Investigation Sub-contractors a3	Official Journal of the E.E.C. c3	Model Maker c4	Selected Tenderers c7
30 Planning approved, proceed to detailed design					✓			>			↑⇉ O				>																																				
31 Programme proposals		✓	✓		↑	↑					⇉= ⊙⇉		↑	→⊙ ↑							→⇉	→						↑																								
32 Revised budget estimate & cost plan		✓									⇉ =⊙										⇉	⇉				↓																								
33 Appointment of consultants											⇉ =⊙										⇉	⇉																													
34 Presentation for inclusion of fees in expenditure budget					✓	↑	↑		↑	↑	⇉		⇉	→							⇉							↑⇉																					
35 Architectural design		✓		↑	↑	↑					⇉ =⊙ ⇉					→↑		→↓	↓	⇉	⇉⇉	⇉							↑	⇉	→	→		⇉	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
36 Structural design											→⇉	=↓								⇉	⇉	⇉	⇉	→	→																									
37 Services design											⊙⇉						→	↓		⇉	⇉ ✓ ⇉	⇉	→	→																											
38 Detailed revision of requirements		✓	✓	→↑							→⇉		⊙		↑					⇉	⇉	⇉							= ↑	⊙ ↑	→	→	⇉⇉	→	→	→	→	→	→	→		⇉		⇉						
39 Detailed cost plans & estimates											⇉									⊙⇉	→⇉ ⇉	⇉			→								⇉										⇉	=↓	⇉					
40 Establish contractual system					✓	↑					⇉= ⊙⇉		↑							⇉									↑																				⇉		
41 Revise programme		✓		✓	↑	↑					⇉= ⊙⇉		⊙ ↑	→ ↑							⇉	⇉							→↑				⇉										⇉		⇉					
42 Application for capital expenditure on bore holes					✓	↑	↑			↑	⇉= ⊙⇉		→	→															⇉↑																					
43 Bore hole investigation											>⇉	↓									↓>			→																									
44 Application for capital expenditure on model					✓	↑	↑		↑	↑	⇉= ⊙⇉		→	→							→								→↑																					
45 Tender action for model											⇉= ⊙⇉			>							→																													
46 Construction of model						>					⊙⇉		↓								→⇉								⇉↑																					
47 Design approved, scheme included in budget	✓	↑		↑	↑	↑	↑		↑	↑	⇉																		⇉↑																				

9/69

KEY: Operating system: ⇉ Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⇉ Coordinating O Directing ↑ Recommending ✓ Approving

Project C **Stage 4b:**
Detail design, main contract

→{47}-‖ →[48]= / →[49]= / →[50]= / →[51]= / →[52]= / →[53]= / →[54]= / →[55]= ‖→[56]→{57}→

() - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1977-79

	1 Secretary of State	2 Home Office 'G3' Division	3 Home Office Dir. of Telecommunications	4 Her Majesty's Inspectorate	5 County Council	6 Police Committee	8 Policy Committee	9 Policy - Lands & Buildings Sub-Ctee	10 Policy - Finance & Gen. Purposes Sub-Ctee	11 Policy - Budget Sub-Committee	12 Planning Committee	13 Planning - Area Sub-Committee	18 Chief Architect	19 Chief Engineer Major Works Division	20 Chief Executive	21 County Treasurer	22 County Planning Officer	23 County Legal Services Officer	24 County Engineer	25 County Fire Officer	26 County Estates Surveyor	27 Senior Building Services Engineer	29 Group Engineer	32 Chief Bridge Engineer	33 Chief Quantity Surveyor	40 Project Architect "1"	43 Project Structural Engineer	51 B.W.B. Area Estates Officer	52 B.W.B. Engineer	56 Electricity Board	65 Chief Constable '2'	67 Asst Chief Constable Buildings	68 Divisional Commander	69 Chief Superintendent Operations & Traffic	70 Police Planning Officer	71 Communications Officer	72 Transport Manager	73 Catering Officer	74 Firearms Officer	75 Crime Prevention Officer	76 Sports & Social Club Divisional Committee	77 Mounted Police Department	78 Dog Handler's Department	79 Scenes of Crimes Department	82 Consultant Partner Services Engineers	83 Consultant Project Services Engineers	84 Consultant Partner Quantity Surveyor	85 Consultant Project Quantity Surveyor	86 Royal Fine Arts Commission	89 M.B.C. Planning & Development Committee	92 M.B.C. Director of Planning
47 Design approved, scheme included in budget	✓	↑		↑	↑	↑	↑		↑	↑															↓					↓																				
48 Contractual proposals		✓	⇉		↑	↑							⇉											↓	⇉	⇉				↓																				
49 Re-submission of budget estimate		✓	⇉	✓									⇉	→						→			→		⇉	⇉				↑	=↓	→⊙	→	⇉	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
50 Re-submission of schedule of accomm		✓	⇉	↑									⇉												⇉	⇉				=✓	⊙↑	→	→	⇉	→	→		→	→											
51 Revision of requirements		✓	✓⇉	→↑									→⇉		⊙			↑				⊙↓				⇉	⇉				↑⇉				⇉																
52 Revise services design			⇉										⊙⇉		→				→	→						⇉⇉	⇉				⇉																				
53 Revise architectural design		✓	⇉	↑	↑	↑							=⊙ / O⇉					→					=⊙		→	→⇉	⇉				⇉				⇉																
54 Revise structural design			⇉										⊙⇉ / ⇉	↓				⊙					=⊙		→	⇉	⇉				⇉				⇉													✓	⊙
55 Detailed planning application			⇉					>			↑	↑	⇕= / ⇕O				→↑			→					⇉	⇉	→	→		⇉				⇉												⇉		→		
56 Formal presentation for budget inclusion			⇉										⇕= / ⇕O	→	→										→⇉	⇉				↑→ / ⇕ / ↑⇕				⇉																
57 Design approved, scheme included in budget	✓	↑		↑	↑	↑	↑		↑	↑			⇉																																					

3/89

KEY: Operating system: ⇕ Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⇕ Coordinating O Directing ↑ Recommending ✓ Approving

Project C **Stage 4c**
Detail design, advance contract

→{47}→ [→[58]= ; →[59]= ; →[60]= ; →[61]= ; →[62]= ; →[63]=] == [→[64]- ; →[65]-] →{66}→

{} - Decision
[] - Operation
→ - Sequential
= - Reciprocal

1979	Secretary of state 1	Home Office 'G3' Division 2	Her Majesty's Inspectorate 4	County Council 5	Police Committee 6	Policy Committee 8	Policy - Finance & Gen. Purposes Sub-Ctee 10	Policy - Budget Sub-Committee 11	Passenger Transport Executive 14	Land Use Transportation Study 15	Chairman of the County Council 16	Vice Chairman of the County Council 17	Chief Architect 18	Chief Engineer Major Works Division 19	Chief Executive 20	County Treasurer 21	County Planning Officer 22	County Engineer 24	County Estates Surveyor 26	Chief Traffic Engineer 31	Chief Quantity Surveyor 33	Chief Officer Legal Services 35	Asst Chief Officer Legal Services 36	Project Architect '1' 40	Project Architect - Drainage 42	Project Structural Engineer 43	B.W.B. Area Estates Officer 51	B.W.B. Engineer 52	Water Authority Rivers Division 53	Water Authority Pollution Inspector 54	Gas Board 55	Electricity Board 56	Post Office Telephones 57	British Oxygen 60	B.R. Estates Surveyor & Manager 61	Chief Constable '2' 65	Consultant Project Services Engineers 83	Consultant Project Quantity Surveyor 85	Metropolitan Borough Council 87	M.B.C. Planning & Development Committee 89	M.B.C. Director of Engineering 91	M.B.C. Director of Planning 92	M.B.C. District Drainage Officer 96
47 Design approved, scheme included in budget	✓	↑	↑	↑	↑	↑	↑	↑																																			
58 Planning application									→	→			⁎= ⊙θ	→⇉			⊙↑					→		→	⇉	→											→	→	✓	↑			
59 Compile tender list				✓	↑								⁎= ⊙θ	→⇉											⇉																		
60 Programme proposals													⊙θ ⇉	⁎				↓=						→	⇉		>	→	→		→	→	→	→	→	⇉							
61 Roads & surface drainage details													⊙θ ⇉	⁎				↓=	→θ ⊙					→	⇉		→↑		→		→	→	→	→	⇉		→	→			→		
62 Foul drainage design details													=⊙ ⇉ ↓θ	⇉						↑					⁎			>		→		→	→		⇉							✓
63 Cost estimates		✓		↑	↑	↑	↑	↑					⊙θ ⇉	⁎				↓=			→			→	⇉				→					⇉							
64 Arrangements for tender approval				✓	↑						>	>	⁎= ⊙θ	⇉											⇉																		
65 Negotiation of easements													=⊙ θ⇉	⇉				→	⁎				→		⇉		→✓	→✓			→			→	→							
66 Design for advance contract acceptable, proceed to contract		✓		✓	↑								↑= ⊙θ						⇉																							

9/89

KEY: Operating system: ⁎ Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: θ Coordinating O Directing ↑ Recommending ✓ Approving

Project C Stage 5a
Contract. main contract

→{57}- | →[67]= / →[68]= / →[69]= / →[70]= / →[71]= / →[72]= / →[73]= / →[74]= = - | →[75]- / →[76]- / →[77]- / →[78]- - | →[79]- / →[80]- | →{81}-

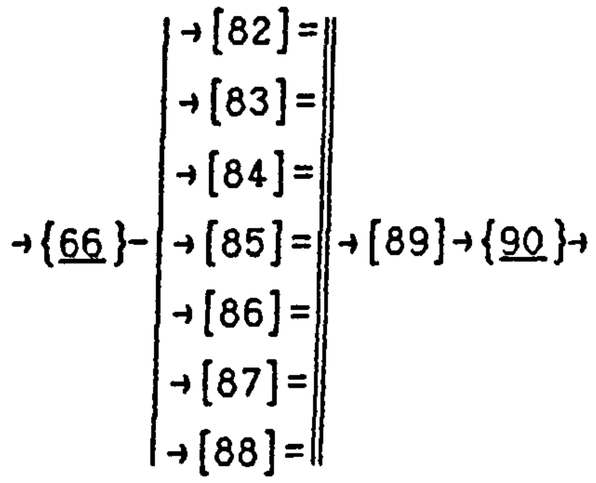
{} - Decision
[] - Operation
→ - Sequential
= - Reciprocal

1979-80

	1 Secretary of State	2 Home Office 'G3' Division	4 Her Majesty's Inspectorate	5 County Council	6 Police Committee	8 Policy Committee	9 Policy - Lands & Buildings Sub-Ctee	10 Policy - Finance & Gen. Purposes Sub-Ctee	11 Policy - Budget Sub-Committee	18 Chief Architect	19 Chief Engineer Major Works Division	20 Chief Executive	21 County Treasurer	22 County Planning Officer	23 County Legal Services Officer	24 County Engineer	25 County Fire Officer	26 County Estates Surveyor	27 Senior Building Services Engineer	28 County Services Engineer	29 Group Engineer	33 Chief Quantity Surveyor	36 Asst Chief Officer Legal Services	40 Project Architect '1'	43 Project Structural Engineer	51 B.W.B. Area Estates Officer	52 B.W.B. Engineer	57 Post Office Telephones	61 B.R. Estates Surveyor & Manager	65 Chief Constable '2'	67 Asst Chief Constable Buildings	68 Divisional Commander	69 Chief SuperIntendent Operations & Traffic	70 Police Planning Officer	71 Communications Officer	72 Transport Manager	74 Firearms Officer	75 Crime Prevention Officer	76 Sports & Social Club Divisional Committee	82 Consultant Partner Services Engineers	83 Consultant Project Services Engineers	84 Consultant Partner Quantity Surveyor	85 Consultant Project Quantity Surveyor	89 M.B.C. Planning & Development Committee	92 M.B.C. Director of Planning	95 M.B.C. District Building Control Officer	c5 Nominated Suppliers	c7 Selected Tenderers
57 Design approved, scheme included in budget	✓	↑	↑	↑	↑	↑		↑	↑																																								
67 Select nominated sub-contractors				✓	↑					=↓ O⇒								⇒		→				⇒	⇒					⇒																				
68 Compile tender list - main contract		.		✓	↑					*= ⊕O								⇒						⇒	⇒					⇒																				
69 Preparation of bills of quantity										O⇒								⇒			→			→⊕ /⇒	⇒					⇒																				
70 Legal technicalities				✓		↑	↑			O⇒		→↑			→	→		*⊕					→⊕ ↑	⇒	⇒	→/	→		→/	⇒																				
71 Cost control		→		↑	↑					⊕⇒						→		⇒						⊕⇒	⇒					⇒																				
72 Detailed structural design										O⇒	↓				=			⇒			↓	→		⊕⇒	*					⇒																				
73 Detailed architectural design		✓	↑	↑	↑					⊕O ⇒					→			⇒						*⊕	⇒					↑ ⇒	⊕ ↑	→	→	→ ↑	→	→	→	→	→									
74 Detailed services design										O⇒						→		⇒	⊙					⊕⇒	⇒			→		⇒											=↓	*		⇒					
75 Finalisation of bills of quantity										O⇒								⇒			→			→⊕ /⇒	⇒																	→⇒	=↓	*⊕					
76 Schedule of furniture & equipment										=O ⇒ ↓⊕								⇒						*	⇒					✓				→↑		-						⇒		⇒					
77 Submission for building regulations										=O ⇒ ↓⊕	→				→			⇒						*	⇒																	⇒		⇒		✓			
78 Revised planning application										=↓ ⇒				→				⇒						*⊕	⇒																	⇒		⇒	✓	→↑			
79 Tender action: services subcontract		✓		↑	↑					⊕ ↑														⊕O ⇒																		=↓	*		⇒					→>
80 Tender action: main contract		✓		↑	↑					*= O⊕														⇒																				⇒					→>
81 Commence main contract construction		✓		↑	↑					=O ⇒														↑																			→⇒		→					

KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⊕ Coordinating O Directing ↑ Recommending ✓ Approving

Project C: Stage 5b
Contract, advance contract



() - Decision
[] - Operation
→ - Sequential
≡ - Reciprocal

1979

	Home Office 'G3' Division 2	County Council 5	Police 6	Chief Officer Legal Services 18	Chief Engineer Major Works Division 19	County Estates Surveyor 26	Senior Building Services Engineer 27	Asst Chief Architect 36	Project Architect 40	Project Architect - Drainage 42	B.W.B. Engineer 52	Water Authority Rivers Division 53	Water Authority Pollution Inspector 54	Gas Board 55	Electricity Board 56	Post Office Telephones 57	M.B.C. District Drainage Officer 96	Fencing Sub-contractor c6	Selected Tenderers c7
66 Design for advance contract acceptable, proceed to contract	✓	✓	↑	↑≡ ⊙Θ															
82 Mark out site boundary		>	>	⊙Θ ⇉		→⊙ ↓			→	⇉	⇉	⇉		⇉	⇉	⇉		*	
83 Water supply contract		>	>	⊙Θ ⇉	⊙Θ	→	→	→		⇉	⇉	*		⇉	⇉	⇉		⇉	
84 Electricity supply contract		>	>	⊙Θ ⇉	⊙Θ	→	→	→		⇉	⇉	⇉		⇉	*	⇉		⇉	
85 Telephone supply contract		>	>	⊙Θ ⇉	⊙Θ	→	→	→		⇉	⇉	⇉		⇉	⇉	*		⇉	
86 Waterways board contract		>	>	⊙Θ ⇉	⊙Θ	→	→	→		⇉	*	⇉		⇉	⇉	⇉		⇉	
87 Gas supply contract		>	>	⊙Θ ⇉	⊙Θ	→	→	→		⇉	⇉	⇉		*	⇉	⇉		⇉	
88 Detailed design - foul drainage				=⊙ ⇉					→Θ	*	⇉	✓⇉	→	⇉	⇉	⇉	→	⇉	
89 Tender action - advance contract			.	*= Θ					+	+⇉	⇉	⇉		⇉	⇉	⇉		⇉	+
90 Commence advance cont. construction		✓	↑	↑≡ Θ															→>

3/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: Θ Coordinating O Directing ↑ Recommending ✓ Approving

Project C: Stage 6a
Advance contract, construction

→{90}→[91]-|→[92]=‖ / →[93]=‖|→[94]→[95]→{96}

() - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1979-80	5 County Council	6 Police Committee	18 Chief Architect	19 Chief Engineer Major Works Division	24 County Engineer	33 Chief Quantity Surveyor	34 Senior Quantity Surveyor	36 Asst Chief Officer Legal Services	38 Deputy Estates Surveyor	39 Deputy Architect	40 Project Architect '1'	45 Highways Engineer - Supervision	46 Site Engineer	60 British Oxygen	61 B.R. Estates Surveyor & Manager	70 Police Planning Officer	84 Consultant Partner Quantity Surveyor	85 Consultant Project Quantity Surveyor	a8 Advance Contractor's Building Manager	a9 Advance Contractor's Site Agent	b0 Advance Contractor's Planning Engineer	b1 Advance Contractor's Quantity Surveyor '1'	b2 Advance Contractor's Quantity Surveyor '2'	b3 Advance Contractor's Foreman	b5 Sheet Piling Specialist	c7 Selected Tenderers
90 Commence advance cont. construction	✓	↑	⇕ |→=																							→>
91 Sheet piling		>	⊙⇕	⊙							⇕					→			↓	=⊙	→	→		⇕	*	
92 Construction work		>		⊙⇕			⊥			→	⇕	⊙				→			→	=⊙				*⇕	⇕	
93 Design information		>	⊙	*	=⊙						⇳			✓	>	→			→	→	→			→⇒	⇒	
94 Advance contract snagging		>		⊙⇒					→		⇳		→⊙			→			↓	=⊙				*⇳		
95 Advance contract final account			⊙			→					→⇳						=⊙	*	→	→			→	→⇒	→	
96 Certificate of final completion	>	>	→⇳					✓		↥						→		⇒								

9/83

KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⇳ Coordinating O Directing ↑ Recommending ✓ Approving

Project C: Stage 6b
Main contract construction

```
                 |→[97]=======||
                 |→[98]=======||
                 |→[99]=======||
                 |------→[105]=||        |→[110]-|
→{81}→|→[100]======||→|       |→[112]→{113}
                 |------→[106]=||        |→[111]-|
                 |→[101]======||
                 |------→[107]=||
                 |→[102]======||
                 |------→[108]=||
                 |→[103]======||
                 |------→[109]=||
                 |→[104]======||
```

() - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1980-85

1980-85	Home Office 'G3' Division 2	Home Office Dir. of Telecommunications 3	Her Majesty's Inspectorate 4	County Council 5	Police Committee 6	Chief Architect 18	Chief Engineer Major Works Division 19	Chief Executive 20	County Legal Services Officer 23	County Engineer 24	County Fire Officer 25	Senior Building Services Engineer 27	County Services Engineer 28	Group Engineer 29	Chief Quantity Surveyor 33	Deputy Architect 39	Project Architect '1' 40	Project Architect '2' 41	Project Architect - Drainage 42	Project Structural Engineer 43	Resident Engineer - Main Contract 47	Clerk of Works 49	Water Authority Rivers Division 53	Water Authority Pollution Inspector 54	Post Office Telephones 57	Chief Constable '2' 65	Asst Chief Constable Buildings 67	Divisional Commander 68	Chief Superintendent Operations & Traffic 69	Police Planning Officer 70
81 Commence main contract construction																	↑													
97 Cost statements						Θ									→		→⇹ O⇒		⇒	⇒										⇒
98 Architectural design information	✓		↑	↑	↑	=Θ ↓				→							#⇹ O		⇒	⇒						↑	⇹↑	→	→	→↑ ⇒
99 Structural design information						Θ	↓			=				↓	→		⇹O ⇒		⇒	#										⇒
100 Services design information					+	Θ					→	Θ↓					⇹O ⇒		⇒	⇒					→					⇒
101 Drainage design information						→Θ											⇹O ↑⇒		#	⇒			✓	→						⇒
102 Lift installation detailed design						Θ					→	↓Θ					⇹O ⇒		⇒	⇒										⇒
103 Briefing information	✓	✓	→↑			→⇹		Θ	↑								⇒		⇒	⇒						=↑	Θ↑	→	→	#⇹
104 Substructure construction					>	→Θ							→		→		⇒	⇹O	⇒	⇒	→Θ									→⇒
105 Superstructure construction					>	→Θ							→		→		⇒	⇹O	⇒	⇒	→Θ									→⇒
106 Mechanical services installation					>	→Θ							→		→		⇒	⇹O	⇒	⇒	→Θ									→⇒
107 Electrical services installation					>	→Θ							→		→		⇒	⇹O	⇒	⇒	→Θ									→⇒
108 Lift installation					>	→Θ							→		→		⇒	⇹O	⇒	⇒	→Θ									→⇒
109 Internal works construction					>	→Θ							→		→		⇒	⇹O	⇒	⇒	→Θ									→⇒
110 External works construction					>	→Θ							→		→		⇒	⇹O	⇒	⇒	→Θ									→⇒
111 Specialist installations					>	→Θ							→		→		⇒	⇹O	⇒	⇒	→Θ									→⇒
112 Snagging & making good					>	→Θ							→		→			⇹O			→Θ									→
113 Certificate of final completion	✓			↑	↑ >	→= ↓Θ							→		→	→Θ		↑⇹		→		↑								→>

1980-85	Communications Officer 71	Transport Manager 72	Firearms Officer 74	Crime Prevention Officer 75	Sports & Social Club Divisional Committee 76	Mounted Police Department 77	Dog Handler's Department 78	Scenes of Crimes Department 79	Consultant Partner Services Engineers 82	Consultant Project Services Engineers 83	Consultant Partner Quantity Surveyor 84	Consultant Project Quantity Surveyor 85	M.B.C. Director of Planning 92	M.B.C. District Building Control Officer 95	M.B.C. District Drainage Officer 96	Main Contractor's Director b6	Main Contractor's Contracts Manager b7	Main Contractor's Contract Surveyor b8	Main Contractor's Asst Surveying Manager b9	Main Contractor's Planning Engineer c0	Main Contractor's Senior Site Agent c1	Main Contractor's Site Agent c2	Mechanical Engineering Sub-contractor c8	Electrical Engineering Sub-contractor c9	Lift Installation Sub-contractor d0	Specialist Sub-contractors d1
81 Commence main contract construction										→		→														
97 Cost statements										⇒	=↓	#										⇒	⇒	⇒	⇒	
98 Architectural design information	→	→	→	→	→					⇒		⇒	Θ									⇒	⇒	⇒	⇒	
99 Structural design information										⇒		→⇒		→								⇒	⇒	⇒	⇒	
100 Services design information									=↓	#		⇒										⇒	⇒	⇒	⇒	
101 Drainage design information										⇒		⇒			→							⇒	⇒	⇒	⇒	
102 Lift installation detailed design									Θ	↓⇒		→⇒										⇒	⇒	⇒	#	
103 Briefing information	→	→	→	→		→	→	→		⇒		⇒										⇒	⇒	⇒	⇒	
104 Substructure construction										⇒		⇒				Θ	⇹	→	→	→	=↓	#	⇒	⇒	⇒	
105 Superstructure construction										⇒		⇒				Θ	⇹	→	→	→	=↓	#	⇒	⇒	⇒	
106 Mechanical services installation									→	→Θ ⇒		⇒				Θ	⇹	→	→	→	=↓	⇒	#	⇒	⇒	
107 Electrical services installation									→	→Θ ⇒		⇒				Θ	⇹	→	→	→	=↓	⇒	⇒	#	⇒	
108 Lift installation									→	→Θ ⇒		⇒				Θ	⇹	→	→	→	=↓	⇒	⇒	⇒	#	
109 Internal works construction										⇒		⇒				Θ	⇹	→	→	→	=↓	#	⇒	⇒	⇒	
110 External works construction										⇒		⇒				Θ	⇹	→	→	→	=↓	#	⇒	⇒	⇒	
111 Specialist installations										⇒		⇒				Θ	⇹	→	→	→	=↓	⇒	⇒	⇒	⇒	#
112 Snagging & making good																Θ	⇹	→	→	→	=↓	#				⇒
113 Certificate of final completion										→		→						→	→	→	→	⇒	→	→	→	→

9/89

KEY: Operating system: # Operating + Cooperating → Consulting ⇒ Input > Receiving
Control system: = Resourcing Θ Monitoring ↓ Supervising
Managing system: ⇹ Coordinating O Directing ↑ Recommending ✓ Approving

APPENDIX D: 3R CHARTS FOR CASE STUDY D

Project D
Stage 1: Inception

[1]→{2}→

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1962	County Council 1	County Librarian '1' 6	Recreation Committee 30	County Librarian's Development Officer 53	Divisional Librarian 54	Borough Council 00
1 Review of facilities		✱= ⊕		→	→	→
2 New library needed	✓	↑	↑			

9/89

KEY: Op. sys: ✱ Oper. + Coop. → Consult. ⇒ Input > Receiving
Con. sys: = Resourcing ⊙ Monitoring ↓ Supervising
Man. sys: ⊕ Coord. O Directing ↑ Recommending ✓ Approving

Project D
Stage a2: Feasibility

→{2}→[3]→{4}→

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1963-66	County Council 1	Library and Museums Committee 5	County Librarian '1' 6	County Planning Officer 7	County Architect '1' 10	Chief Quantity Surveyor 13	Borough Council Gen Purposes Ctee 19	Recreation Committee 30	Southern Division Planning Committee 32	County Surveyor 77
2 New library needed	✓		↑					↑		
3 Site feasibility studies	✓		→⇒		✱= ⊕	→				→
4 Site identified (site no. 1)	✓→	↑		+=	↑		↑		↑	

9/89

KEY:
Opg. sys: ✱ Operating + Cooperating → Consulting ⇒ Input > Receiving
Cnt. sys: = Resourcing ⊙ Monitoring ↓ Supervising
Mng. sys: ⊕ Coordinating O Directing ↑ Recommending ✓ Approving

Project D
Stage a3: Sketch scheme

→{4}→[5]→[6]-|→[7]=|→[9]→[10]→{11}→
|→[8]=|

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

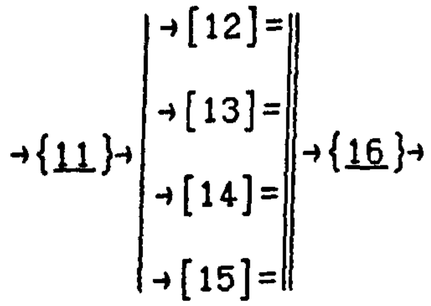
1966-68

	1 County Council	2 Clerk to the County Council	3 County Education Officer	4 Senior Land Acquisition Officer	5 Library and Museums Committee	6 County Librarian '1'	7 County Planning Officer	8 Consultant Partner Architect	9 Consultant Project Architect	10 County Architect '1'	11 Principal Land Acquisition Officer	14 Borough Engineer	19 Borough Council General Purposes Ctee	22 County Engineer (Highways Department)	24 County Librarian's Chief Admin Officer	25 Consultant Project Quantity Surveyor	26 Consultant Partner Quantity Surveyor	29 County Finance Committee	30 Recreation Committee	31 Borough Planning Committee	32 Southern Division Planning Committee	36 Borough Libraries & Museums Sub-Ctee	53 County Librarian's Development Officer	54 Divisional Librarian	77 County Surveyor	00 Borough Council
4 Site identified (site no. 1)	↑				→✓		+=			↑			↑								↑					
5 Acquisition of site no. 1			*⊖				→⇉					→		→											=✓	→
6 Formulate brief			⇉			*= ⊖									→								→	→		
7 Sketch scheme						→O ⇉		=↓	*	→⊖						⇉										
8 Budget estimate						⇉			⇉	→⊖						*	=↓									
9 Presentation for inclusion in five year programme			→			*= O			⇉	→	→				→	⇉		↑	↑			→	→			
10 Outline planning application	>	→				→O ⇉				*=	→									→						
11 Site no. 1 unacceptable - find alternative site	✓	→					↑=			⇉											↑					

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing System: ⊖ Coordinating O Directing ↑ Recommending ✓ Approving

Project D
Stage b2: Feasibility



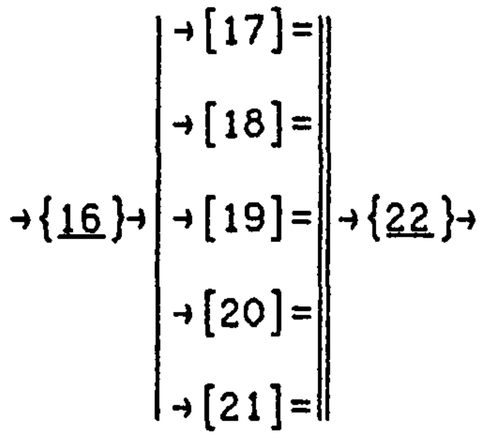
{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1968-72	1 County Council	2 Clerk to the County Council	3 County Education Officer	4 Senior Land Acquisition Officer	6 County Librarian '1'	7 County Planning Officer	8 Consultant Partner Architect	10 County Architect '1'	11 Principal Land Acquisition Officer	13 Chief Quantity Surveyor	14 Borough Engineer	15 Project Architect '1'	16 Borough Town Clerk	17 Borough Council Highways Committee	20 Medical Department	32 Southern Division Planning Committee	36 Borough Libraries & Museums Sub-Ctee	53 County Librarian's Development Officer	54 Divisional Librarian	59 Neighbour Touring Landowner	77 County Surveyor	00 Borough Council
11 Site no. 1 unacceptable - find alternative site	✓	→				↑=		⇉								↑						
12 Site feasibility studies		⊙›	→	→	→	→⇉	→	=⇹ ⇉		→	→	*		→					⇉		→	
13 Consolidate brief					=O	⇉		→⇉				⇉						→	*			
14 Integration of library scheme with proposed health centre scheme		›	→		→	⇉		*= ⇹	→		→	⇉			→				⇉	→	→	
15 Planning application for site no. 2		⊙›	→		→O	⇉		*=	→			⇉		→			↑		⇉			
16 Planning application rejected	✓	→				↑		⇉				⇉	⇹			↑			⇉			↑

9/89

KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input › Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⇹ Coordinating O Directing ↑ Recommending ✓ Approving

Project D
Stage b3: Sketch scheme



{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1972-73	1 County Council	2 Clerk to the County Council	3 County Education Officer	6 County Librarian '1'	7 County Planning Officer	10 County Architect '1'	12 County Treasurer	14 Borough Engineer	16 Borough Town Clerk	27 County Land Agent	28 Southern Divisional Planning Officer	29 County Finance Committee	30 Recreation Committee	31 Borough Planning Committee	32 Southern Division Planning Committee	61 Owner of part of the site	75 Senior Quantity Surveyor '2'	77 County Surveyor	00 Borough Council
16 Planning application rejected	✓	→			↑	⇉			⇿						↑				↥
17 Feasibility design work for site 1		⊙>		→O ⇉	→	⁂⇿		→	→		⇉						⇉	→	⇉
18 Cost planning				⇉		⇿⇉					⇉						⁂=		⇉
19 Integration of library scheme with housing scheme on site 1		⊙>	→	→ ⇉	=↓	⇉		→	→		⁂					→	⇉	→	⇉
20 Outline planning application, site 1			→	⇉	+	⁂⇿			→	→	⇉			→	>		⇉		⇉
21 Presentation for inclusion in capital expenditure budget				⁂= O		+⇉	→				⇉						⇉		⇉
22 Project deferred, planning problems too complicated to overcome	✓			⇉	↑	→⇉	→				⇉	↥	↑		↑		⇉		

9/89

KEY: Operating system: ⁂ Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⇿ Coordinating O Directing ↑ Recommending ✓ Approving

Project D
Stage c2: Feasibility

→{22}→[23]→[24]→ ‖ [25]= / [26]= ‖ → ‖ →[27]→[28]− / →[29]→[30]− ‖ →{31}→

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1973-80	1 County Council	3 County Education Officer	6 County Librarian '1'	7 County Planning Officer	10 County Architect '1'	11 Principal Land Acquisition Officer	12 County Treasurer	14 Borough Engineer	15 Project Architect '1'	18 Borough Engr, Survr & T.P. Officer	21 County Architect '2'	27 County Land Agent	28 Southern Divisional Planning Officer	29 County Finance Committee	30 Recreation Committee	31 Borough Planning Committee	32 Southern Division Planning Committee	33 Central Regional Library Committee	34 Church Minister	35 Land Procurement Steering Group	36 Borough Libraries & Museums Sub-Ctee	38 County Estates Officer	40 Borough Development Sub-Committee	43 Project Architect '2'	54 Divisional Librarian	67 Poster Group Property Manager	75 Senior Quantity Surveyor '2'	77 County Surveyor	96 County Secretary	97 Neighbouring Resident	98 County Treasurer Accountancy Division	01 Town Planning Consultant	02 County Secretary Legal Department	03 Poster Group Development Manager
22 Project deferred, planning problems too complicated to overcome	✓			↑	→		→							⊣↑	↑		↑																
23 Consider alternative locations		→	↑ O		*= ⊖	→⊕		→		→			→	⇉				>	→	✓	>												
24 Reformulate proposals for site 2		→	→⊙ O		*= ⊖	⊖		→	→			→			↑		→										→	→					
25 Resolve design & planning issues			→O		⇉						*= ⊖		→		✓		→					⇉		→			→						
26 Resolve boundary dispute				→	⇉						⇉											*= ⊖		⊙					→		→		
27 Negotiate pedestrian access to site			→O							→	⇉					→						*= ⊖			→	→				→			✓
28 Alternative arrangements for posters										→	⊙⊖					→						✓⇉		→		→					→		*	✓
29 Outline planning application			→O	↑			→				→⇉					→	↑					*⊖	→						→					
30 Presentation for inclusion in capital expenditure budget			*= ⊖O				→				+						→					⇉											
31 Development proposals accepted	✓		⇉	↥										↑	↑	↑	↑															⇉		

9/89

KEY:
Operating system: * Operating + Cooperating → Consulting ⇉ Input > Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⊖ Coordinating O Directing ↑ Recommending ✓ Approving

Project D
Stage c3: Sketch scheme

→{31}→[32]→ ‖ →[33]= ‖ →[34]= ‖ →[35]= ‖ →[36]= ‖ →[37]= ‖ →[38]- ‖ →[39]→{40}→

{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1980	1 County Council	6 County Librarian '1'	7 County Planning Officer	21 County Architect '2'	23 County Architects Land Survey Section	29 County Finance Committee	30 Recreation Committee	31 Borough Planning Committee	32 Southern Division Planning Committee	43 Project Architect '2'	46 Project Structural Engineer	49 Partner Services Engineer	52 Project Services Engineers	54 Divisional Librarian	70 Architect's Dept Budget Officer	71 Archt's Dept Principal Admin Officer	72 Archt's Assistant Programme Officer	73 Archt's Principal Structural Engineer	74 Partner Structural Engineer	75 Senior Quantity Surveyor '2'	76 Archt's Asst Director (Engineering)
31 Development proposals accepted	✓		↥			↑	↑	↑	↑												
32 Appointment of consultants			⇒	*= ⊙O			✓			→		→			⊖	→	→	→	→		→
33 Cost planning				⊙O ⇒						⊖⇒ ⇒	⇒		⇒							*=	
34 Architectural proposals				⊙O =⇒						*⊖	⇒		⇒	→						⇒	
35 Structural engineering proposals				⊙O ⇒						⊖⇒	*		⇒					→	=↓	⇒	
36 Services engineering proposals				⊙O ⇒						⊖⇒	⇒	=↓	*							⇒	
37 Programme proposals				⊙O =⇒						*⊖	⇒		⇒	→						⇒	
38 Land survey				⊙= ⇒	*					⊖↓											
39 Submission of project appraisal 1		→O		*= ⊙⊖	⇒					→⇒	→⇒		⇒							⇒	
40 Project Appraisal 1 satisfactory	✓			⇒			↥=													→	

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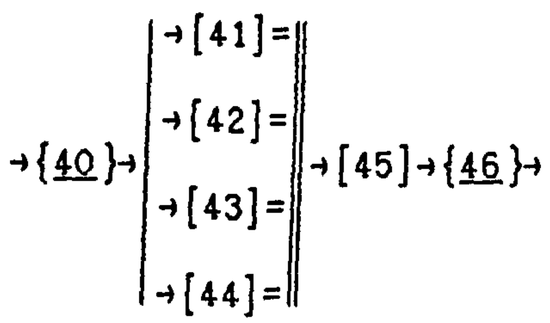
KEY: Operating system: * Operating + Cooperating → Consulting ⇒ Input › Receiving
Control system: = Resourcing ⊙ Monitoring ↓ Supervising
Managing system: ⊖ Coordinating O Directing ↑ Recommending ✓ Approving

Project D
Stage 4: Detail design



{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1980	1 County Council	6 County Librarian '1'	7 County Planning Officer	17 Borough Council Highways Committee	21 County Architect '2'	30 Recreation Committee	37 Borough Dir. of Technical Services	38 County Estates Officer	39 Electricity Board	40 Borough Development Sub-Committee	42 Building Control Officer	43 Project Architect '2'	44 Gas Board	46 Project Structural Engineer	49 Partner Services Engineer	52 Project Services Engineers	53 County Librarian's Development Officer	54 Divisional Librarian	72 Archt's Assistant Programme Officer	73 Archt's Principal Structural Engineer	74 Partner Structural Engineer	75 Senior Quantity Surveyor '2'	99 Borough Chief Planning Officer
40 Project Appraisal 1 satisfactory	✓				⇒	↑=																→	
41 Cost control					⊙O	⇒						⊖⇒		⇒		⇒						*=	
42 Detailed architectural design					⊙= ↓O	⇒					→	*⊖		⇒		⇒	→	→	→			⇒	
43 Detailed structural design					⊙O	⇒						⊖⇒		*		⇒	→	→		→⊙	=↓	→⇒	
44 Detailed services design					⊙O	⇒			→			⊖⇒	→	⇒	=↓	*						⇒	
45 Submission of project appraisal 2	→O			→	*= ⊙⊖		→	⊖		→		⇒		⇒		⇒						⇒	→
46 Project Appraisal 2 satisfactory	✓		⊙		⇒	↑=																⇒	

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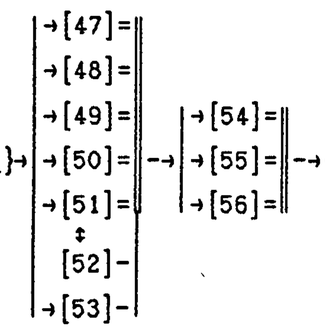
Project D
Stage 5: Contract



{} - Decision
[] - Operation
→ - Sequential
‖ - Reciprocal

1980-81	1	7	17	18	21	24	30	31	37	39	40	42	43	44	45	46	47	48	49	50	51	52	53	54	56	57	58	60	62	63	64	74	75	77	78	79	81	84	96	99	00
	County Council	County Planning Officer	Borough Council Highways Committee	Borough Engr, Survr & T.P. Officer	County Architect '2'	County Librarian's Chief Admin Officer	Recreation Committee	Borough Planning Committee	Borough Dir. of Technical Services	Electricity Board	Borough Development Sub-Committee	Building Control Officer	Project Architect '2'	Gas Board	Water Authority	Project Structural Engineer	Senior Quantity Surveyor	Project Architect's Assistant	Partner Services Engineer	Project Q.S. (Taking Off)	Partner Q.S. (Taking Off)	Project Services Engineers	County Librarian's Development Officer	Divisional Librarian	Building Materials Supplier	Timber Importers	Clay Product Manufacturers	Tendering Contractors	Fire Officer	County Supplies Officer	British Telecom Sales Office	Partner Structural Engineer	Senior Quantity Surveyor '2'	County Surveyor	County Surveyor's Asst Soils Engineer	County Surveyor's Materials Engineer	Glass Suppliers Technical Laboratory	Building Inspector's Agents	County Secretary	Borough Chief Planning Officer	Borough Council
46 Project Appraisal 2 satisfactory	✓	⊙			⇉		⊢↑=																																		
47 Cost control					⊙O =		⇉						⇹⇉			⇉	*			⇉																					
48 Preparation of bills of quantity					O		⇉						⇹⇉			⇉	⇉			*	=↓	⇉																			
49 Architectural working drawings					=⊙ O	→	⇉						⇹⇉			⇉	⇉		→	⇉		⇉	→	→	→	→	→			→			→				→				
50 Structural engineering working drwgs					⊙O		⇉						⇹⇉			*	⇉	→	→	⇉		⇉										=↓								
51 Services engineering working drwgs					⊙O		⇉			→			⇹⇉	→	→	⇉	⇉	→	=↓	⇉	→	*							✓		→									
52 Services engineering taking-off													⇹							*	=↓	⇉																		
53 Geotechnical report					⊙O		⇉																										=⊙	*	→						
54 Detailed planning application		→	→	→	*= ⊙O			✓			✓↑		⇹⇉			⇉	⇉			⇉		⇉	→										→	⇉				→	↑	✓
55 Building regulations submission					*= ⊙O				→			✓	⇹⇉			⇉	⇉			⇉		⇉												⇉			→			
56 Tender action					⊙O =								⇹⇉			⇉	*⇉			⇉		⇉												⇉						
57 Successful bidder chosen, proceed to construction					⊙O ⇉								⊙				→⇉											→>										↥		

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KEY: Operating system: * Operating + Cooperating → Consulting ⇉ Input > Receiving
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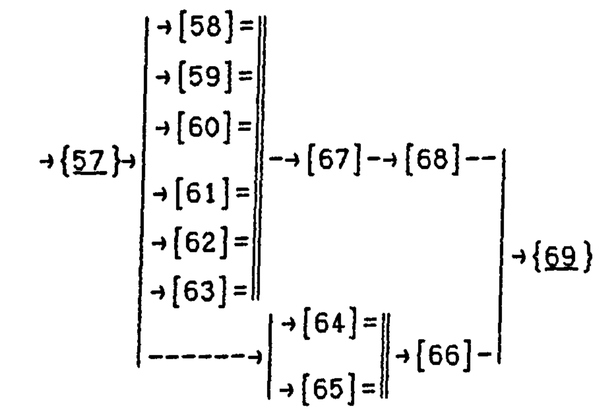
Project D
Stage 6: Construction



{} - Decision → - Sequential
[] - Operation = - Reciprocal

1981-85

	1 County Council	6 County Librarian '1'	21 County Architect '2'	41 County Librarian '2'	43 Project Architect '2'	46 Project Structural Engineer	47 Senior Quantity Surveyor	49 Partner Services Engineer	50 Project Q.S. (Taking-off)	53 County Librarian's Development Officer	54 Divisional Librarian	55 Arts Council of Great Britain	60 Tendering Contractors	64 British Telecom Sales Office	65 Artist	66 Furniture Manufacturers	68 Lift Manufacturers	69 Visual Arts Officer	74 Partner Structural Engineer	80 Main Contr's Timber Fabrication Cons	82 Reinforced Steel Suppliers	83 Brick Supplier's Chief Technician	85 Sealant Supplier's Sales Manager	86 Chipboard Supplier's Marketing Dir.	87 Main Contractor's Director	88 Main Contractor's Contracts Manager	89 Elect. Engr Sub-contrs Site Agent	90 Elect. Engr Sub-contrs Manager	91 Main Contr's Planning & Buying Mgr.	92 Mech. Engr Sub-contrs Site Agent	93 Mech. Engr Sub-contrs Site Agent	94 External Works Sub-contr's Site Agent	95 Ext. Wks Sub-contractor Contr Manager	96 County Secretary
57 Successful bidder chosen, proceed to construction			⊙O ⇉		⊙		→						→>																					
58 Main contract construction					⊙Θ ⇉		⇉			→										→					=↓	*Θ	⇉		→	⇉		⇉		
59 Electrical services installation					⊙Θ ⇉		⇉			→																⇉⇉	*	=↓		⇉		⇉		
60 Mechanical services installation					⊙Θ ⇉		⇉			→																⇉⇉	⇉			*	=↓	⇉		
61 Design information			=⊙ O		*Θ	→	⇉	→			→			→		→	→				→	→	→	→		⇉	⇉			⇉		⇉		⇉
62 Cost statements					Θ⇉		*=		→																	⇉	⇉			⇉		⇉		⇉
63 Landscaping					⊙Θ ⇉		⇉																			Θ= ⇉	⇉			⇉		*	=↓	⇉
64 Establish funding for art work	✓	→	*O	→	Θ					→		✓			→		→																⇉
65 Appoint artist			*O	✓						→		✓			→																		⇉
66 Undertake art work			⊙O ⇉		Θ					→					*																		
67 Certificate of practical completion			=↓ ⊙O	→	*Θ		→⇉	→										→								→⇉	⇉	→		⇉	→	⇉	→	
68 Snagging & making good				→	⊙Θ ⇉					→	→														=↓	*Θ			→					
69 Final completion			⊙O =↓	→	↑Θ		→	→							⇉			→								→⇉		→			→		→	

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APPENDIX E: SAMPLE P.O.E. QUESTIONNAIRE

LIVERPOOL POLYTECHNIC
DEPARTMENT OF SURVEYING

Research project: The efficiency of building project organisations.

POST OCCUPANCY EVALUATION

Users and workforce questionnaire.

This questionnaire is designed to collect information which will be used as part of a study to assess the structure of the organisation used to build the **Kitchen and Dining Room at** [redacted]. Your assistance in this research will be greatly appreciated.

1. Which of the following categories do you fit into (underline one)

   Workforce General public

2. How do you rate your overall satisfaction with the finished building?

   Unacceptable Poor Average Very good Excellent

Briefly state any deficiencies you can recognise in the finished project:

.....

The remaining questions are based on a scale of 1 to 6, please circle one of the numbers for each of the questions. The numbers represent the following opinions:

1 = Don't know	**3 = Poor**	**5 = Good**
2 = Unacceptable	**4 = Average**	**6 = Excellent**

3. For each of these categories, how well does the building function?

Siting and location	1 2 3 4 5 6
Access	1 2 3 4 5 6
Circulation	1 2 3 4 5 6
Layout	1 2 3 4 5 6

4. HUMAN RESPONSE: In your opinion, how good is the building for:

Warmth	1 2 3 4 5 6
Visual appearance	1 2 3 4 5 6
Noise	1 2 3 4 5 6
Safety	1 2 3 4 5 6
Size	1 2 3 4 5 6
Shape	1 2 3 4 5 6

5. How easy is the building to operate in according to the following criteria?

Suitability for its purpose	1 2 3 4 5 6
Maintenance of building (incl. cleaning)	1 2 3 4 5 6
Level of accommodation	1 2 3 4 5 6
Flexibility of use of bldg.	1 2 3 4 5 6

6. What do you think of the time taken to complete the project?

   1 2 3 4 5 6

7. How has your overall satisfaction with the building changed since it was occupied? (Underline one item)

   Increased Not changed Decreased

Finally, please could you give your Job Title (in confidence).

..... Thank you for your help.

APPENDIX F: GLOSSARY OF TERMS

(The numbers in parentheses refer to the paragraph where the concept is first introduced)

3R (4.1.7) The mapping technique which represents Roles, Responsibilities and Relationships

Activity (2.4.1) The generic term for work packages which take place between Decision points.

Boundary Control (3.4.2) The Integrating Mechanism defined by Walker, and other previous analysts.

Client involvement (3.9) The involvement of representatives from the client's organization with the management of the project.

Continuity (3.7) The absence of Differentiation in the Managing System.

Control System (3.1.2) The system of roles which achieves the needs for observation, comparison and correction of work taking place in the Operating System.

Co-ordination (3.4.3) The Integrating Mechanism at the level of the intra-operational Link.

Definition, of environment (3.3.1) This describes how well-defined a particular environmental influence is.

Differentiation (2.4.4) The differences in cognitive and emotional orientation among contributors to projects who offer specialist skills.

Discontinuity (3.7) A Discontinuity occurs when a change in the Managing System creates Differentiation in the Managing System.

Duplication (3.8) The exercising of Managing Roles by more than one person per Operation.

ECI see Environmental Complexity Index

Environmental Complexity Index (3.3.5) The quantification of complexity in the environment.

Feedback (3.1.2) Changing the objectives of a system or sub-system so that they match the work being undertaken.

Forward Control (3.1.2) Changing the work being undertaken so that it matches the objectives of a system or sub-system.

Integrating Mechanism (3.4) The provision made by the organizational structure to overcome the adverse effects of Differentiation.

Integration (2.4.4) The Integrating Mechanism at the level of the inter-operational Link.

Interdependence (2.4.3) The information flows between Operations.

Links (3.3.6) A Link in the Operating System exists when one person executing an Operation has an information transfer with another.

LRA (2.3) The technique of Linear Responsibility Analysis, developed by Walker.

Macro-environment (2.5.2) The general level of the environment, at the interface between the project and society in general.

Managing System (2.3.3) That combination of contributors and roles which maintains and regulates the Operating System.

Micro-environment (2.5.2) The specific environment immediately surrounding those who undertake work on the project.

Mitigability, of environment (3.3.3) The extent to which environmental factors can be mitigated.

Non-duplication (3.8) The number of Operations whose Managing System has no Duplicated Roles.

Objectives (3.1.1) The purpose behind the existence of any system or sub-system.

Operating System (2.3.3) That combination of Operations, contributors and Roles which undertakes work and progresses the project.

Operations (3.1.4) That package of work which can be undertaken by one organizational unit without interruption by decision points.

Policy Decision (3.1.1) The highest ranking decisions on a building project, which trigger and terminate the Process of Building Procurement.

Primary Integrator (3.9) The person identified as being primarily responsible for information flows between the project team and the client's organization.

Primary Differentiation (2.4.4) The Differentiation in the Operating System due to Technology.

Reciprocal dependence (2.3.1) The mutual interaction between two or more inter-connected Operations.

Role (3.1.6) The relationship of a contributor to an Operation.

Secondary Differentiation (2.4.4) Types of Differentiation other than that due to Technology.

Sentience (2.3.2) The factor of Differentiation which arises out of contributors' emotional allegiances to groups.

Sequential dependence (2.3.1) The Link between Operations when one follows on from another.

Skill Diversity (3.3.6) Differentiation due to Technology which arises as a consequence of Environmental Complexity.

Stability, of environment (3.3.2) The degree to which the environment is subject to change.

Strategic Decision (3.1.5) Those decisions which deal with matters of the environment impinging on the project boundary.

Tactical Decision (3.1.5) Those decisions which are concerned with the deployment of resources and the management of the project on a day-to-day basis.

Technology, differentiation of (2.3.2) Differentiation due to the type of skill demanded by the task.

Territory, differentiation of (2.3.2) Differentiation due to the geographical separation of the contributors.

Time, differentiation of (2.3.2) Differentiation due to work taking place on a project at different times.
