# A MODEL FOR THE DESIGN OF PROJECT MANAGEMENT STRUCTURES FOR BUILDING CLIENTS

A Thesis Presented by

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to the

Council for National Academic Awards
for the degree of

Doctor of Philosophy

AUGUST, 1980

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## ACKNOWLEDGEMENTS

The author wishes to express his sincere gratitude to the following who have supported and advised him throughout this research.

Dr. Alan Wilson, B.Eng., M.I.O.B., and Mr. A. Lancaster Britch, B.A.(Arch.), B.Sc., A.R.I.B.A., M.B.C.S., for supervising this research and for their guidance and encouragement at all times.

Mr. Edward Hall, F.R.I.C.S., F.I.Q.S. for his advice.
The Institute of Quantity Surveyors, who kindly provided funds to support this work.

The clients, consultants and contractors of the projects used for testing the model, for providing data and for giving their time and co-operation. Their depth of understanding of their projects and their willingness to discuss them enabled the model to be tested. Without this co-operation this research would not have been possible.

Mr. Paul Hodgkinson for his many diligent hours preparing the diagrams and for the thousand and one other jobs he undertook in support of this work.

Last, but by no means least, my colleagues in the Department of Surveying of Liverpool Polytechnic for their help, encouragement and understanding, and the typing and clerical staff for their assistance.

## ABSTRACT

This research constructs and tests a model of the organisation of building projects for maximum benefit to clients. The model is developed from systems theory, independently of conventional organisational assumptions. It is based upon the premise that the process to be managed must be identified before organisational structures can be designed and it recognises the influence of environmental forces upon projects.

The model proposes that the process of building provision consists of sub-systems created by decision points and identifies the inter-dependency and hence the differentiation within and between the sub-systems. The major propositions of the model are that;

a) there should be a match of differentiation and integrative effort,

b) the operating and managing systems should be differentiated,

c) the managing system itself should be undifferentiated and,

d) the client and process of building provision should be integrated.

The model was tested against three commercial buildings for private clients. Data is presented from interviews and other sources and is interpreted using Linear Responsibility Analysis, which was adapted and developed in this research. The testing method examines the overall compatibility of the model and the test projects, and also identifies the causes of deficiencies in the outcomes of the projects and whether they can be explained by divergence of the projects from the model.

The model was found to be valid for the type of project used in the tests. It provides a theoretical framework against which the effectiveness of organisation structures for the management of building projects can be predicted and which can be used for the design of such structures. It is suggested that Linear Responsibility Analysis provides a useful tool for organisation analysis and design. Finally, implications of the results for the organisation of building projects in practice are discussed.

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Many of the concepts in this research are developed progressively throughout the text. To assist the reader, this Key Word Index gives the pages on which the principal terms are introduced for the first time and/or where they receive a further conceptual treatment.

VOLUME 1

## PART I

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# PART I - INTRODUCTION AND HISTORICAL BACKGROUND

## 1.1 INTRODUCTION

The management of building projects has been carried out since men first co-operated to erect buildings, yet we have little documented material concerning the way in which people interact in this process. Hence, we have little formal knowledge or understanding of the effects upon projects of the way in which relationships are established.

The efficiency and effectiveness of the process of providing buildings is determined by many factors. At the project level, perhaps the most important to the client are;

a) the way in which the client's requirements are defined and

b) the way in which resources are managed on his behalf,

particularly in view of the influences of the increasingly complex circumstances within which buildings are provided.

The effectiveness of the processes of establishing a client's requirements and of managing resources on his behalf depend fundamentally upon the organisational framework which is established for a project.

The conventional relationships of the contributors to building projects were established historically in conditions which were quite different from those of today. Such relationships are being increasingly challenged and modified, but we lack a framework which provides a theoretical basis against which the effectiveness of conventional and emerging patterns of organisation can be judged, and which would provide a proper basis from which to design organisational structures for building projects in the future.

This research seeks to identify and test such a framework for management of the total building process from conception to completion on behalf of clients.

The origins of the conventional pattern of organisation, its evolution and contemporary influences upon it are described as a prelude to examining, in abstract, the process of management of building projects on behalf of clients. Arising from this examination, a model of the process is proposed and is subsequently tested against recently competed building projects.

## 1.2 THE ORIGINS OF ORGANISATIONAL STRUCTURES FOR BUILDING PROJECTS

Today's patterns of organisation of the contributors to building projects have their origins in the Middle Ages, but the original patterns have, of course, been influenced significantly by complexity resulting from changes in the conditions in which building took place and by the building industry's attempts to cope with the prevailing conditions.

The surviving records of building in the Middle Ages, which are for prestigious structures, mainly show that a master mason, was responsible for acquiring and organising labour and material and for the technicalities of construction on the basis of an outline from the client. Alongside the master craftsman there often existed a client's representative, many of whom did not have practical experience of building, but who were amongst the few people who were literate and numerate. They were expert administrators and went under a variety of titles, such as surveyor, clerk of works and sacrist.

The client would pay directly for the labour and material consumed. This direct method predominated until towards the end of the seventeenth century, although there is evidence as early as 1512[1] of work being let on a contract or 'bargain' basis.

This basic pattern probably had many varieties as the recorded titles are confusing and the relative responsibilities difficult to determine.[2,3]

The eminence of master masons led to the most eminent being appointed King's Mason with responsibility for oversight of the king's palaces and castles. They also acted as advisors on a number of projects, a role akin to that of architect in later years.[4]

The relatively stable conditions in which the 'building industry' existed in the medieval period did not create conditions for change in the organisational pattern of building work until demand for building began to rise in the 16th Century when the distinctive role of the architect began to emerge and more work began to be awarded to a contract or 'bargain' basis. The Elizabethan, John Thorpe, is often cited as the first professional English architect.

Engineers were more concerned with mechanical devices for military purposes than with buildings, but through their work on fortifications and castles their influence on buildings began to be felt although master craftsmen developed their own empirical engineering and jealously guarded this knowledge.[5]

The period from the 16th Century to the Industrial Revolution saw many changes which had profound effects on the organisation of building projects. England had become a principal trading country of the world and travel had awakened interest in the buildings of ancient Greece and Rome, leading to a demand for such designs. This led to the clearer identification of the architect and the associated complexity led to an increasing tendency to let building work on a contract basis, although 'architects' also often acted as developers. Further impetus to change was created by the Great Fire of London which led to the 'measure and value' method of settling payments and the employment of separate measurers. It also led to the first Building Act and the forerunners of Building Control Officers. There still appears to have been little application of formal engineering to building, although some road and bridge building took place.

The great surge in the demand placed upon the building industry occurred through the Industrial Revolution. The concentration of prosperity created demands for housing, for both workers and owners, and for buildings for the new industries. The demand for improved transportation led to developments of new engineering and building techniques, and to further industrialisation and further demand for buildings. In response to such demands new materials were being developed which allowed new building techniques to be devised.

These activities created a concentration of the specialist skills of the members of the building industry. The importance of the engineer emerged, there was the further separation of the architect and builder as specialists, quantity surveying skills were more firmly identified and engineering was sub-divided into civil, mechanical and electrical skills. However, this was an incremental process and the specialists often acted in dual capacities.

The new complexity of the conditions within which building work was executed, with greater emphasis on economy, value and prestige, the complexity of new building materials and technologies and the developing skills of the building industry specialists themselves, created the need for greater specialisation amongst them. These pressures led to the establishment of societies for the discussion of common problems. Architectural clubs were formed in 1791, the civil engineers as early as 1771, the surveyors in 1834 and the builders also in 1834.

Subsequently, to protect themselves from economic pressures on one hand and from the unscrupulous on the other, the clubs developed into professional institutions as the means of defining their position and creating their public image through the acquisition of royal patronage. This process created the basis from which today's conventional organisational structure for building projects has grown.

The major institutions representing those involved in the building industry were all formed during the 19th Century as follows:

| Original Title | Formed | Royal Charter |
|---|---|---|
| Architects Institute | 1834 | 1840 |
| Institute of Civil Engineers | 1818 | 1828 |
| The Surveyors' Institute | 1868 | 1881 |
| Institute of Mechanical Engineers | 1847 | 1929 |
| Society of Telegraph Engineers (Institution of Electrical Engineers) | 1871 | 1921 |
| The Institute of Builders | 1884 | - |

Subsequently, two further important professional associations were established. From the Concrete Insitute, formed in 1908, was established the Institute of Structural Engineers in 1922 which subsequently gained a Royal Charter in 1934 and in 1938 that Institute of Quantity Surveyors was formed to cater specifically for quantity surveyors. Membership of the latter was not confined to surveyors unconnected with building firms as in the case of the R.I.C.S.

These move further emphasised the separation of skills associated with building and so reinforced allegiance to specialist skills rather than to the industry as a whole.

The period from the late 19th Century to the First World War saw a continuing rapid increase in the growth of the building industry[6]. This was accompanied by the rise of the general builder for both speculative and contract work, and the parallel emergence of specialist craft firms. This occurred in response to the need for organising ability and financial strengths required for the process of urbanisation and industrialisation.

The architectural profession was moulded on the social and aesthetic pattern of the 18th Century, when architecture was considered one of the arts with the purpose of building being secondary. By the late 19th Century the idea that there should be any connection between architects and the mass of industrial buildings and working class housing seems to have been generally disregarded. Architects were, by then, concerned primarily with prestigious buildings. These attitudes were reflected in the 1887 supplementary charter of the R.I.B.A. which laid down that no member of the Institute could hold a profit making position in the building industry and retain his membership.

This separation of architects and builders was accompanied by further separation of architects and engineers. The development of industrialisation and the position adopted by architects decreed that industrial building was the province of engineers but, at the same time, engineers were commonly employed to advise on the structure of architect designed buildings. Hence, architects were technically dependent upon engineers, but engineers were not dependent upon architects. Significantly, engineers did not exclude themselves from being principals of engineering or building firms. Further separation occurred when, in 1907, the R.I.C.S. instituted the Contractors' Rule which prohibited its members from being employed by building firms.

Bowley[7] describes the pattern which emerged as 'the system' and believes that it had acquired a strong flavour of social class distinctions - architects being the elite, engineers associated with trade and industry, surveyors on the next rung of the social hierarchy and builders were 'in trade'. As a result, she believes that aesthetic and technical innovations in the late 19th and early 20th Centuries were completely out of step with each other, which inhibited the development of the major technical innovations of steel framed and reinforced concrete structures vis a vis other countries and created a conservatism in the building professions.

Building activity between the First and Second World Wars was much greater than before 1914 but there were no important changes in the way in which the design and production of buildings were organised, although the efficiency of site operations was enhanced, particularly through mechanisation.

The period was one of consolidation of the main professions through the establishment of professional qualifications tested by examination and of professional codes of conduct which raised their status and reinforced adherence to the established patter of project organisation.

Bowley[7] believes that the lack of innovation in building in Britain in this period was due primarily to the lack of a built-in mechanism in the organisational pattern of design and construction which could create the necessary stimulus. The innovations which did take place tended to be outside the industry, particularly in the organisation of the building materials industry and in the materials themselves. In addition, there was great concern with housing needs and the switch in this area from commercial speculative development to public development reinforced the prevailing pattern of organisation by bringing this work within its ambit. The pattern of organisation of design and construction does not appear to have been fundamentally questioned during this period as reflected in the list of official government publications, none of which concern themselves with organisation, but which are predominantly concerned with materials and housing.

Present day organisational arrangements for building projects and attitudes to innovations within the industry still reflect, to a large degree, the conservatism generated by patterns laid down before the Second World War. However, there are indications following a succession of official reports on these topics, that the professions and industry are slowly responding to the demands of an environment which is far more complex than that in which the patterns were originally established. For example, the dramatic changes in transportation, communications, health care, manufacturing technologies and associated economic, social and technological order.

## 1.3 A PERSPECTIVE OF CONTEMPORARY INFLUENCES ON THE ORGANISATION OF BUILDING PROJECTS

### 1.3.1 The Second World War and Post War Activity

The impetus to innovation provided by the Second World War was dramtic and focussed upon the need for economy in labour and reduction in ths use of materials in short supply. This need was demonstrated by the rapid adoption of prestressed concrete, prefabricated buildings and the tendency to replace steel with reinforced concrete. Wartime also generated the first governmental enquiry[8] directly concerned with the organisation of building work which was the fore-runner of reports which questioned the suitability and efficiency of the organisation of the building process. Nevertheless, this report accepted the established patterns and concerned itself, primarily, with tendering methods and arrangements for subcontractors.

Following the Second World War, the demands placed upon the building industry rapidly increased in complexity. The demands created by the need for rebuilding in the aftermath of war were followed by an acceleration in complexity of demands through the development of the welfare state which required new and more advanced buildings. Also, increased sophistication of industry required increasingly sophisticated buildings and there arose the need to redevelop cities to cope with a more technological age. The driving forces behind these demands were the increase in the relative importance of government sponsored buildings and the consequentially increasing involvement of government in building and the tendency to increase the size of production units, arising from the development of large scale organisation in industry.

In spite of the substantial changes in demands placed upon building industry, the pattern of organisation of building projects remained largely unaltered. Increased government sponsorship of building projects served to reinforce allegiance to the traditional pattern by the need for public accountability which was seen to be satisfied by tendering on finished designs. Nevertheless, there were some innovations in organisational patterns through the use of negotiated tenders and 'package deals', but the resistance to change of the established pattern is illustrated by the reluctance of public authorities to adopt selective, as opposed to open, tendering even though this had been strongly recommended in the Simon Report of 1944[8] and again in the Phillips Report of 1950.[9] Other developments were concerned with improving the effectiveness of site operations, particularly through prefabrication and in house construction. [10]

However, recognition of the need for greater co-operation began to be recognised following the Phillips Report[9] which commented upon the ease with which variations could be introduced during construction, the problems created by drawings issued late, the extensive use of nominated sub-contractors and the desirability of establishing a common basic education for all those involved in the design of buildings and their production.

Increasingly discussion centred upon the need for greater co-operation between all parties to the building process which was additionally stimulated by the greater need for engineers to be involved in the more complicated buildings being demanded, the need for reliable cost control and an increase in the number of large building firms.

The difficulties of the traditional pattern of organisation in coping with the demands of modern building, which were evident between the wars, were greatly intensified after the Second World War, but the greater spirit of co-operation within the industry which had began to emerge took place against the backcloth of the traditions which existed and was not concerned with a fundamental re-appraisal of the structure which had been established. This situation was reflected in the next major official enquiry - the

Emmerson Report [11] in 1962, which reiterated the findings of the previous two post war reports regarding the need to improve co-ordination of the members of the building team.

### 1.3.2 Emmerson, Banwell and other reports of the 1960's

The Emmerson Report[11], whilst also being concerned with supply and demand in the building industry, standards of training, research and technical information, is particularly significant for its observations on relationships within the building professions and industry and with clients and in connection with the placing and management of contracts. It identifies a common criticism of the building process as the lack of liaison between architects and the other professions and contractors, and between them and clients. It comments that, 'In no ther important industry is the responsibility for design so far removed from the responsibility for production'. The report pointed out that although a common course of initial study for designers and producers of buildings had been recommended in 1950[9], no practical steps had been taken by 1962[(i)].

Emmerson came to the conclusion that there was still a general failure to adopt enlightened methods of tendering in spite of the recommendations of earlier reports. His recommendations in this respect led directly to the establishment of the Banwell Committee[12] later in 1962, to consider

(i)
Indeed they still have not been taken (1980).

these issues in more detail.

Emmerson recognised that the R.I.B.A. was aware of the need for improved efficiency in architectural practices and the R.I.B.A. subsequently made a significant contribution to efficiency and co-operation by publication of the first edition of their Handbook[13] and Plan of Work in 1965.

Of the official reports, the Banwell Report[12], published in 1964, and its review 'Action on the Banwell Report'[14] in 1967 are considered to have had a significant impact upon the building industry and is professions[15]. A particular concern of the report was the unnecessarily restricted and inefficient practices of the professions leading to over-compartmentation and the failure of the industry and its professions to think and act as a whole. The 1967 review found some progress on preplanning projects but that professions had done little to 'de-restrict' their practices. The review was encouraged by the increase in selective tendering and urged further consideration of serial and negotiated tendering.

The Emmerson and Banwell Reports brought into sharp focus the need to reform the organisational approach to building projects and were accompanied by other reports which were making similar points. At the time, building project management was seen to be a passive procedural activity[16] but the movement towards a more dynamic integrated approach was being suggested by Higgins and Jessop[17] in a pilot study sponsored by the N.J.C.C.[(i)] They clearly identified that the problems of communication in the building industry were created to a large extent by attitudes and perceptions about the values of contributors to the building process. They were probably the first to suggest that overall co-ordination of design and construction should be exercised by a single person (or group). Concurrently, a review of the Construction Industry by N.E.D.C.[18] was calling for improvement in the management of the building process and in the co-ordination of activities of the members of the construction team and the administrative framework within which they were working and a rather rhetorical report [19] by the Institute of Economic Affairs was condemning the restrictive practices of the building professions.

This spate of activity and concern with the performance and organisation of the industry and its professions marked the beginning of a self examination by the professions and the industry. It was induced, to a large degree, by external pressures which reflected the greater complexity of the influences at work upon the industry and its clients. The economic expansion of the early 1960's and rapidly developing technology and changing social attitudes were manifest in demands for more complex and sophisticated buildings and a more economic utilisation of resources.

(i)

National Joint Consultative Committee of Architects, Quantity Surveyors and Builders.

Such forces were transmitted to the industry through its clients [20] and also directly upon the techniques and attitudes of the industry.

Such self examination was likely to be slow when undertaken against the polarization of skills and attitudes which was inherent in the professional structure which had emerged over the preceding century.

The reorientation of management studies of the construction process that had begun to take place is well illustrated by the Building Research Station's report[21] in 1968 which identified that up to that date most of the B.R.S.'s work had been concerned with the management of building sites and building firms but which recognised that future work would be concerned more with the management of the total building process.

### 1.3.3 Emergence of the Project Manager and other Organisational Initiatives

During the 1960's and subsequently, progress has been made in developing collaborative work and skills and in the derivation of procedures which provide a variety of organisational patterns, particularly in connection with the introduction of the contractor at various stages of the design process. However, there was still a need in official reports in 1975[22], 1976[23] and 1978[24] to stress that more attention should be paid to structuring and managing project organisations to create conditions for co-operation between contributors. Each of the reports recognised the distinctive nature of the project management process and the role of a project manager.

These reports reflect the changes in attitudes and views expressed since the mid 1960's. They arose from the distillation of the professions' and industry's experience of working with novel forms of organisation but the 1976 report recognised the need for futher study which would analyse existing patterns of use of alternative methods of organisation of the design and construction process.

The external pressures causing the professions to reconsider organisational arrangements for projects have been accompanied by challenges to their codes of conduct and fee scales[25] and created conditions for change. Further pressure has emerged through the definition and development of project management concepts and applications in other industries[26,27,28,29] and the recognition by project management theorists that the concepts and techniques are applicable to construction.

The professions' and industry's response to these influences reflects the manner in which the traditional structures emerged as each sector has pursued its own approach to project management whilst recognising generally that the role of project manager was not the right of any one group.

The R.I.B.A. recognised the role of project manager in its handbook[13], the R.I.C.S. takes a broad view of his responsibilities which reflects its membership[30,31], the I.Q.S. provided a review of activities of project management[32] and the C.I.B.S. published a paper which stressed an engineering orientation[33]. The I.O.B. was able to take advantage of these views prior to publishing a well balanced view of project management activities but which stressed design and construct contracts and management contracting[34]. Of the professions, architects have, perhaps, been less concerned about project management development than others. Battle[35] believes that architects may be allowing the project management role to pass from them by default.

A reflection of the unco-ordinated empirical evolution of project management as an activity separated from design skills is given by the number of definitions which have emerged in recent years. The Institute of Building's paper identifies thirteen definitions and comments that the confusion of terminology and usage is unsatisfactory, and proposes a further definition. In addition, there are definitions by James[30] and Massey[36] and others. It is, perhaps, to be expected that those writing on such an important emerging idea which is contrary to their traditional backgrounds should seek to express their ideas in their own words. However, this results in a range of definitions which tend to reflect the particular background and experience of the writer rather than a generalised definition of the concept.

The empirical nature of publications on project management are reflected in their emphasis on defining the jobs to be done by a project manager at various stages of a particular project rather than upon identifying the process of project management. Nevertheless, such publications have been useful in emphasising the patterns which can be adopted with advantage to the client. Frank Graves's work[37] on the development of the National Exhibition Centre provided great stimulus to the project management idea, Peaching's [38] review of the organisational structure used for Mobil Services illustrated a particular approach as did Nicklin's[39] report of his firm's involvement as architects in a design construct contract for Trafalgar Vickers Mitchell.

Against this background of pressure for change in organisational approaches, which has emerged from a number of sources from both outside and within the professions and industry, and the inertia of the established patterns and attitudes within the professions and industry, there have been a number of project based initiatives. The project manager idea is only one, rather ill-defined, idea which has been used to cover a range of organisational patterns. Others include Management Contracting[40], which is designed to introduce construction skills into the design stage but which does not necessarily overcome the problems of integration as polarization of professional attitudes are not directly affected, Research Into Site Management (R.S.M.)[41], which requires the design team to be directly involved in the construction process and

Alternative Methods of Management (A.M.M.)[42] which also requires the design team to be involved in the organisation of the actual construction process through the integration of sub-contracts. Both R.S.M. and A.M.M. demand that the design team are on site for the majority of a project's construction stage. These approaches are directly concerned with integrating the design and construction activities whilst maintaining the client's independent professional advisors. They take a positive approach to overcoming differentiation of the skills involved in building projects. Other techniques which do not take such a positive stance, but which seek to overcome the same problem are Design and Construct Contracts, the use of which is increasing[23], and Negotiated Contracts[43].

Whilst useful for learning from the experience of others, such developments do not provide a conceptual framework which would allow identification of the features of significance in the process as a basis for designing organisational structures which takes account of them. Nor do they provide any indication of an approach to measuring the outcome of projects which is necessary in order to draw conclusions regarding the performance of the structure used.

Snowdon[44,45] has gone some way towards identifying a conceptual framework by visualising a capital project as an instrument of change and analysing the management steps against this background. In this context he takes a wide view of a project and tentatively identifies 'The Management

Envelope' which contains the factors outside the project which may affect the project. He recognises the need to be able to measure the outcome of projects to facilitate comparison of project organisations and the need to identify separately management and professional activities.

Many writers[27,31,33] see the objectives of project organisations defined in terms of function and quality, time and cost but Snowdon sees time and cost not so much as objectives but as constraints. It is considered [23,46,47] that a conceptual framework is now needed to allow identification of project management functions which reflects the demands of different projects and which may resolve the apparent differences which appear to exist when identifying functions from an empirical base. For example, an R.I.C.S. report[31] does not believe that a project manager should carry out the duties of individual members of the team but other reports[34] see him carrying out those duties concerned with control, whilst Barnes[48] sees the need for more forward looking and integrated cost and time control and recognises that techniques to do this are available but questions whether they are properly employed. Barnes and others[49] also believe that management on behalf of the client during construction is inhibited by the standard forms of contract which assume that the clients intends to leave management entirely in the hands of the contractor.

Techniques for project control have been available for some time[50,51] but their rate of application has been variable depending upon the inclination of the team leader who traditionally has been the architect. Indeed, project management is sometimes seen as a collection of techniques rather than the framework in which they are applied.
The British Standards Committee on Project Management had to be persuaded to change the title of its guide from 'Guide to Project Management' to 'Guide to the Use of Network Techniques in Project Management'[52] to avoid such misunderstanding. Even so, Snowdon[53] criticies the draft as taking too narrow a view of project management. Newly developing techniques, such as cost modelling[54], are seen to provide a strong integrating force given leadership which is prepared to take advantage of them.

Similarly, a significant amount of research has been undertaken on industry wide information systems and data co-ordination[55,56,57] and resultant computer applications as well as on information flow[58] within firms. However, the implementation of systems on an industry wide basis, which it is considered would significantly increase the industry's efficiency[56], had been inhibited by the lack of an hospitable framework of project organisation[59]. It is considered by Trimble that whilst a great deal is known about project management information systems, very little is known about managers' reactions to the information that they receive from those systems[60]. In 1970, Gray[59] believed that the problems of development and implementation of information systems would not be finally resolved until a widespread reorientation in the thinking habits of professionals had taken place. A 1976 study[56], whilst recognising a similar situation, was concerned not with advocating costly or major industry wide initiatives but simply making more effective use of current experience and existing arrangements. It believes experience shows that, to be successful, changes of this nature must evolve from familiar practices, nevertheless, its recommendations placed considerable emphasis upon the development of organisational frameworks which would provide a satisfactory degree of collaboration and exchange of information.

## 1.4 THE OBJECTIVE OF THIS RESEARCH

Whilst there have been some valuable isolated initiatives in response to the pleas of successive official reports for greater co-ordination of the building professions and industry and their clients, there remains a resistance to change in the organisational structure of building projects. This resistance relfects the attitudes[49,61] and loyalties[47] of the parties concerned and it has been recognised that, against such a background, any progress will have to be incremental[62]. However, an equally significant inhibition to progress has been identified as the lack of a fundamental framework[23,46,47] of organisational theory related to building projects against which experience of the various organisational initiatives can be measured and compared.

Such a framework would allow discrimination between the attributes and deficiencies of empirical work and form the basis for organisational design of building projects.

The objective of this research is to identify such a framework. The determinants of organisational structures are pursued as a function of the needs of the process of building provision and are not constrained or predetermined by conventional assumptions The basic premise is that the design of organisations should follow the definition of the process to be managed.

The objective is achieved through the development of a model which is tested against recently completed building projects. The model seeks to incorporate the features of significance to the structuring of effective organisations for the management of projects on behalf of building clients and to identify the relationship of the features within the proposed framework. The objective of this research is specifically client orientated and is not directed towards the objectives of the contributors to projects except insofar as they affect client's satisfaction with project outcome. From this basis emerges the activities of project management and their relationship to the effectiveness of organisational structures.

## 1.5 SYSTEMS THEORY AND ITS APPLICATION TO THE BUILDING PROCESS

General Systems Theory (G.S.T.)[63] originated in the biological sciences, but its originator, Von Bertelanffy, has acknowledged its general applicability which he considers encompasses business organisations. Systems theory has been usefully applied to organisational problems in industries[64,65,66] other than the building industry, but it has been recognised that there has been a relative lack of determined effort to use it in tackling real world problems[66].

The attraction of systems theory as a medium for identifying a conceptual framework for the management of the building process lies in the basic premise that a system is an organised or complex whole; an assemblage or combination of things or parts forming a complex or unitary whole which is greater than the simple sum of the parts[67,68]. The systems approach stresses the contribution of the interrelationships of the parts of the system and the system's adaptation to its environment in achieving its objective.

The application of systems concepts to organisational design of the building process has been suggested by systems experts[28,69,70] and three significant approaches have been developed.

The work of Morris[71] developed an approach to studying the interplay at what he identified as the Design/Construction interface. It suggested specific relationships for the intergration found on building projects and suggested general conditions under which particular forms of integration may occur. The work compared six projects with different stages of contractor appointment to the building team.

Systems design was seen as an important aid in the development of an integrated form of building project and drew heavily upon the work of Lawrence and Lorsch[65] on differentiation and intergration.

Morris states that problems of co-ordination and control in building projects increase as the projects increase in size, speed or complexity. He finds that these problems may be reduced by designing interfaces within the project that are not in themselves complex. To achieve this, he believes that the number of sub-systems and the interdependency at the interfaces should be kept to a minimum wherever possible. Paradoxically he then recognises the need to split the project work into clearly separate sub-systems and remarks that managing a project with such a degree of separation is not easy. He considers that to manage these interfaces requires expertise in applying organisational design, programming, co-ordination and control skills to planning and monitoring the project's development. He suggests that the deployment of these skills is essentially what constitutes the management of the project.

However, he has, in arriving at this conclusion, taken a narrow view of the building process by focusing attention on the Design/Construction interface.

There is some danger in generalising the management of a project from a specific study of one interface in the process.

The management of a project is concerned with the total building process and requires a consideration of all the interfaces in the total process. This is suggested in passing by Morris, but not pursued, when he states that the Sketch Design/ Detailed Design interface, for instance, is an interface which was seen to receive inadequate integrative attention. This view is supported by Morris's lack of specification of the project management process and his acceptance, without serious question, of the stages of the R.I.B.A. Plan of Work[13] as the differentiated parts of the process. The Plan of Work, devised in 1965, specifies the stages of progress of projects and the work to be done by the contributors at each stage. The Plan has evolved as the conventional way of organising building projects. Since Morris's work, the Property Services Agency has produced its own Plan of Work[72] based on assumptions which they believe better reflect project management functions. Morris's work supports the approach of this study in that he found organisational theory, especially when employed in the context of a system framework, can be used to describe and explain the nature of the management process for building projects. This is useful even though he did not pursue the application to the total building process where the concept has its greatest relevance.

A further application of the systems concept was made in Sweden by Napier[73]. In this work he attempted to gain an understanding of the problems of the Swedish building industry as a whole as a basis for the design of systems for the future through systems theory and a theoretical model. He draws almost exclusively upon the work of the Tavistock Institute carried out by Higgins[74,17]

Crichton[75], Miller and Rice[69], and Burns and Stalker[76]. He concludes that the theoretical model seems to function well as an instrument for interpretation and that by considering the building industry as a system with a number of sub-systems, and by studying these systems in their environment it has been possible for him to obtain a realistic picture of the industry and the causes of its major problems.

Handler's work[77] is principally concerned with the building as a system. This concept is developed by reference to General System Theory by drawing an analogy between living organisms and a building. The concept of a building as a system is transferred to the need for designers to design buildings from this concept. This work is basically an abstraction of the manner in which architects should work and think rather than how the building process should be organised, although he recognises in passing the need for a structure to integrate the work of specialists and the value of the systems concept in its achievement.

These major studies show the potential for the application of systems theory to the building process. Each study has taken a different perspective, but has employed the same basic concepts. In taking the perspective of the process of providing a building and the relationship of management on behalf of clients, this research takes a broader view than did Morris but a more specific one than Napier.

As a prerequisite to the application of the systems approach to the analysis of the process of building provision, it is necessary to construct an outline model of the process. The use of systems concepts to construct the outline requires that the identification of the process of building provision precedes the design of organisational structures in order to avoid the imposition of artificial organisational boundaries[67,68]. Hence, the outline is of the process of building provision and not of organisational structures.

The development of the model from the outline begins, therefore, with the process and identifies the influences acting upon it, the relationships within it and system control concepts and their relationships to the process. From this basis it is then possible to identify propositions regarding the relationships amongst contributors to projects which are of significance to the effective organisation of building projects for clients.

The model is then tested against three projects which have recently been completed. In order to test the model an approach to interpreting projects for testing purposes is developed in which methods are devised for analysing organisational structures used to provide buildings. In order to assess the performance of the processes used for the test projects as a prerequisite to comparing the model with the test projects, methods for analysing project outcomes and the environmental conditions in which they were achieved are developed.

Conclusions are then drawn regarding the validity of the model as a representation of the determinants of organisational structure for the effective management of building projects for clients.

## PART 2

## THE MODEL

2.1 An Outline of the Process of Origination and Realisation of a Building

2.2 The Systems Approach

2.3 Systems and Organisations

2.4 Development of the Outline Model

## PART 2 - THE MODEL

### 2.1 AN OUTLINE OF THE PROCESS OF ORIGINATION AND REALISATION OF A BUILDING

The construction of a model of the process of origination and realisation of a building is the fundamental basis of this research. The prerequisite of such a model is an outline of the process of building provision which is devoid of artificial organisation boundaries but which identifies the major forces which influence the process. The purpose of the outline is to provide a foundation for the development of a theoretical model against which processes in practice can be measured.

The process has a start point (which may be difficult to identify specifically in practice). It also has a finish point which is taken as the completion of a building. The process of origination and realisation of a building is those events that joint these two points, as shown in Fig. 1.

Start Point                Finish Point

Process

FIG. 1.

Potential start points are activated by project generators[i] and are a result of project generators' motivation and opportunity

(i) The term 'project generator' is used to refer to a sponsor of building work who can generate the finance, information and authority necessary to embark upon the process of building. A more common term is 'client', but 'project generator' is preferred at this stage, as various meanings are ascribed to 'client' by different users. Finance, information and authority arising from the project generator provide the motivation for the whole process.

as influenced by external stimuli. Such external stimuli may be economic forces which give the opportunity for profit, sociological forces which present the chance to respond to a social need, but more usually are combinations of different classes of stimuli. The basic responses of a project generator to external (environmental) stimuli is the result of its need to survive, above this level the project generator responds in order to expand as the result of its motivation as illustrated in Fig.2

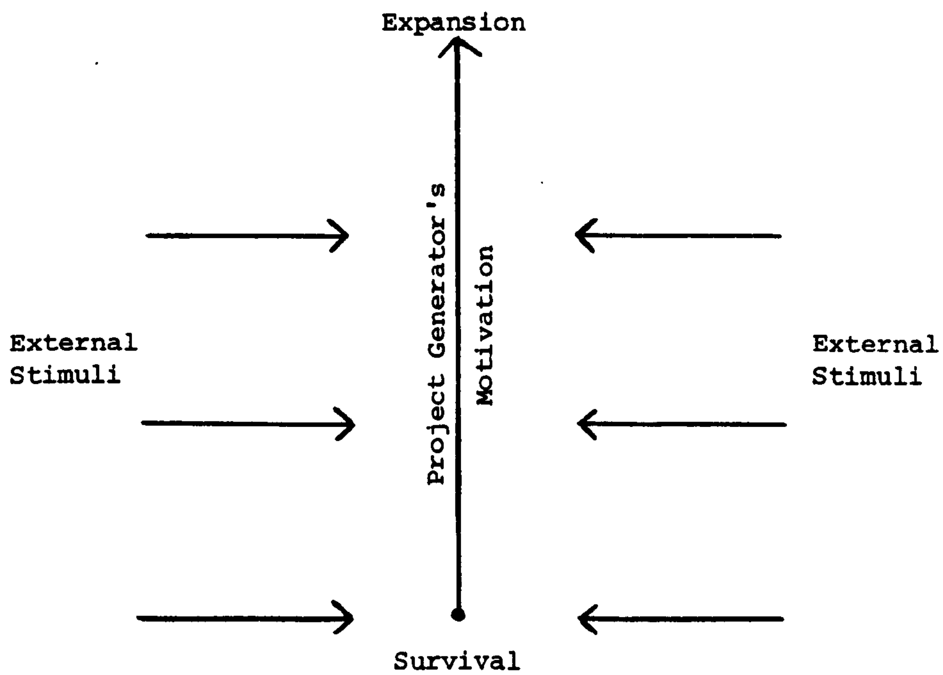



FIG.2 A PROJECT GENERATOR'S RESPONSE TO EXTERNAL INFLUENCES

Survival is the basic goal of a project generator and can be defined as the project generator maintaining its position relative to its competitors. In order to achieve this, the project generator must continue to obtain a return acceptable to its environment in terms of the project generator's role, (e.g. profit, acceptability). This is more easily conceived for commercial organisations, but is also true for public authorities. In commercial terms, this requires a sufficient response to remain in business. In terms of a non-proft organisation, it means a sufficient response to prevent the organisation from being replaced by some other mechanism. For example, the establishment of Urban Development Corporations to undertake some of the tasks of certain local authorities.

In responding to external stimuli to expand the project generator takes advantage of events in its environment which allow it to expand. The degree to which the project generator takes such opportunities are determined by its motivation, which is, in turn, influenced by incentives provided by the environment, e.g. taxation, status, satisfaction.

The purpose of expansion will be to give the project generator greater power over its environment (which includes its competitors) and will be achieved by acquiring greater influence through, for example, greater profit and prestige in combinations appropriate to the project generator's task.

The project generator can, therefore, be said to have a purpose which is the product of its motivation in response to the environmental demands or opportunities placed upon it. The start point is the recognition of the need or opportunity to achieve this purpose. The options available to a project generator may include the acquisition of real property which, in turn, may require the construction of a new building.

At the initial activation of a start point, the plane within which the finish point is feasible will be very large and will encompass all those alternatives which will provide a performance[(i)] which allows a project generator to achieve its purpose. The alternatives which are available to a project generator will vary depending upon the nature of the project generator's role. There will be basic differences between the choices available to commercial and public authorities. Similarly, there will be differences between the choices available to different types of commercial organisations and different types of public authorities. However, it is possible, for every category, that one of the alternatives will require the acquisition of real property to achieve the required performance.

This outline of the process is now developed further in this research using the origination and realisation of a building by a commercial organisation as the concepts are more readily understood in terms of commercial criteria. Fig. 3, therefore, gives examples of some alternative initial feasible decisions from a start point in a commercial organisation.

(i)
The term 'performance' is used to describe the facility required by the project generator to enable it to survive or expand to achieve its purpose.

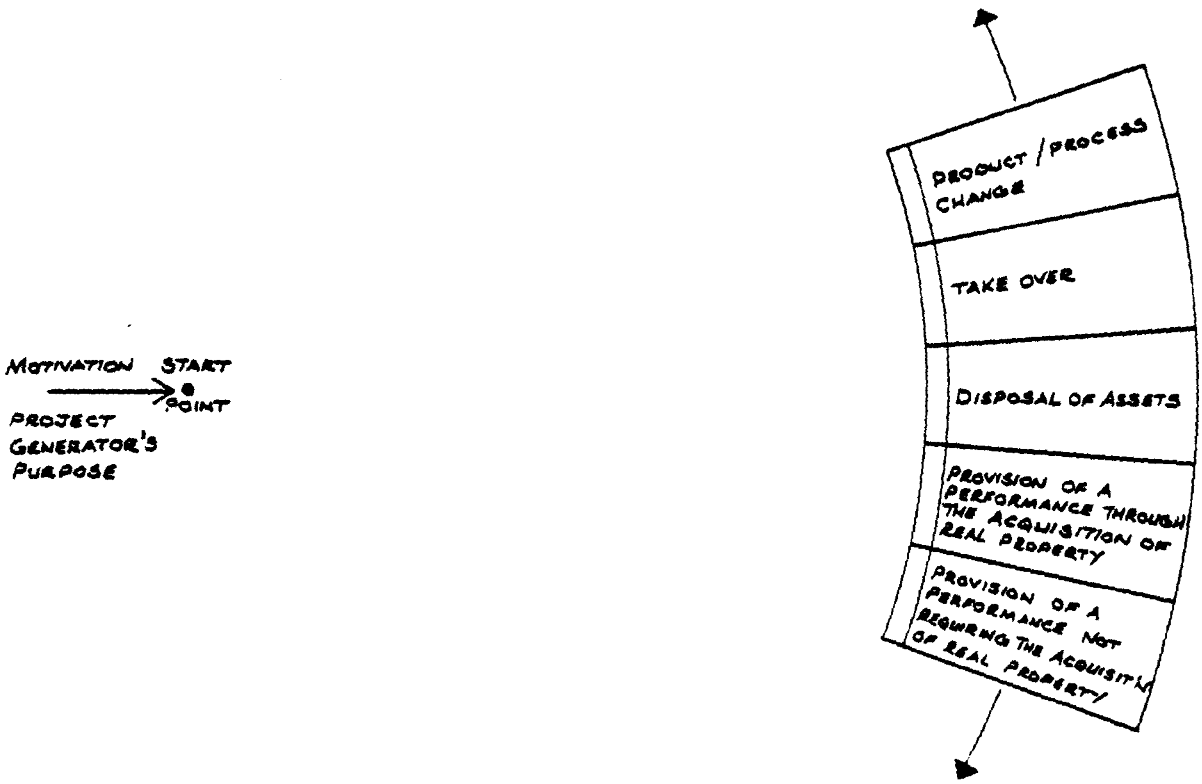



FIG: 3 EXAMPLES OF INITIAL FEASIBLE DECISIONS

In making progress towards the finish point, the process of arriving at one of the initial decisions may be called the Project Conception Process. (Fig. 4)

External influences are transmitted to the project generator through his importation of information, energy and materials(i) during the Project Conception Process. Such influences can be broadly classified as Political, Legal, Economic, Institutional, Sociological, and Technical. The action of these influences will determine the initial decision. The Project Conception Process will entail the consideration of each alternative within the environmental context and a decision will be made on the basis of the influence of the external constraints, given that the project generator has the capacity to survive. For example, economic conditions may make a process change appropriate, but it may then be discovered that trade union action (sociological influence) will make this difficult, by which time economic conditions may have made the take-over of another firm more appropriate. Adaptation to environmental influences will continue until an initial feasible decision is reached.

The goal of this process is adaptation to external influences. The outcome of the Project Conception Process can be seen as a preferred change in the configuration of the project generator which will allow it to achieve its purpose.

It is assumed in this research that the preferred outcome of the Project Conception Stage is the provision of a performance through the acquisition(ii) of real property.

(i) The meaning of information and material are self evident although it should be pointed out that material encompasses any material whatsoever. Energy, similarly means any type of energy but in the context of this work, people are a particularly important source of both physical and mental energy.[67]

(ii) At this stage, the definition of acquisition of real property includes existing or new property or improvement or modification of property already owned.

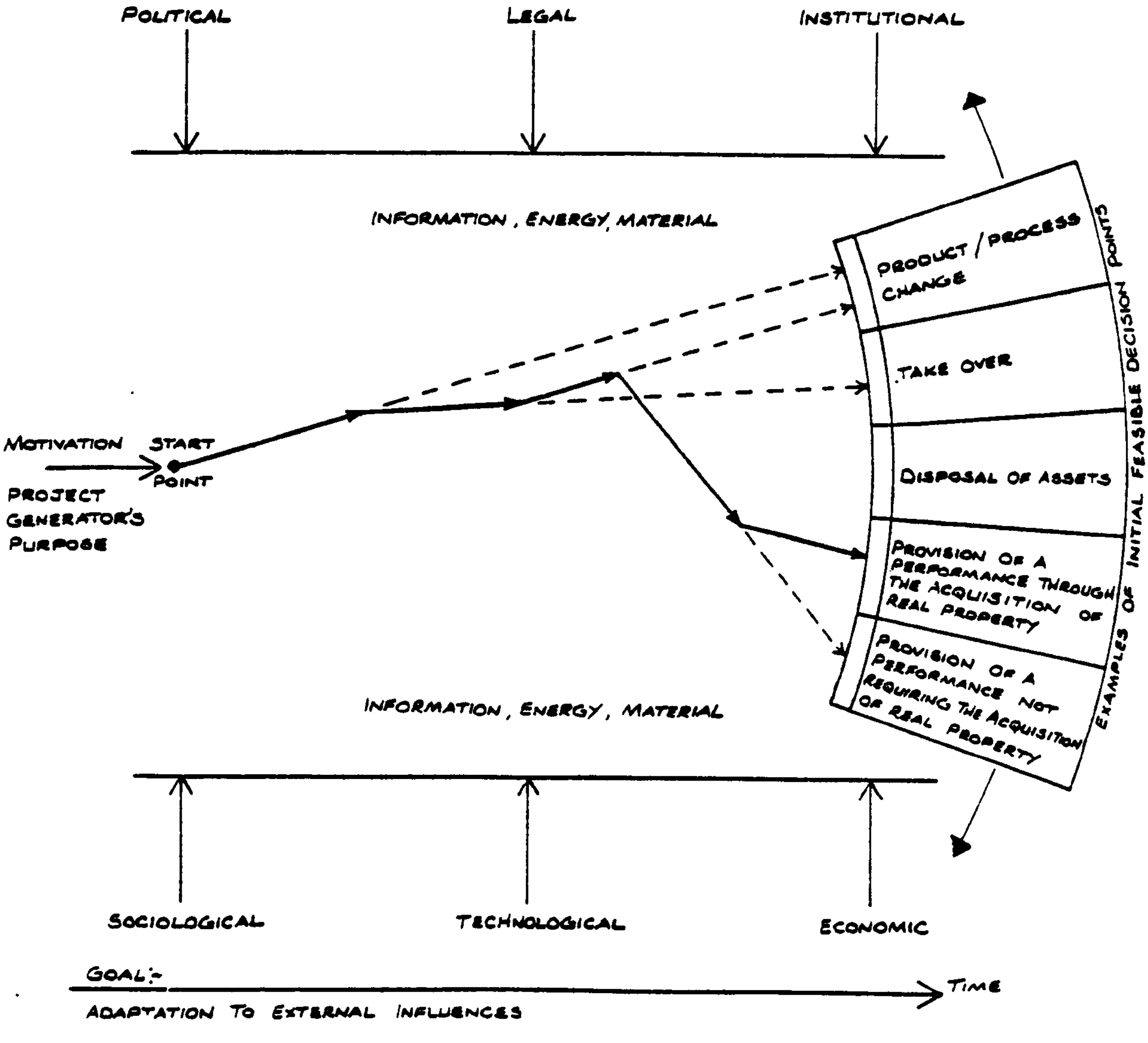



FIG: 4 THE PROJECT CONCEPTION PROCESS

Having reached this preferred initial decision, the objective is reach the finish point. The preferred initial decision of the Project Conception Process of providing a performance which requires the acquisition of real property contains a number of alternatives which can be considered as intermediate feasible decision points. The process of arriving at one of these alternatives in making further progress towards the finish point, may be called the Project Inception Process (Fig.5). The intermediate feasible decision actually taken is determined by the ability of the alternative chosen to provide the optimum performance demanded by the external influences to enable the project generator to achieve its purpose. The external influences acting upon the process of reaching an intermediate decision are the same as those given before, but may exert different influences during this process. The Project Inception Process will receive information, energy and materials from external influences and will transform them in its task of identifying the intermediate decision which provides the optimum performance. Interacting with these influences in arriving at a decision will be the commercial activity of the project generator which will itself be influenced by the external constraints.

During this process the goal is the achievement of the project generator's purpose through the acquisition of real property. The motivation of the project is the authority, information and finance arising from the project generator.

It is further assumed for this research that the preferred outcome of the Project Inception Process is the provision of

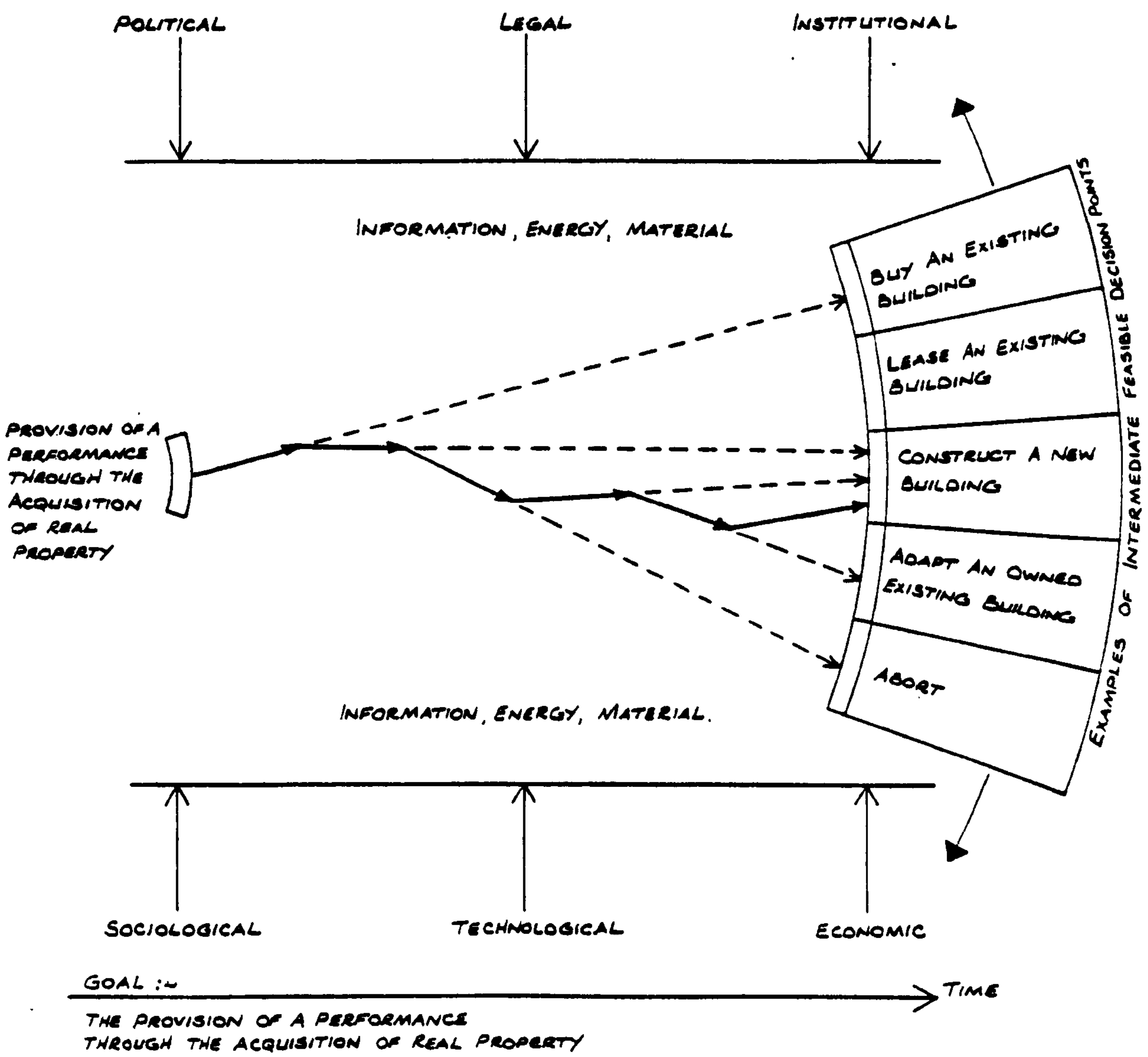



FIG : 5 PROJECT INCEPTION PROCESS

a performance through the construction of a new building.

The new building which is actually constructed will lie within a finish spectrum ranging from total satisfaction with performance requirement to total dissatisfaction with performance requirement and the performance of the completed building will be between these extremes. The process of arriving at the finished building is called the Project Realisation Process (Fig.6) The process of achieving the finished building will be determined by the external influences acting on the process. The external influences are classified as before and provide information, energy and material for the process. As was the case with the Project Conception and Inception Processes, the external influences act in two ways upon this process; directly upon the process and indirectly through their influence upon the commercial activity of the project generator. The Project Realisation Process transforms these inputs into the output of the process which is the finished building. The effectiveness of the transformation process will determine the outcome actually achieved.

An example of the effect of external influences during this process could be that economic and/or institutional forces determine that construction work is awarded on the basis of competitive tender. Such a decision would divide this process into two sub-processes, but only if appropriate external influences are present, such an assumption would be unfounded at this stage of development of the outline of the process.

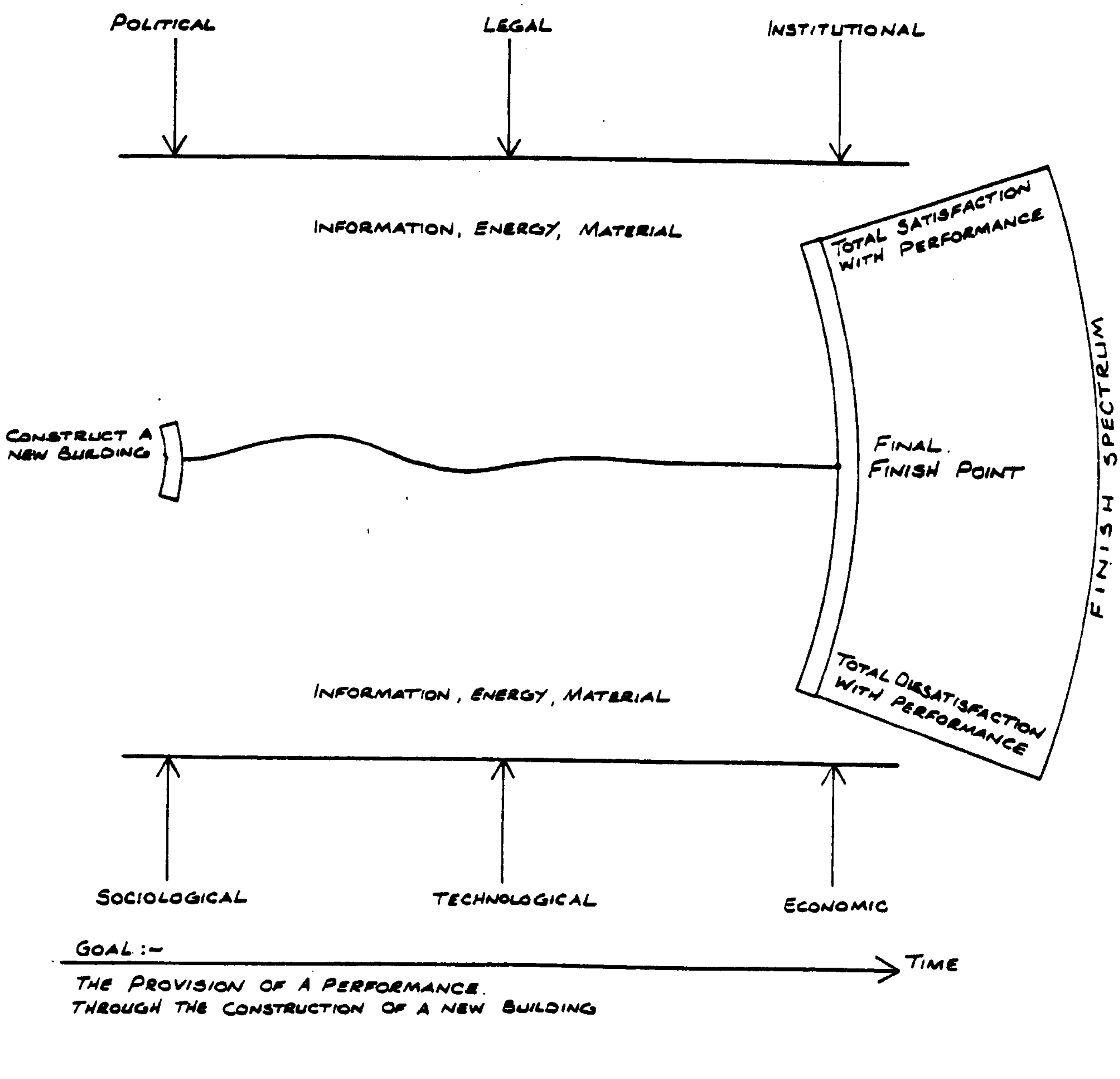



FIG : 6 PROJECT REALISATION PROCESS

During this process, the goal is the construction of a new building which enables the project generator to achieve its purpose. The motivation for the project is authority, information and finance arising from the project generator.

A composite illustration of the three processes of the process of origination and realisation of a building is given in Fig.7. For economy in the rest of this work the process of origination and realisation of a building is referred to as the process of building provision.

## 2.2 THE SYSTEMS APPROACH

### 2.2.1 Introduction

Examination of the outline of the process of building provision developed in 2.1 shows that the process reflects systems concepts. The systems approach is, therefore, examined in more detail for use in developing the outline into a fuller model of the process.

### 2.2.2 Open and Closed Systems

A system can be defined as any entity, conceptual or physical which consists of interdependent parts. Each of a system's elements is connected to every other element, directly or indirectly, and no sub-set of elements is unrelated to any other sub-set.[79]

It was the evolution of the concepts of open and closed systems by the originator of General Systems Theory (G.S.T.), Von Bertelanffy, which developed systems theory into a more useful tool for analysis. He defines an open system as a system in

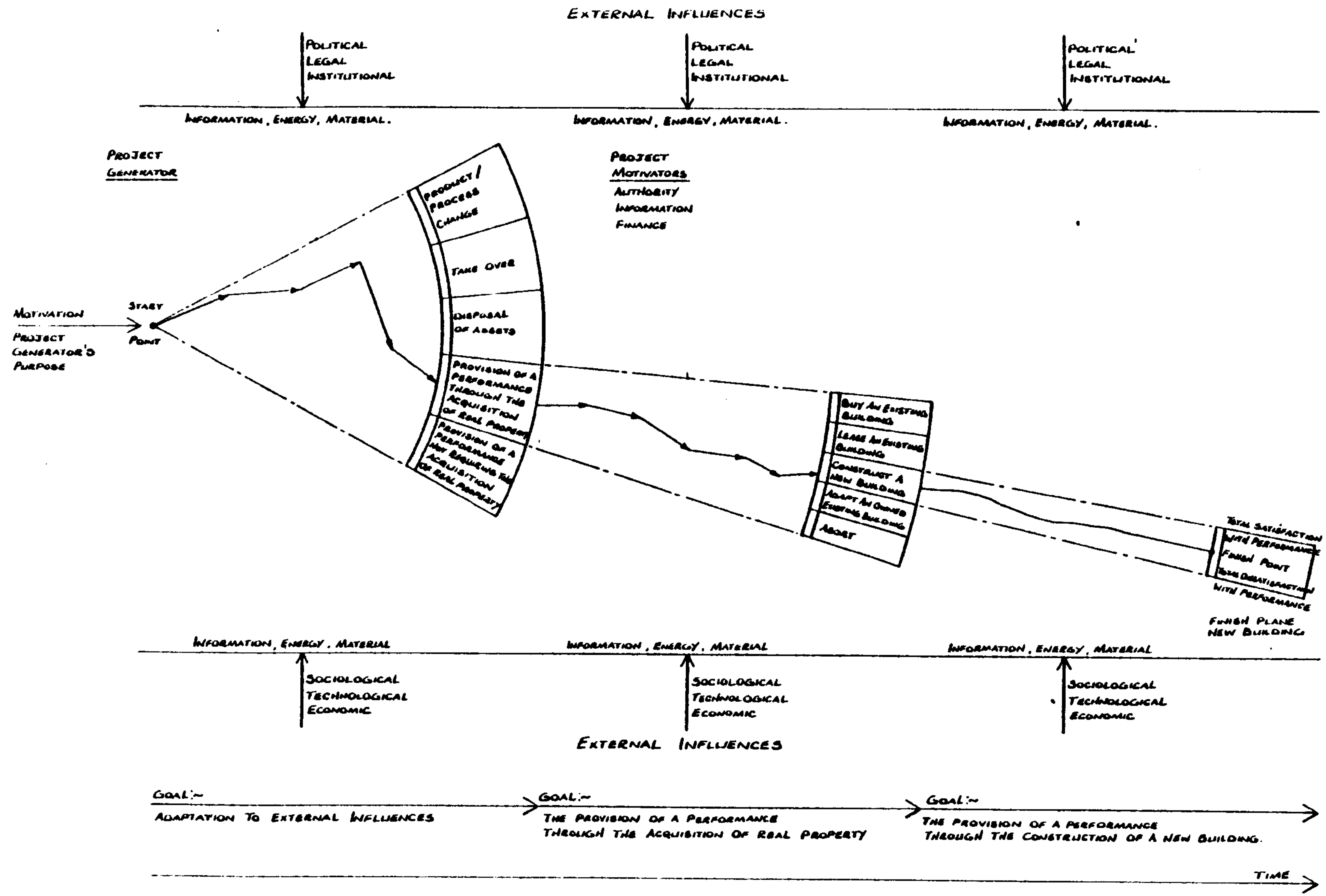



FIG: 7 AN OUTLINE OF THE PROCESS OF ORIGINATION AND REALISATION OF A BUILDING.

exchange of matter with its environment, presenting import and export, building up and breaking down of its material components.[63] A closed system is defined as one that has no environment. Closed systems are static, predictable and ultimately tend towards a state of equilibrium, stillness and inactivity.[80] An open system has an environment to which it adapts by changing the structure and processes of its internal components.[81,82] Although stable, open systems are always changing, always evolving although identifiable and classifiable, they present differences over time and in changing circumstances.[80]

Organisations could never have existed as closed systems they have always been open systems. But the idea of closed and open systems encouraged sociologists to think of and treat organisations as open systems which altered the way in which organisations were analysed.[83] Von Bertelanffy considers that G.S.T. encompasses business organisations, however he believes that modelling of systems of organisations has not yet reached a mathematical representation and acknowledges the validity of other forms in developing an understanding of systems.[63]

The outline of the process of building provision in 2.1 can be seen to be an open system. It is determined by its environment and even at the level of abstraction employed can already be seen to consist of three interdependent elements or subsystems: Project Conception Process, Project Inception Process, Project Realisation Process. Further application of systems concepts to the outline should identify further sub-systems and their relationships to each other and to their environment.

The application of systems theory requires the recognition of the pervasive nature of systems as demonstrated in G.S.T. by K. Boulding[36] who identified nine levels of systems in his hierarchy.

The process of building provision lies in Boulding's social organisation level, but more important is the recognition that this process is a sub-system of larger systems which form its environment. The system also contains sub-systems which can themselves also be seen as systems within the system of the process of building provision which forms part of their environment. This concept of systems within systems is fundamental to an understanding of the context within which any system exists.

G.S.T. has been used by researchers in a wide variety of disciplines, but their attempts to apply the principles of an evolving area of scientific endeavour has resulted in problems of semantics. Such problems are referred to by Ackoff[81] in his attempts to set down a preliminary definition of the conceptual framework of systems, although he recognises Emery's[84] warning against too hasty an effort to do this. Emery believes that pioneers of systems thinking have felt it incumbent upon themselves to work out their intuitions in their own language, for fear of what might be lost through trying to work through the language of others. He sees benefit in this approach through a rapid development of systems thinking in diverse disciplines which are transferable into different language. Nevertheless, Ackoff (1971)[79,81] and others[87] have offered definitions with wide applicability, which have assisted workers in specific areas to evolve their own applications and which are useful in the further development of this work.

### 2.2.3 The Environment

The distinguishing feature of the open system concept is that of the environment and its implication for understanding the behaviour of systems. Ackoff[81] defines the environment of a system as a set of elements and their relative properties, which elements are not a part of the system but a change in any of which can produce a change in the state of the system. Thus a systems's environment consists of all variables which can effect its state. Emery and Trist[85] recognised that open systems theory enabled exchange processes between an organisation and elements in its environment to be dealt with but that it does not deal with those processes in the environment itself which are the determining conditions of the exchanges. To analyse these, an additional concept - the causal texture of the environment - was proposed. They stated that organisational environments differ in their causal texture, both as regards uncertainty and in many other important respects and they identified four 'ideal types' on a scale of increasing complexity of causal interconnectedness.

Empirical studies by Lawrence and Lorsch[65] and others[86] have shown the relationship between organisation structure and environmental circumstances and Katz and Kahn[87] have pointed out that we cannot understand an organisation as a system without a constant study of the forces that impinge upon it. Emery and Trist[88] see the primary task in managing an enterprise as a whole as relating the total system to its environment and not in internal regulation per se. This does not mean that managers will not be involved in internal problems but that such involvement will be orientated consciously or unconciously to certain assumptions about the external relations of the enterprise.

A further feature is the presence, in relation to systems of protected environments. Protected environments have been referred to by Child[89] and Napier[74]. Child, in relation to monopolies and Napier in relation to the institutions, federations and associations concerned with the building industry. Child believed that such organisations might well be in a position to control or ignore environmental contingencies. Also that an organisation can afford to accept a level of sub-optimal performance it if chooses not to match its structure to suit prevailing contingencies.

Systems theory would suggest that the environment is of fundamental importance to what takes place within the process of building provision previously outlined. The process is the result of its environment. The environment acts in two ways: Indirectly upon the primary commercial activity of the project generator's organisation and directly upon the activities of the process itself.

The influence of the environment upon the project generator's primary commercial activity will be determined by:

(i) The nature of the activity of the project generator in terms of its sensitivity to changes in its environment.

(ii) The relationship between the elements of the activity's environment and the way in which they become connected.

For example, the receipt of an unexpected large order for the project generator's goods may make realisation of the building more urgent.

Environmental factors will also directly affect the sub-systems[i] of the process itself and their influence will be determined by:

(i) The nature of the task of the sub-systems in terms of its sensitivity to changes in its environment.

(ii) The relationship between the elements of the sub-system's environment and the way in which they become connected.

For example, a rise in activity in the building industry may create uncompetitive conditions in terms of price and completion time for buildings which make it difficult to advance completion of the building if a large order is received by the project generator.

(i)

The sub-systems, as previously identified, are: Project Conception Process Project Inception Process, Project Realisation Process.

It is possible, therefore that the manner in which environmental influences act upon the project generator's commercial activity and the process of building provision may be incompatible and such conflict will need to be resolved. It will be necessary to specify the criteria against which any proposed solution to such conflict can be measured. Such criteria should be in terms of benefit to the project generator.

### 2.2.4 Adaptation

The reaction of an open system to its environment results in a system achieving a dynamic equilibrium or steady state. The importation of energy from its environment to arrest entropy - negentropy - operates to maintain some constancy in energy exchange so that open systems that survive are characterised by a steady state. This contrasts with the equilibrium of a closed system. The steady state in its simplest form is homeostatic and functions to maintain the given structure of the system and is referred to as self-regulatory[82] ( or state maintaining) whereas a system which changes its basic structure as a function of its experience and environment is referred to as adaptive. In adapting to their environment such systems will attempt to cope with external forces by ingesting them or acquiring control over them.[87] They are open 'internally' as well as externally in that interchanges among their components may result in significant changes in the nature of the components themselves with important consequences for the system as a whole.[82]

It is this process of adaptation which triggers the start point identified previously in the outline of the process of building provision. The system identified in the outline is created as a result of this need or opportunity to adapt. The three sub-systems identified in the outline (i) represent the processes of adaptation to specific combinations of environmental forces. The manner in which the sub-systems are undertaken may or may not entail the annexing of other systems in order to achieve the goal of the system. Nevertheless, the process of building provision illustrated by the outline is fundamentally a sub-system of the project generator's larger system. It is a system of adaptation with the goal of enabling the project generator to achieve its purpose.

### 2.2.5 The Goal

The concept of equifinality further characterises open systems. The concept states that a system can reach the same final state from differing initial conditions and by a variety of paths.[87] The equifinality of social systems has major importance for the management of complex organisations. The closed system cause and effect relationship adopted from the physical sciences would suggest that there is only one best way to achieve a given objective. The concept of equifinality suggests that a manager can utilise a varying bundle of inputs into an organisation, can transfer these in a variety of ways, and can achieve variety of output. Extending this view further suggests that the management function is not necessarily one of seeking a rigid

(i) Project Conception Process, Project Inception Process, Project Realisation Process.

solution but rather one of having available a variety of satisfactory solutions to problems.[90]

A system which has the characteristic of having more than one method for achieving an objective is referred to by Ackoff[81] as a purposeful system which he defines as one which can produce the same outcome in different ways in the same (internal or external) state and can produce different outcomes in the same and different states. Thus a purposeful system selects ends as well as means and thus displays will. He defines the goal of a purposeful system as a preferred outcome that can be obtained within a specific period and an objective as a preferred outcome that cannot be obtained within a specific period but which can be obtained over a longer time period.

The outline of the process of building provision demonstrates such features for the whole system and for each of the three sub-systems. The goal of the system is refined in at the end of each sub-system as further methods of achieving the goal are presented. During refinement of the goal it is crucial that the objectives of the whole system is adhered to and not distorted by the sub-goals of the sub-systems.

### 2.2.6 Growth Through Internal Elaboration

Systems concepts recognise growth through internal elaboration. Open systems tend to move in the direction of greater differentiation and a higher level of organisation. Bertalanffy points to the continual elaboration of biological organisms. This same process appears to hold true for most social systems[90] and complex organisations tend to achieve greater differentiation and specialisation among sub-systems. This tendency to internal elaboration and differentiation leads to demands for integration arising from the interdependency of the differentiated tasks within the system. The notion of interdependency is explicit in the earlier definition of systems and the concepts of differentiation and integration arising from them have been defined in organisational terms by Lorsch.[91] He defines differentiation as the differences in cognitive and emotional orientations among managers in different functional departments and the differences in formal structure among these departments. He defines integration as the quality of the state of collaboration that exists among departments that are required to achieve unity of effort by the environment.

Closely related to the concepts of differentiation and integration is that of boundaries.[69] An open system has a permeable boundary between itself and its environment. Boundaries also separate the sub-systems which are defined by identification of internal boundaries. They arise as a result of differentiation within a system and in social organisations are determined primarily by the functions and activities of the organisation.[90] One of the key functions within any organisation is that of boundary regulation between sub-systems. A primary role of management is serving as linking pin or boundary agent between the various sub-systems to ensure integration and co-operation.[92]

The level of abstraction of the outline of the process of building provision identifies three sub-systems[(i)] which are differentiated as a result of choices in terms of outcomes produced by the complexity of the environment. That is, the options available and the outcome of each sub-system are created by the environment, not by the system. The management of the boundaries between the sub-systems is important to ensure that the sub-systems' tasks remain orientated to the objective of the whole system.

In addition to the boundaries between the sub-systems,[(i)] there exists the boundary between the project generator's principal system (commercial activity) and the process of building provision. This boundary is also created by the environment as it is the environmental forces which activate the start point and create the process of building provision. A further boundary is that between the environment and the project generator's principal system and process building provision referred to previously.

The development of the model from the outline will seek to identify further internal boundaries which arise as a result of the tasks to be performed, and the effect of environmental forces.

### 2.2.7 Feedback

The concept of feedback is fundamental to understanding how a system maintains its steady state. Ackoff[81] believes that at

(i)

Project Conception Process, Project Inception Process, Project Realisation Process.

least one sub-set of a system has a system-control function which compares achieved outcomes with desired outcomes and makes adjustments in the behaviour of the system. It also determines what the desired outcomes are. The control function is normally exercised on a feedback principle and operates within the system and between the system and its environment.

The type and amount of feedback is important to system stability and equilibrium.[93] The simplest type of information found in all systems is negative feedback. Information feedback of a negative kind enables the system to correct its deviation from course, that is encouraging a return to the initial situation. Positive feedback further amplifies the deviation from course.[87,94]

The operation of feedback loops requires the sample taken at the freeze point to be measured against the goal of the system. This requires that the goal is appropriately and accurately defined to enable the monitoring and comparing device to carry out its function. Similarly, monitoring and comparison procedures need designing with appropriate methods of measurement of the output for comparison with the goal. Systems should be designed with the ability to take action on the basis of feedback information. The frequency and position of feedback loops within the systems need to be established in relation to the nature of the task being undertaken and the influence of the environment on the system. The control functions which arise from the application of a systems approach to the design of organisations should axiomatically establish feedback mechanisms.

In the outline of the process, feedback is the mechanism designed to ensure that the system remains on course to achieve the goal of the system. This will entail ensuring that the direction of the system remains orientated to maintaining the purpose of the project generator through feedback from the system to the environment and, internally, ensuring that the sub-systems are achieving the current goal. The position of the internal feedback loops will be determined by the output of the differentiated sub-systems to be identified in the development of the model.

## 2.3 SYSTEMS AND ORGANISATIONS

### 2.3.1 Introduction

It is recognised that, relative to its origins in the natural sciences, the application of G.S.T. to organisations is an application to contrived or man-made systems.[67] Organisations have structure but the structure of events rather than of physical components, and their structure cannot be separated from the processes of the system.[90]

In order to develop the model it is therefore appropriate to examine the applications of G.S.T. to the theory of organisations. The aim of this examination is to identify those concepts which allow the processes of the system under consideration to be described in a useful manner for the purpose of developing the model.

### 2.3.2 Traditional Views

Many of the earlier concepts in the social sciences and in organisation theory were closed system views because they considered the system under study as self contained. They concentrated only upon the internal operation of the organisation and adopted highly rational approaches taken from physical science models.[90] What is referred to as the classicist's approach to the design of organisation structures originated from the school of Fayol, Urwick, Taylor and their contemporaries and successors in the early twentieth century. Their 'principles of management' were concerned with such things as Pyramidial Structure, Unity of Command, Line and Staff, the Scalar Chain, Span of Control. The primary element was the bureaucratic form, with its pyramidal organisation structure and the idea that authority is delegated downwards. Division of labour was advocated so that the sub-goals of the various units add up to the overall organisational goals and co-ordination would be handled through the management hierarchy.

This traditional approach to organisation and management was essentially rigid and stemmed from military and church models. It did not make explicit the effect of the human component and influences external to the organisation. A more serious study of people in organisations did not begin until it was explicitly recognised that informal organisations existed in parallel with formal organisations.[95] An extension of the recognition of the human aspect of organisations and the shortcomings of organisational theory saw the emergence of the behavioural and social system schools which believed that the study of management should be centered on inter-personal relations or that it should be seen as a social system. However, Koontz[96] and others doubt whether the field of human behaviour is the equivalent of the field of management. Lorsch[91] considers that the nature of the task of many organisations makes this approach impracticable and he questions the implied assumptions that all individuals are motivated by different needs.

Within these two major movements are a range of schools, which are well analysed by Koontz.[96] The major criticism now levelled at these schools of management thought is that they were offered as the one best way to organise. Recent organisation structure research denies such an assumption.[65,97]

### 2.3.3 Systems Views

General Systems Theory was developing alongside the schools of management thought. It had an attraction for management researchers as it presented an opportunity to converge the strands of management thinking into an acceptable and theoretically sound framework. However, evidence of the demand for a convergent view was demonstrated[98] initially outside the systems framework.

Similarly Carzo[99] moved towards a systems approach without specifically recognising it when he argued for less rigidity and more recognition of interdependency in organisations than the traditional principles imply.

The absence of a theoretically sound framework led to each of the various management theory schools proposing that their approach represented the only way to organise in all conditions. The systems approach however, reflects the interdependency created by the nature of the tasks to be undertaken and the effects upon the task of environmental influences and therefore discounts rigid approaches which propose one method for all circumstances. This is not to say that the systems approach discounts as irrelevant the ideas of traditional management and the behavioural schools but rather that the systems approach provides a framework for understanding and analysing organisations through their internal and external relationships which places into context the earlier views of organisations.[69] For example, the behaviour of individuals within a system of organisation remains important but it is more easily understood and relevant if it is seen within the context of the relationships demanded by the task being undertaken and the environment within which it takes place.

Lawrence and Lorsch's major study[65] led to the Contingency Theory of Organisation Design which states that there is no one best way to organise but rather that organisation is a function of task and environment and it encompasses many recent applications of systems ideas to organisations. They found that different environments require varying degrees of differentiation among organisational units. The extent of organisational differentiation depends upon the uncertainty of the environment and its diversity. They recognised that complex organisations segregate their environment into parts and identify the relative certainty of the parts of the environment. They state that they have found that the state of differentiation in the effective organisation was consistent with the environmental demand for interdependence. In developing their Contingency Theory they state that this starting model is complicated as soon as we move to a complex, multi-unit organisation in which each unit strives to cope with different parts of the environment. As soon as this happens, it introduces the complication of integrating the work of different units. They see the existence of an integratery unit and conflict-resolution practices as contributing to the quality of integration and, in turn, to overall performance.

Whilst they recognise the need to separate the environment into sub-environments of each part of the organisation, nevertheless there is a total environment in which the organisation operates. They accept that the total environment and the sub-environments of the parts will differ and it would seem that one aspect of the role of the integrating mechanism would be to overcome such problems.

A number of other significant research studies led up to the Contingency Theory. One by Burns and Stalker[76] analysed firms in the electronics industry and identified two patterns of organisations and management. One they termed 'mechanistic' was similar to the classical model referred to earlier. The other, termed 'organic', had a participative character. These classifications corresponded closely to the two types of manager classified by McGregor[100] prior to the application of systems to organisations. Burns and Stalker did not suggest that either was superior to the other. They concluded that when taken in context with task and environment, one pattern will be more appropriate for the specific tasks and environment in question.

A further study which made a contribution was undertaken by Woodward[86] who found from analysing manufacturing firms that successful organisations in industries with different technologies were characterised by different organisation structures. Industries with a unit or job shop technology had wider spans of supervisory control and fewer heirarchical levels than did successful firms with continuous process technologies.

A substantial contribution was made by Miller and Rice[69,101] in their analysis of systems of organisations. Their work on the identification of boundaries and the differentiation of task[(i)] and sentient groups,[(ii)] together with Miller's analysis of the determinants of differentiation arising from technology, territory and time provide some of the basic tools for modelling organisations.

(i) A task group was defined as the human resources required for a system of activities.

(ii) A sentient group was defined as the group to which individuals are prepared to commit themselves and on which they depend for emotional support.

The Contingency Theory is a succinct summary of a great deal of the detailed work which went before it. It is perhaps a reflection of the management disciplines apparent need to sum up a complex situation in just a few words.[89] Child is critical of the Contingency Theory on these grounds and believes that contingency theorists have not in the main recognised the organisation design difficulties which may result from the presence of multiple contingencies. Child is concerned at the situation in which a configuration of different contingencies is found which are conflicting in terms of organisation design. He questions the cost effectiveness of the additional integrating mechanism required as he is not convinced that there is evidence that they improve performance.

For similar reasons, whilst drawing upon the principles of the Contingency Theory, the development of the model in this research will be undertaken from the basis of the work which contributed to the Contingency Theory, in particular that of Miller and Rice.

## 2.4 DEVELOPMENT OF THE MODEL

### 2.4.1 The Purpose and Elements of the Model

This section is concerned with developing the model of the process of building provision by the application of systems concepts to the outline proposed previously. The purpose of the developed model is to present an abstraction of the process which makes explicit the main elements and provides a framework for further exploration of the way in which the process may be organised and managed for clients to achieve their requirements. From the previous chapters it is possible to identify the essential elements of a systems model of the process as follows:

(a) Identification of the mode of operation of the system.

(b) Definition of the goal of the system.

(c) Identification of the factors in the environment of the system and the manner in which they influence the tasks of the process.

(d) Definition of the sub-systems of the total system and the nature of their relationships.

(e) Definition of the feedback routes necessary for the maintenance of the system.

### 2.4.2 Input - Output

The system of activities which make up an organisation can be considered in terms of a general open systems model [67, 69, 90] as in Fig. 8.

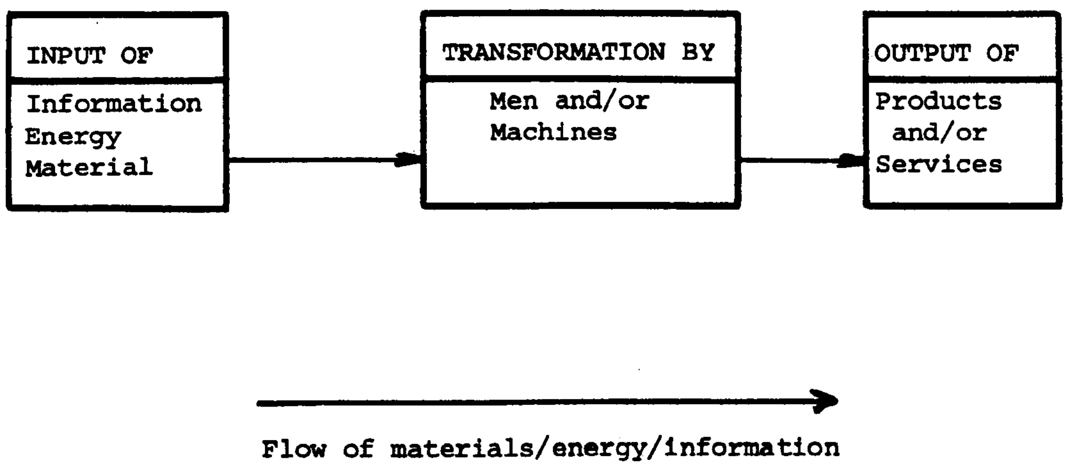



Fig. 8 General model of an organisation as an open system

The open system is in continual interaction with its environment and achieves a steady state whilst still retaining the capacity for work or energy transformation. The system must receive sufficient input of resources to maintain its operations and also to export the transformed resources to the environment in sufficient quantity to continue the cycle. For example, the business organisation receives inputs from society in the form of people, materials, money and information. It transforms these into outputs of products, services and rewards to the organisational members sufficiently large to maintain their participation.

Emery and Trist[88] have developed this general model of their view of organisations as open sociotechnical systems which recognises the technological and social components. They believe that an analysis of the technological system can produce a systematic picture of tasks and task inter-relations required by the technological system but that, in practice this is tempered by human behaviour. Kast[90] et al see this as the structuring and integrating of human activities around various technologies in which the social system determines the effectiveness and efficiency of the utilisation of the technology.

Johnson et al[67] take this a step further and see an open socio-technical system comprised of a number of conceptual sub-systems. These conceptual sub-systems are:

(i) The technical sub-systems, which refers to the knowledge required for the performance of tasks, is determined by the task requirements of the organisation, and frequently prescribes the type of organisational structure and the psychological sub-system.

(ii) The psychological sub-system which consists of individual behaviour and motivation is affected by environmental forces and the technology and structure of the organisation.

(iii) The organisation structure sub-system which is inter-meshed between the technical and psychological sub-systems and is concerned with the way in which the organisation tasks are differentiated and integrated. The linkage is not complete as many interactions and relationships occur between the technical and psychological sub-systems which bypass the formal structure.

(iv) The management sub-system which spans the entire organisation by relating the organisation to its environment, setting the goals, and planning, organising and controlling the necessary activities.

Whilst recognising the human behaviour system of organisations, it can be seen that the technological system in the prescribing system. Hence the abstract model to be developed here will be concerned with modelling the process on the basis of the relationships of the tasks to be performed as determined by the technology of the task and the environment within which the process is undertaken. The characteristics of the people involved in carrying out the process will need to be harnessed to the benefit of of the project generator and although this research is concerned with structure it may be that when the model is compared with the process in practice deviations can be explained by the actions of the social or psychological system.

The application of the input - transformation - output concept to the process of building provision is illustrated in Fig. 9. The project generator's task[(i)] can be seen as an input - transformation - output process and as a result of environmental forces acting upon this system the need or opportunity to adapt to achieve its purpose is identified and triggers the start point. A part of the input to the project generator's task (e.g. money, energy) is then diverted to become input to the Project Conception Process which will also acquire other input direct from its

(i) The project generator's task is the primary commercial activity of its organisation.

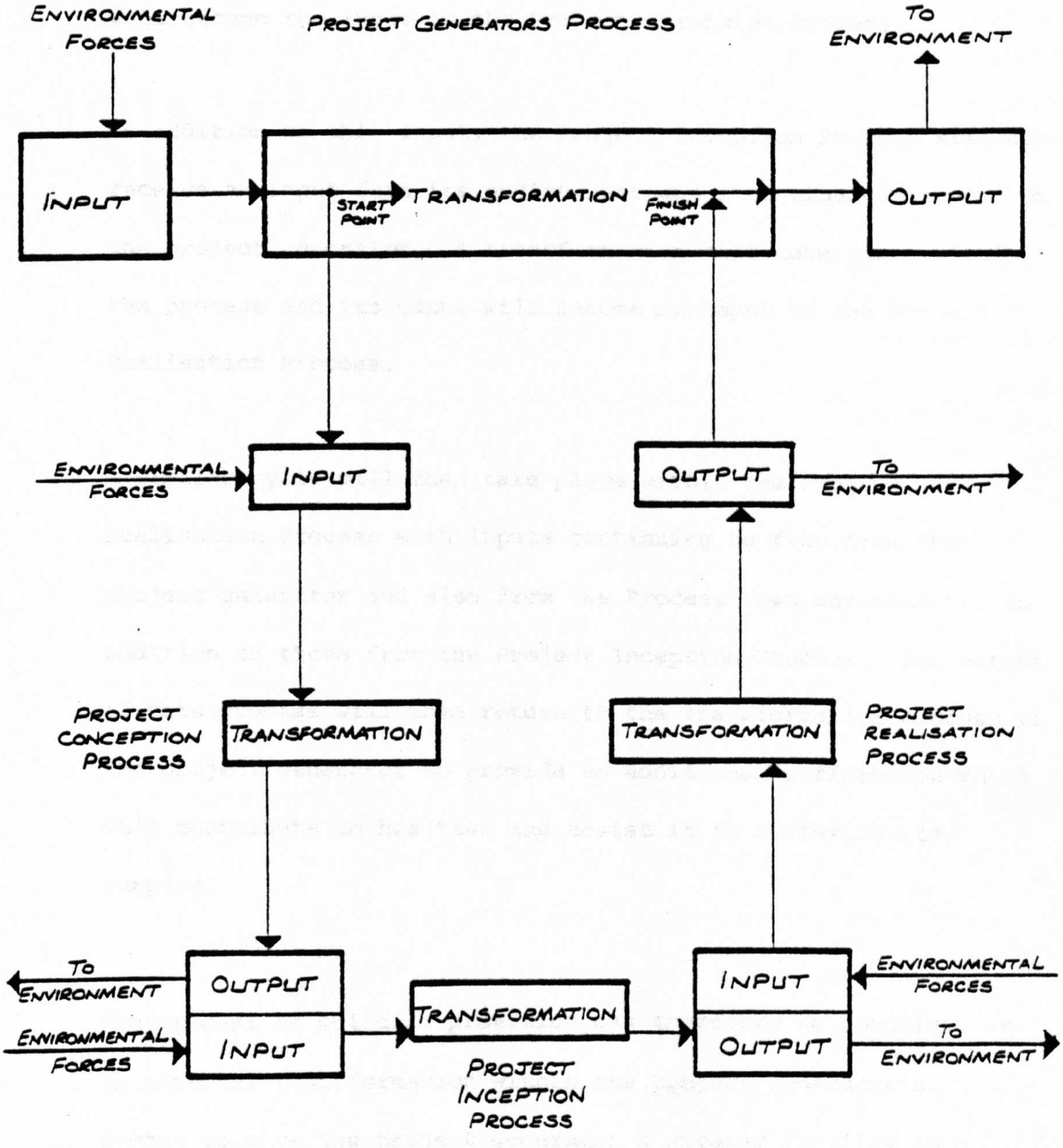



FIG. 9. AN INPUT-OUTPUT MODEL OF THE PROCESS OF BUILDING PROVISION

environment. In both cases the inputs will be in terms of information, energy[(i)] and materials. A transformation will then take place within the Project Conception Process and its output will become the input to the Project Inception Process.

In addition to this input, the Project Inception Process will also receive an input from its environment and a continuing input from the project generator. A transformation will take place within the process and its ouput will become the input to the Project Realisation Process.

A similar cycle will then take place within the Project Realisation Process with inputs continuing to flow from the project generator and also from the Process' own environment, in addition to those from the Project Inception Process. The output of this process will then return to the transformation process of the project genetator to provide an additional performance which will contribute to his task and assist it in achieving its purpose.

The process of building provision can therefore be conceived as an internal transformation within the project generator's system to give the project generator a greater facility to to achieve its purpose, and is a sub-system of the project generator's system carrying out the commercial activity of his enterprise.

(i) Energy is taken to be the input which drives the transformation process and therefore includes people, ideas, power, etc.

### 2.4.3 Purpose, The Primary Task and Feedback

A dominant feature of a system is that it has goals and objectives.[31] Writers have recognised that systems in practice tend to have multiple goals and that some form of compromise of conflicting goals takes place.[78,102] Multiple goals arise as a result of the network of relationships which exist within a system. Traditional approaches to organisation also stress the importance of goals to an enterprise[103,104] but the approach was one of breaking down the enterprise goal into sub-goals for the various parts of the enterprise and did not make explicit the conflicting multiple goal concept of the systems approach.

However, the multiple goals of systems arise not as a result of the system needing to pursue multiple goals in order to achieve its purpose, but because of the individual aspirations of the sub-systems which tend to develop their own purpose outside the main purpose of the system. This has led a number of researchers to put forward the need to identify and relate the system to a predominant goal. Miller and Rice[69] refer to this goal as the primary task and define it as 'the task that it must perform if it is to survive.' Checkland[66] terms it the root definition of the system. All goals of the sub-systems must therefore stem from the primary task of the system and relate to it. One of the tasks of management will be to ensure that sub-systems remain orientated to the primary task of the system. The idea of a primary task in terms of survival is important as it determines the level at which the project generator must respond to environmental influences. The model developed in this work sees the project generator having purpose, of which the primary task is part. Above the level of survival the model sees the project generator as taking advantage of opportunities provided by the environment in order to expand and thereby achieve its purpose as a result of its aspirations and drive. Nevertheless the primary task concept is significant as it determines the lowest level of response to the environment by the project generator if it is to survive.

Whilst an enterprise has a long-term primary task which determines the input - transformation - output process of the enterprise, other tasks may temporarily become primary because they are essential if the main process is to function. For example, if an essential item of machinery breaks down, the primary task shifts temporarily to the repair of the machinery.

In terms of the model, the long-term primary task of the project generator will be that process which it continuously undertakes in order to survive. For example the primary task of a transport company is to move items from one location to another at a profit and is not, for example, keeping its vehicles in pristine condition. The process of building provision will develop its own discrete primary task which must remain compatible with the primary task of the project generator, for example the acquisition of a particular property, or the design and construction of a new building which should,in the case of a transport company, ultimately enable the company to move items more effectively. Circumstances could arise in which the primary task of the process of building provision temporarily becomes the primary task of the project generator's system but normally it will remain subservient to it. A danger following a temporary shift of the primary task is that it may lead to a permanent redefinition of the primary task of the system to the detriment of its ability to survive. Similarly, if the leaders or members of an enterprise do not agree on their definition of the primary task the survival of the enterprise will be in jeopardy.

The sub-systems[(i)] of the model, which are sub-systems of the project generations system, will have primary tasks through which they themselves survive, which will be to contribute to the achievement of the project genetator's purpose (which, encompasses his need to survive). As far as the project generator is concerned, they will not themselves have a purpose in terms of expansion although they may have as far as the members of the sub-systems themselves are concerned if they are from outside the project generator's system and are annexed to it for the duration of the project e.g. professional firms, contractors.

It is important to the project generator that the primary task of the sub-systems remain related to his primary task and purpose and that any purpose which the sub-systems themselves have does not conflict with the achievement of his primary task and purpose. Orientation of the process of building provision towards its primary task is achieved through feedback loops as illustrated in Fig. 10.

(i) Project Conception Process, Project Inception Process, Project Realisation Process.

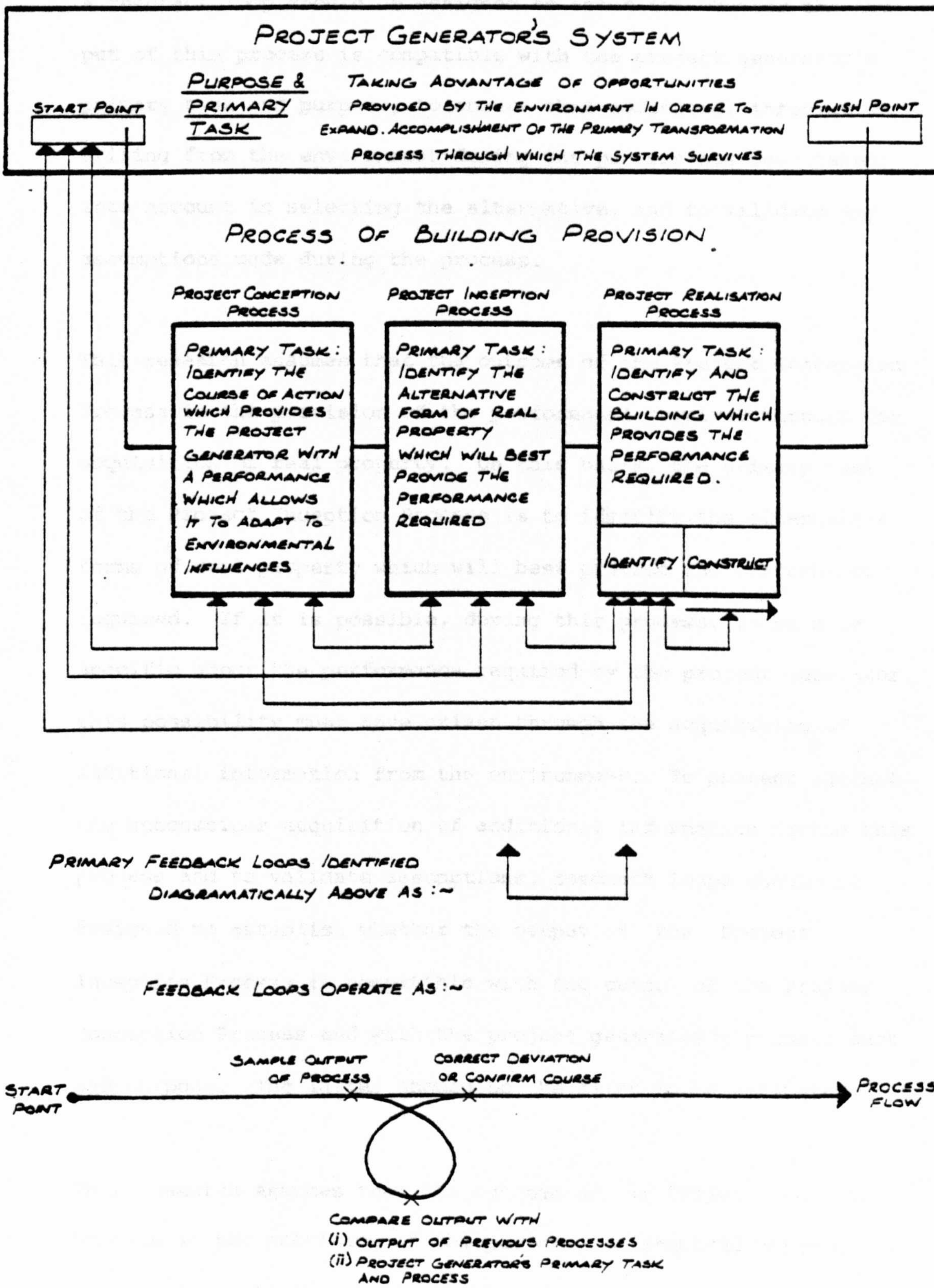



FIG. 10 PRIMARY TASK AND PRIMARY FEEDBACK LOOPS

The primary task of the Project Conception Process will necessitate the definition, in terms appropriate to the options available, of the performance required by the project generator. A feedback loop should be designed to establish whether the output of this process is compatible with the project generator's primary task and purpose, to ensure that additional information arising from the environment during the process has been taken into account in selecting the alternative, and to validate any assumptions made during the process.

This research assumes that the outcome of the Project Conception Process is the provision of the performance required through the acquisition of real property. On this basis, the primary task of the Project Inception Process is to identify the alternative forms of real property which will best provide the performance required. If it is possible, during this process, to be more specific about the performance required by the project generator, this possibility must have arisen through the acquisition of additional information from the environment. To protect against the unconscious acquisition of additional information during this process and to validate assumptions, feedback loops should be designed to establish whether the output of the Project Inception Process is compatible with the output of the Project Conception Process and with the project generator's primary task and purpose. The latter should be the first to be activated.

This research assumes that the outcome of the Project Inception Process is the provision of the performance required through the construction of a new building. On this basis, the primary task of the Project Realisation Process is to identify and construct the building which will provide the performance required.

Initially the information upon which the identification of the new building is based is that which was available at the end of the Project Inception Process. A feedback loop should occur between identification of the new building and the output of the Project Inception Process as additional information may have becone available and may amend the decision taken at that time. Similarly, a feedback loop should be established to the Project Conception Process output and to the project generator's primary task and purpose. The latter should be the first to be activated, followed by the loop to the Project Conception Process and finally to the Project Inception Process. These feedback loops should validate any assumptions made during the Project Realisation Process.

Once the building has been identified and the control stages have confirmed that the identification of the new building is compatible with the project generator's primary task and purpose then this decision places a constraint on the construction of the new building. The feedback loops during construction can only be to the identification of the new building but the feedback loops between the identification of the new building and the previous processes as described above must be maintained. Any change in the project generator's performance requirement during this part of the process will require a decision on the action to be taken, which must take into account the state of construction of the new building. The implication of this is that the maximum amount of information regarding the peformance requirement of the project generator must be known when the new building is being identified. Alternatively, in conditions of uncertainty of the project generator's performance requirements, flexibility must be maintained either by not selecting a long-term fixed solution such as a new building or by identifying a new building which exhibits the flexibility demanded by the project generator's environment if this is possible within the current state of technology.

The feedback loops identified in this section are at the primary control stages defined by the model as illustrated in Fig. 10. Further control stages within the system will be identified as the model is developed.

### 2.4.4 The Environment

#### (a) Generally

As environmental contexts of organisastions rapidly increase in complexity and uncertainty, researchers have recognised the importance of the environment in determining the state of a system, particularly the relative stability/ uncertainty of the environment and its implications for organisation structure[65].

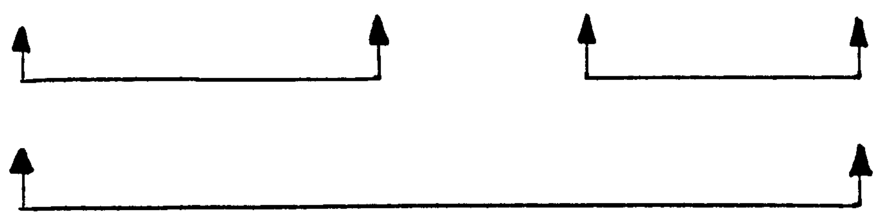
Kingdom[105] appropriately believes that any study of organisational choice should begin with some understanding of the environmental problems, particularly as they are influenced by rapid technological change. Ackoff[81] defines the environment of a system as a set of elements and their relative properties, which elements are not part of the system but a change in any of which can produce a change in the state of the system.

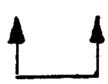
In developing the model, this part of the work examines the manner in which envrionmental forces act upon the process of building provision. An understanding of the manner in which such forces act will form a basis for explaining the organisational structures appropriate to the processes involved.

## (b) Environmental Forces

Environmental forces can be classified for example, in the following general groupings, applicable to any system of organisation, and interdependent as illustrated.

| | | | |
|---|---|---|---|
| Political<br>Legal/Political<br>Institutional | Cultural<br>Sociological | Technological | Economic<br>Competitive |

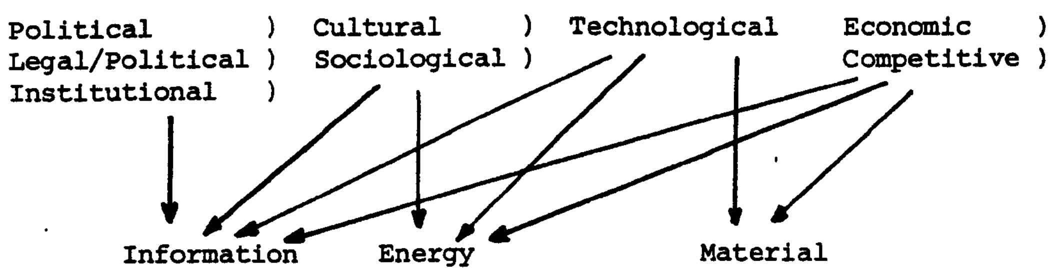


 Interdependency

A system receives information, energy and material from its environment, transforms them and returns them as output to the environment. Information is received, for example, regarding the economic climate and the opportunities it presents, regarding new technological advances, and the attitudes of trades unions and employers associations. Energy is received, for example, through power to drive machines and provide heat, and importantly through ideas and people imported into the organisation.

Material is the raw or partly or fully formed materials used by the system. For the system which is the topic of this research, this return is actually achieved by the use to which the project generator puts the building and the effect on the community of the establishment of the building in a particular location, and the effect of his enhanced activities on his competitors and the economic climate.

The forces described provide an input to the system in a variety of ways, for example:-




The relative importance of the various environmental forces and their impact upon the project generator's system and the process of building provision will vary between different classes of project generator and their selected process of building provision. However, the same classes of environmental forces will be acting upon each system and can be broadly visualised through the following examples:-

Political — The influence of government policy, e.g. the control of the level of activity through investment and taxation, control of the

| | |
|---|---|
| | distribution of activity through investment incentives, influence upon availability of finance, influence upon the labour market. Educational policies. |
| Legal/Political | Legislation affecting the project genetator's primary task. Legislation directly influencing the process of building provision - e.g. the building regulations, safety regulations, planning regulations. Legislation affecting the incentive to build - e.g. control of the availability of land.<br>Legislation affecting the relationship of participants - e.g. control of monopolistic activity. |
| Institutional | The influence of professional institutions upon the activities of its members through rules of conduct, education, conditions of engagement, fee scales. The influence of trade and employer associations upon the activities of their members. Influence of parent company, head office, shareholders. |
| Cultural )<br>Sociological ) | Acceptability of specific activities by the general public, particularly as reflected by the local community. Affect of events in the world on the values and expectations of employees. Influence of unions. Influence of |

informal contacts upon members of the system.

| | |
|---|---|
| Technological | The influence of technology on processes through the development of new materials, techniques, and ideas. Experience of others with materials, technologies, ideas. Current developments of technology and its potential for solving problems. |
| Economic )<br>Competitive ) | The level of general economic activity and the demands placed upon tasks. The state of competition, monopolistic phenomena. Availability of finance, level of interest rates. Availability of materials and labour. |

(c) <u>The Action of the Forces</u>

The action of environmental forces between themselves and then upon the project generator and process determines the climate in which the system exists. A low level of activity of the environmental forces upon the system will lead to a relatively stable system, whereas a high level of activity will lead to the system existing in an uncertain climate.

In terms of the process of building provision environmental forces would appear to act in two ways:-

(i) Upon the project generator's task and hence be transmitted to the process of building provision (Indirect)

(ii) Directly upon the process of building provision (Direct)

In circumstances where the indirect and direct environmental influences act in a conflicting manner the process of building provision will be required to resolve the conflict to the benefit of the project generator.

The indirect influences will be acting directly upon the project generator's company and should determine the organisational structure and mode of operation appropriate to its task and environment. In addition, environmental influences will present opportunities to the project generator, and will determine the manner in which such opportunities need to be taken. For example, if a project generator's environment determines that an additional performance is required quickly in order to take advantage of environmental factors, then the organisation set up to achieve this must be such that it is capable of acting quickly. Similarly, if environmental influences present an opportunity, yet at the same time indicate that uncertainty is likely to prevail, the organisation set up to take advantage of the situation must be capable of achieving the flexibility required.

If the method of acquiring an additional performance is the acquisition of a new building, then direct environmental forces will be acting upon the processes required to achieve this. These environmental influences will be to do with the level of activity in the building industry, the facilities and processes available for the achievement of the project generator's aims and whether in fact the environmental forces allow the project generator's aims to be achieved (e.g. legal requirements may prevent this).

The process of building provision exists, therefore, in a complex environment as illustrated in Fig.11 which must be reconciled in the interests of the project generator.

The task of managing a process of building provision is made complex by the type of environment in which it exists which creates a need for high level managerial skills. If the process must approach certainty at the technical level but must also remain flexible and adaptive to satisfy environmental requirements, the managing system will be required to reconcile these competing demands which will become more difficult as environmental complexity increases[106].

This development of the model sees the process of building provision as a sub-system of the project generator's system and, as such, being influenced by the project generator's environment as well as by the particular environment of the process. This view is a development of the tentative view of the Tavistock Institute[75] which, although not conceiving the process of building provision as a sub-system of the project generator's system (in their terms, the client), drew attention to the obsolescent nature of the concept of the architect 'taking a brief from his client' in the conventional process.

The recognition of the process of building provision as a sub-system of the project generator's system identifies a boundary between the process and the project generator's system which will need to be integrated. The need for an integrative mechanism has as great an implication for the project generator's systems as it has for the process of building provision as it will demand that both systems establish appropriate mechanisms

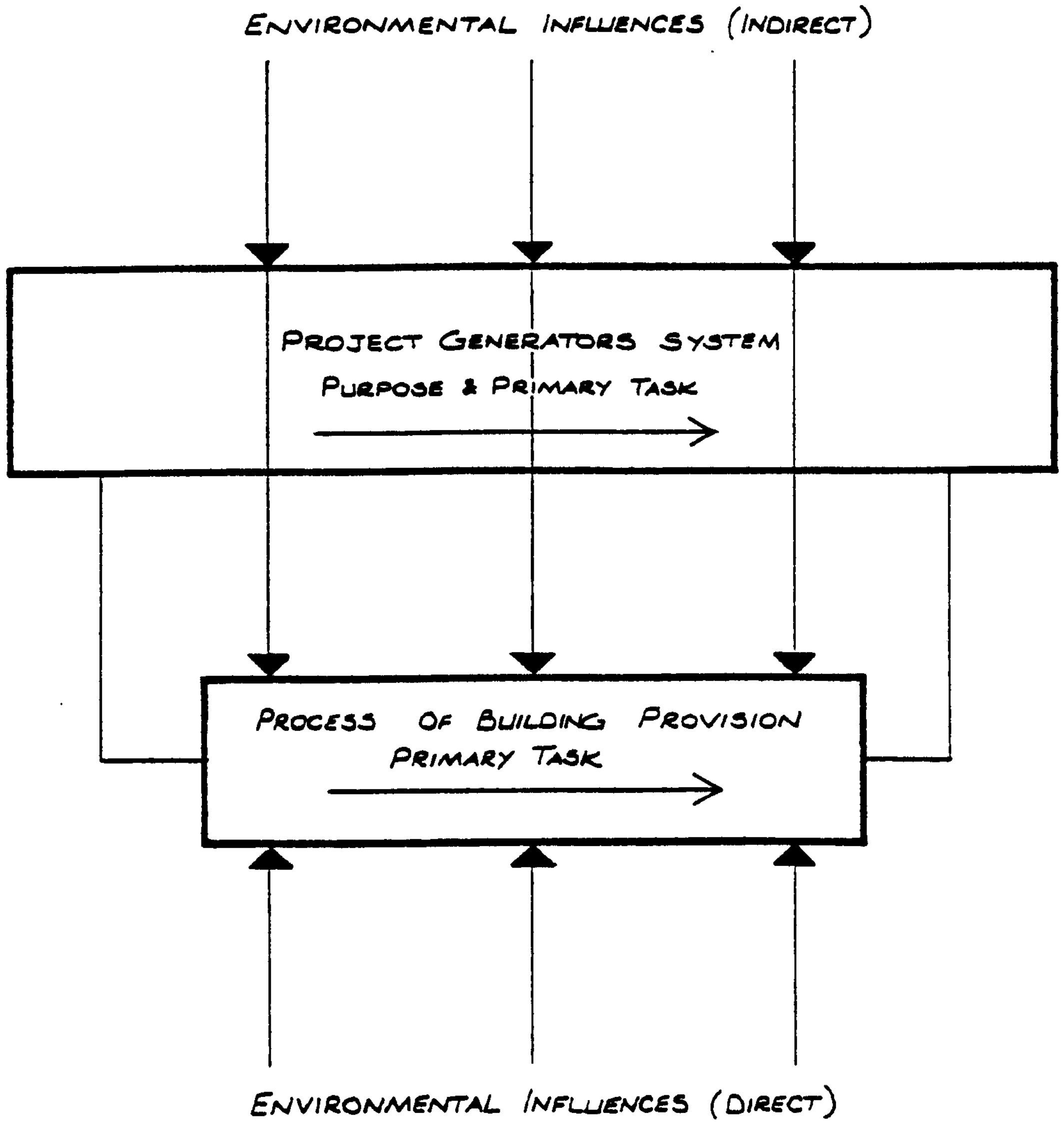



FIG. 11. THE ENVIRONMENT OF THE PROCESS OF BUILDING PROVISION

to achieve the level and style of integration demanded by the environemnt and task. Both the N.E.D.O. report[22] and the Tavistock study[75] have referred to the lack of integration at this boundary in the conventional process.

The implication of this relationship between the systems is that changes in the elements of the project generator's environment or their relative properties may require a change in the process of building provision. The integrative device at the boundary should therefore recognise and take action on changes in the project generator's environment. In the event of changes in the environment of the process of building provision responses of the system should be in terms of maximising the benefit or minimising the deficit to the project generator's purpose and primary task and this should be the objective of the integrative device.

The relative uncertainty of the environments and the nature of the tasks of both the project generator's system and the process of building provision should determine the nature of the integrating device and the organisation structure of the process of building provision. In an uncertain environment - e.g. economically uncertain, technologically uncertain or a combination, the organisational structure of the process should be designed to be sufficiently organic[76] to respond to stimuli. This necessity can be visualised, for example, in large scale long programme hospital development. Conversely, a stable environment could more readily accept a more mechanistic[76] organisational structure, this could be visualised for small scale school building.

### 2.4.5 The Determinants of the Sub-System

#### (a) Generally

The purpose of this part of the development of the model is to identify and explore the factors which determine the sub-systems of the process of building provision. Its purpose will not be to define the sub-systems explicitly, as the actual sub-systems will be defined by the nature of the particular task being undertaken and its environment, but it will be concerned with determining how sub-systems arise within the system, the nature of their relationships, and their need for integration as determined by the differentiation and interdependency created by the task and environmental influences.

The project generator's task as embodied in its system will itself be differentiated into a number of sub-systems but the model is primarily concerned with the sub-systems of the process of building provision. The susceptibility of the project generator's task to environmental influences has implications for the organisational structure of the process of building provision as described earlier but the differentiation of the system of activities required to undertake the project generator's task will not be affected by the differentiation of the process of building provision. However, the integrating device between the project generator's system and the process of building provision will have to take account of the differentiation of the project generator's system.

(b) <u>The Basis of the Development of the Model</u>

The basic tool for constructing this part of the model is the Contingency Theory of Organisation Design[65] which states that organisation is a function of task and environment. However, this premise is in itself not sufficiently rigorous and it is necessary to examine the concepts underlying this theory and apply them in developing the model,

The concept of differentiation - the difference in cognative and emotional orientation among managers in different functional departments[65] - is useful if related to the identification of boundaries and subsequent ideas of managing and operating systems, and of task and sentient groups[69].

Certain important boundaries have already been identified. The boundary between the system and its environment has been shown to be complex and to need management to ensure the project generator's purpose and primary task are satisfied. The model also identified boundaries between the project generator's system and the process of building provision and between the Conception Process and the Inception Process and between the Inception Process and the Realisation Process within the system. Whereas the environment boundary is external to the system, the other boundaries are internal.

Internal boundaries occur between identifiable sub-systems of activities which are differentiated by the nature of the task performed.[69] This idea is useful in identifying sub-systems but, in the building process sub-system differentiation is often created by Decision Points which may or may not be accompanied by differentiation on the basis of the nature of the task performed. The model demonstrates this feature in the case of the boundary between the Conception and Inception Processes. Such Decision Points will be accompanied by a degree of irrevocability that will be characterised by a loss of resources already used or in terms of delay which result in a loss of resources in the future. Such Decision Points will represent boundaries in the system which will require management in the interest of providing the performance which contributes to the project generator's purpose and primary task.

The management of the boundaries which occur within the system is concerned with making decisons and integrating the inter-dependent sub-systems to ensure that propositions upon which decisions are based are arrived at in a manner appropriate to the project generator's purpose and primary task. The integrative mechanisms used should be determined by the type of interdependency which exists between the differentiated sub-systems which may be pooled, sequential or reciprocal[106].

Pooled interdependence is basic to any organisation. Each part renders a discrete contribution to the whole. The parts do not have to be operationally dependent upon or even interact with other parts, but the failure of any one part can threaten the whole and therefore the other parts, for example the decentralised divisions of a large, diversified company.

Sequential interdependence takes a serial form. Direct interdependency between sub-systems can be identified and the order of the interdependence can be specified. For example, sub-system A must act properly before sub-system B can act.

Reciprocal interdependence is when the outputs of each sub-system become the inputs for the others. The process moves forward through a series of steps but each step requires interaction between the sub-systems. Each sub-system is penetrated by the others.

The three types make a scale of complexity in the order of:-

| | |
|---|---|
| Least Complex | Pooled |
| ↓ | Sequential |
| Most Complex | Reciprocal |

A more complex type also contains the lesser complex types.

The order of complexity is also the order of most difficulty of integration. If therefore, there are different types of interdependence there would need to be different methods of integration.

The integration of pooled interdependence is best achieved through standardisation and formal rules, sequential interdependence through planning, and reciprocal interdependence by mutual adjustment and feedback between the sub-systems involved.[106] These ideas underlie and underpin recognition of the importance of integration and are useful in developing the model.

An important tool for analysis is the identification of the internal boundary between the operating system (those systems of activity through which the dominant import - transformation - export process is accomplished) and the managing system (the system that provides the regulatory and maintenance activities to keep the operating system going).[69] Before developing the model in terms of the managing system it is necessary to develop further the model of the operating system of the process as, in organisation model building, it is essential to start with process flow and move on the sub-systems and their boundaries before examining organisational boundaries. The operating system is therefore the sub-systems through which the building is achieved.

It was stated earlier that open systems tend to move in the direction of greater differentiation and that this tendency leads to demands for integration arising from the interdependency of the differentiated tasks. The managing system will integrate the differentiated sub-systems in addition to mediating the effects of environmental influences upon the system and in making decisions. The organisation structure which is designed to encompass both the managing and operating systems must be designed to recognise the condition of the system's environment and its demands for differentiation of the task of the operating system. The less the differentiation of the operating system, the less will be the demands for integration by the managing system and therefore the simpler will be the system, yet the more complex is the environment, the greater will tend to be the pressure upon the operating system to differentiate to cope with the complexity and hence the more complex will be the system and the greater will be the integrative demands upon the managing system.

As the nature of the task of the operating system will vary between classes of project generators depending on the demands of their environments, it is inappropriate to define universal differentiated sub-systems in developing the model. What is required is the identification of the determinants of differentiation so that they can be applied when analysing the system.

(c) The Determinants of Differentiation

The determinants of differentiation as expressed by Miller[101] are:-

(i) Technology - the technical demands of the task which determine the way in which work is divided between groups of people.

(ii) Territory - the geographical distance between groups of people.

(iii) Time - the period of time when groups are at work. Although this category was visualised in terms of shift working, it is possible to conceive differentiation on the basis of time in terms of the sequence of activities where one sub-system cannot act until another has acted.

An additional determinant of differentiation identified by the model is the introduction of discontinuity in a system and the creation of a region of control. Differentiation for this reason may also be accompanied by differentiation on the basis of the above determinants but it can also be the only determinant. The boundaries created by differentiation due to discontinuity of the process and the creation of a region of control are characterised by the need to make decisions which implies a degree of irrevocability. To revoke such decisions would entail the project generator in loss of either resources already expended or in the future. The process of building provision is characterised by such discontinuity due to the incremental nature of the task and as they reflect the flow of the process they are fundamental to the organisation structure.

In a study[86] of 100 manufacturing firms which were classified into three main groups, it was stressed that firms producing units or small batches to customers' individual orders (which demonstrates similarities with the process of building provision) had the greatest difficulty in exercising effective control, particularly in prototype manufacture. It was found that however well developed production procedures may be, there will be a degree of uncertainty in the prediction of results. It is due to such features that discontinuity at regions of control occur in building projects and create boundaries within the process. Feedback loops will be necessary between such boundaries to ensure that the process is continuing to meet the performance required by the project generator's purpose and primary task and that decisions are consistent with this goal.

The determinants of differentiation within the process of building provision arising from the nature of the process are therefore:-

(i) Discontinuity of the process and the creation of a region of control.

(ii) The type of skill demanded by the tasks (Technology)

(iii) The geographical distance between groups undertaking tasks (Territory)

(iv) The sequence of the tasks (Time)

For the development of the model it is essential to start with consideration of the factors which differentiate the process of building provision as a result of the nature of the process flow. An analysis of the process using these tools will establish the actual sub-systems and their boundaries irrespective of organisational boundaries which may arise in practice without adequate appraisal of the need for them.

Nevertheless, it is important to recognise that, in addition to organisational boundaries which may be inappropriately drawn, due to historical reasons, expediency, or other accidents of organisational design, boundaries can occur or be reinforced within systems due to sentience. A sentient group is a group to which individuals are prepared to commit themselves and on which they depend for emotional support[69]. In this research sentience is identified as arising from the firm or from profession or both, to which members give allegiance. It is therefore conceived as the result of the structure of the contributors and as reinforcing differentiation.

Sentience is likely to be strongest where task and sentient boundaries coincide. At one end of the spectrum is a group of unskilled and semiskilled workers, whose roles are interchangeable and each individual dispensable, which cannot acquire sentience unless it finds supplementary activities through which members can make individual and complementary contributions. At the other end is the professional body which confers on members the right to engage in professional relations with clients in which task and sentient boundaries coincide. However, there is a danger in such coincidence of boundaries as it may produce a group that becomes committed to a particular system so that, although both efficiency and satisfaction may be greater in the short run, in the long run such an organisation is likely to inhibit technical change. The group may come to redefine its primary task and behave as if this had become the defence of an obsolescent system. Thus any analysis of a process will need to be aware of the overlay of sentience boundaries and the danger of interpreting them as sub-system boundaries. Similarly differentiation on the basis of territory may not be a result of the nature of process flow but may be created by factors other than the needs of the process, for example the location of the offices of the contributing firms. Inappropriate differentiation on this basis could be a factor in creating sentient groups.

### 2.4.6 The Operating System

On the basis of having identified the determinants of differentiation and the types of interdependency it is now possible to develop the model of the operating system of the process of building provision in abstract terms. The outline in 2.1 identified three systems which are in fact sub-systems of the operating system but which for hierarchical convenience will be called Systems of Activity. These Systems (Conception, Inception, Realisation) were differentiated by discontinuity of the process and the creation of a region of control at what will be called Primary Decision Points, and will apply to all processes of building provison. At this stage it is not possible to identify in concrete terms any other boundaries created by discontinuity as the incidence and position of such discontinuity will be determined by the environment and resulting nature of the task of the process for each particular project.

However, at the level of abstraction of this model, it is appropriate to model the configuration of the sub-systems of the process as determined by their differentiation and the nature of their interdependency in order to identify, in abstract terms, the boundaries with which the managing system will be concerned.

The interdependency of the Systems of Activity created by Primary Decision Points is sequential and requires feedback loops as shown in Fig. 10. It may be that these systems are also differentiated by Technology, Territory or Time, but the dominant differentiation is through the need for a Primary Decision.

It can then be said that each of these Systems of Activity may comprise a number of Sub-Systems of Activity. These Sub-Systems will be differentiated by discontinuity of the process and the creation of a region of control at Key Decision Points as the dominant differentiation. The Key Decisions contribute to and constrain the Primary Decisions and again must be accompanied by feedback to ensure that the system does not deviate from the project generator's purpose and primary task in the development of the decision in the next sequential sub-system to which it is transmitted.

It is possible to conceive sub-systems of activities differentiated by discontinuity created by tertiary decisions and so on, but for the purpose of the model progression is halted at the secondary level.

Each Sub-System of Activity will consist of at least one task sub-system which undertakes the activities which are required to produce the output which will form propositions upon which Key Decisions will be based. The interdependency of the task sub-systems will be either sequential or reciprocal during the execution of the tasks but will finally be reciprocal in preparation of the propositions. The task sub-systems will be differentiated not upon the determinant of discontinuity but on the basis of Technology, Territory, Time and Sentience. Again, feedback loops should be present to ensure that the propositions brought forward are compatible with the performance required by the project generator's purpose and primary task.

The resulting development of the model for the operating system is given in Fig. 12.

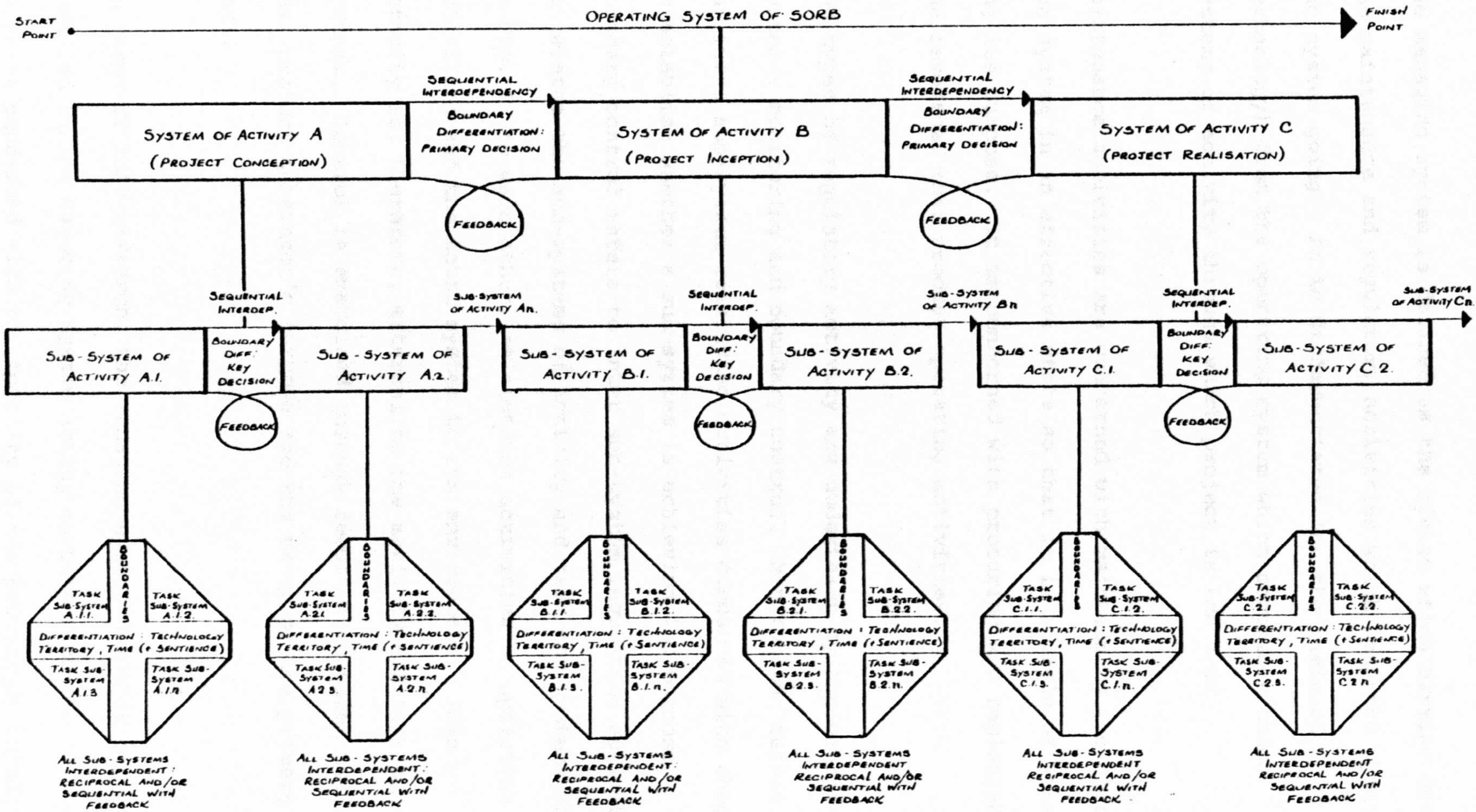



*Fig: 12 The Operating System*

## 2.4.7 The Managing System

The managing system is defined as the system which carries out the maintenance and regulatory activities which keep the operating system going. It is differentiated (on the basis of Technology) from the operating system which comprises those systems of activity through which project is achieved.

Maintenance activities are concerned with maintaining the operating system in an effective state so that it is capable of achieving its purpose. It is concerned with procuring and replenishing the resources that produce operating activities.

Two types of regulatory activity are undertaken by the managing system - monitoring and boundary control. Monitoring refers to the intra sub-system regulating activities concerned with checking to establish whether a sub-system is achieving its purpose. Boundary control refers to inter sub-system regulating activities. It relates the sub-systems of activity and task sub-systems shown on Fig. 12 to each other, maintenance activities to operating activities and the total system to its environment. This activity is, therefore, external to the activity and task sub-systems. Control is exercised through feedback measured against the project generator's purpose and the needs of its primary task.

In terms of this research, the managing system which is being modelled is the managing system acting on behalf of the client which is concerned with the totality of the process of building provision and that part of the project generator's system which is relevant to the process and with relating the process to its environment and to the environment of the project generator.

Its goal starts as the achievement of the project generator's purpose and primary task by adaptation to environmental influences and, in the terms of the model, develops into the achievement of the project generator's purpose and primary task through the provision of a performance through the construction of a new building.

It has been shown in Fig. 12 that the operating system is differentiated into a number of systems and sub-systems of activities and tasks sub-systems between which internal boundaries occur. It is recognised that each system and sub-system of activity and task sub-system into which the process of building provision is differentiated may have its own managing system but which will not be managing the total system for the client and that differentiation can continue until undifferentiated sub-systems are reached in which the managing system and operating system cannot be differentiated; this level is usually the individual person.

The managing system of the total system for the client controls the boundaries between the systems and sub-systems and integrates the output of the systems and sub-systems at their boundaries to ensure that the Primary and Key Decisions taken at these boundaries are compatible with the project generator's requirements (See Fig. 12). The managing system, therefore, ensures that boundaries are appropriately drawn in relation to the process and that facilities for appropriate feedback are available and are used and that correct decisons are taken. To achieve this, the managing system also controls the boundaries between the process of building provision and its environment, between the process and the project generator and its environment (See Fig. 11) and between maintenance and operating activities.

In order to support this role, the managing system monitors the performance of the systems and sub-systems. Such intra-system regulatory activities are intended to ensure that the manner by which systems and sub-systems arrive at the propositions upon which Primary and Key Decisions are based are appropriate. This will entail the design and use of feedback mechanisms and will require the managing system to integrate the sub-systems and to ensure that appropriate techniques are used. Whilst monitoring activities will also be carried out by the systems and sub-systems own managers, nevertheless the managing system of the total process acting for the client will need to convince itself that the operating system is using appropriate methods.

Each sub-system of activity and task sub-system is, to some degree, 'self-regulating' as the nature of the process will impose constraints upon associated sub-systems. Such regulations is not part of the regulating activities of the managing system but the effect of such regulation will be monitored by the managing system as will be the internal management of each sub-system.

The maintenance activities of the managing system ensure that the resources that produce the output of the systems and sub-systems are procured and replenished. These activities aim to ensure that the operating system has the capacity both quantitatively and qualitatively to perform its tasks. Whilst maintenance activities will also be carried out by the system and sub-systems own managers, nevertheless the managing system of the total process acting for the client will need to convince itself that the operating system has the capacity to perform its tasks.

In order to act as an integrative mechanism and provide continuity at Decision Points, the managing system for the client should be undifferentiated. If it is differentiated, then a higher level managing system will be necessary to provide the integration of the differentiated parts. The managing system modelled is the undifferentiated managing system whose purpose is to ensure achievement of the performance required by the project generator's purpose and primary task.

From this analysis of the managing system on behalf of the client, its purpose can be summarised as:-

(i) Establishing the performance required by the project generator as a contribution to its purpose and Primary task

(ii) Identifying any necessary adaptation to environmental influence of the performance requirement established.

(iii) Transmitting the required performance and any subsequent adaptation to the systems of activity, the sub-systems of activity and task sub-systems.

(iv) Harnessing and mitigating the influence of the environment of the process of building provision to the maximum benefit of the project generator.

(v) Contributing to the Primary and Key Decisions require to be made to ensure that the project generator is provided with a performance which contributes to his purpose and primary task.

(vi) Integrating the sub-systems of activity and task required for the achievement of that performance.

(vii) Monitoring the activities of the sub-systems of activity and task to ensure that they are working appropriately to provide the required performance.

(viii) Ensuring that the sub-systems of activity and task have the capability to provide the required performance.

The ability of a managing system to operate effectively depends upon an appropriately structured operating system and complimentary managing system. The developed model has identified in system terms the elements of importance in structuring organisations and has, at this stage, related them to the process of building provision in abstract terms. The model does not, therefore, contain a rigid proposition for the organisation structure of the process of building provision, but proposes an approach which responds to the specific demands of individual projects. A role of the managing system of the process is to design the organisation through which it will work in seeking to achieve the project generator's goal.

The managing system must, therefore, be provided with the authority to design the operating and managing systems and to make them function. Such authority will stem from the project generator and will be derived from finance and information provided by the project generator. Finance and information are the project motivators which allow the project generator to embark upon the project and to establish an organisation structure for that purpose. In this, the project generator will receive advice from various sources but ultimately it will be the project generator who must decide the pattern of authority which is established for the project and hence the authority of the managing system to design the operating system and the project's organisation structure.

### 2.4.8 The Propositions Arising from the Model

Underpinning the developed model are five fundamental propositions which can be summarised as follows:-

(i) The process of building provision is divided into the Systems of Activity of Conception, Inception and Realisation, at Primary Decision Points and into Sub-Systems of Activity at Key Decision Points, all of which identify clear feedback loops.

(ii) The differentiation of the system should be matched by the provison of a corresponding level of integrative effort.

(iii) The managing system and the operating system should be differentiated.

(iv) The managing system should itself be undifferentiated.

(v) The project generator and the process of building provision should be integrated.

The model suggests that if a project's organisational configuration subscribes to the above propositions then it should possess the ability to mitigate and harness environmental influences and achieve the project generator's purpose. The propositions, therefore, form the basis for testing the model against the performance of project organisations in practice.

# PART 3

# TESTING THE MODEL

PART 3 - TESTING THE MODEL

## 3.1 INTRODUCTION

### 3.1.1 Objective and Approach of the Tests

Having proposed a model of the process of building provision it is necessary to test its validity. This is achieved by testing the model against three projects to establish whether the model adequately identifies and explains the particular outcome of projects in practice as a result of the organisational features of each project.

The testing procedure entails acquiring the test project data, interpreting the data and testing the model against the interpretation, as shown in Fig. 13. The method of collection of the raw data is described in 3.2. The raw data had to be translated into a form suitable for testing and details of the method of interpretation is given in 3.3 and the methods of testing in 3.4.

The tests seek to match particular organisational features to project outcomes, taking into account project environments, and to identify the ability of the managing systems to mitigate and harness environmental influences. This is achieved by testing the model's propositions given in 2.4.8 against the organisational features of each test project. This is followed by more detailed tests which trace the causes of the deficiencies in the outcome of each test project to

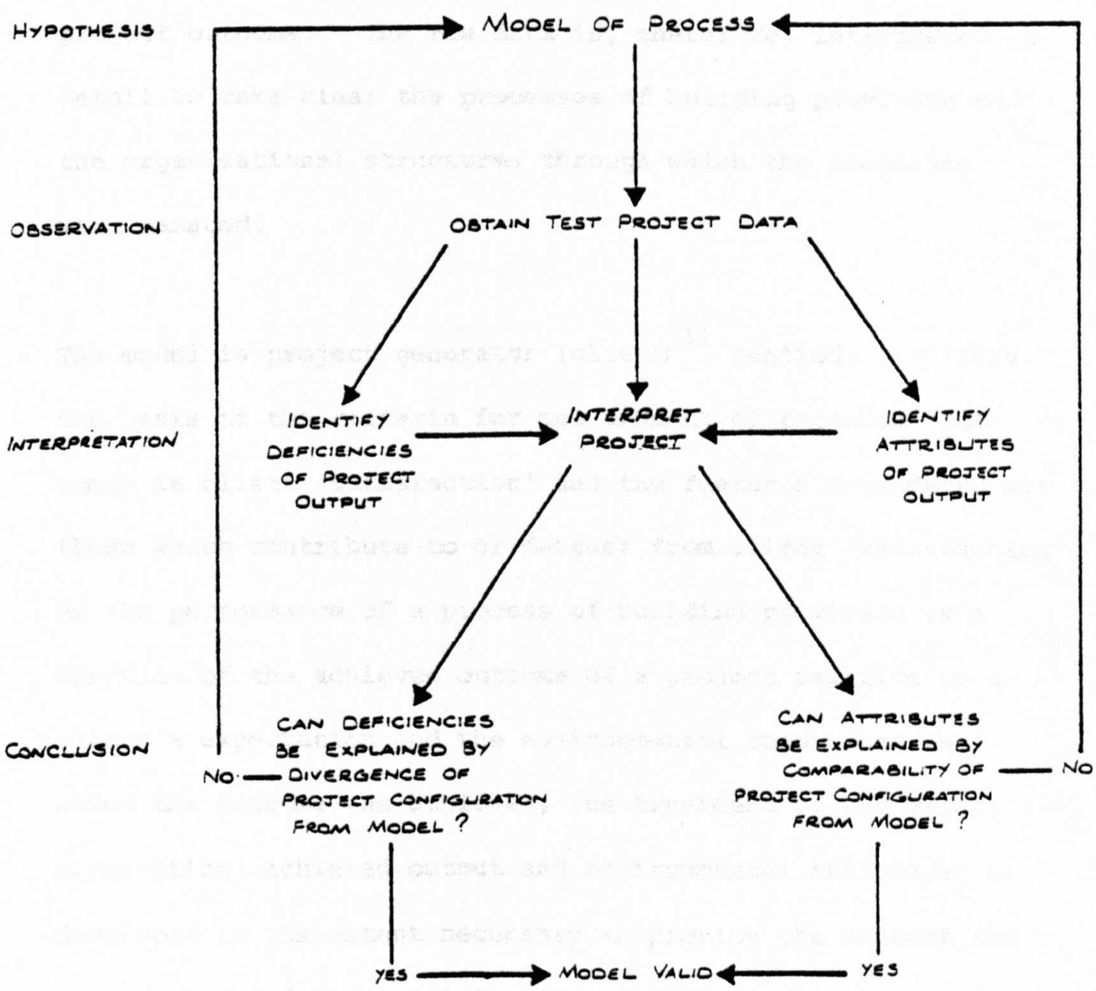



FIG. 13 RATIONALE OF TESTING

establish whether they can be explained by divergence from the model. If they can, the model can be deemed to be valid. If not, revisions to the model will be identified.

The focus of the tests is upon the process of building provision, in particular the correlation of the model with the organisational features of the test projects relative to the project outcome. The raw data is, therefore, interpreted in detail to make clear the processes of building provision and the organisational structures through which the processes were managed.

The model is project generator (client)[(i)] centred, therefore, the basis of the criteria for measurement of projects' outcomes is client 'satisfaction' and the features considered are those which contribute to or detract from client 'satisfaction'. As the performance of a process of building provision is a function of the achieved outcome of a project relative to a client's expectation and the environmental conditions in which the outcome was achieved, the treatment of the client's expectation, achieved output and environmental influences is developed to the extent necessary to provide the context for testing the model against the organisational structures of the test projects.

(i)
The term 'project generator' is used in the model for sponsors of building work and related to the more common term 'client' (see 2.1). In this and subsequent sections the term 'client' is used as it was more familiar to the contributors to the test projects and consistently used by them. As the test projects were for private clients for industrial buildings for their own use the terms can, in these cases, be taken as synonymous.

## 3.2 TEST PROJECT DATA

### 3.2.1 Selection of Test Projects

It was important for testing purposes that the test projects were for clients who had clear objectives for their projects. It was decided therefore, to use industrial/commercial projects for private clients, as opposed to clients in the public sector. The projects were similar regarding the type of building and client, but used different organisation structures for achieving the projects. Ideally, test data should be obtained by monitoring the project from its conception through to completion in real time, but this approach was impracticable due to the time scale involved. The most efficient way of obtaining the test data was, therefore, to use projects which had been recently completed. This requirement, which needed projects completed between 1977 and 1979, together with restriction of the project and client type, the desirability for the project to be located in the North-West of England, for efficiency and economy in data collection, and the need for the willing co-operation of contributors and access to documents, meant that the first three projects identified which subscribed to these requirements were used for testing purposes.

The number of projects used limit the conclusions regarding the validity of the model but nevertheless provide a good indication of its validity and provide a basis for futher development, testing and application.

### 3.2.2 Data Sources

The types of raw data obtained for testing purposes were :

Project description : To provide the general context of the project within which the more specific data is considered. This data was obtained from the project drawings, specification and other formal documents.

Project diary : To provide a catalogue of significant events on the project within the project timescale. This data was obtained from the project files and by enquiry.

Contributors' perception of the project : To provide information on the way in which the major contributors to the project perceived the project's objectives, the way in which the project was managed and the project outcome. This data was obtained by interviewing each major contributor.

The data obtained is given in Appendices 1, 2 and 3 for Test Projects 1, 2 and 3 respectively. To respect the anonymity requested by the interviewees all references which may identify the projects and interviewees have been deleted. However, the data has been verified by the contributors, including validation of the transcripts of each interview in order to obtain as accurate a description of the project as possible.

### 3.2.3 Rationale of the Approach to the Interviews

As the tests aim to establish whether the projects' outcomes are explained by the model, the model's propositions were used as the basis for structuring the interview questions. A schedule of the aspects to be identified (given in Appendix 4) was established from the model and the questions which were put to each contributor derived from the schedule. The aspects identified in the schedule were not put directly to the interviewees for two reasons. Firstly, because they are couched in terminology with which the members of the construction industry and their clients are not generally familiar.

Secondly, and more importantly, to avoid the tendency to constrain the response of the interviewee in such a way as to bias their responses towards the model's propositions. Generalised questions were therefore derived from the schedule to overcome these objections and to encourage interviewees to introduce into their responses aspects other than those determined by the model. The framework of questions posed by the author is given in Appendix 4. The approach adopted in the interviews was that if a response was given to the principal question, supplementary questions were posed along the direction indicated in parenethesis following the questions given in the Appendix 4 or to develop specific aspects referred to by the interviewees.

All the contributors agreed to the interviews being taped for subsequent transcription as given in Appendices 1, 2 and 3 for

Test Projects 1, 2 and 3 respectively. To reduce the possibility of journalistic license in transcription, each transcribed interview was submitted to the interviewee for validation.

The decision to undertake personal interviews rather than requesting the completion of written questionaires was based upon:

(a) The requrement not to inhibit or limit the responses.

(b) The depth of information required. Yes or no answers to structured questions would not necessarily reveal the nuances of the relationships which it was necessary to identify.

(c) The need to gain first hand familiarity with the contributors and 'get under the skin' of the project.

(d) The necessity to explore the degree of correlation between the responses of the various interviewees.

(e) To assist in ensuring that a complete set of data was obtained for each project. It is possible to be more persuasive in obtaining interviews with contributors, having interviewed other contributors than to persuade a contributor to complete and return a written questionnaire.

A representative of all the major contributors who played a role in the managing and operating systems was interviewed. The interviews averaged about one hour each. In a number of cases a second and occassionally, a third interview was held, particularly with the client, in order to clarify certain aspects.

## 3.3 INTERPRETATION OF THE DATA

### 3.3.1 Generally

Prior to testing, methods of interpreting the raw data are considered in two parts:-

(a) The Process of Building Provision and its Organisational Structure.

(b) Client's Expectation, Environmental Influences and Achieved Output.

The interpretation of the raw data is structured, and techniques are developed,which distil and rationalise the data to generate information which is useful for testing the propositions of the model[(i)].

The actual interpretations of the raw data for each test project are given in Appendices 1, 2 and 3 for Test Projects 1, 2 and 3 respectively, as is the raw data which, as described previously, was acquired from a range of sources.

The testing method appears in 3.4 and the actual tests for each test project are given in the respective Appendix. The results of the tests are discussed in Part 4 of the Main Text.

(i)
See 2.4.8.

## 3.3.2 The Process of Building Provision and its Organisational Structure

### (a) Introduction

This primary section is concerned with interpreting the process and organisational structure of each test project, as represented by the raw data, for subsequent testing.

The first step is to establish the operating system used. From this basis the sub-systems and their boundaries will be identified followed by identification of the managing system.

The interpretation, which is a rationalisation of the information obtained from all sources, is intended to give visibility to the processes and relationships established on the projects.

To achieve these objectives, the interpretation should make clear the following features:

Operating System:

Tasks; their sequence and relationships

Differentiation; technology, territory, time, sentience

Interdependency; reciprocal, sequential (pooled excluded)

The Operating System activities.

Differentiation of Operating and Managing Systems.

Managing System:

Organisational structure; job positions

Boundary control

Monitoring

Maintenance

Authority; approval powers, recommendation powers

Other Managing System activities.

The visibility of these features will enable identification of the task sub-systems and the systems and sub-systems of activity[(i)], the relationships within and between them and hence the integration need of the system as a whole. It will also make clear the managing system used to provide integration.

(b) Techniques

Two technqiues TREND and LRC, were given serious consideration for use in interpreting the projects. TREND (Transformed Relationships Evolved from Network Data)[97] was considered to be potentially useful but was discarded principally as it had been found to have limited application on long duration projects with much aggregation in the project plan[107].

(i) Systems and sub-systems of activity are defined by the position of decision points and are overlaid following identification of the task sub-systems - See (e)(i) following.

L.R.C. (Lineal Responsibility Charting) first appeared about 1954[108, 109, 110], but was not further developed until 1975. It originated as an improvement upon the pyramidal organisation chart so that an LRC shows who participates and to what degree when an activity is performed or a decision made. It was subsequently discovered that it could serve as a tool for organisational analysis since it can be made to display systems interfaces and inter-relationships[68].

Typically the LRC consists of a matrix which:

(i) Lists a series of job positions along the top of the table.

(ii) List a series of tasks down the side of the table.

(iii) Uses matrix symbols to indicate the degree of authority and/or explain the relations between horizontal and vertical listings.

(e.g. general supervision, approves, gave advice, did the work)

An LRC can be enhanced by visualising it as an input - output device as shown in Fig. 14, with the jobs positions held by persons in the organisation being the input and the tasks carried out being the output. The LRC can then be transformed into schematic form as illustrated in Fig.15, which shows the way in which the tasks are connected and how people act and interact within the organisation in carrying out the tasks. This presentation clarifies the operating system (the linked tasks), the managing system (the job

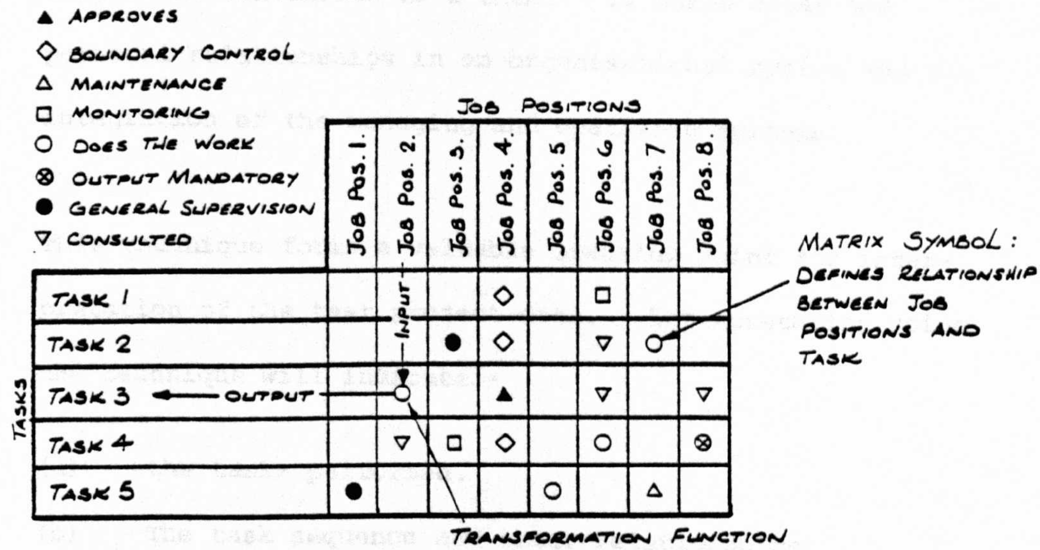



FIG:14 LRC MATRIX (SHOWING INPUT - OUTPUT APPLICATIONS)

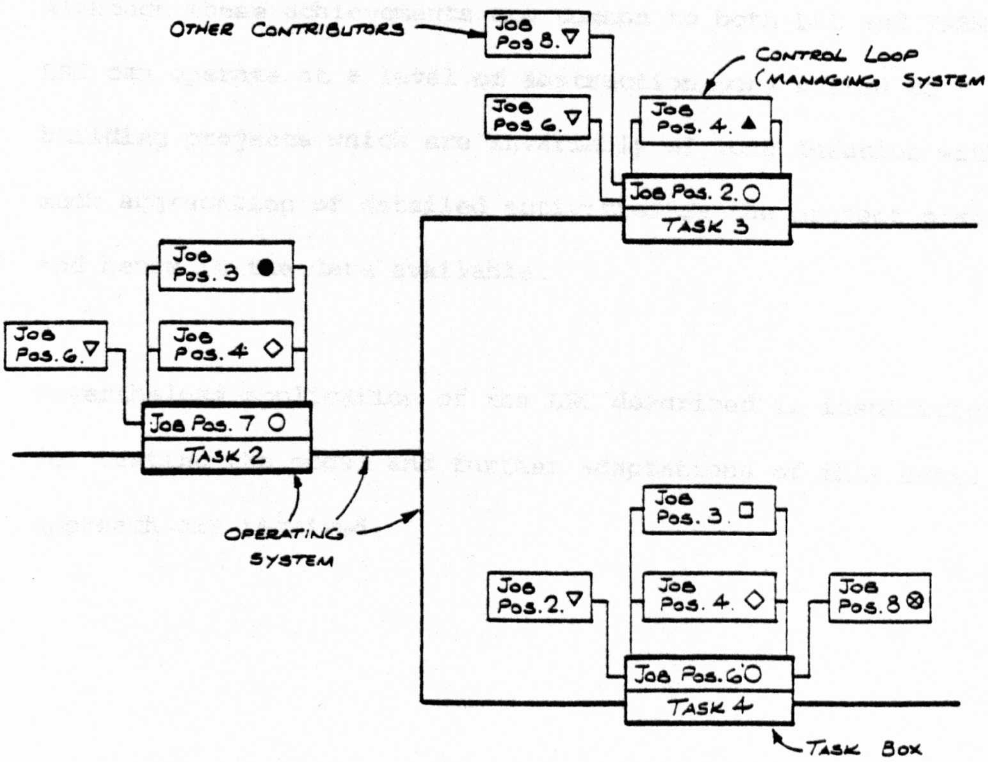



FIG. 15 SCHEMATIC LRC

positions in the control loops) and the relationship of others who contribute to a task. It makes clear the personal relationships in an organisational system and the integration of the managing and operating systems.

This technique forms a valuable starting point for interpretation of the test project data. Interpretation using the technique will indicate:-

(a) the tasks performed.

(b) The task sequence and inter-relationships.

(c) the job positions and relationships of each job position to each task.

Although these achievements are common to both LRC and TREND, LRC can operate at a level of abstraction more suited to building projects which are invariably of long duration with much aggregation of detailed activities in the project plan and hence in the data available.

Nevertheless application of the LRC described is insufficient for testing the model and further adaptations of this basic approach are required.

(c) <u>The Method Adopted</u>

Of the features to be identified, given in 3.3.2(a), a schematic LRC will show:

Operating system:

The Tasks; their sequence and relationships

Differentiation of the Operating and Managing Systems

Managing system:

Organisational structure; job positions

However, adaption of the technique is required to identify the following features:

Operating system:

Differentiation; technology, territory, time, sentience

Interdependency; reciprocal, sequential

The Operating System activities

Managing System:

Boundary control

Monitoring

Maintenance

Authority; approval powers, recommendation powers

Other managing system activities

In order to identify the above features the following enhancements were made to the LRC approach:

Operating System:

Differentiation:

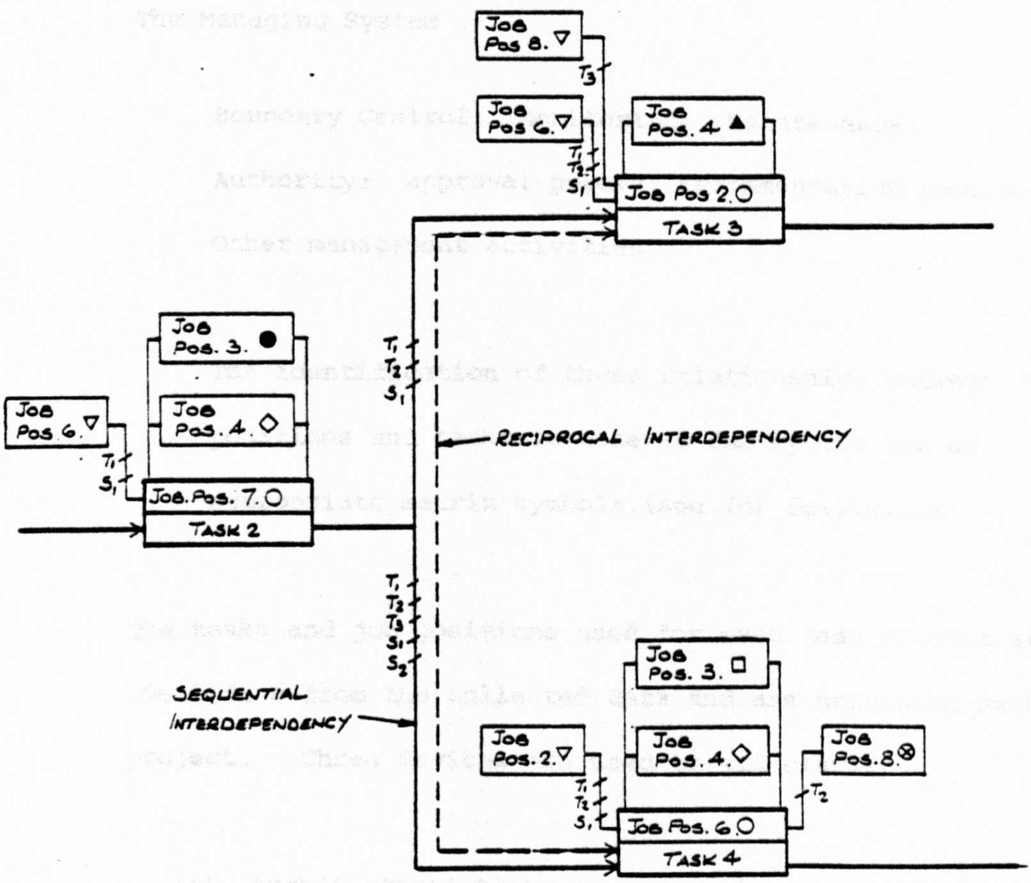
The determinants of differentiation - technology, territory and time identified by the model are incorporated into the schematic LRC.

Sentience, which reinforces differentiation is also incorporated and identified in two types that arising affinity to a profession and that arising from affinity to both a profession and a firm.

Differentiation between tasks and within tasks is identified as illustrated in Fig. 16. Differentiation with the managing system (control loops) is considered later when analysing the intergration provided by the managing system, hence it is not shown on the schematic LRC at this stage.

Interdependency:

The schematic LRC shows the sequential interdependency of tasks if arrow heads are added. Reciprocal interdependency is overlaid on the schematic LRC. Reciprocally interdependent tasks are drawn in parrellel and joined by broken lines as illustrated in Fig. 16.




DIFFERENTIATION AS THE BASIS OF :–

$T_1$ : TECHNOLOGY
$T_2$ : TERRITORY
$T_3$ : TIME
$S_1$ : SENTIENCE BY PROFESSION ONLY
$S_2$ : SENTIENCE BY PROFESSION AND FIRM.
(AMPLIFIED IN THE MODEL – SECTION 24.5)

FIG: 16 THE METHOD ADOPTED FOR LINEAR RESPONSIBILITY ANALYSIS

The Operating System activities:

The identification of the relationships between job positions in the operating system and tasks is catered for by the use of appropriate matrix symbols.(see (d) following)

The Managing System :

Boundary Control; Monitoring; Maintenance:
Authority; approval powers, recommendation powers
Other management activities

The identification of these relationships between job positions and tasks is catered for by the use of appropriate matrix symbols.(see (d) following)

The tasks and job positions used for each test project are identified from the collected data and are unique to each project. Three devices are used to aid clarity:

(i) Architectural tasks are entered in two parts - those parts concerned with spatial design and those parts concerned with technical aspects. Inter-dependencies with other contributors have implications for both parts of the architect's tasks, even though they are not clearly separated in practice.

(ii) The job position of Main Contractor's Contract Manager or equivalent is taken to encompass Planning, Buying, Quantity Surveying, etc., for the Main Contractor. This reduces complexity yet allows the major relationships relevant to the orientation of this research (management on behalf of the client) to be exposed.

(iii) Sub contractor's tasks are aggregated into 'Nominated Subcontractors' and the Main Contractor's direct 'Subcontractors'. This enables the nature of the relationships to be exposed whilst avoiding over-complication.

An interpretation of each test project is made using the adapted LRC technique which is referred to hereafter as the Linear Responsibility Analysis (LRA). Each LRA forms the basic interpretation from which further information for testing purposes is derived. Each LRA covers the test project from the Start Point to the Finish Point.

The Task Boxes on the LRA represent the task sub-systems of the operating system. Systems and sub-systems of activity are defined by the position of decision points which are overlaid on each test project LRA as described in (e)(i) following. The data upon which each LRA is based is that obtained through interviews and other sources as described in 3.2 and is given for Text Projects 1, 2 and 3 respectively in Appendices 1, 2 and 3, together with each LRA and LRC.

At the level of aggregation of detailed activities used in this research, the identification of the tasks appearing in the task boxes, their sequence and the relationships of job positions can be obtained objectively from the interviews. At times it was necessary to piece the arrangements together from a number of interviews but normally the arrangements were confirmed by more than one interviewee. Occasionally it was necessary to check back with an interviewee to clarify certain points. However, it would seem that if a greater level of detail were employed it would be necessary to plot projects in real time as limitations are likely to exist if dealing with historic data.

(d) Definition of the Matrix Symbols

The relationships represented by the matrix symbols adopted for the LRAs are common to all test projects and have been designed by the author to reflect the categories of involvement of contributors to building projects and management system activities proposed by the model.

The symbols define the way in which job positions relates to tasks.

Each relationship can be classified into one of four categories;

(i) A transfer function of input into output within the operating system.

(ii) A control loop function concerned with managing the operating system.

(iii) A contribution of input to a task, external to the operating system.

(iv) A receipt of output from a task, external to the operating system.

(i) Transfer Function:

O Does the Work: This is where inputs to tasks are transformed into outputs from tasks in accordance with instructions. It is the juncture of managing and operating systems where the output is transfered under the control of the managing system to be input to the next task. This relationship appears in each Task Box(i) and the total of the task boxes define the Operating System and those involved in it.

(i) See Fig. 15.

(ii) Control Loop Functions:[i]

| | |
|---|---|
| ▲ Approves: | This constitutes the final control loop function. The person in this executive relationship has the authority to approve the output of tasks for use in further tasks on the project. |
| ▼ Recommends: | The person in this relationship is charged with the responsibility of making recommendations for approval of the output of tasks. |
| ● General Oversight: | This is the broadest administrative control element and the source of policy guidance to whose wishes the person in the Direct Oversight relationship responds. The person in this relationship will not himself be exercising the skills of a task over which he has oversight.<br><br>The primary role of this relationship is to furnish policies and guidance of a scope which permits as much decision making flexibility as possible within a task in arriving at the output. |

(i)
See Fig. 15

The omission of the relationship from a control loop indicates that the task was assumed not to involve questions of policy.

◆ Direct Oversight: This is the administrative control element immediately below the General Oversight relationship. Whilst having no specific project functions the person in this relationship has, and will, exercise when necessary, the skills demanded by a task over which he has oversight. He is seen by others involved in the project to be maintaining a presence close to project activities. The omission of this relationship from a control loop indicates that the task was of such a routine nature that Direct Supervision was not necessary.

Δ Boundary Control: When this appears in a control loop it indicates the specific operational control activity of ensuring functional compatibility within the task for which it appears and between it and other tasks. The person in this job position does not normally also have an administrative role in the control loop.

In addition, this relationship is concerned with relating the total system to its environment.

Omission of this relationship from a control loop indicates that the task is undertaken independently of other tasks in the operating system.

- **Monitoring:** This is the specific operational control activity of intra task regulation concerned with checking prior to output to ensure that a 'Does the Work' activity is achieving its purpose. Omission of this relationship from a control loop indicates that it was not necessary to carry out such checks.

| | |
|---|---|
| ◇ Maintenance: | This is the specific operational control activity of ensuring that a 'Does the Work' activity is being maintained in an effective state, both quantitatively and qualitatively so that it is capable of achieving its purpose. Omission of this relationship from a control loop indicates that it was not necessary to maintain the 'Does the Work' activity. |

(iii) Contribution to Input

| | |
|---|---|
| ■ Consultation - gave instructions and information | This is an input of instructions and information to a 'Does the Work' activity and does not therefore appear in the control loop. |
| ▽ Consultation - gave advice and information | This is comparable with the last relationship but advice and information is input to a 'Does the Work' activity. |

(iv) Receipt of Output

| | |
|---|---|
| ⊗ Output Notification Mandatory | This is placed in the output of a task when it is essential that the person in this relationship with a task receives timely information concerning a task output. The concept of this relationship is one of passive transmission of information. |

The control loop activities are concerned with ensuring that the input and output relationships in (iii) and (iv) are utilized.

The matrix symbols define the relationship between the persons involved in the test projects relative to the operating system. They are used to interpret how the managing and operating systems were integrated.

(e) Extraction of Information from the Linear Responsibility Analyses

The model identifies five propositions (i) which are tested. Material for the test is extracted from the Linear Responsibility Analysis for each project in the following sections:-

(i) See Section 2.4.8.

(i) Identification of Primary and Key Decision Points and Systems and Sub-Systems of Activity.

(ii) Establishment of the Differentiation and Integration of the Operating System.

(iii) Establishment of the Differentiation between the Managing and Operating Systems.

(iv) Establishment of the Differentiation within the Managing System itself.

(v) Establishment of the Integration of the Client and the Process of Building Provision.

These sections correspond with the propositions of the model.

## The Methods Used to Extract the Information

(i) Identification of Primary and Key Decision Points and Systems and Sub-Systems of Activity.
(Shown on each LRA in each Appendix)

The model proposes that all processes of building provision are divided into the System of Activity of Conception, Inception and Realisation at Primary Decision Points. These systems are fundamental to all processes and provide major feedback opportunities at Primary Decision Points. If these systems are identified, the tests will establish whether feedback was used effectively at Primary Decision Points.

The model also proposes that within the defined Systems of Activity, Key Decision Points determine the Sub-Systems of Activity of a project and that they are characterised by:

(a) A degree of irrevocability unless loss of resources already expended or in the future is accepted.

(b) A committment which constrains subsequent tasks.

(c) Discontinuity and the creation of a region of control which provides a major feedback opportunity.

(d) Identification of major boundaries within the system and hence definition of Sub-Systems of Activity.

Key Decision Points are identified on the test projects by applying these criteria to the LRA and interview data. Identification of the Key Decision Points establishes the feedback loops which were available to the project team and the tests will establish whether they were effective in both their design and use.

For presentation purposes, Primary and Key Decision Points, decisions taken, feedback loops and Systems and Sub-Systems of Activity are superimposed on the LRAs presented in the Appendices.

Note: During interpretation of the data it was discovered that a sub-system level existed between the Sub-Systems of Activity and the Task Sub-Systems shown on Fig. 12 (The task sub-systems are represented by the task boxes on the LRA s as shown in Fig. 15)

These new sub-systems were characterised by:

(a) Discontinuity and the creation of a region of control due to Operational Decisions which contribute to and constrain Key Decisions.

(b) Provide further feedback opportunities.

These sub-systems are termed Operational Sub-Systems. Operational Decisions Points, decisons taken, feedback loops and Operational Sub-Systems are superimposed on the LRA s presented in the Appendices.

(ii) Establishment of the Differentiation and Integration of the Operating System

The Differentiation of the Operating System

(Table 1 of each Appendix)

This section establishes from an LRA, the integration needed by an operating system which is demonstrated by the degree of differentiation existing within the system.

The degree of differentiation is presented both quantitatively and qualitatively.

The quantitative element is given by the number of links which exist:

1) between tasks and

2) between job positions within tasks.

The links between tasks represent the differentiation which has to be integrated in managing the output of the tasks to realise the project. The links between job positions within tasks give the differentiation to be integrated in achieving the output of the tasks.

A qualitative measure of differentiation is given by identifying the proportion of each permutation of differentiation factors (i.e. technology, territory, time and sentience) comprising the 'between tasks' and 'between job positions within tasks' links. Theoretically it is possible to have any permutation of differentiation factors ($T_1$, $T_2$, $T_3$, $S_1$, $S_2$,)[(i)] but in practice the configuration of the contributors limits the range which occurs on any project. For example, within a task the various professions in a multi-disciplinary practice in which all members are located on one office can only have a differentiation of $T_1$, $S_1$ (Technology and Sentience by profession).

The Integration of the Operating System provided by the Managing System

This section establishes, from an LRA, the pattern, style and intensity of integration provided by a managing system. Integration provision falls into two related categories:

(1) The pattern of consultation established between the contributors by the managing system.

(2) The pattern and intensity of integration exercised by the managing system.

(i)

$T_1$ Differentiation by Technology

$T_2$ Differentiation by Territory

$T_3$ Differentiation by Time

$S_1$ Sentience by profession only

$S_2$ Sentience by profession and firm (See 2.4.5)

## Pattern of Consultation (Table 2 of each Appendix)

It is to be expected that intensity of integration in the control loops will only be possible if an appropriate pattern of consultation has been established between the contributors. Such a pattern of consultation is demonstrated by all relevant job positions being in the 'gave advice and information' relationship with each task.

Similarly the degree of differentiation of the system will be a function of the pattern of consultation established. It is to be expected that differentiation will be greater as the number of contributors to each task increases and will therefore demand greater intensity of integration.

The pattern of consultation established is indicated by identifying the number of contributors exercising the 'gives advice and information' relationship for each task as a percentage of the contributors who would normally be expected to be exercising this relationship for the task. The number of contributors who would normally be expected to be consulted is established by including those contributors who's work impacts upon the task being considered within limitations imposed upon the pattern of consultation by the key and operational decisions (e.g. contractual arrangements can exclude the contractor from the design phase). The pattern of consultation identified is that which was possible within such hierarchical decisions, the effects of which are considered elsewhere.

Pattern and Intensity of Integration (Tables 3 & 4 of each Appendix)

The pattern and intensity of involvement of job positions in control loops of the tasks is given over all tasks by expressing the number of times a job position is in a control loop as a percentage of the total number of tasks, categorised by the type of relationship. This information is given for each Sub-System of Activity separately and over the total system. This analysis gives visibility to the pattern of involvement of the job positions in the managing system. It shows the range of relationships and the intensity of involvement of each relationship for each job position.

Each task is given an equivalent weighting. Interpreting the tables it is, therefore, necessary to refer to the LRA to determine the scope and significance of tasks, particularly in relation to the lower value entries (e.g. Contract Manager for Contract No.1 on Test Project No. 1).

Formally Minuted Meetings (Tables A1 - A6 for Appendix 1 only)

Supplementary data is provided from the records of formally minuted meetings for projects for which such information is available.

Analysis is made of the proportion of meetings attended by the contributors for the total system and for each Sub-System of Activity. Analysis is also made of the incidence of meeting of the various contributors at the formal meetings to give an indication of the intensity of their formal contact. This analysis is also given for the total system and for each Sub-System of Activity.

### (iii) Establishment of the Differentiation between the Managing and Operating Systems

(Table 5 in each Appendix)

A statement is presented of the differentiation between the managing and operating systems. If the managing and operating systems were totally undifferentiated, there would be no control loops and all task boxes on the LRA would be occupied by the same job position. If the systems were totally differentiated, none of the task boxes would be occupied by any job position appearing in any control loop. The statement of differentiation is, therefore, expressed as a percentage of task boxes occupied by a control loop (overall management) job position for each Sub-System of Activity separately and for the total system. Total differentiation of the managing and operating systems would be given an entry of zero.

## (iv) Establishment of the Differentiation of the Managing System Itself

### Differentiation of the Managing System within Tasks

(Figs. 1 - 10 in Appendix 1, Figs. 1 - 16 in Appendices 2 and 3)

The model proposed that the managing system should be undifferentiated if it is to be effective. Therefore the distribution of undifferentiated management units within control loops is established together with the distribution of the total number of job positions in control loops.

For the purpose of defining undifferentiated management units, differentiation is taken as previously, but in the case of management units within tasks:

Technology is common as all relationships in control loops are managing activities.

Time is common as within control loops is being examined.

Territory is common if job positions are within the same firm. Differentiation on the basis of firm is, therefore, the only determinant of differentiation within control loops, and occurs when those occupying managing job positions are from different firms. In such cases Sentience reinforces differentiation on the basis of allegiance to a firm.

Therefore, an undifferentiated management unit entered in the histograms is a group of job positions occupied by persons from the same firm.

Differentiation of the Managing System between Tasks (Table 6 in each Appendix)

Differentiation of the Managing System between tasks creates potential discontinuity. This occurs when the person in the boundary control relationship does not appear in the same relationship in successive task control loops or in successive task boxes. Such occurrances are identified and discontinuity between tasks expressed as a proportion of all task links. Such discontinuity may be particularly significant at Key Decision Points and the proportion of discontinuity at these points is given.

Duplication of Managing Relationships within a Control Loop

(Table 7 in each Appendix)

Duplication of managing relationships within a control loop represents split management functions for the associated task and may further add to the complexity of the managing system. Such occurrance are identified for each Sub-System of Activity.

(v) Establishment of the Integration of the Client and the Process of Building Provision

This section is concerned with establishing the specific integration achieved within the managing system between those people representing the client and those representing the process of building provision.

Within Task Integration and Between Task Integration

(Tables 8 & 9 in each Appendix)

Integration of the Client and the Process should take place within the tasks and between them and may be exercised at various levels.

The interpretation of the LRAs consider the 'Primary Integrators' who are seen by the project contributors to be exercising this role and notes where others in the managing system who, although exercising other roles, undertake an integrating role when the primary integrators are not present.

Examples of 'Primary Integrators' would be a specific individual appointed by a client from his organisation to co-ordinate with the project team and a person appointed project manager from within the project team.

Integration is taken as occuring within a task when the job positions being considered appear together in the control loop or appear one in the control loop and one in the task box. Integration is taken as occuring between tasks when both job positions being considered appear in the control loops or task boxes of successive tasks.

The integration levels achieved within tasks for various conditions of integration are established from the LRAs. The amount of integration between tasks is also established from the LRAs by identifying the proportion of links for which the integrators appear in successive control loops or task boxes. Both sets of data are given for each Sub-System of Activity and for the total system.

Formally Minuted Meetings

(Table A7 Appendix 1 only)

Supplementary data is provided from the records of formally minuted meetings for projects for which such information was available. Analysis is made of the incidence of joint attendance at meetings of the Primary Integrators.

### 3.3.3 Client's Expectation, Environmental Influences and Achieved Outcome

#### (a) Introduction

The outcome of a project which a client expects the process of building provision to achieve, together with the outcome which it actually achieves within the context of the environmental influences which it had to mitigate and harness, indicate the performance of the process of building provision.

Deficiences in outcome can be identified and their specific causes traced through the process. Attributes of the outcome can be identified and a general assessment of the overall performance of the process made, in order to place conclusions regarding deficiences into context and to identify the degree to which the propositions of the model are met in producing the attributes.

Conclusions can be drawn regarding the validity of the model for explaining the manner by which attibutes and deficiencies of the outcome of projects were created.

(b) Components of Satisfaction

The components of a client's expectation of satisfaction at the Start Point and a client's satisfaction with the outcome achieved are identical. However, the actual components and the values ascribed to them may vary between clients and projects. Similarly, variations in the scale and nature of the impact of environmental forces between clients and between projects demand compensating variations in the nature and quality of the process of building provision to produce the same level of client satisfaction with the outcome.

For the range of projects used for testing, the components of client satisfaction are taken as:

Function (including quality)

Time

Price

For the industrial projects used, these were the components most readily perceived by the clients, as demonstrated by the interviews. They are readily acceptable as all have immediate relevance to privately developed industrial projects conceived to enhance the performance of the company.

For different classes of client, other components would be relevant, such as aesthetics, life cycle costs, social acceptance.

Thus, client satisfaction can be conceived as a vector $\vec{S}$ in three dimensions with the rectangular component vectors of Function ($\vec{F}$) Time ($\vec{T}$) and Price ($\vec{P}$) and initial point O as illustrated in Fig.17, so that

$$\vec{S} = \vec{F} + \vec{T} + \vec{P}$$

and the magnitude of $\vec{S}$ is

$$S = \sqrt{F^2 + T^2 + P^2}$$

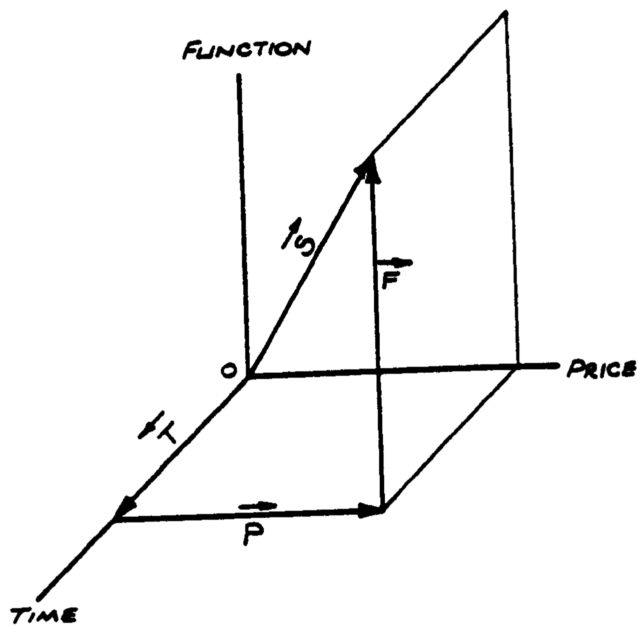



FIG: 17

## (c) Client's Expectation and Environmental Influences

For the purpose of assessing the performance of a process of building provision it is necessary to describe the context in which it was undertaken. The factors of interest are those concerned with the impact of environmental forces upon a project. Before considering the impact of such influences, it is necessary to identify a client's expectation of the outcome of a project. Environmental forces will influence the possibility of achieving a client's expectation and the process of building provision will seek to mitigate or harness environmental forces in seeking to achieve it.

### Client's Expectation

The expectation of a client of the outcome of a project at the Start Point can be represented by the vector $\vec{S}_R$ which comprises the component vectors for satisfaction of functional requirements $(\vec{F}_R)$, completion of the project on time $(\vec{T}_R)$ and within the price he is prepared to pay $(\vec{P}_R)$ such that:

$$\vec{S}_R = \vec{F}_R + \vec{T}_R + \vec{P}_R$$

At the Start Point a client's expectation is that each component will be fully satisfied in the achieved outcome. The magnitude of $\vec{S}_R$ is:

$$S_R = \sqrt{F_R^2 + T_R^2 + P_R^2}$$

This premise assumes that a process of building provision can be designed and can be made to function satisfactorily with any valid expectation. The state in which this premise does not hold is when the required outcome is invalidated through impossibility

Environmental Influences

Environmental influences act upon a process of building provision from outside the system and can affect the ability of a process to achieve a client's expectation for any of his components of satisfaction. Therefore, for the purpose of assessing the performance of a process the environmental forces acting upon it have to be taken into account.

The level of uncertainty within which a project has to be accomplished is determined by the environmental forces acting upon the client, both at the start point and during the process. At the start point they will be manifest in how convinced a client is that he requires the project and how well he is able to define what he requires.

During the process, the effect of environmental influences may lead to changes in what the client initially decided he required or may enable him to define more closely what he requires.

A further manifestation of environmental forces is conflict between the client and the process of building provision. Conflict is the result of environmental forces acting upon a client or process of building provision and creating situations in which the primary task of the sub-systems of the process are ~~and~~ potentially in conflict with the primary task of the client. Although arising from within the client or process, conflict is created by environmental forces which the managing system must seek to overcome to achieve the required project outcome.

A further example arises from the inherent functional, technical and aesthetic demands of a project upon the skills of those involved. These skills are demanded by a project irrespective of its environment and would exist in a perfectly stable project environment. However, complexity is created by the environmental context of a client's primary task. The environmental context determines the task and hence the complexity of the building which is needed to undertake it and hence determines the demands upon the design skills of those involved. All other skills demanded by a project, e.g. financial, programming, management, are skills demanded directly by the environment of a project.

The significance of complexity of a project arises from the premise that environmental forces on a complex project place greater demands on the process of building provision than on a simple project.

The tests of the model assumes that the personnel involved in the projects used in the tests are competent in the skills required for those projects.

The effect of environmental forces (C), serves to create a potential margin of shortfall in meeting a client's expectation of Function, Time and Price, such that the magnitude of the lowest potential vectors for Function, Time and Price are:

$$F_P = F_R - C_1$$

$$T_P = T_R - C_2$$

$$P_P = P_R - C_3$$

and the lowest potential vector of the client's satisfaction $(\vec{S}_P)$ is given by:

$$\vec{S}_P = \vec{F}_P + \vec{T}_P + \vec{P}_P$$

and its magnitude is given by:

$$S_P = \sqrt{F_P{}^2 + T_P{}^2 + P_P{}^2}$$

The range of client satisfaction within which achieved outcome can be expected to lie can be conceived as the vector $\vec{S}_e$ which joins the terminal points of vector $\vec{S}_R$ and $\vec{S}_P$ as illustrated in Fig. 18.

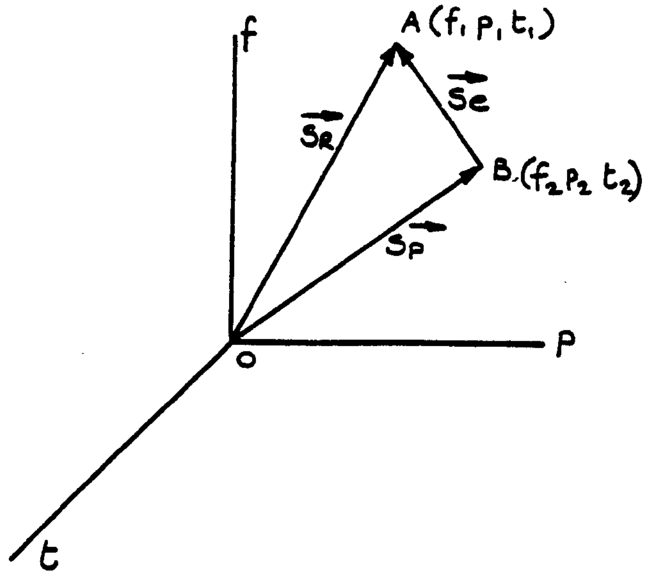



FIG: 18

Such that $\vec{S}_e = \vec{S}_R - \vec{S}_P$

and magnitude of $\vec{S}_e$ is given by:

$$S_e = \sqrt{(f_1-f_2)^2 + (p_1-p_2)^2 + (t_1-t_2)^2}$$

A client's expectation at the Start Point can therefore be conceived as a vector which in perfect conditions is given by the vector $\vec{S}_R$. The concept recognises that, in imperfect conditions, potential for meeting a client's expectation is reduced to a lowest potential satisfaction represented by the vector $\vec{S}_P$. The vector $\vec{S}_e$, joining $\vec{S}_R$ and $\vec{S}_P$ represents the scope available to the process of building provision for overcoming environmental influences in seeking to satisfy the client's expectation for the project.

(d) Achieved Outcome

A client's actual satisfaction can be conceived as a vector $\vec{S}_A$ which represents the achieved outcome with component vectors $\vec{F}_A$, $\vec{T}_A$, $\vec{P}_A$, representing achieved outcome for Function, Time and Price respectively, such that:

$$\vec{S}_A = \vec{F}_A + \vec{T}_A + \vec{P}_A$$

The deficiency in meeting the client's expected outcome is measured by the distance between the terminal point of $\vec{S}_R$ and $\vec{S}_A$ as illustrated in Fig. 19 and given by the magnitude of $\vec{S}_d$

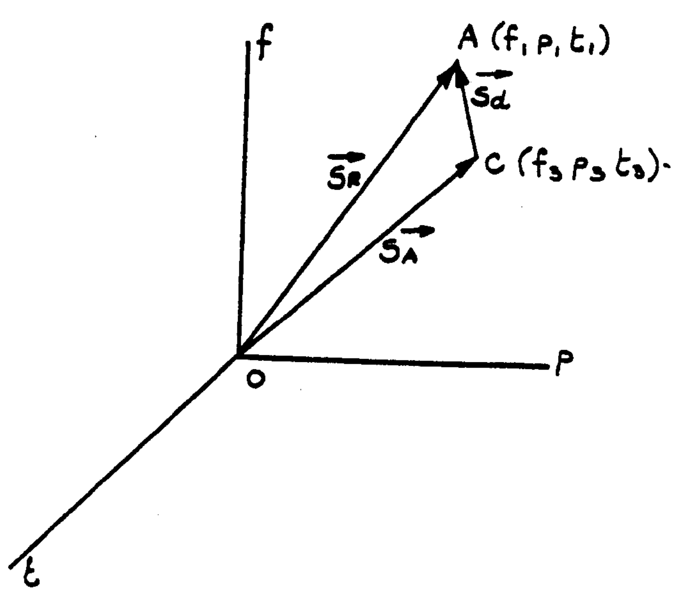



FIG: 19

The magnitude of $\vec{S}_d$ is given by

$$S_d = \sqrt{(f_1-f_3)^2 + (p_1-p_3)^2 + (t_1-t_3)^2}$$

(e) Application to Testing

Whilst the vector approach to the interpretation of a client's expectation, environmental influences and achieved output provides a useful conceptual presentation of these factors, it has not been the aim of the work to develop a mathematical approach to the extent of defining how numerical values can be established for the calculation of the magnitude of the vectors.

Nevertheless, in order to carry out initial tests of the model, a statement of the output achieved and the impact of environmental forces for each test project is necessary to indicate the extent to which the outcome satisfied the client's requirements, taking into account the environmental influences which the process of building provision had to handle.

The vector analysis approach provides the mental pictures necessary for constructing such descriptions and so provides a context for the tests. It also indicates the possibility of representing these factors mathematically in the future.

Statements[i] of the achieved outcome of each test project are identified from the interview information and reference to it. Both attributes and deficiences are identified, in terms of client's satisfaction, and are summarised by classification into the components of satisfaction - Function, Time and Price.

In addition, each client was asked for his personal assessment of his satisfaction with the outcome of each component of satisfaction on the following scale:-

| | % |
|---|---|
| Very Satisfied | 81 - 100 |
| Satisfied | 61 - 80 |
| Adequate | 41 - 60 |
| Dissatisfied | 21 - 40 |
| Very Dissatisfied | 0 - 20 |

The clients' assessments are given in the appropriate Appendix[i].

The impact of environmental forces are described[i] for each test project as identified from the interview information. These descriptions indicate the degree of uncertainty surrounding each project and the presence of any conflict between the client and the process. The complexity of each project is summarised to indicate the demands placed on the project by environmental forces.

(i) Appendices 1, 2 and 3. Section 2.3.

The description of the achieved outcome for each component, the client's assessment of the outcome, and the description of the environmental conditions provide an overall statement for each test project of the performance of each of the processes of building provision for initial tests of the model. The identified deficiences in the outcome of each test project form the basis of more detailed tests for which the initial tests provide the context.

## 3.4 THE TESTS

### 3.4.1 Introduction

Testing the model against the test projects begins with an initial test of the model's propositions against the configuration of each project. This is followed by more detailed tests against the particular outcome deficiences of each project. The results of the tests are considered within the context of the outcomes achieved and the environmental conditions in which they were achieved.

A high correlation between the model and projects which achieved client satisfaction, taking into account environmental conditions, validates the model. Where the converse occurs, identification is made of those elements of the model requiring revision.

The test results for each test project are discussed in Part 4 of the main text. The tests themselves are given in Appendices 1, 2 and 3 for Test Projects 1, 2 and 3 respectively and where appropriate in the tests, cross references are given to the interpretation of the process.

### 3.4.2 Initial Test

These tests[(i)] establish, in principle, the compatibility of the model with the configuration of each test project. Each proposition of the model[(ii)] is compared with the configuration of each project as determined by the interpretation of the data. For each test project, the interpretation extracts from the LRA information both quantitative and qualitative, which is specifically relevant to each of the model's propositions. For each project, each of the model's propositions is taken in turn and compared with the information extracted from the LRA and correlation or deviation of the project for each proposition is identified.

For example, the model proposes that differentiation of the process of building provision should be matched by a corresponding level of integration. The interpretation shows the degree of differentiation within the project both quantitatively and qualitatively, and the degree of integration provided. Thus, the match of differentiation and integration within a project can be established and hence compatibility or deviation of the project and the model's proposition.

The results of the tests against all propositions for each project establish the overall compatibility of each project with the model and identify specific deviations. This enables

(i) Appendices 1, 2 and 3. Section 3.1.

(ii) Main Text, Section 2.4.8

the results of the Outcome Deficiency Test to be placed in the context of the overall compatibibility of the project and the model and allows discussion of the results to take account of the attributes of the outcome of the project as well as the deficiencies. The Initial Test is particularly useful in exposing correlation and deviation for the purpose of identifying the causes of outcome deficiencies in the Output Deficiency Test.

At this level of testing, the model can be considered to be indicating validity if overall compatibility is accompanied by success of the project in achieving client satisfaction with the outcome, taking into account the environmental influences acting upon the project, but validity cannot be confirmed unless the Outcome Deficiency Test gives results which are consistent with those of the Initial Test.

### 3.4.3 Outcome Deficiency Test

This level of the tests[(i)] takes, in turn, each of the outcome deficiencies of each project, classified as Function, Time and Cost Deficiencies, and traces the causes of each deficiency through the interpretation of the process of providing the building. The interpretations of the projects identify the deficiencies in the outcome. The reasons for each deficiency is obtained from the interviews. The tests then trace the causes of each deficiency through the information extracted

(i) Appendices 1, 2 and 3. Section 3.2.

from LRA, and through the LRA itself, to establish the occurrences or project arrangements which created the conditions which allowed the deficiency to occur.

This procedure establishes whether the deficiency arose from the configuration adopted for the project or from some other cause. Where deficiencies are found to be caused by the arrangements adopted for the project, the result is compared with the results of the Initial Test to identify whether the causes were due to divergence of the project's configuration from the model's propositions and to establish consistency between the tests. These tests also establish whether the effect of environmental influences upon the project caused the deficiencies and whether or not they occurred in spite of the project subscribing to the model.

If the causes of outcome deficiencies are identified as due to deviation of the project's configuration from the model, then the model is further validated. Alternatively, it may be found that deficiencies arise due to environmental forces even though the project subscribes to the model, which will raise questions regarding the ability of projects subscribing to the model's propositions to mitigate environmental forces. If deficiencies are found to be caused by organisational factors not incorporated in the model these will be noted.

### 3.4.4 Features

The interviewees identified specific features of the project which they considered influenced the performance of the process of building provision. Although such features cannot be defined as outcomes, they should be capable of being explained by the model. Such features are likely to be effects rather than causes and, if the model is valid, should be capable of being explained by the propositions of the model.

Therefore, a secondary level of testing takes each of the major groups of features and examines them in terms of the results of the Initial and the Outcome Deficiency Tests. If a feature can be rationalised in terms of a previous results, correlation or deviation between the project and the model is confirmed. If rationalisation is not possible, the occurrence of the feature will either question a previous result or identify a condition not manifest in an outcome deficiency and/or not identified by a proposition of the model.

The major features identified from the interviews are summarised[(i)] and classified for each project as providing potential advantage or disadvantage to the performance of the process.

(i) Appendicies 1, 2 and 3. Section 3.3.

# PART 4

# THE RESULTS

# PART 4 - THE RESULTS

## 4.1 INTRODUCTION

This section draws together and discusses the results of the Initial and Outcome Deficiency Tests for each test project, given in Appendices 1, 2 and 3 for Test Projects 1, 2 and 3 respectively. Where statements are made regarding compatibility or deviation of the model and the project they arise as a result of the Initial Tests. The Outcome Deficiency Tests are summarised for each test project and cross references given in the text where necessary. The results are presented for each test project within the framework of the sub-systems identified on the LRA and indicate the compatibility of the model and the project for both the structure of the sub-systems and the configuration within and between each sub-system. They are summarised for each project within the context of the project outcome and the environmental conditions in which it was achieved and on this basis conclusions are drawn regarding the validity of the model for each test project. The following are identified:-

(a) The propositions of the model validated by the tests through:

- (i) Correlation of the model producing client satisfaction with the outcome.
- (ii) Deviation from the model producing client dissatisfaction with the outcome.

(b) The propositions of the model questioned by the tests through:

- (i) Correlation with the model producing client dissatisfaction with the outcome.

(ii) Deviation from the model producing client satisfaction with the outcome.

(c) The propositions of the model not demonstrated by the project because they were:

(i) Not identified

(ii) Irrelevant to the project outcome

## 4.2 TEST PROJECT NO.1

### 4.2.1 The Project

The project was a £1.4M (1977 prices) extension to a production facility which had been established incrementally over the last 12 years on a site which was acquired for a planned expansion programme. The system adopted produced a project with which the client was satisfied (61-80%) in terms of function very satisfied (81-100%) for Price but found performance in terms of Time only adequate (41-60%).[i] Environmental influences were not particularly active.[ii] If the model is to be considered to be valid when tested against such a project, then it is to be expected that the project's configuaration would correspond closely to the model's propositions.

The data available related predominantly to the Project Realisation System of Activity identified by the model and testing was restricted to this System. This System of Activity was identified by a Primary Decision but no further consideration of Primary Decisions was possible.

Sub-Systems of Activity of the Project Realisation System were defined by Key Decision Points and clear feedback lines were established. However, the effectiveness of the system established by this structure was impaired by deviation from certain of the models other propositions which created outcome dificiencies as summarised in Table 1. and discussed later.

(i)
Appendix 1, Section 2.3.1

(ii)
Appendix 1, Section 2.3.2

TABLE 1 The Causes of Outcome Deficiencies - Test Project No.1.

| Outcome Deficiency \ Model Proposition | Environmental Forces | Key Decisions/ Feedback | Differentiation/ Integration provision | Differentiation of Managing/Operating Systems | Integration of Client and Process of Building Provision | Differentiation of Managing System Itself. | Complexity of Task |
|---|---|---|---|---|---|---|---|
| 3.2.1-A (Underprovision of space) | | | | | X | | |
| -B (Low quality of warehouse floor) | X | | | | X | X | |
| -C (Low quality of construction work) | X | | | | X | X | |
| -D (Dissatisfaction with manufacturing area) | | | | | X | | |
| 3.2.2-A Reason 1 (Delay in design stages) | | X | | | X | | |
| Reason 2 | | | | | | | X |
| Reason 3 | | X | | | X | | |
| 3.2.2-B Reason 1 (Delay in construction stage) | X | | | | X | X | |
| Reason 2 | X | | | | X | X | |
| Reason 3 | X | | | | | X | |
| Reason 4 | X | | | | | X | |
| 3.2.3-A (Price was marginally high) | | Not confirmed as a deficiency | | | | | |
| 3.2.3-B (Lack of anticipation of inflation) | | | | | X | | |

Note: The references numbers given for the Outcome Deficiencies refer to the Outcome Deficiency Tests in Appendix 1. Where there is more than one reason for a deficiencies, each reason is dealt with separately in the Tests in Appendix 1.

The Sub-systems of Activity identified and shown on the LRA were:-

| Systems of Activity | | Sub-Systems of Activity |
|---|---|---|
| Project Realisation | Sub-System A | Identification of need and outline requirements and obtaining Head Office Budget approval to proceed to the next sub-system. |
| | Sub-System B | Definition of requirements (Preparation of Transmittal Document) and obtaining Head Office approval to proceed to the next sub-system. |
| | Sub-System C | Preparation of working drawings and contract documentation, obtaining tenders and appointing contractors. |
| | Sub-System D | Construction |

### 4.2.2 The Results

Project Conception Process

Project Inception Process

The Primary Decision to provide a performance through the acquisition of real property and the subsequent Primary Decision to achieve this through the construction of a new building were taken about 12 years prior to this project, when it was decided to purchase the site and develop it over a long period. It is assumed that this decision must have been confirmed prior to embarking upon this project. It is also assumed that there had been no changes in the client's environment sufficient to change that decision. However, these circumstances meant that it was not possible to test the model against this project for these two processes.

## Project Realisation Process

### Identification

The Project Realisation Process was identified as the System of Activity between the Primary Decision to achieve the client's purpose through the development of a new building and the realisation of the new building.

### Environmental Influences.

There was a low level of activity of environmental forces on the client's primary task and hence the process of building provision was stable in this respect.

The action of environmental forces directly upon the process of building provision were more pronounced and, with the exception of the resignation of the Services Engineering Manager, all manifest in Sub-System of Activity D. The most significant of the forces were those which influenced the decision to submit the project to competitive tender after completion of the design (taken for economic reasons). The ability of the organisational structure to mitigate the environmental influences will be examined below.

### Sub-Systems of Activity, Decision Points and Feedback

The model proposes that the Systems of Activity (Conception, Inception and Realisation) are defined by differentiation though discontinuity of the process caused by Primary Decisions. It also proposes that each of the Systems of Activity comprise a number of Sub-Systems of Activity differentiated by discontinuity created by Key Decisions which provide regions of control which present opportunities for feedback. The model suggests that the development of this idea can be halted at this level for the purpose of examining the managing system acting for the client. The tests show that this proposition is generally valid for this project but that a third level of sub-systems and decision points should be added. Decisions at this level are termed 'Operational Decisions' and they create a new Sub-System level termed 'Operational Sub-Systems'. The three levels of decisions creating the Systems and Sub-Systems identified for this project are:

| | | |
|---|---|---|
| Primary decisions: | | concerned with defining the Conception, Inception and Realisation Systems with feedback to the Start Point. |
| Key Decisions | : | concerned with obtaining approval from the client to expend further resources within a System created by a Primary Decision with feedback to Primary Decisions Points. |
| Operational Decisions | : | concerned with decisions required to progress a Sub-System of Activity, with feedback to Key Decision Points. |

Each of the sub-systems created by Operational Decisions will consist of at least one task sub-system. The Key Decision Points provided a feedback opportunity as suggested by the model which was used for approval purposes by the client. However, a shift in approval powers occured between the Sub-Systems, from the client in Sub-Systems A, B and C to the project manager in Sub-System D. Continuity of the managing system at Key Decision Points was absent on the project and this occurance contributed to the delay to project completion as given in Outcome Deficiency Test 3.2.2 -A and the lack of anticipation of inflation in 3.2.3 -B. The stable client's environment lent itself to a structure of pre-determined approval decisions.

Sub-System of Activity A

The project's configuration corresponded to the Model's propositions in this Sub-System with the exception of the level of integration between the client and the process of providing the building which was low. Of the Outcome Deficiencies, 3.2.1.-A and D were the result of this low level of integration which further confirms the model's proposition regarding such integration.

Sub-System of Activity B and C

The project's configuration corresponds to the model's propositions in these Sub-Systems except for the managing systems structure which is differentiated. However, this differentiation is not compounded by duplication of managing roles and the managing system was enhanced by the client's presence in the control loops. None of the deficiencies originated in these Sub-Systems and their internal performance was successful and supports the model. Relationship between these and other Sub-Systems is considered under Sub-System D. The environmental forces which led to the resignation of the Services Engineering Manager were overcome so that they did not produce an outcome deficiency arising in these Sub-Systems.

Sub-System of Activity D

The project's configuration corresponds to the model's proposition for match of differentiation and integration provision and for differentiation of the managing and operating systems. However, there is divergence for integration of the client and the process of building provision and for differentiation within the managing system itself. In particular the structure of the control loops is unique to the Sub-System through the introduction of duplication of managing activities.

The Outcome deficiencies 3.2.1 -B and C and 3.2.2-B originated in this Sub-System and were the result of environmental influences which the managing system was unable to overcome. The major environmental influences were economic and determined that the contract should be let by competitive tender which created the consequent conditions of contract. This decision prescribed the managing system of Sub-System D which, although there was intensity of integrating provision, was unable to mitigate environmental influences which caused [redacted] outcome deficiencies. The contractor could not overcome poor site supervision, resignation of the site agent and shortage of bricklayers and, due to contractual conditions the project manager (the other half of the duplicated managing activities) could not sufficiently influence these features to prevent delay in completion as shown in Outcome Deficiency 3.2.2 -B.

The problem was one of incompatibility of the managing systems between Sub-Systems B/C and D, created by a decision in Sub-System B. Similarly the decision to award the contract in two stages (3.2.2 -B Reason 4) was made in Sub-System C and the lack of compatibility with Sub-System D negated its anticipated outcome effect.

In addition to the difficulty of overcoming environmental influences, the deviation from the model's propositions created conditions in which control along the feedback lines could not be adequately exercised, resulting in Output Deficiencies 3.2.1-B and C.

The organisational structure of Sub-System D was not designed to cope with environmental forces and although it corresponded with two of the model's propositions, the significant divergence in other respects was sufficient to produce deficiencies. The duplication of the integrating managing activities worked to negate the apparently high integration provision and eliminated an apparent correlation with the models proposition for match of differentiation and integration. Whilst validating the model, these results must be set against any financial advantage gained by the client through letting the contract by competitive tender. Such 'trade off' considerations and other implications are considered in the main conclusions.

4.2.3 Summary

The tests identified Operational Decision levels (not identified by the model) and clarified the manner by which they and other decision levels determine Systems of Activity, Sub-Systems of Activity and Operational Sub-Systems.

The match of differentiation and integration corresponded with the model as did the differentiation of the operating and managing systems. Integration of the client and the process of building provision reflected the model for Sub-Systems B and C. Whilst the complexity of the managing system did not totally contradict the model's proposition in Systems A, B and C, there was divergence in Sub-System D through duplication of integrating roles.

The result was that Sub-Systems B and C were successful but that deficiencies were caused by deviation from the model's propositions in Sub-Systems A and D.

The causes of the deficiencies can be generalised as:

(a) Lack of integration of the client and the process of building provision:

Although the process of building provision provided sound integrating mechanisms wherever possible, never-the less a shortfall of integration occured through the lack of ability of the client to respond to the integrating demands placed upon him. This situation was particularly evident in Sub-System A. Integration was very successful in Sub-Systems B and C but broke down at the boundary of the Sub-Systems, again due to the client's lack of response which impaired the effectiveness of the system by inducing delay at a Key Decision Point and creating conflict within the subsequent sub-system and delay in project completion.

The client was not integrated in an equivalent capacity in Sub-System D as he was in Sub-System B and C due to the contractual arrangements adopted and the consequential contractual conditions, and this contributed to the cause of deficiencies arising in Sub-System D.

Whilst validating this aspect of the model these results stress that the process of building provision cannot provide integration in isolation but must receive a corresponding response from the client who must create internal conditions in his organisation which allow integration to take place and which allow his responses to be apposite and timely in assisting the process of building provison to achieve its objectives:

(b) Lack of integration between Sub-Systems:

Despite generally high integration on the project, specific instances of a lack of integration between Sub-Systems B and C and between C and D were the cause of deficiencies. The lack of integration between B and C has been referred to above. That between C and D was due to the contractual arrangements adopted, which prescribed the managing system of Sub-System D, and resulted in the introduction of new management units at this stage and duplication of integrating roles.

The interdependencies at this point were sequential and whilst the model postulates that the integration demands of reciprocal interdependencies are greater than for sequential interdependencies this would appear not to be the case between sub-systems where dicontinuity of the managing system occurs.

Although the model was generally validated in terms of differentiation and integration need, it can be enhanced by recognition of the need for additional integrating effort between sub-systems where discontinuity occurs or alternatively by recognition of the need to eliminate discontinuity.

(c) Complexity of the Managing System:

The complexity of the managing system in Sub-System D, principally through duplication of managing activities, contributed to the cause of a series of deficiencies. This result validates the model's proposition but draws attention to the importance of this proposition which is not given prominence in the model.

(d) Environmental Influences:

Responses to environmental influences created conditions which produced many of the causes of deficiencies referred to above, in particular the decision to award the contract by competitive tender for financial reasons and the consequential contractual arrangements. These arrangements inhibited the managing system's ability to alleviate subsequent environmental influences. The tests showed that the degree to which the managing system could mitigate environmental influences was significant to the project outcome.

The tests of the model's propositions against this project have begun to confirm its general validity and have enhanced the model by giving greater clarity to certain propositions.

Any degree of implied criticism of the performance of the process of building provision should be judged against the high measure of success achieved in the project outcome. It is interesting to observe that the outcome deficiencies were generally as a result of organisational defects within the managing system itself rather than defects in the way in which the operating system was managed or within the operating system itself and reflect a sustained and successful effort by the managing system as constructed.

## 4.3 TEST PROJECT No.2

### 4.3.1 The Project

The project was a £0.6M (1978 prices) factory and office block on a virgin site for an engineering company established in the vicinity of the new site. The system adopted produced a project with which the client was satisfied (61-80%) for function, very satisfied (81-100%) for Price, but found performance in terms of Time only adequate (41-60%).[(i)] Environmental influences were particularly active on this project.[(ii)] The failure to achieve full satisfaction, as represented by the output deficiencies, was due in all cases to the system's inability to fully mitigate all the environmental forces acting upon the system as summarised in Table 2 and discussed later. Nevertheless, when considered against the high level of activity of environmental forces, it is apparent that the system was able to successfully overcome a large proportion of the forces acting upon the system.

It is argued, therefore, that the project outcome was successful within such conditions and that, in general the validity of the model would be supported by compatibility of the project's configuration with the model's propositions. However, the tests highlighted the difficulty of alleviating strong environmental forces and enhanced the model by focussing attention upon such problems.

(i)
Appendix 2, Section 2.3.1

(ii)
Appendix 2, Section 2.3.2

TABLE 2 The Causes of Outcome Deficiencies - Test Project No.2

| Output Deficiency \ Model Propositions | | Environmental Forces | Key Decisions/ Feedback | Differentiation/ Integration Provision | Differentiation of Managing/Operating Systems | Integration of the Client and the Process of Building Provision | Differentiation of Managing System |
|---|---|---|---|---|---|---|---|
| 3.2.1-A | (Underprovision of Space) | X | | | | | |
| -B | (Overprovision of toilets) | X | | | | | |
| -C | (Low quality of construction work) | X | | | | X | X |
| 3.2.2-A | (Delay in design stages) | X | | | | | |
| -B | (Delay in construction stage) | | Not Confirmed as a Deficiency | | | | |
| 3.2.3-A | (Final price greater than tender) | X | | | | | |
| -B | (Early estimates less than final price) | X | | | | | |
| -C | (Price paid may not represent good value) | | Not Confirmed as a Deficiency | | | | |

Note: The reference numbers given for the Outcome Deficiencies refer to the Outcome Deficiency Test in Appendix 2.

Identification and acquisition of the site was part of the system studied and the test was therefore able to encompass the Inception and Realisation Systems of Activity identified by the model. These Systems of Activity were defined by Primary Decisions and correlate with the model. It was possible to identify but not to test the Conception System, which was internal to the client's organisations, and for which data was not available.

Within the Systems of Activity, Key Decisions defined Sub-System of Activity as proposed by the model. However there was a low incidence of useful Key Decisions which meant that, throughout, the project's development had to be measured against the client's definition of his requirement at the Start Point. Decisions refining his requirements were not made and could not therefore be used in feedback loops.

The Sub-Systems of Activity identified and shown on the LRA were:-

| <u>System of Activity</u> | | <u>Sub-System of Activity</u> |
|---|---|---|
| Project Inception | Sub-System A | - Identification of need and outline requirements, search for alternative existing premises, search for and identification of site, site acquisition. |
| Project Realisation | Sub-System B | - Development of outline requirements, and detailed design. (Detailed drawings for factory and offices prepared). |

| System of Activity | Sub-System of Activity | |
|---|---|---|
| Project Realisation (Cont'd) | Sub-System C | - Programming for two phase contract, consequential contractual arrangements, documentation and tender for factory. |
| | Sub-System C(a) | - Further development of office requirements and detailed design (Revised detailed drawings for offices prepared). |
| | Sub-System C(b) | - Contract documentation and negotiation of price for offices. |
| | Sub-System C(c) | - Redesign offices. (Revised detailed drawings for offices prepared) |
| | Sub-System D | - Construction. |

4.3.2 The Results

Project Conception Process

The Primary Decision to provide a performance through the acquisition of real property was taken internally within the client's organisation. The decision was generated by environmental influences which determined conditions for expansion and the inability of the organisation's existing premises to cope with such expansion. The alternative strategy of adapting the client's existing premises was not felt to be appropriate due to their unacceptable condition.

Details of the internal activities of the client's organisation were not available for this research so that detailed testing of this System of Activity was not possible. However the principles of the model are supported in outline on the basis of the information available.

Project Inception Process

Identification

The Project Inception Process was identified as the System of Activity between the Primary Decision to achieve the client's purpose by the acquisition of real property and the Primary Decision to achieve this through the development of a new building.

Environmental Influences

There was a high level of activity of political and economic environmental forces on the client's organisation leading to instability of the process of building provision which the managing system had to control. The forces impacted upon this System of Activity through the hesitation of the client in commiting resources to expansion in a political and economic climate in which he did not have great confidence.

The ability of the organisation structure to overcome the environmental forces is examined below.

Sub-Systems of Activity, Decision Points and Feedback

The tests confirmed the result of Test Project No.1 in identifying an operational level of decisions which identify Operational Sub-Systems. The decisions in the Project Inception Process, with the exception of the Primary Decisions, were operational decisions. They cannot be conceived as Key Decisions due to the incremental nature of searching for suitable premises/site which did not produce Key Decisions with a degree of irrevocability. Such irrevocability did not occur until legal agreement to acquire the site took place. Such a decision is a Primary Decision. Thus the nature of this Process is that it contains only one Sub-System of Activity with feedback from Operational and Primary Decisions to the Start Point. The nature of this Process is organic and the configuration adopted reflects the nature of the Process. This allowed a range of alternatives to be appraised before a decision with a degree of irrevocability was taken (Primary Decision No.2).

The instability of the client's environment and the nature of the task undertaken lent itself to a structure without Key Decision Points in this Process and therefore reflects the model.

Sub-System of Activity A

This is the only Sub-System in the Project Inception Process and is synonymous with the System of Activity which constitutes this Process.

The projects configuration corresponds to the model's propositions in this Sub-System with the exception of the differentiation of the managing and operating systems. This was due to the project manager exercising all the skills required in this Sub-System and thus reducing the number of job positions and undifferentiated management units in control loops.

None of the output deficiencies arose as a result of this Process. In this Process, the managing system was, therefore,able to alleviate environmental forces in presenting the client with a proposition which was acceptable to him.
As the project manager was one of the partners in his firm and had the professional skills necessary for this Sub-System, the situation which arose was one in which the managing and operating systems were practically undifferentiated and close integration with the client achieved. Therefore, this process approximated to the level of the individual person who's performance depends solely on individual skills and is not dependent upon a managing system. Such a situation was identified in the development of the model.

## Project Realisation Process

Identification

The Project Realisation Process was identified as the System of

Activity between the Primary Decision to achieve the client's purpose through the development of a new building and the realisation of the new building.

Environmental Forces

As referred to earlier, there was a high level of activity of environmental forces acting upon the client's organisation and hence on the project. This created instability in the process of building provision which the managing system sought to control.

The action of the environmental forces during the Project Realisation Process was manifest in the client's hesitation regarding the desirability of pursuing the project which created difficulty in defining the client's requirements and hence created a high level of uncertainty in the project.

This situation was compounded in the Project Realisation Process by further environmental forces which induced conflict between the client and the process of building provision. This conflict arose through the client's expectation of the standard of project with which he should be provided and his belief that the members of the process of building provision did not have similar standards. These factors provided the context within which the project was pursued and was evident in the project's configuration through the lack of progressive Key Decisions and the need for feedback to use the client's requirements established at the Start Point without further refinement, throughout the Process.

The tests have shown that environmental influences which the managing system was unable to mitigate, created or contributed to a number of Outcome Deficiencies (3.2.1.-A, B, C. 3.2.2.-A, 3.2.3.-A, B).

The ability of the organisation structure to overcome the environmental forces is examined below.

Sub-Systems of Activity, Decision Points and Feedback

As referred to previously, this test confirms the tests using Project No.1 in identifying a level of Operational Decisions not identified by the model.

The Project Realisation Process is characterised by a lack of progressive Key Decisions between Sub-System B C, C(a), C(b) and C(c) resulting in feedback lines to the Start Point.

The model and project configuration are compatible in principle and the project demonstrates the influence of strong environmental forces upon the shape of a project's structure and feedback opportunities.

Sub-System of Activity B

The project's configuration corresponds with all the model's propositions in this Sub-System. Nevertheless some environmental forces were not overcome and were manifested as outcome deficiencies. (3.2.1.-A, 3.2.2.-A, 3.2.3.-B).

Sub-System of Activity C

The project's configuration corresponds with all model's propositions in the Sub-System. None of the output deficiencies arose in this Sub-System.

Sub-Systems C (a) (b) (c)

The project's configuration corresponds with all the model's propositions in each of these Sub-Systems except for integration of the client and the process of building provision in Sub-System C(b). This deviation was not significant as the activities' of the Sub-System were overtaken by Sub-System C(c). None of the deficiencies arose from these Sub-Systems but the Sub-Systems were themselves created by deficiencies arising in the previous Sub-System B .

Sub-System D

The project's configuration corresponds to the model's propositions for match of differentiation and integration provision and for differentiation of the managing and operating systems. However, there is divergence for integration of the client and the process of building provision and for the structure of the managing system itself. In particular the structure of the control loops is unique to this Sub-System through the introduction of duplicated managing activities.

Output Deficiency 3.2.1.-C arose from this Sub-System. This deficiency was the result of environmental forces determining that the contract should be let by competitive tender and so, through the conditions of contract, prescribing the managing system of Sub-System D. This situation was compounded by further environmental influences manifesting as conflict between the client and the process of building provision regarding what the client saw as differing expectations of the standard of work to be provided.

Although there was a match of differentiation and integration, the managing system was unable to overcome the environmental influences which led to a change in the site agent and problems with the bricklaying gangs. Due to the duplication of managing activities and the contractual situation of the project manager, he was unable to resolve these occurances.

The problem was one of incompatability of the managing system between Sub-Systems B/C and D created by the decision on Sub-System C to submit the project to competitive tender.

Deviation from the model's propositions meant that Sub-System D was not designed to cope with environmental forces, resulting in Output Deficiency 3.2.1.-C. This conclusion corresponds with a similar conclusion for Test Project No.1 but the deficiency is not so severe on this project.

Whilst further supporting the model, these results must be set against any financial advantage gained by the client through letting the contract by competitive tender. Such 'trade off' considerations are considered in the main conclusions.

### 4.3.3 Summary

Whilst Sub-Systems of Acitivity were defined by Key Decisions, there were few useful Key Decisions. This delayed development of the project and created feedback loops for which output had to be measured against the client's requirements at the start point. This occurance was a result of the high level of uncertainty surrounding the project. Whilst supporting the model generally, this occurance refined the concept of Key Decision Points by identifying that, in uncertain conditions, the project configuration will be characterised by a scarcity of useful Key Decisions resulting in long feedback loops. The presence of Operational Decisions creating Operational Sub-Systems was confirmed (See Test Project No.1).

Sub-Systems B,C, C(a) and C(c) were compatible with all the propositions of the model and Sub-System C(b) with all propositions except integration of the client and the process of building provision. However, the process was still not able to overcome the effect of all the environmental forces impacting upon the project, even though the internal integrating effort of the managing system was high. Nevertheless the process did overcome strong environmental influences in achieving a project outcome which was generally successful.

Sub-System A was compatible with the model, except for differentiation of the managing and operating systems and integration of the client and the process of building provision. The latter was not particularly severe and was brought about by the client undertaking some early tasks before the project team were introduced to the system. This Sub-System approached the level of a simple undifferentiated system which is recognised by the model.

None of the output deficiencies originated in this Sub-System and it had therefore, been able to overcome the environmental forces acting upon it.

Sub-System D was compatible with the model except for duplication of integrating roles in the control loops and a lack of integration of the client. This situation arose through the use of a competitive tender and the consequent conditions of contract which prescribed the managing system of the Sub-System. It created a shortfall in the quality of construction work as perceived by the client which the managing system working on his behalf was unable to overcome. The divergencies from the model and the resulting deficiency further supports the propositions of the model and demonstrates how a response to environmental forces can inhibit the managing system in later sub-systems. The situation described reflects that found for Test Project No.1.

The tests of the model's propositions against this project have further supported its validity and have enhanced it by emphasising the significance of the influence of environmental forces upon the project outcome and the difficulty facing a project team in fully controlling them. The test results question the implication in the model that it is possible to mitigate environmental forces by appropriate structuring of the project team. It suggests, rather that project teams can be structured to cope with environmental forces for which there is a limit beyond which they may not be able to cope. However, this can only be a tentative statement on the basis of this project as the project team were not involved in the Conception System. Had they been involved, they may have exercised more influence over the impact of the environmental forces.

Any degree of implied criticism of the performance of the process of building provision should be judged against the high measure of success achieved in the project outcome in what were extremely difficult environmental conditions.

## 4.4 TEST PROJECT No.3

### 4.4.1. The Project

The project was a £160,000 (1978 prices) extension to a wholesale food warehouse which had been established on the site about 6 years previously when an option had been taken out on ajoining land for expansion. The extension was to house a butchery department which was to be transfered from premises which had been acquired when a bankrupt butchery business had been taken over.

The system adopted produced a project with which the client was satisfied (61-80%) in terms of function, found performance in terms of Price adequate (41-60%) but was dissatisfied (21-40%) with performance for Time.(i) The activity of environmental forces was low.(ii) If the model is to be considered to be valid when tested against such a project, then it is to be expected that the project's configuration would not correspond closely to the model's propositions.

The data available related to the Project Inception and Project Realisation Processes identified by the model but the Inception Process was, in these conditions, simple and the tests concentrate upon the Realisation Process. However, the Inception and Realisation Processes were defined by Primary Decisions and correlate with the model. It was impossible to identify but not to test the Project Conception System, which was internal to the client's organisation and for which data was not available.

(i) Appendix 3, section 2.3.1

(ii) Appendix 3, section 2.3.2

Sub-Systems of Activity were defined by Key Decision Points as proposed by the model and feedback lines were established but there was substantial deviation from the model's propositions which created the outcome deficiencies as summarised in Table 3 (Page 191) and discussed later.

The Sub-Systems of Activity identified and shown on the LRA were:-

| <u>Systems of Activity</u> | <u>Sub-System of Activity</u> | |
|---|---|---|
| Project Inception | Sub-System A - | Acquisition of butchery business, extension of lease and identification of outline requirements. |
| Project Realisation | Sub-System B - | Preliminary programme, contractual arrangements, development of outline proposals. |
| | Sub-System C - | Development of detailed proposals, estimates. |
| | Sub-System D - | Contract documentation (main contract), revisions to reduce cost, negotiation with lowest tenderer, tender action. |

| System Activity | | Sub-System of Activity |
|---|---|---|
| Project Realisation (Cont'd) | Sub-System E | - Contract documentation (refrigeration contract), tender action. |
| | Sub-System F | - Construction (main contract). |
| | Sub-System G | - Installation (refrigeration). |

TABLE 3 THE CAUSES OF OUTCOME DEFICIENCIES - TEST PROJECT No.3

| OUTCOME DEFICIENCY \ MODEL PROPOSITION | ENVIRONMENTAL FORCES | KEY DECISIONS/ FEEDBACK | DIFFERENTIATION/ INTEGRATION PROVISION | DIFFERENTIATION OF MANAGING/OPERATING SYSTEM | INTEGRATION OF CLIENT AND THE PROCESS OF BUILDING PROVISION | DIFFERENTIATION OF MANAGING SYSTEM |
|---|---|---|---|---|---|---|
| 3.2.1.-A (Dissatisfaction with wall and floor finishes) | X | | | | | X |
| 3.2.2.-A (Delay in design stages) | | | X | | X | X |
| -B REASON 1 (Delay in construction stage) | X | | | | | |
| REASON 2 | X | | | | | |
| REASON 3 | | | X | | X | X |
| REASON 4 | | | X | | | |
| 3.2.3.-A (Tender greater than cost limit) | | | X | | X | X |
| -B (Reduced tender still above cost limit) | X | | X | | X | X |

Note: The reference numbers given for the Outcome Deficiencies refer to the Outcome Deficiency Tests in Appendix 3. Where there is more than one reason for a deficiency, each reason is dealt with separately in Appendix 3.

## 4.4.2. The Results

### Project Conception Process

The Primary Decision to acquire the backrupt butchery business was taken within the client's organisation. Details of the internal activities of the client's organisation were not available for this research so that detailed testing of this process was not possible but its identification supports the basic structure of the model.

### Project Inception Process

Identification

Due to the interest acquired in the butchery business and the condition of the building, the Primary Decision to construct a new building on the client's main site for which he held an option on further land was taken practically simultaneoudly with the Primary Decision to acquire the butchery business. Nevertheless, the Project Inception Process was identified as the Systems of Activity between these two Primary Decision in which it was confirmed that a new building should be erected to house the butchery activities.

Environmental Influences

For the reasons identified above, uncertainty was low during this process and conflict did not occur.

Sub-Systems of Activity, Decision Points and Feedback

Due to the environmental conditions in which it took place, the Project Inception Process consisted of one simply structured

Sub-System. There were no Key Decision Points and feedback measured progress against the Primary Decision to acquire the butchery business and the consequent need for new premises due to the unsuitability of those acquired. The Primary Decision at the end of this Sub-System confirmed the original intention to develop the new building on the optioned site.

The simplicity of this Process does not allow any conclusion to be drawn regarding the validity of the model for these aspects.

Sub-System of Activity A

This is the only Sub-System in the Project Inception Process and is synonymous with the System of Activity, which constitutes this process.

The project's configuration does not correspond to the model's propositions for match of differentiation and integration and for composition of the managing system due to the absence of a representative of the process of building provision in either the control loops or task boxes.

Although none of the output deficiencies arose directly from this Sub-System, it was within this Sub-System that the client assumed a cost for the project which led to the misunderstanding in the Project Realisation Process which resulted in Output Deficiencies 3.2.2.-A,B (Reason 3), 3.2.3.-A,B. In this Sub-System, the client also assumed a commencement date for design and consequently construction which created pressure upon the time available which contributed to Output Deficiencies in 3.2.2.-B.

These occurances support the model which proposes that integration effort should match integration need. If integration of the representative of the process of building provision had taken place in this Sub-System subsequent problems may have been avoided.

Project Realisation Process

Identification

The Project Realisation Process was identified as the System of Activity between the Primary Decision confirming that the client's purpose should be achieved through the development of a new building to the realisation of the new building.

Environmental Forces

There was a low level of activity of environmental forces on the client's organisation and the process of building provision.

However, environmental forces did affect the project and were all manifest in the construction stage (Sub-System F). In two cases they were part contributors to Output Deficiencies (3.2.1.-A and 3.2.3.-B), and in two cases the sole cause of Output Deficiencies (3.2.2.-B (Reasons 1 and 2)).

The ability of the organisation structure to mitigate environmental forces and the reasons why those identified were allowed to effect the project are examined below.

Sub-Systems of Activity, Decision Points and Feedback

This project confirms the tests using Projects Nos. 1 and 2 in identifying a level of Operational Decisions not identified by the model.

The model and project's configuration were compatible in the manner by which Key Decision Points identify Sub-Systems of Activity. However, the tests identified that Key Decision No.1 was inappropriate as it did not state clearly the client's cost limit. Abortive work was carried out subsequently, until Key Decision No.1 was by-passed at Key Decision No.2 and reference made to Primary Decision No.1 which confirmed the client's cost limit.

The inappropriateness of Key Decision No. 1 and subsequent failure to rectify it (discussed later), created Output Deficiencies 3.2.2.-A, B (Reason 3), 3.2.3.-A.B and involved loss of resources both up to the time it was rectified and subsequently. This occurance confirms the model's concept of Key Decisions and gives further insight into their impact upon projects.

Although subsequent Key Decision Points and feedback loops operated satisfactorily there was a lack of continuity of the managing system at Key Decision Points, which contributed to the failure at Key Decision Point No.1.

Sub-System of Activity B

The project's configuration does not correspond with the model's propositions in this Sub-System for match of differentiation and integration, for differentiation of the managing and operating systems and for the structure of the managing system itself within control loops (distribution of undifferentiated units is erratic). Although this Sub-System has the best results for all Sub-Systems for integration of the client and the process of building provision, it is still not particularly high. (The best integration occuring for 60% of tasks).

This Sub-System culminated in Key Decision No.1 referred to previously, which created Output Deficiencies 3.2.2.-A,B (Reason 3) and 3.2.3.-A,B, which accounted for the majority of client dissatisfaction with the outcome.

This situation supports the model's propositions as deviation from its propositions was accompanied by dissatisfaction of they client with the outcome.

Sub-System of Activity C

The project's configuration does not correspond with the model's propositions in this Sub-System for match of differentiation and integration, for structure of the managing system itself within control loops and for integration of the client and the process of building provision. The differentiation of the managing and operating systems is reasonably near the model's proposition (71%).

This Sub-System continued to work in accordance with the inappropriate Key Decision No.1, and was unable to identify this deviation from the client's requirement until the end of the Sub-System which culminated in Key Decision No.2. It was not until this point that cost was brought into focus and an appropriate decision taken. However, this decision was taken in an inappropriate position in the process, thus necessitating revision to the scheme at a late stage.

The effect was that Sub-System B and C could be considered as one Sub-System due to the uselessness of Key Decision No.1 in which case Key Decision No.2 was taken at an inappropriate position in the System to enable correction of deviation from the client's requirement. The corrective action which was subsequently taken corrected deviation of cost in part but in so doing created deviation in time for completion of the project.

The situation further supports the model's propositions as continued deviation from its propositions prevented identification of deviation from the clients requirements.

Sub-System of Activity D

The project's configuration does not correspond with any of the model's propositions in this Sub-System except for differentiation of the managing and operating systems.

This Sub-System performed the corrective action for the deviation in Sub-System B and C. The delay in completion of the project eminated from this Sub-System as a consequence of the deviation in Sub-Systems B and C and contributed to Outcome Deficiencies 3.2.2 -A and B (Reason 3). Feedback was to the properly take Key Decision No.2 but two attempts to correct the deviation (Tasks 18 and 19) were necessary which further contributed to the delay. The adjusted cost was not completely in accordance with the client's requirement at the end of this Sub-System but he was prepared to accept it.

That this Sub-System was unable to completely correct the deviation, further supports the model's propositions but by this stage it had probably become impossible to make a perfect correction.

Sub-System of Activity E

The project's configuration does not correspond with any of the model's propositions in this Sub-System except for differentiation of the managing and operating systems.

This Sub-System established a direct contract with the client for refrigeration outside the main contract. The difficulty of integrating the refrigeration contractor into the process of building provision originated in the conditions created in this Sub-System which ultimately led to delay in completing the refrigeration contract, identified in Output Deficiency 3.2.2.-A (Reason 4).

This occurance further supports the propositions of the model, particularly in relation to integration effort.

Sub-System of Activity F

The project's configuration does not correspond to any of the model's propositions except for differentiation of the managing and operating systems. However, Sub-System F has a pattern which differs from the other Sub-Systems in that it is the only Sub-System where some boundary control, maintenance and monitoring activities took place and it has the widest spread of the number of undifferentiated management units in control loops. In addition, in Sub-System F, the Primary Integrators do not appear together in control loops, but in a large majority of cases, the Managing Director is in an input-output relationship when the Architect is in the control loop or task box. Therefore, whilst in common with the other Sub-Systems, Sub-System F does not conform to the model's proposition, it also differs significantly in its configuration from the other Sub-Systems. These differences are the result of environmental forces acting upon the client which determined, in Sub-System B, that the contract should be let by competitive tender and so, through the conditions of contract, prescribing the managing system of Sub-System F. As a result, the Architect undertook an approving role, strictly in accordance withe the conditions of contract. The boundary control and other integrating activities were therefore undertaken by the contractor and the client did not have a professional advisor acting in a comparable dynamic integrating role during this Sub-System. The circumstances led to the occurance of Output Deficiency 3.2.1.-A, which was created by failure of the integrating activities exercised by the contractor.

The structure of this Sub-System was unable to overcome environmental influences which manifest in Outcome Deficiencies 3.2.2.-A (Reasons 1 and 2) and contributed to Outcome Deficiency 3.2.3.-B. In the case of deficiencies 3.2.2.-A (Reasons 1 and 2), due to bad weather and an industrial dispute on another site, it is unlikely that any organisation structure could have avoided them.

The Sub-System was also unable to mitigate the environmental influence which contributed to Outcome Deficiency 3.2.3.-B - the additional unanticipated cost of fire doors required by the Fire Officer - although this deficiency could have been said to have arisen in earlier Sub-Systems when it should have been anticipated.

The tests of this Sub-System do not contribute particularly to an assessment of the validity of the model, except to identify that the configuration adopted allowed Output Deficiency 3.2.1.-A to occur. The actual performance of the Sub-System cannot be clearly identified due to the effect upon it of the problems brought forward from previous sub-systems which may have allowed deficiencies arising in this Sub-Systems to be disguised.

Sub-System of Activity G

The project's configuration does not correspond with any of the model's propositions in this Sub-System except for differentiation of the managing and operating systems.

This Sub-System was for the installation of the refrigeration equipment which was the subject of direct contract with the client. The difficulty of integrating the refrigeration contractor into the process of building provision was manifest in this Sub-System and led to delay in completing the refrigeration contract identified in Output Deficiency 3.2.2.-B (Reason 4).

This occurance repeats the support for the propositions of the model given under Sub-System of Activity E.

4.4.3 Summary

Whilst Sub-Systems of Activity were defined by Key Decision Points, the quality of the decision taken at Key Decision Point No.1, which was equivocal on cost, meant that the feed-back lines did not operate effectively and so affected the operation of subsequent Sub-Systems. The presence of Operational Decisions creating Operational Sub-Systems were confirmed (See Test Projects Nos. 1 and 2).

The only correlation of the project's configuration with the model's propositions occured for differentiation of the managing and operating system in all Sub-Systems other than Sub-Systems A and B. However, it was in Sub-Systems A and B that the major deficiencies originated. For all other propositions in all

Sub-Systems, the project's configuration was at variance with the model. The model's propositions were partly satisfied for integration of the client and the process of building provision in Sub-Systems B and F.

In particluar the lack of integrating activities (boundary control maintenance and monitoring) by the manager of the project or the client, resulting in reciprocal interdependencies not being established, pervaded the project's configuration creating divergence from the model. The model suggests that reciprocal interdependencies require greater integrative effort than sequential interdependencies, but the results of these tests qualify that proposition by identifying the priority criterion that this will be the case only if the reciprocal and sequential interdependencies are appropriately drawn in response to the task being undertaken.

The manifestation of the divergence of the project's structure from the model occured at Key Decision No.1 at the end of Sub-System B in the lack of definition of the client's cost limit for the project. This occured through a shortfall of integration both within the Sub-System and between the client and the process of building provision. The former was due to a deficiency in reciprocal interdependencies in this Sub-System and the concurrent lack of appropriate consultation between the contributors which followed through to deficiency in the integration of the client who was not exposed to any other contributors other than the Architect and Services Engineer at this stage, and even this was erratic.

The process being undertaken in Sub-System C, was therefore, not in accordance with the client's requirements and, because the same relationships occured in Sub-Systems C as in Sub-System B, the deviation was not corrected. The feedback mechanism which was operating during this Sub-System was therefore faulty as development of the project was being measured against a goal which had been inappropriately defined. At the end of Sub-System C the deviation was discovered and the goal of Sub-System D was to correct it by reducing the scope of the project. However, Sub-System D was structured as the previous Sub-Systems and was unable to apply a perfect correction in terms of cost. In addition, the need for this additional Sub-System induced a delay in the process which meant that the client's requirement in terms of the time for completion of the project could not be met. However, by this stage it is likely that both the cost and time targets could not have been met irrespective of the structure adopted. The delay which was induced was not only in design time. There was a 'knock on' effect to Sub-System F through delay in issuing drawings.

Running parallel with these Sub-Systems were Sub-Systems E and G which concerned a direct subcontract with the client for refrigeration. The lack of integration within and between all Sub-Systems including E and G meant that the delay on the buidling contract was likely to delay the refrigeration contract which in fact was the case.

The lack of a homogeneous and consistent managing system meant that appropriate reciprocal interdependencies were not established leading to a shortfall in integration within and between the Sub-Systems and between the client and the process of building provision. This produced deviation from the client's requirements which could not be fully corrected when discovered at a late stage in the process resulting in the occurance of the most significant output deficiencies of delay in completion and exceeding budget. Members of the process were not integrated into the Project Inception System and it is possible that the deficiencies described above may not have occurred if this had been the case. Not only may the design team have been more aware of the cost limit but their presence may have reduced the duration of this system so as to relieve the pressure on time in the Project Realisation System.

The lack of a homogeneous and consistent managing system was continued in Sub-System F and was compounded by the addition of new undifferentiated managing units representing the contractor. This managing system was prescribed by the conditions of contract adopted as a result of the competitive tender which was used in response to economic environmental forces and those associated with the client's experience of other tendering methods. The Contractor's managing unit only acted in an integrating role in connection with the work for which he was responsible. The Architect adopted an approval/recommendation role strictly in accordance with the contract, which was similar to the role he had adopted in previous Sub-Systems. Thus an integrative role over all activities in this Sub-System on behalf of the client was not undertaken. This potential weakness manifested itself only in the necessity for remedial work to the floor and wall finishes and a subsequent lack of satisfaction with the resulting finish. It is unlikely that the other deficiencies occuring in this Sub-System - delay due to inclement weather and due to a strike on another site, - could have been overcome on such a short duration contract by an alternative managing system.

The managing system adopted was unable to overcome environmental influence in the form of the Fire Officer's requirement for additional fire doors which occured late in Sub-System F although this deficiency may have originated in an earlier Sub-System where is was not anticipated.

The tests of the model's propositions against this project have further validated the model by identifying how deviation from the client's purpose in developing a project can occur when inappropriate structures are used. They have also shown how difficult it is for inappropriate structures to identify and correct such deviation when effective feedback lines are not established. The tests have also enhanced the model by clarifying the need to establish sequential and reciprocal interdependencies appropriate to the task being undertaken before integrative effort can be effective.

It is important to note that, in spite of the difficulties encountered on the project in meeting cost and time objectives, the completed building was satisfactory functionally to the client both spatially and technically, and in terms of quality with the exception of the wall and floor finishes.

## 4.5 THE THREE TEST PROJECTS

Although the objective of this research is to use the projects to test the model and is not to undertake a comparative study of the three projects, nevertheless, a brief commentary on some comparative aspects may be useful.

Each project comprised a number of Sub-Systems of Activity within the Project Realisation System of Activity. Project No.1 had four, No.2 had six and No.3 also had six and although there were similarities in the sub-system of the projects, in no case were they identical (as summarised in 4.2.1, 4.3.1, and 4.4.1.). The number of sub-systems of Project No.2 was influenced by the re-design of the offices, and some sub-systems were therefore supplementary to the main design activity. The number for Project No.3 was influenced by refrigeration being a direct contract with the client and the need for modification of the proposed design at a late stage. The variety of sub-systems employed is reflected in the 'shape' of the LRAs for the projects. The LRA for Project No.1 has a regular shape from which the 'pinch points' at Key Decisions can be clearly observed which reflects the closely controlled progress that it was possible to make on this project. The LRA for Project No.2 does not demonstrate 'pinch points' so clearly and shows the first main block of activity extending over a long period of time. Instead of being followed by a group of tasks for construction alone, it also has, in parallel with construction tasks, a group of tasks which continued with development of the design after the commencment of construction and which created a number of small sub-systems. This 'shape' reflects the need to squeeze out Key Decisions at 'pinch points' and reflects the difficulty of making progress with a project in environmental conditions which created uncertainty. Project No.3 has yet another 'shape', which shows two parallel systems (for the main contract and for regrigeration) and a 'bulge' in the flow of the LRA caused by the need to reduce the scope of the project after design which again created a number of small sub-systems and which reflects the lack of control on the project.

The 'shape' of a project LRA is influenced by the nature of the project and the tasks to be undertaken to achieve it an by the manner in which the managing system interprets the task and structures the organisation to cope with the environment. It will, of course, reflect any perconceived notions the managing system may have about how this should be done. It is to be expected that there will be a wide range of 'shapes' for projects but that these may be classifiable. On the LRAs of all three projects it is interesting to note the complexity of the construction stage in terms of both the number, and degree of differentiation, of the relationships.

The 'shape' of the LRAs, particularly the control loops, is influenced by the structure of the firms involved. Project No.1 employed a project manager from the firm which provided all engineering skills, but 'sub-contracted' architecture, with quantity surveying as a direct appointment by the client. Project No.2 used a multi-disciplinary practice of which the project manager was a partner, and Project No.3 used a conventional pattern of contributors with the Architect as designer/team leader and all other consultants from separate practices. Project No.2 produced a more closely knit group of relationships than Project No.1 which was more homogeneous than Project No.3. Similarly, the nature of the client is reflected in the LRAs, again particularly in the control loops, and in the structure of the Decision Points. Project No.1 was for a corporate client represented mainly by his project engineer and integration with this type of client was potentially more difficult to achieve than on the other two projects which were for privately owned companies which were represented by the Managing Director in one case and the Company Chairman in the other. Nevertheless, client integration for Project No.1 was as effective as the other projects except in those cases where higher authority than the project engineer was necessary to make progress. Integration broke down at these points, illustrating the difficulty of integration with this type of client. However, the objectivity of the clients and their ability to assess their satisfaction with the outcome of their projects seems to reflect consistently the outcome deficiencies of the projects. Although numerically greater on Projects Nos. 1 and 2, the deficiencies were more severe on Project No.3 which was reflected in the client's assessment of satisfaction

Although deficiencies were, in some cases, similar between projects, e.g. delay in design and in construction, and exceeding budget, they did not all have the same causes, although environmental forces did contribute to many of them. This was probably due to the projects being subject to some common environmental forces, e.g. the particularly inclement weather in the winter of 1977/78 (Projects No. 2 and No.3), a shortage of bricklayers (ProjectsNo.1 and No.2), and strikes not directly concerned with these projects but which affected them (Projects No. 1 and No.3). The projects were susceptible to common effects as they were located in the same region and time period. However, deficiencies were only rarely caused by the effect of only one factor, but normally occurred because of a number of interrelated elements.

## PART 5

## CONCLUSIONS

5.1 The Model

5.2 Activities of the Managing System

5.3 The Testing Technique

5.4 Implications of the Results of of this Research for the Organisation of Projects in Practice.

5.5 Limitations of this Research and Proposals for Further Work.

5.6 Postscript

# PART 5 - CONCLUSIONS

## 5.1 THE MODEL

### 5.1.1 Introduction

This research explored the relevance of organisational theory to building projects and sought to establish a framework against which organisational structures adopted in practice could be judged in terms of their benefit to the management required by clients. This was achieved by developing a model of the process of building provision from a basis of systems theory irrespective of conventional organisational assumptions. The model identified a number of propositions of significance to successful organisation and management of building projects for clients. These propositions were tested against three recently completed projects, each of which was an industrial building for a private client. The tests confirmed and extended the propositions and suggest that the model is valid for analysing organisations for the management of such projects.

The objective of the tests was to establish whether the model could identify the degree to which any shortfall in the satisfaction of clients with their completed projects, relative to the outcome they expected, could be attributed to the organisational structure adopted.

Clients' satisfaction was conceived as a vector in three dimensions as shown in 3.3.3(b) with the component vectors of:

a) satisfaction with the building's function

b) satisfaction with the completion date

c) satisfaction with the final price

The model aimed to identify the reasons arising from the organisational structure adopted which led to any difference between the magnitude of the vector of the client's expected satisfaction and that of his actual satisfaction. This difference is represented by the magnitude of the vector joining the terminal points of the vectors for expected and actual satisfaction as shown in 3.3.3(d). The actual magnitude of the joining vectors for the test projects are given in Table 4 using clients' assessment of their satisfaction with the outcome as described in 3.3.3(e) converted to a scale of 1 to 5, the lower figure representing greatest dissatisfaction.

The coarseness of the scale used in such that there are only 125 possible outcome combinations available for each project. This limitation is due to the ability of people (in this case clients) to accurately choose a ranking from a wide scale. Hence the quantitative analysis is only a guide to the degree of dissatisfaction of the clients with the outcome of their projects. The magnitude of the vector for the greatest possible client dissatisfaction is approximately 7 and is obtained by scoring 1 for each component of clients satisfaction. The value of the least client dissatisfaction is 0 and is obtained by scoring 5 for each component and is represented by the vectors for expected and achieved satisfaction coinciding.

TABLE 4 - Magnitude of Vectors for Project Outcome Deficiency for Test Projects

| Test Project | Function | Time | Price | Magnitude of Vector ($S_d$) |
|---|---|---|---|---|
| 1 | 4 | 3 | 5 | 2.24 |
| 2 | 4 | 3 | 5 | 2.24 |
| 3 | 4 | 2 | 3 | 3.74 |

The model was, therefore, tested by examining whether the shortfall in client satisfaction represented by the magnitude of the vectors of project outcome deficiency could be explained by the model's propositions.

Conclusions regarding the significance of the model's propostions follow in 5.1.2. from which it will be seen that the tests validated the propositions and also enhanced some of them. Of particular importance are the decision points within the process of building provision which determine the flow of the process and feedback opportunity. Of equal fundamental importance is the project's environment. The identification of decision points, and hence feedback routes, within a project and the identification of a project's environment were shown to be essential prerequisites of organisational design in order to ensure that organisational structures are designed to reflect the process to be managed.

The model's propositions regarding the implications for effective organisational structures of the degree of differentiation and integration were all shown to be relevant to the achievement of successful project outcomes. Great differentiation was shown to exist within building projects - between contributors, between the operating and managing systems, within the managing system itself and between the building process and the client. The degree to which it was successfully integrated on behalf of clients was shown to be significant in achieving successful project results.

Compared with the application of systems theory to organisation and management in other fields, its application to building projects has shown how complex building projects are in terms of the types of relationships they generate. The organisational independence of many of the contributors to the test projects, and the independence of the client company created a large number of the most complex types of differentiation identified by the model. The degree of interorganisational integration required is consequently very high and it has been found that the need for a high level of integration is not always recognised by those responsible for managing the process and by clients.

Insufficient attention to the management needs of projects resulting in inappropriate organisational structures and insufficient integration effort in conditions as complex as those found for building projects is always likely to produce deficiencies in project outcomes. It is surprising, therefore, that so little attention has been paid to establishing and developing the management skills required to provide building clients with the management service they are entitled to expect from the building professions and industry.

The systems approach, the model and technique of Linear Responsibility Analysis (LRA) used in testing have provided a method for analysing projects which enabled what appeared to be a confused association of contributors to be understood and related to the project outcome. The tests highlight the benefits to projects to be gained by careful definition and implementation, at an early stage, of an organisational structure appropriate to the particular needs of a project. The lack of such an approach was at the root of practically all the identified deficiencies in the outcomes of the test projects.

### 5.1.2 Project Environment and the Model's Propositions

a) The Environment

This research has shown that managing systems need to explicitly recognise and define project environments. The environment of a system, using Ackoff's definition as in 2.4.4., is a set of elements and their relative properties which are not part of the system but a change in any of which can produce a change in the system. For every test project, some of the output deficiencies were caused by the effects of environmental forces. for example, political influences leading to uncertainty on Test Project No 2, sociological/political/economic forces leading to strikes on other sites which affected Test Projects Nos. 1 and 3 and economic forces leading to competitive tenders on all Test Projects. Although it is, perhaps, unreasonable to expect a managing system to overcome the effects of all such forces, their definition and the design of organisational structures to cope with them can reduce the likelihood of them affecting projects detrimentally.

The environmental conditions of a project should, therefore, be identified by the managing system before designing the organisational structure. It is insufficient for the manager of the project team simply to receive from the client a statement of the building he requires and to develop the details from that base. It is equally important for the managing system to identify the susceptibility of the client's firm, and hence the proposed project, to changes in environmental conditions in order to determine the type of organisational structure which will provide the appropriate degree of flexibility and the greatest possibility of satisfying all the client's requirements.

Similarly, the managing system should monitor the movement of environmental forces during the process of providing the building and be prepared to modify the direction that process is taking if the effect of environmental influences on the activities of the client's company dictate a change.

A primary purpose of the managing system will, therefore, be to mitigate or harness environmental influences in pursuit of a project outcome which meets the client's requirements. It will be seen from Table 4 in 5.1.1. that Test Projects Nos. 1 and 2 had the same magnitudes for the vectors representing the shortfall in achieving the client's required satisfaction. However, the environmental forces which had to be dealt with on Test Project No.2 arising from the client's uncertainty, due mainly to political influences, were far greater than those influencing Test Project No.1. although the inherent complexity of the building itself was greater for Test Project No. 1. Test Project No.3 had a stable environment and was a relatively simple building and the outcome achieved was the least satisfactory of the test projects.

If the managing system is to act in the manner described, it will require the client (who is part of the managing system) to allow the manager of the project for the client access to information required by him to advise properly an organisation structure. Ideally, this requires the manager to be involved as near as possible to the point at which the client first thinks about the project which is identified in 2.1 as the start of the Project Conception Process. It also requires that the client has no preconceived notions of what he thinks the appropriate structure should be and that he will take advice from the manager. On all the test projects the clients insisted that the projects be submitted to competitive tender for construction work. This was seen as an environmental influence arising from economic forces, and in each case it contributed to deficiencies in the outcome of the projects. Although there is a trade-off between competition, completion and quality, on none of the projects was thus considered in detail by the client or project team. Similarly, there was reluctance or a lack of awareness by the client of the need to involve the manager in the Project Conception Process identified in 2.1, yet it is in this stage that the nature of the project is clearest. If this had occurred, major deficiencies of two of the test projects may have been avoided. It is likely that the involvement of the manager will occur earliest on projects using 'in house' professional staff rather than when professional practices are employed.

The onus for establishing the organisation structure lies, therefore on both the client and the organisation managing the building process on his behalf but where professional practices are employed the initiative for early involvement of the manager will have to arise from the client.

The degree of uncertainty of the projects' environments determined the ability of the managing systems to identify the decision points in the projects (see (b) below). This interplay is of major significance and is the key to determining the appropriate organisation structure. With a high level of certainty, the decisions to be taken and the time at which they are to be taken can be determined at the outset and a clearly defined structure employed with precise feedback loops (e.g. Test Project No.1). However, at the other extreme, foresight of decision points will be short and a flexible and adaptable structure will need to be employed (e.g. Test Project No.2)

The managing system should also be concerned with the interplay between the environmental forces acting upon the client's organisation and those acting directly upon the process of building provision. It will be seeking a compromise between conflicting effects of such forces and harnessing the forces acting upon the process of building provision to the benefit of the client. Such conflict is due to environmental influences acting directly upon sub-systems (e.g. when a key member leaves a contributing firm). The organisation structure should ideally be designed to allow such situations to be resolved by the managing system. On the test projects the adoption of standard conditions of contract as a result of competitive tenders inhibited the managing systems' ability to resolve such issues which arose in the construction sub-systems. For example, on Test Project No.1 environmental forces determined the project completion date, but other environmental forces created a reluctance to employ bricklayers from another site in the area due to previous industrial action on the other site, which caused delay. In this case the manager of the project for the client was unable to be directly involved due to the conditions of contract adopted for construction. This represents a trade-off situation of legal protection against the ability of the managing system to directly influence events on the project.

b) Decision Points and Feedback

This research finds that building projects are basically structured by a hierarchy of Decision Points which can be ranked in the priority of Primary, Key and Operational Decisions and which define the sub-systems of the process of building provision. The decisions create 'pinch points' through which a project's development must pass if progress is to be made.

The model identified Primary and Key Decision Points In addition, Operational Decisions Points, described in 3.3.2(e)(i), were identified by the tests for each test project as described in Part Four of the main text and shown on the LRA's. Thus, an additional level of sub-systems to those shown in Fig.12 is identified, as illustrated in Fig. 20.

The model identified the type of decision to be made only in the case of Primary Decisions and proposed that Primary Decision points determine the Project Conception, Project Inception and Project Realisation Systems as the only systems common to all projects. This was confirmed by two test projects. There was insufficient information on the third project to identify the Conception and Inception Systems.

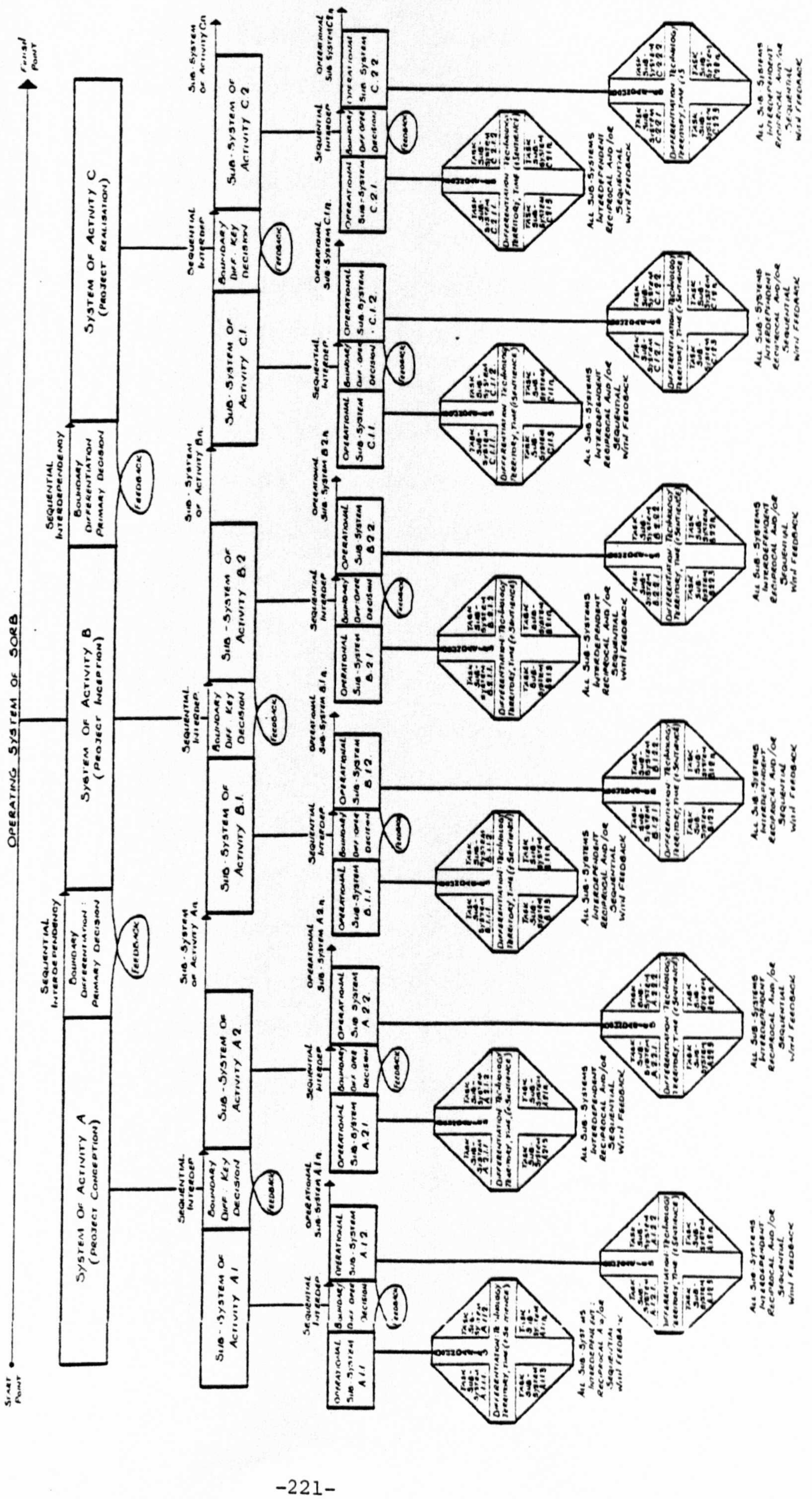



FIG. 20 THE OPERATING SYSTEM

The type and position of Key and Operational Decisions in the system is not predetermined, but occurs as a result of the demands of the environment upon the client's major commercial activity. Key Decision Points are likely to be determined by environmental influences manifest in the client company's internal procedures for expenditure or similar approvals. 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. The Key Decisions on the Test projects are shown on the Linear Responsibility Analysis in the Appendices. However, if the client's organisation is not responsive to environmental forces, Key Decision Points may be inappropriately identified. As well as acting as feedback opportunities within the client's firm, they also act as major feedback opportunities for the process of building provision. Operational Decisions contribute to Key Decisions and are constrained by them. They will mainly be concerned with implementation of procedural aspects of building project organisation and will move the project incrementally towards a Key Decision. Their position in the system will be determined by the previously taken Key Decisions and the subsequent effect of environmental influences. Operational Decision Points represent secondary feedback opportunities.

The manager of the project for the client should, therefore, identify Key and Operational Decision points and establish the feedback provision as a prerequisite to designing the organisational structure. The extent to which the manager is able to clearly define this process will depend upon the relative uncertainty of the client's environment and its resultant effect upon the clarity of his objective and his objective's susceptibility to change. Test Project No.1 had a relatively stable environment in which it was possible to identify frequent Key and associated Operational Decision Points which produced short feedback loops in terms of number of tasks between feed-back points. An organisational structure was established to cope with those characteristics which produced a system which was relatively easy to design and control. By comparison, Test Project No.2 had a most unstable environment in which there were consequently few progressive Key Decisions which meant that, throughout the project development had to be measured against the client's definition of his requirement's at the start point. Decisions refining his requirements were not made and could not therefore be used in feedback. This produced long feedback loops which created difficulties of control and potential for abortive work. However, each of the approaches was appropriate to the prevailing environment, but it is important that the particular characteristics of a project are recognised at the beginning of the project so that appropriate structures can be designed.

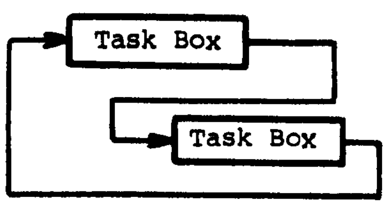
The obvious significance of arriving at an appropriate Key Decision on the basis of appropriate feedback mechanisms was confirmed by Test Project No.3 where an inappropriate Key Decision was taken on the basis of an inaccurately defined goal against which performance was measured. This decision created abortive work and had a 'knock-on' effect to subsequent sub-systems causing a major deficiency in the outcome of the project due to the inability of an inappropriately designed structure to apply the necessary correction.

Whilst both the position of the Key Decision Points and the actual decisions taken will be mainly determined by the client, the manager of the project will have more discretion in placing Operational Decision Points within the framework provided by Key Decision Points. Thus, in designing an organisational structure, a manager should begin by identifying Key Decision Points and arranging them to the benefit of the project within the discretion available to him, persuading the client to adapt to suit the prevailing environment where appropriate, and should structure the Operational Decision Points within the framework of the Key Decision Points. This approach will ensure that the design of organisational structure will begin on the basis of the process for which the structure is required and the environmental conditions in which it has to be achieved before actual structures are designed, ensuring that structure follows process and that artificial structures are not superimposed on the process.

It is significant that the interviewees did not explicitly recognise the Decision Points in the projects with which they were involved, yet explicit recognition of them is required as the first step in designing organisation structures which reflect the process to be managed and provides feedback opportunities which are vital to the success of the project outcome. Hence, in a number of instances on the projects, feedback was vague and therefore led to deficiencies. For example, on Test Project No.2 the design of the offices was undertaken before the client's requirements were clearly established, hence there was nothing to measure feedback against, resulting in re-design and delay in completion. As referred to earlier, on Test Project No.3 an inaccurately defined goal let to a faulty feedback mechanism.

c) Match of Differentiation and Integration

The differentiation which is created by the structure adopted demands a consequential degree of integration. The amount of differentiation will depend upon the number of specialist contributors employed on a project (which will usually depend upon the complexity of the project) and upon the inter-organisational relationships of the contributors. For example, if the specialist contributors are employed by different firms, this will produce a greater differentiation than if they are all employed by the same firm, thus the degree of integration required will be greater. This is evident from comparing Test Project No.2 which uses a multi-disciplinary practice with the other two projects which did not. Similarly, certain arrangements of contributors may be made for primary reasons other than for effective management, e.g. for financial reasons, as in Test Project No.3. If so, it is important that effective integrating mechanisms are used or the advantage to be gained could be lost. However, the tests identified that this proposition (that the differentiation of the system should be matched by the provision of a corresponding level of integrative effort) requires the caveat that this match can be valid only if an appropriate pattern of consultation, as defined in 3.3.2(e)(ii), is established between the contributors to the project. This requires the managing system to identify the skills required for the process of producing the building and the way in which they are interdependent. Thus sequential and reciprocal interdependencies appropriate to the process to be undertaken are defined. These arrangements generate the differentiation in the system from which the degree of integration needed can be identified. Although an objective in designing organisation structures may be to reduce differentiation and hence integration need, this should not be at the expense of the skills demanded by the process, but rather that effort should be put into integration to overcome the consequent differentiation. If design of organisational structures does not proceed in the manner outlined a fálse level of differentiation will occur and hence a false level of integration with interdependencies inappropriately identified in such a way that sequential interdependencies will occur which should, in fact, be reciprocal. The construction of sequential interdependencies which should have been reciprocal occured on Test Project No.3 and appear on the Linear Responsibility Analysis as:



Such an arrangement is the most difficult interdependency to integrate and creates areas of potential weakness in the system.

This finding develops Thompson's concepts on sequential and reciprocal interdependencies used in the model and given in 2.4.5 which state that reciprocal interdependencies are more difficult to integrate than sequential. Whilst this is generally true for the test projects, with the exception above, the projects suggest that the scale of difficulty of integration of sequential and reciprocal interdependencies implied by Thompson may not be so great on building projects, particularly in the sub-systems leading up to construction. This arises from the abilities of the professions associated with building to work in reciprocal situations in which they are self-regulating and the difficulty in planning sufficiently well in conditions of uncertainty to achieve ease of integration of sequential interdependencies. The test projects showed that effective integration of reciprocal interdependencies required frequent personal contact between the receiprocally interdependent contributors in which all contributors met together. This was shown to be needed at both a formal and informal level. In the case of Test Project No.1 the contributors had in the past arranged to work on a project together in the same location although employed by different private practices. Although this did not occur for this project it did mean that they were well versed in each other's methods of working and frequently met informally on the project. In addition, they met formally in a carefully prepared sequence of action minuted project meetings. In the case of Test Project No.2, personal contact of all contributors was maintained through the interdisciplinary private practice although the formal meetings on the project were not particularly frequent nor action minuted. For Test Project No. 3 similar approaches did not exist and contributors met infrequently, if at all, during design. Reliance was placed upon transmitting information by mail and telephone which created sequential interdependencies where reciprocal should have been formed. As stated earlier, such a situation is the most difficult to integrate and the lack of additional integrative effort on this project meant that deficiencies in the project outcome occurred as a result. As referred to above, the professions associated with building have the ability to work in reciprocal situations provided they are given the opportunity to do so and it is the responsibility of the managing system to create such opportunity and to monitor their activities to ensure that the contributors' activities remain orientated towards the client's requirements. Competitive tendering arrangements for construction work and the consequent conditions of contract adopted on all the test projects meant it was not possible for the design team and contractor to adopt reciprocal association.

Sequential interdependencies were integrated through transmission of information, for example, from architect to quantity surveyor for preparation of contract documentation, from design team to contractor. Although this should be an easier type of interdependency to integrate than reciprocal interdependency, the variety and volume of information generated by building projects and the lack of adoption of formal information systems in the industry creates difficulties, particularly in relation to the compatibility of designer produced production information and the needs of the constructor. Sequential interdependencies are, therefore, integrated using a wide range of unco-ordinated devices; drawings, bills of quantities, schedules, forms of contract, letters, telephone messages, word of mouth. Additionally, the uncertainty of project environments affects the efficiency of integrating sequential interdependencies. In conditions of uncertainty it is difficult to predict when the output of reciprocal interdependencies will be ready to be transmitted through a sequential interdependency. It will be a role of the managing system to decide when this is appropriate and such a decision may be delayed in uncertain conditions leading to uncertainty in subsequent sequentially interdependent tasks. This situation was particularly noticeable on Test Project No.2 in which the details of the design of the offices could not be completed and transmitted to the contractor. If the potential occurrence of such situations is identified when designing organisation structures the managing system should be able to allow for them, as happened on Test Project No. 2 on which the managing system arranged for negotiation of the contract sum for the offices following the award of the contract for the factory.

The need for the integrating activities of boundary control, maintenance and monitoring as a result of the pattern of relationships established requires explicit recognition.

They need to be clearly understood by all contributors as well as by the managing system, as amplified in 5.1.3.(b). A lack of recognition of the need for these activities on Test Project No. 3 pervaded the project and was the underlying cause of divergence from practically all the model's propositions and of a significant shortfall in the client's satisfaction with the project outcome

d) Differentiation of Managing and Operating Systems

It has been found that generally the managing and operating systems on building projects should be differentiated. That is, the persons who are exercising the skills required for the realisation of the project should not also be concerned with managing the total system. Although no specific outcome deficiency was found to be directly attributable to this proposition, Test Project No.3 had substantially less differentiation than Test Projects Nos. 1 and 2 and produced a project outcome which was the least satisfactory.

This indicates the wide implication of this proposition as the effectiveness of the other propositions is dependent upon concentration upon the management requirements of projects which is provided by a separate managing system. However, total differentiation within a sub-system was only rarely found although in most cases there was substantial differentiation as shown in Table 5 for each Test Project in Appendicies 1, 2, and 3. The most common task for which the managing and operating systems were undifferentiated was programming the time required for the project which was invariably done by a person in an overall managing position and not by a member of the operating system,as shown in the LRA for each test project.

An exception to this general conclusion was found in the Inception Process of Test Project No.2 in which a person was able to provide the necessary skills independently of any other skills. In such a case there was no need for a managing system and the sub-system was able to operate satisfactorily as a simple undifferentiated system. Such a situation is likely to occur very infrequently on building projects which even at low complexity require dependent contributions from a range of skills.

e) The Differentiation of the Managing System Itself

Ideally, the managing system itself should be undifferentiated, but this requires that the client should be capable of managing the process of building provision himself. However, only in exceptional circumstances is the client likely to have the necessary skills. It may occur for clients who have the required 'in house' skills, for example, a developer/builder company or a large commercial organisation. However, the tests found that in cases where these special circumstances do not occur, the managing system will be differentiated into two parts - one part drawn from the client's organisation and one part from the process of building provision. The relationship between the parts is significant to the success of the project as discussed in (f) following. However, each of the parts should be undifferentiated.

The tests highlighted deficiencies on all test projects arising from duplication of the managing roles resulting in divided responsibility for managing activities, which is likely to negate what may appear to be a good match of differentiation and integration. This arose due to contracts being let on a competitive basis (due to environmental influences) resulting in the introduction of duplicated activities during construction on all projects, and also, on Project No.3, due to parts of the project being organised outside the main project. The advantages expected to be gained through such arrangements need to be set against the complexity which is induced in the managing system and the consequent potential for deficiencies in the project outcome.

Consistency of membership of the managing system was shown to be necessary and is disturbed in the circumstances described above. It can also be disturbed when the managing system is arranged in two parts - client and the process of building provision. If, for example, the manager of the project for the client is excluded from the managing system at any point in the process, as did occur on Test Project No. 1, there is likely to be an effect on the project outcome. In such circumstances, decisions which significantly affect the ability of the process of building provision to provide what the client requires may be made by the client without consultation with the manager of the project. This was shown to be particularly true on Test Project No.1 when it occurred at a Key Decision Point but can also be expected to be of significance at any type of decision point. The result on Test Project No.1 was a delay in project completion due to the manager of the project being excluded during the taking of the key decision to proceed to detail design and the consequent effect on project completion of the delay in taking the decision.

f) Integration of the Client and the Process of Building Provision

The quality of integration of the client and the process of building provision was found to be important in achieving the desired project outcome. Of particular significance in this respect was the ability of the client's organisation to respond to the integration effort required of it. The process of building provision cannot provide integration in isolation, but must receive a corresponding response from the client who must create internal conditions which allow integration to take place and which allow apposite and timely responses in assisting the process to achieve the desired project outcome. Making such arrangements can be difficult for client organisation which are themselves complex, particularly if the project is generated from a location or division of the client company which is divorced from head office but which requires head office approvals to make progress on the project. It is important that the manager of the project ensures, at the commencement of the project, that the client has established appropriate integrating devices and that the client is co-operative in this respect. It is particularly important that integration is maintained at Key Decision Points. Test Project No.1 had sound integrative arrangements, through regular meetings of the client's representative, the manager of the project and other contributors and through other devices such as the signing of all drawings by the client's representative before use. Nevertheless, integration of the building team with the Key Decision making level of management within the client's organisation did not occur leading to deficiency in the project outcome.

There is a particular need for clients to be aware of the integration demands placed upon them in the Project Conception and Inception Processes. Lack of such awareness produces situations in which the manager of the project is not sufficiently integrated into these Processes. On Test Project No. 3 this contributed in the building not being completed by the time required, as the client did not recognise the urgency in proceeding in order to meet a mandatory completion date for the project. Unless the client is aware of the integration need, the manager can do nothing about it if he has not been appointed at the time of need for integration. If he has been appointed, the onus for generating the required integration lies with the manager of the project.

The contractual arrangements resulting from competitive tenders on all the test projects created conditions in which the client was not integrated during the construction sub-system to the extent that he was integrated in other sub-systems. This was due to the relationship of the 'Employer' (client) adopted by the Joint Contracts Tribunal (JCT) Form of Building Contract used on all test projects. This situation is reflected in the absence of the client from the control loops of the construction tasks on the Linear Responsibility Analyses in the Appendices. This created dissatisfaction in some clients and led them to believe that output deficiencies arose from this situation. This condition is a 'trade-off' against the decision to award contracts on a competitive basis and the client's legal protection but questions whether the philosophy underlying the JCT Form of Contract places the client in the most appropriate relationship with the contractor. However, there was no evidence on any of the test projects that alternative approaches had been evaluated formally with reference to the client's integration during construction.

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Whilst the above identifies and discusses the influence of the propositions of the model upon the outcome of projects, it should be recognised that only rarely were outcome deficiencies of the projects caused by the effect of only one component. Invariably, a number of interrelated components contributed to an output deficiency, as indicated for each test project in Tables 1,2 and 3 in Part Four of the Main Text. This situation is to be expected once the process of building provision is recognised as a system consisting of a number of interrelated and interdependent parts, which should be the perspective taken by the managing system.

### 5.1.3 Activities of the Managing System

a) Introduction

Working through the operating system, the managing system establishes and monitors the goal of the operating system in terms of the functional (including quality), time and price requirements of the client and seeks to achieve these requirements to the satisfaction of the client. This research has identified a range of activities undertaken by the managing system in seeking to meet this objective. These activities are carried out for and between each task required to complete a project and have been explored through the test projects. The range and type of process required to be carried out by the operating system will vary between projects depending upon the project's environmental context and the consequential arrangements of decision points. Nevertheless, the activities of the managing system can be generalised irrespective of the structure of the project as:

Boundary control, monitoring and maintenance
General and direct oversight
Recommendation and approval

b) Boundary control, monitoring and maintenance

The project management activity of boundary control is fundamental to the achievement of the level of integration and control demanded by a project and to a satisfactory project outcome. Its objective is to ensure functional compatibility of contributors' work within and between tasks, to relate the system to its environment and to control the system's direction towards the required outcome. This activity is normally accompanied by the complementary activities of monitoring and maintenance. Monitoring is intra task regulation to check and control prior to output to ensure that a task is proceeding in a manner which will achieve its purpose. Maintenance ensures that a task has the capability to achieve its purpose.

Boundary control activities involve setting up formal control mechanisms using the feedback loops defined by the Key and Operational Decision Points identified when designing the organisation structure and with establishing the supporting information system. It ensures that information flows as intended and that feedback mechanisms are activated. In addition, it should ensure that the reciprocal and sequential interdependencies identified in designing the organisation structure are made to work in the manner intended. Methods of achieving this will have to be devised and used. Sequential interdependencies will be integrated by ensuring proper information flow in accordance with the information system, but reciprocal interdependencies will need to be integrated using mechanisms which ensure that the contributors meet in the correct combinations and at the right time. Such mechanisms would normally include action minuted meetings and exploratory and less formal meetings early in the process. These activities include ensuring that the client is integrated in the appropriate manner at the various stages and with keeping in close contact with the client to identify any changes in his environment and requirements.

Whilst boundary control activities relate the parts of the system to each other in the way described above, monitoring ensures that the individuals or groups undertaking a specific task respond to the demands to integrate and so allow boundary control to take place effectively and also to ensure that techniques and procedures appropriate to the specific task are being used.

Maintenance involves keeping in close touch with each contributor and ensuring that each is equipped to carry out the task required of him and requires regular formal reviews of the quality and quantity of resources dedicated to the project.

Boundary control, monitoring and maintenance are managing system activities and, in accordance with the model's propositions (that the managing and operating systems should be differentiated and that the managing system itself should be undifferentiation), they should be vested in one person who is not also undertaking operating system skills on the project. This situation appertained predominantly on Test Projects Nos. 1 and 2 through the Project Manager but not on Test Project No.3. The exceptions on Test Project No. 1 were in the early tasks before the project team was formally appointed when the client undertook these activities and, on both projects, in the few cases where the manager of the project also undertook operating activities. On Test Project No.3 there was a marked lack of such activities. The results was that the outcomes of Test Projects Nos. 1 and 2 were far more satisfactory than for Test Project No. 3.

Problems were encountered on Test Project Nos. 1 and 2 resulting in some deficiency in the outcomes due to the duplication of these activities between the manager of the project for the client and the contractor's manager. This situation did not occur on Test Project No. 3 as the manager of the project for the client did not undertake these activities to any extent during construction.

c) General and direct oversight

Two supervisory activities - general oversight and direct oversight - were identified. General oversight provides policy guidance for the project and direct oversight is concerned with directly supervising specific skills used on the project. The manner by which these activities are distributed amongst the project team depends upon the structure of the firms which contribute to the project organisation. However, in the case of general oversight, this will often be exercised by the client in the Conception Process of the project until the broad outlines of the project are approved by him. The actual person within the client organisation who undertakes this activity will depend upon the structure of the client's organisation. The only time this activity will not be undertaken at this early stage will be when a senior member of the client's organisation is himself actually doing the work which would otherwise be subject to general oversight, as occurred on Test Project No.3.

As the project progresses, the general oversight activity passes from the higher management levels of the client's organisation to lower levels as illustrated by Test Project No. 1 where it passed from the Board of Directors to the client's 'in house' Project Engineer. Subsequently, it will pass to the project team when the detailed work on the project commences. This is illustrated by Test Projects Nos. 1 and 2. The person who then exercises it depends upon the structure of the firm providing the management of the project for the client. For example, in Test Project No. 1 it passed to the Senior Partner of the firm and not the project manager. In Test Project No.2, as the project manager was also a partner of his firm, it passed to the partner/project manager who was also exercising boundary control, monitoring and maintenance activities. For Test Project No. 3, in which the professional contributors pursued their work relatively independently, general oversight was not provided.

The degree to which direct oversight was provided depended upon the structure of the contributing organisations. For example, in Test Project No. 1, structural and mechanical engineering was carried out by the firm providing project management and the managers of these departments were involved in the project and provided direct over-sight to the operating system tasks, similarly, the partners of the architecture and quantity surveying firms took a comparable role. On Test Project No. 2 however, where all skills were provided in an interdisciplinary organisation, the partner/project manager did not possess the skills of the operating system and there were no departmental managers, so direct supervision was not provided and professional skills were exercised without direct supervision. Test Project No. 3 followed a similar pattern although the contributors came from separate firms. In this case Architecture and Services Engineering was carried out by partners of the firms, so direct supervision was not undertaken. Similarly, the project structural engineer and quantity surveyor worked without direct supervision of the kind intended by the definition used in this research, although they did they did work within the general direct supervision of their practices. In the case of quantity surveying, a partner of the firm undertook some of the work. Generally, professionally qualified members of contributing firms do not require direct supervision but this does depend on their status and the policy of the firm by which they are employed.

Due to the use of competitive tenders for construction work and the consequential conditions of contract, both general and direct supervision of construction work was not provided by the manager of the project for the client or any of the design team contributors but vested directly in the contractor and sub-contractors. The conditions of the standard form of building contract used on all test projects casts the architect (or with amendment, any other manager of the project for the client) in a passive role in connection with the contract which was directly between the employer (client) and the contractor. The rights and duties of both parties to the contract are specified and the architect is defined as acting to monitor that they are carried out. The architect cannot intervene directly to ensure compliance with the contract but must follow the administrative procedures laid down with final recourse to arbitration or law by either party to settle disputes. If dissatisfied with the contractor's performance, the manager of the project for the client must recommend legal action to the client as a last resort if satisfaction cannot be achieved by pursuasion, as he does not have the right of direct intervention.

d) Recommendation and Approval.

The pattern of approval and recommendation powers between the client himself and the person managing the project for him will depend upon the role decided for himself by the client and the structure of his organisation. On the three test projects, the client reserved for himself approval of the output of the tasks up to commencement of construction with the exception of a small number of tasks which did not involve choices between alternatives, e.g. contract documentation. The level at which approval powers were vested in the client organisation's hierarchy depended upon the structure of his organisation. For example, on Test Project No. 1, the early decisions were approved by local directors or the parent company, until the basic parameters had been established when approval powers passed to the client's 'in house' project engineer. Subsequently, the higher levels were only involved in approvals at Key Decision Points. Then for the construction phase, approval powers passed to the manager of the project for the client with the exception of the approval of further project instructions and documentation emanating from the design team which the client's project engineer approved. The manager of the project for the client had the role of recommending courses of action for the client's approval which included presenting and advising upon the choices available. It was this activity from which he derived his authority on the project. Whilst the project manager may approve proposals of the contributors, the final approval to proceed remained with the client. As the organisational structure of the client's organisation was simpler for Test Projects Nos. 2 and 3, with the Group Chairman and Managing Director respectively representing the clients' organisations throughout the projects, they personally had approval powers for all decisions except during construction. Again, the manager of the project recommended actions to the client except during construction when the manager had approval powers and for a small number of mechanistic tasks during design, but for these projects additional design information during construction was not subject to approval by the client. The manager of the project drew his authority from his recommending activity. In addition on Test Project No.2, the project manager was also a partner in the interdisciplinary firm providing the operating skills which gave him significant additional authority over the contributors.

These arrangements demonstrate the client's wish to be closely associated with his project and an unwillingness to delegate approval powers for the industrial projects used in the tests.

It also demonstrates the importance of integration between the client's organisation and the process of building provision. It is clear that the client will determine the approval pattern within a project and hence define the authority of his manager of the project.

e) Pattern of Activities

The pattern of managing activities on a project will, therefore, be dependent upon the structure of the firms used in the project organisation and upon the client company's organisation structure and his requirement regarding the approval powers he wishes to retain. However, the manager of the project on behalf of the client should, in all cases, undertake the activities of boundary control, monitoring and maintenance. When a project organisation is designed, it is important that the people exercising the various managing activities are identified and their roles understood by all contributors. In this way the authority of the members of the contributing firms will be recognised by others. For example, it will be known whether the job quantity surveyor has full authority for quantity surveying matters or whether he is subject to direct oversight by a more senior member of his firm. This will depend upon the firm from which he comes and his status within his firm.

It has been found that the manager of the project for the client is usually involved in recommending courses of action to the client for approval. Hence, the manager's authority does not derive from his authority to approve the output of the tasks but from his power of recommendation which implies approval of the output and hence his power to influence decisions made by the client. Thus his authority is derived from his access to the client and, although this should not bar other contributors from the client if integration of the client and the process of building provision is to take place, the client must vest authority in his manager by considering recommendations only from this source and requiring other contributors to route recommendations through the manager. Only in this way will the manager have the authority necessary to ensure that the other contributors perform adequately and the opportunity to fully exercise his integrating activities. Nevertheless, this situation will only be maintained for any length of time if the manager has the professional respect of the other contributors.

The manager of the project may be under general supervision by another person higher in the hierarchy of his firm and this may affect the regard in which he is held by other contributors, at least initially. His authority is likely to be enhanced if he is a partner or director of his firm. Whilst it would be beneficial if the client stated formally the authority of the manager of the project and of the other contributors, the informal authority of the manager, derived from the respect in which he is held by the client and other contributors, will be the most potent and will be the instrument which is most likely to elicit the necessary level of performance from all contributors.

The allocation of responsibility for the project amongst the contributors will depend upon the types and association of firms involved in the project and will be created by the design of the organisation structure and be the subject of negotiation between the client and the contributors. Although this research did not address itself directly to this aspect, it is possible to put forward ideas as to how responsibility may be distributed.

Conditions of contract for construction work will usually define responsibility for this aspect and the related responsibility of the other contributors in connection with this stage. Responsibility for design and associated work is the aspect for which responsibility can be more difficult to define. If a project is managed and designed by a multi-disciplinary practice then responsibility will rest with that firm. Similarly, responsibilities when a conventional arrangement is used, with the architect as designer/manager, are generally understood. If the consultants are directly appointed by the client, then they will be responsible to the client for their own work. The difficulties which arise in this respect are due to the interrelationship of the contributions made and hence in allocating final responsibility. If management of the project for the client is given to a firm separate from the firms making up the operating system, a similar situation will arise if the contributors are appointed directly by the client. Alternatively, if the project is managed by a firm which appoints the consultants directly, i.e. as 'sub-contractors' to them, then the managing firm will take responsibility for their work. If a legal action is successfully brought against them by a client, they may have recourse against their 'sub-contractors'. This arguement can be extended to 'package deals' in which the firm will be responsible for the whole of the design and construction for a project. Naturally, the greater responsibility accepted by a firm the greater is the risk they are carrying and firms, either managing firms or 'package deal' firms, are unlikely to accept it unless they have direct control over the contributors through direct employment or a facility to bring an action against a contributor if one is brought against them by the client. A situation in which responsibility for the project rests with only one firm or at least one firm for management, design and related aspects and one firm for construction is likely to be attractive to clients. Clients are in a position to decide upon the pattern which they want for their project although the reaction of the contributors is likely to be to wish to spread responsibility unless they are appropriately recompensed for risk. An illustration of one client's view of an appropriate pattern is given by Test Project No. 1 in which one firm was responsible for managing the project for the client and also provided engineering skills and 'sub-contracted' architectural aspects, but quantity surveyors were appointed directly by the client and directly responsible to him for cost control.

Ideally, responsibility should be matched by authority, but this is difficult to achieve. The responsibility pattern adopted should reflect the project structure and the approval and recommendation pattern required by the client and provide the client with legal protection which is sufficiently practical to be applied. Authority and responsibility patterns for projects is an area well worthy of further research.

### 5.1.4 A Definition of Project Management

There have been a large number of definitions of project management[34]. Most of them have arisen as the result of one person's experience of a particular form of implementation and, therefore, have had difficulty in gaining general acceptance.

Those that are more generalised tend to be oversimplified and reflect Cleland and King's view[64] that complex concepts such as management do not lend themselves to standard dictionary style definitions. Their view, that an operational definition is more appropriate is a useful one. They suggest that the definition should be stated in terms of what would be observed if certain operations were performed. The problem is then transferred to generalising what would be observed if project management was taking place and is consequently more easily stated.

A further issue with current definitions is that they invariably refer to 'managing a project' and do not make reference to managing people to achieve a project. Although it may be implied that projects can only be achieved by working through people, nevertheless it is important that definitions make specific reference to this fundamental aspect of project management.

Arising from this research, the following is offered as a definition:

'Building project management is the planning, control and co-ordination of a project from conception to completion (including commissioning) on behalf of a client, and is concerned with identification of the client's objectives in terms of utility, function, quality, time and cost, the establishment of relationships between resources [(i)], the integration, monitoring

(i) Resources is a general term which includes materials, equipment funds, and, of course, particularly people.

and control of the contributors to the project and their output and the evaluation and selection of alternatives in pursuit of the client's satisfaction with the project outcome'.

It should be stressed that the implementation of this definition could take many forms, depending upon the nature of the project and its environment but that, whatever structure is adopted, the activities within the definition should be observable. The detailed functions of those responsible for managing the project in relation to those offering other skills and the necessary authority and responsibility pattern will be created as a result of each client and each project's requirements.

There is considerable confusion between the use of the term 'Project Management' and other management titles in building. It is important that Project Management is only conceived as the overall management of a project on behalf of a client. Other management titles will then imply the orientation of management activities which will not necessarily have the client's interest as their dominant concern(e.g. construction management) or which are not concerned solely with the achievement of the specific project, (e.g. general management).

### 5.1.5 The Design of Organisational Structures for Building Projects

On the basis of the findings of this research it is possible to summarise an approach to the design of organisational structures for building projects for clients of industrial/ commercial companies as follows:-

a) The manager of the project for the client must convince the client of the need to design a structure for project achievement and of the need for the client to design a corresponding structure in his organisation and should make the client aware of the demands that will be placed upon this organisation.

b) It is the role of the manager of the project for the client to design the organisational structure which should be designed at the very beginning of the process of building provision.

c) The objective is to design a structure which has the potential for mitigating and harnessing the effects of environmental forces upon the process and therefore requires identification of the potential impact of environmental influences.

d) The available choices of Primary, Key and Operational Decisions should be identified and their position within the system established as far as possible on the basis of (c).

e) Sub-systems and feedback loops should be identified on the basis of (d) to establish the process to be managed.

f) The skills required to carry out the process and their relationships should be identified and the operating system established. The way in which the skills are to be provided will determine the degree of differentiation which will exist in the system. Hence, the quality of integration required should be identified.

g) Methods of achieving the required level of integration identified in (f) should be established, including the method of integrating the client and the process of building provision.

h) The pattern of managing system activities should be identified as a product of the constituent firms and members of the project organisation structure and the authority and responsibility of the managing system and contributors to the operating system should be established.

## 5.2 THE TESTING TECHNIQUE

The Linear Responsibility Analysis (LRA) technique was devised to give insight into the types and complexity of the interrelationships and interdependencies of contributors demanded by building projects. From this analysis it was anticipated that quantitative data relating to the differentiation within projects and the integration effort provided could be generated for testing the propositions of the model within the environmental context.

The technique was successful in maximising the use of historic interview data for this purpose. It also demonstrated the viability of deriving quantifiable data on relationships in a form which allowed the major influences on project outcomes to be exposed.

The model, analytical techniques and available data are iter-related for the purpose of further developing the model. If data could be obtained in real time, the subsequent LRA is likely to provide data for testing with the potential for further enhancement and refinement of the model. However, care would be needed to ensure that concentration upon the detail of relationships did not overcome the perspective of the whole system. In particular, more detailed knowledge of the Project Conception and Inception stages and of the relationship of sub-contractors, both main contractor appointed and nominated, would be particularly beneficial.

The effectiveness of the LRA technique lies in its ability to expose both the process of providing a building and the way in which the managing and operating systems are arranged in relation to the process, together with identification of the activities of the managing system in relation to the tasks of the operating system. The visibility provided is well illustrated by the LRAs given in Appendices 1, 2 and 3 for the three test projects, which exhibit three quite different patterns which are reflected in the data which is quantified for the tests.

The detailed tests,given in 3.2 of each test project appendix (Appendices 1, 2 and 3), used data quantified from the LRAs to test the propositions of the model against the causes of deficiencies in project outcomes. The testing procedures were successful in achieving this. The detailed tests were carried out within the context of an initial test of the model against the performance of projects as a whole,given in 3.1 of each appendix, which incorporated both attributes and deficiences of outcomes, so that conclusions could be drawn regarding the overall validity of the model within which conclusions drawn from the detailed tests using outcome deficiencies could be placed.

The initial tests required definition of the projects environments and statements of client satisfaction with the outcomes. Whilst these aspects were pursued only to the extent necessary for the initial tests, the possibility of a mathematical approach to the measurement of the impact of environmental influences upon projects and the measurement of the satisfaction of clients with project outcomes was proposed and a framework for such an approach was provided using vector analysis techniques. In developing mathematical approaches to these factors, problems will exist in testing them. In the case of environmental influences it will require detailed, and what could be confidential, information from within client organisations. In the case of client satisfaction, there will be problems in reconciling the value criteria of various clients, both between clients and against what clients could reasonably expect at the outset of projects, which will influence the ranking of output attributes and deficiencies.

The method adopted exhibits potential for computer application which would allow the actual configuration adopted on projects to be manipulated to test the sensitivity of the outcome of projects to changes in both the process and the relationships between and within operating and managing systems. Although this research did not adopt a comparative approach, the data quantified from the LRAs demonstrated a potential for such an approach using statistical analysis which would also benefit from computer application to the LRA technique.

This research has indicated that the LRA technique has potential for applying of the model's propositions to the design of organisation structures as well as for analysing completed projects. The approach to designing organisation structures given in 5.1.5. would be implemented by building up an LRA for a project. This would have the effect of ensuring that the designer considered each aspect of the model in arriving at the proposed structure. The use of the LRA as a planning technique would provide a facility for controlled adaptation of the structure in the light of environmental changes as the rationale of the structure would be clearly stated.

## 5.3 IMPLICATIONS OF THE RESULTS OF THIS RESEARCH FOR THE ORGANISATION OF PROJECTS IN PRACTICE

Although the model was tested against only three industrial/commercial projects for private clients, it is possible at this stage to put forward some implications for the management of building projects in general.

The overriding implication is the benefit to be derived from an explicit recognition of project management skills in their own right rather than as something which is subservient to other professional skills and that the initial task of those exercising project management skills on behalf of clients would be to design project organisational structures appropriate to particular projects and their environments. Although alternative methods of structuring project organisations are emerging, in a large proportion of cases conventional arrangements[(i)] of contributors are automatically adopted and preordain the structure to be used irrespective of the particular requirements of projects to be managed. The conventional arrangement has arisen from the relative positions achieved historically by the various professional institutions and their influence upon the manner of contractor appointment and project organisation.

(i) With the architect as the design team leader and, by implication, exercising project management fuctions and the contractor appointed, by competition, after substantial completion of design.

The institutions have, therefore, achieved some degree of monopoly and hence what Child[89] calls a 'protected niche' in the environment. This allows an organisation comprising members with such protection to accept a level of sub-optimal performance if the organisation chooses not to match its structure to suit the prevailing environment. Thus clients, on whose behalf such organisations manage building projects, may not be provided with the optimum organisational structure for their projects.

There is some evidence that the 'protective niche' is being broken down as the professions seek to survive in an increasingly complex environment. However, the mismatch of organisational design and project need arising from the automatic assumption that the conventional manner of project organisation is appropriate for all projects still persists for a large proportion of projects.

The strength of the professional institutions, and hence the standing of their members arose through their establishment and maintenance of standards of professional conduct and skill. Thus, their members' clients were protected against the unscrupulous and unskilled. This objective had the effect of creating the 'protective niche' referred to above, and established patterns of working which inhibited innovation, particularly in the management of projects. Individual institutions concentrated upon the development of professional skills in environments which were relatively stable and, in the case of architects, concentrated upon the enhancement of design abilities at the expense of project management skills - a situation which is strongly reflected in the education of architects in the U.K.

The need to protect building clients from the unskilled and unscrupulous is of great importance but should not be a barrier to flexibility in the design of organisations for the management of projects, yet the innovations which have taken place in this field have tended to be initiated outside the institutional framework, e.g. Managing Contracting[40], Research into Site Management[41]. Institutions have not worked together to develop the management aspect of their contribution, yet a corporate approach is necessary.

The characteristics of the model represent an abstract approach and other criteria may need to be balanced against its propositions in practice. One of those criteria may be the need for the protection afforded clients by the conventional arrangement. Another may be achievement of minimum cost of a project leading to the adoption of competition for the award of the building contract (which, it has been shown, inhibits the design of appropriate organisational structures). The adoption of such criteria may produce a sub-optimal organisational structure, inhibit management performance and produce deficiencies in project outcomes greater than the advantage gained by satisfying the particular criteria.

The model does not represent a panacea for good management, it provides only the criteria against which organisational structures should be judged and will, naturally, require the application of sound management skills within the structure. However, it does represent an approach to designing structures which give managers a better chance of success than those currently employed and one which should provide an organisational framework which has potential for reconciliating competing criteria to provide a satisfactory project outcome for clients.

The concept of project organisation arising from the institutional framework is represented by the RIBA Plan of Work for Design Team Operation[13]. The Plan represents a sound approach if the conventional arrangement of working is appropriate for a particular project and was probably a useful step forward when it was devised in 1963, but the fact that it has not been significantly revised since then indicates the pace of professional institutions' thinking in this area. The Handbook in which the Plan appears assumes that projects will be architect designed and managed, and also assumes a project cost of about £300,000 at 1973 prices, which is about £800,000 at 1980 prices. No reference is made to the uncertainty surrounding projects caused by environmental influences or inherent complexity due to the type of building required. It does not, therefore, discriminate between the various needs of different projects and although it recognises the need for adaption of the procedure to suit particular circumstances it does not propose any criteria upon which this should be based. It makes a number of other assumptions which are challenged by the model proposed in this work and which invalidate the Plan as a generalisation for project organisation.

The Plan does not recognise the effect on project organisation of the influence of the client's environment and, as a result, lays down a rigid pattern of sub-systems. Whilst, by implication, it recognises that Decision Points will occur, it assumes their positions in the system and does not recognise that their positions will vary between clients and projects as a result of clients' environments. Such an assumption leads to rigidity in approach to project organisation. This view is reflected in the Plan's proposition that the client sets up an internal organisation for management of the project 'from the client end' before appointment of any consultants and there is no reference to the task of organisation design. The result is that the Plan builds in a potential for inappropriate design of feedback loops and does not stress the need for the project team to advise the client on mechanisms for integration of client and project organisations.

The lack of recognition of environmental variability is further demonstrated by the statement that the brief should not be modified after the Scheme Design stage and the assumption that tenders will be obtained on a competitive basis after completion of production information, although there is a passing indication that the contractor can be appointed earlier.

A fundamental assumption of the Plan is that the architect will exercise both management and design functions. This arrangement conflicts with the model which proposes that managing and operating systems should be separated to avoid conflicts which may not be reconcilable in the client's interest if managing activity and operational skills are undifferentiated. If management and some operational roles are vested in one person, e.g. the architect, there is potential in the system for those skills to dominate, which could lead to imbalances in the project outcome between competing criteria. This arrangement allows the person in the managing and operating skill position to determine the interdependencies between himself and others in the operating system and may lead to him establishing sequential interdependencies where reciprocal are more appropriate. Separation of managing and operating skills allows the person in the managing position to establish interdependencies and to decide priorities between competing criteria independently of any vested interest in particular operating skills.

The Plan identifies the co-ordination role of the architect in carrying out management functions but makes no reference to the differing degree of differentiation which may occur due to the manner in which the project organisation is designed and hence does not recognise the need for different levels of integrative effort. The Plan does not make explicit the need for reciprocal interdependencies between contributors and, although it is implied, it is left to the interpretation of user. This could also lead to sequential interdependencies being created where reciprocal are needed and hence difficulty in integration, particularly where the architect is also exercising management functions.

The Plan envisages the managing system itself being undifferentiated and reflects this principle of the model but conceives it being undertaken only by the architect, which is not in accordance with the model, and creates rigidity in the Plan. However, refinement of the model identified that generally, in practice, the managing system would have two parts - the manager of the project organisation and the client. The Plan does not reflect this degree of involvement of the client in managing the process, but rather sees the client responding to the architect's request for information and decisions. Thus the Plan casts the client in the relatively passive role of transmitting information to the architect at his request rather than being closely involved with the management of his project. As a consequence of this, the integration of the client in the process implied by the Plan is not high and does not recognise the need for this integration to be varied to suit the prevailing environment.

The Plan further demonstrates its management perspective in its definition of management functions during construction, the contract for which is assumed to be awarded on the basis of a competitive tender. The management functions are seen to be administrative in accordance with the form of contract adopted which is normally the Joint Contract Tribunal Standard Form. As has been shown, this creates duplication of managing functions and hence a differentiated managing system and does not achieve integration of the client and allow him to be involved in the managing system to any great extent during this stage of his project.

This relatively passive role during construction, of both architect and client, is created by the use of the JCT Standard Form of Building Contract[111] which is by far the most commonly used. This situation is typically illustrated by the 'Extension of Time' clause which does not allow the architect to be dynamically involved in correcting deviation from the desired project completion date and places this responsibility on the contractor. The recently revised edition[112] does not alter the general tenor of the contract although there is a new provision for the contractor to supply a 'master programme' for the contract and to update it within 14 days of certain specified occurrences. However, the new form does not define the content and level of detail required in the 'master programme' which could lead to disagreement between the contractor and the manager of the project for the client and severely limits the usefulness of this clause. The need for involvement of the client's managing system in the management of the construction stage and any consequential amendment to contract clauses this may require, or the use of specially devised forms of contract, need to be weighted against the legal protection afforded by contracts of the JCT Standard Form type. The effect of the standard forms of contract upon the management of projects for clients is a useful area of research which has not been considered in detail in this work.

This outline comparison of the conventional process and the model illustrates the rigidity in the approach to project organisation which generally exists. However, it is interesting to note that the RIBA Handbook which contains the Plan does acknowledge that a project management function separate from design skills may exist for very complex projects but it does not attempt to recognise the range of complexity of projects and environments and the variety of organisation structures which may be appropriate. In addition, the Handbook visualises such a project manager in a non-executive role and therefore being concerned only with co-ordination of contributors and not involved with decisions which are assumed to be taken by the professional consultants.

A release from the general rigidity of the conventional systems needs recognition by the building professions and industry that:

a) successful project management is fundamentally important to the successful outcome of projects,

b) project management functions should be undertaken separately from the operational skills required by the project, and,

c) the initial project management function is to design an organisational structure appropriate to the needs of the particular project.

Such a focus on the management requirements of projects and the design of structures would give the required platform for innovation, not only in the design of organisation structures, but also in the techniques and methods of project control and accomplishment. Such an approach has emerged tentatively in recent years in the guise of the appointment of a project manager from an independent firm, 'in house' project management and project management by firms which also provide some operational skills. The latter often in the case where there is a need for a dominant operational skill and a project manager with such a background is felt to be appropriate. The implication of this research is that there cannot be one prescribed approach for all projects and that each approach will be valid in different circumstances. If the model is used for classifying experience from a wide variety of projects, it should be possible to devise a taxonomy of matched projects and organisation structures.

An interesting feature which emerged from the test projects was that, whilst operational skills were available from the professions for design and cost aspects, the time frame and programming of work prior to construction was a function of the managing system. Thus, whilst managing systems were concerned with controlling on the basis of design and cost proposals produced by the operating system, managing systems undertook an operating activity in producing programming proposals as well as exercising control over time. The control parameters of Function, Time and Cost are set by the managing system on the basis of discussion with and agreement by the client and confirmed as acceptable on the basis of the professional advice of the contributors. However, although professional contributors are able to offer advice on Function and Cost, there is a weakness in the skills of the professional contributors in programming both design and construction.

Recognition of the need for greater integration between the contributors has been reflected in novel project arrangements devised recently. However these approaches have tended to concern themselves with reducing differentiation rather than with providing greater integrative effort. The approach of Management Contracting [40] (MC), Alternative Methods of Management[42] (AMM), and Research into Site Management[41] (RSM) have all been of this type and have all been particularly concerned with reducing differentiation between design and construction. In the case of AMM and RSM the objective has been mainly to involve designers on site during construction and in the case of MC to involve constructors in the design process. Whilst valuable contributions to project organisation, they tend to attempt to solve only one problem within the system and would probably make a greater contribution if they were able to be incorporated within an approach which aims to implement other proposals of the model. Similarly, projects which are designed and constructed by one firm, i.e. 'Package Contracts' should have lower integration needs, as differentiation within a single firm should be relatively low. However, project organisations designed on this basis will also have to subscribe to the model's other proposition. This type of project organisation has the potential to adapt to meet the model's proposition in different environmental conditions particularly if the client has 'in house' professional skills which can form the client's side of the managing system. Alternatively, the structure could be compatible with the model if the client has a managing team which includes advisors from professional practices and if the client structures his organisation to fully incorporate his professional advisors and to incorporate the managing system of the design/construction company at the appropriate time. A carefully designed integrating mechanism is necessary for such projects. The approaches which seek to reduce differentiation are useful, but the majority of projects are likely to be influenced by them only slowly. There is a need, therefore, to devise methods of achieving greater integrative effort for the majority of projects for which contributors are greatly differentiated due to the structure of professional firms and contractors.

Innovation in the design of project organisations should lead to the identification of a group of people whose primary concern is the management of building projects for clients. Their common purpose could have important effects upon information systems and the application of management techniques in the building industry. To carry out project management effectively, one of their major requirements would be to establish effective information flow and the application of management techniques on individual projects. This can be expected to act as a stimulus to industry-wide information systems and data co-ordination and the development and application of management techniques appropriate to building projects. It is significant that although theoretical work has been done on these aspects, their application has been severely limited. With such developments it can be expected that the uneven and unco-ordinated applications of electronic aids in the building industry would also have a framework for concerted and co-ordinated application, particularly in view of the advent of microprocessors. Such effects arising from project management developments would be a significant stimulus to further concentration upon the management needs of projects through the provision of effective tools for project management. Structural innovations, information systems, techniques and computer applications would feed off each other to the benefit of the building industry and its clients.

Although not formal conclusions regarding the model, a number of issues arise from the test projects which should have attention drawn to them. There was quite a marked variation in clients' perception of the building process and their approach to the design team, varying from a relatively structured and formal approach to an informal and amorphous attitude which tended to reflect the level of definition of their requirements. It is important to note that even when the client's approach appears structured, using an integrator from within the client organisation, integration between the client's integrator and higher decision making authorities within the client organisation must be achieved in the interests of project progress.

The benefit of an explicit and formally documented statement of client's requirements is essential to sound feedback mechanisms (as illustrated by the Transmittal Document on Test Project No. 1). This need is not confined to projects for which the client can clearly identify his needs but is equally necessary, if not more so, on projects with a high level of uncertainty. Naturally, for the latter, the statement cannot be as detailed, but will form a basis for revision and updating as the design develops. 'Sketch proposals' are unlikely to be sufficient for this purpose. A dossier containing all relevant matters, including 'sketch proposals', would create a more useful basis for feedback. Similarly, action minutes of meetings are particularly important in uncertain situations from which information can be extracted for revising and updating the requirements dossier and aid feedback. Such developemtns are only likely to take place if initiated by someone whose primary concern is management of the project for the client.

The quality of construction work, particularly that carried out by the bricklayers, caused concern on all test projects. It was claimed that this stemmed from the use of competitive tenders but probably also rose from the quality of supervision by contractors and consultants and reflected the level of expectation of clients. Clients would be better served by permanent or semi-permanent supervision e.g. Clerk of Works, on site directly on their behalf but would have to be prepared to bear its cost.

The employment of nominated sub-contractors created problems and dissatisfaction on the test projects due to the duplication of managing activities during construction. Nominated sub-contractors tended to communicate directly with the managing system for the client rather than with the contractor, leading to a breakdown in communications and difficulty in sequencing work. This situation was compounded on Test Project No. 3 due to a direct contract with the client for a substantial part of the project. Similarly, separation of projects into sequential contracts can produce communication problems. It should be clearly recognised that nomination of sub-contractors and establishment of contracts separate from the main contract are likely to create significant problems in managing projects under conventional competitive arrangements.

The question of fees is invariably raised in discussions on project management. It should be acknowledged that the architects' fee scale and conditions of service[113] include management of projects for clients. The fee for an architect's normal service is charged upon the total cost of the building, including work designed by other consultants, and although management of the project is not explicitly included, reference is made to integration of other consultants. However, the statement of architects' responsibilities at construction stage is passive, for example 'to determine in general if work is proceeding in accordance with contract documents'. Similarly, he is only required to inform the client if the total authorised expenditure or contract period are likely to be materially varied. The payment of the bulk of professional fees by the commencement of construction reflects the relatively low level of input to the construction stage by the professions. Due to the limitations imposed by the JCT Form of Contract their influence is passive and concerned with monitoring the work of the contractor rather than being dynamically involved in ensuring that the client's requirements are met. The balance of fees does not reflect the management input which is really demanded during construction, but will influence the amount actually provided. However, it should be acknowledged that clients should be able to expect an appropriate level of management of their projects. A project management fee in addition to the normal fees for professional skills would, therefore, appear to be unreasonable just to ensure that management is done properly. An additional fee may be justifiable if special management services are to be provided which produce savings in costs in other areas or if it can be shown that the existing fee scales do not reflect the management demands of projects in today's complex environment. A part of the design of organisational structures should, therefore, be the negotiation of fees between the contributors which clients should not normally expect to be greater in total than the normal combined fees of the contributors. It is accepted that this may be difficult to achieve against the background of conventional fee scale arrangements, but negotiation in terms of payment based on the actual services to be provided should give an acceptable outcome given the support and involvement of clients. The calculation of professional fees as a percentage of the cost of construction means that the amount of work done for the fee paid is not known outside the individual professional practices. It is, therefore, difficult to establish the management costs of building projects and whether an additional fee for undertaking this work to the extent demanded by today's conditions is justifiable. This research did not examine the level and distribution of fees for management of projects for clients relative to the actual time spent on management activities but this could be a fruitful area of further research if linked to an investigation of the management skills employed.

The complexity of the environment of many of today's building projects presents a direct challenge to the inertia of the building industry, its professions and its clients. A greater concentration upon the management requirements of projects and innovation in the design of organisation structures should go some way to providing a platform and framework for solving many of the problems encountered in providing satisfactory outcomes of building projects.

## 5.4 LIMITATIONS OF THIS RESEARCH AND PROPOSALS FOR FURTHER WORK

By definition, the application of systems theory to the organisation of building projects requires consideration of the total system and the manner in which its parts are interconnected. This work has identified the components of the system, the way in which they interrelate and hence their influence upon each other and the system as a whole, for a sub-set of buildings. This approach has the advantage of exposing the range of factors which influence the effectiveness of management of building projects for clients. In so doing, it also exposes both the limitations of this work and some other gaps which exist in understanding. This in itself is an advantage as it gives direction to further research.

There are limitations to this work in using historical data for analysis. This approach limited the ability to obtain information in the most useful form. Testing the model against projects in real time rather than using historical data would significantly enhance understanding of the system, particularly if comparative studies of different organisational approaches were incorporated. To derive the greatest benefit, such an undertaking should commence at the very start of the project and encompass the Conception and Inception Processes for which little data was available in this work. Similarly, concentration on the construction stage, particularly with regard to sub-contractors, would be useful in identifying the relationships which emerge, their relationship to earlier systems and influence on project outcomes. Whilst aggregation of tasks in this area occurred in this work, nevertheless, these relationships were shown to have a significant effect on project outcomes. The difficulty of mounting such a research programme should not be underestimated. The major problems would be in gaining access to clients' organisations and what may be confidential data and the actual duration of such a programme as determined by the duration of the projects used.

Whilst the analytical method adopted in this work enabled cause and effect relationships between project outcomes and organisation structure to be traced, it has emerged that a mathematical approach could produce benefits through a closer and more formal definition of relationships which could be used to enhance aspects of the model. Development of the vector analysis approach for measuring clients' satisfaction with project outcomes and understanding and classifying the effects of environmental forces would be a necessary base for such further work. In particular, a greater knowledge of environmental forces and their impact on building projects would make a significant contribution to understanding the performance of project organisations.

Although this research did not adopt a comparative approach, the data quantified from the LRAs illustrates a potential for such an approach which could usefully employ statistical tests, such as Student's t Test, in a statistical analysis of projects with different organisation structures. Such an approach would require a sufficiently large sample and would also probably require further work on environmental factors and outcome satisfaction referred to above. Alternatively, it may be possible to set up a statistical analysis of specific parts of the data. A fruitful approach may be an analysis of the integration of the client and project team using data similar to that provided by Table 8 and 9 of the Test Project Appendices. The relationships which emerge, if viewed within the context of the total system should add considerably to understanding of the working of the system.

Reference has been made previously to the advantage to be gained from sensitivity analyses of projects in which structure is changed and the resulting outcome of projects measured. Such an approach would require the application of mathematical techniques to the data arising from the LRA, perhaps matrix analysis, so that cause and effect relationships can be accurately established. This approach could lead to the identification of priorities of the model's propositions and provide proposals for the order of priority of further research.

Any further research using the LRA technique would benefit from computer application. The programming of the LRA technique and derived data should not be difficult and would add significantly to the efficiency of any future research. More importantly, however, such a program should enable a wider range of data to be extracted from the LRA and would allow rapid manipulation of the data and experiments with different formats. Such a program could be linked with programs for any statistical or other mathematical techniques employed in analysing data to produce a suite of programs for project analysis and design.

This research has been concerned with the structure of organisations as a product of the process to be managed. It has recognised, but not incorporated, that behavioural characteristics of contributors have a significant effect on the performance of the system and this is a limitation on the results. An objective of management will be to harness the characteristics of the people involved in the process to the benefit of the client. However this needs to be achieved within a structure which is appropriate to the achievement of the particular project. Although a significant amount of work has been undertaken in other fields on behavioural characteristics, there has been little application to the building. This work identified sentience as reinforcing differentiation which, although it may be considered a behavioural phenomenon, is predominantly a product of structure (i.e. of profession and of firm). This work also assumed that the people involved were competent in the skills they used and there was no evidence to show that this was not so. Nevertheless, there is an important need for research into the behavioural characteristics of people involved in building and their effect on project outcomes. An associated area for further work is authority and responsibility patterns of different organisation structures and the legal protection afforded to clients and contributors. The interrelationships of contributors to building projects make it difficult to apportion responsibility and this represents an aspect of concern to newly emerging organisation structures.

This research is also limited by the number of projects against which the model was tested and by the fact that it was tested against only one building type for only one class of client. Therefore, in parallel with the alternative approaches outlined above, there is scope for development of this research along the lines it has followed. Additional testing of the model against a wider range of industrial and commercial projects would further examine its validity and give more insight. In particular, tests against projects which employed tendering arrangements other than competitive would be useful, especially if they involved early appointment of the contractor. The enhancement of the model by testing it against projects for types of buildings and for classes of clients other than industrial/commercial clients would seem to be an extension of primary interest.

This research has found that,during construction,standard forms of building contract inhibit the management of the project for the client by his manager. However, the research has not analysed in detail the manner in which this occurs. This would seem to be a useful avenue to explore and will probably require analysis of the effect of each clause of the contract in relation to its inhibition of effective management on behalf of the client. This approach would require a clear under-standing of the relationships between legal protection of clients and the opportunity for managers to influence project outcomes. Benefit could also be derived from a comparison between various standard forms of contract from the position of the facilities offered for the manager of the project for the client to be dynamically involved in managing the process during construction. Of particular interest would be a comparison between the forms of contract generally used in building and those used in civil engineering and other industries and between those used for competitive tenders after completion of the design by professional contributors and those used for 'package deals'.

This work did not consider the level and distribution of fees for management of the project for the client but this could be a useful approach for further research. It would require the identification of the time spent by the various contributors on management of the project for the client. This would require careful monitoring of inputs in real time or the obtaining and analysis of accurately prepared time sheets. It may be possible to match the time spent on various projects against the project outcome and also to investigate the quality of the management skills employed. The results of such a research project could form the basis for a formal revision of fee scales in which they could be structured to reflect the actual time spent on projects by various contributors.

On particular interest is the scope provided by this work for less extensive research projects than those suggested above.

Investigations of specific aspects of the system, for example the conduct of site meetings, relationship between client and design teams, the use of nominated sub-contractors, can be carried out within the context of the system analysed in this work in such a way that they can be related to the system in which they occur, thus making their findings more relevant to the management of projects.

## 5.5 POSTSCRIPT

This research has adopted a holistic approach to the management of building projects for clients using a methodology as near as possible to that adopted in more traditional research fields: Hypothesis - Observation - Interpretation - Conclusion. In order to achieve penetration in an holistic study of such a wide area, the projects used for testing the model were restricted to industrial buildings for private clients.

The systems approach was a valuable starting point for this work as it contains concepts which are pertinent to the complexity of the interrelationships which building project organisations generate and the objectives they seek to reach. In applying systems theory to building, abstract concept had to be developed from diverse sources and it has been found productive to learn from applications in other fields. This produced challenges in interpreting approaches in other fields as researchers work in the language of their own discipline as well as in the language of systems theory. The model was, therefore, derived from a discrimination of work in other areas as well as from the basic concepts of systems, as there was found to be little work related to building. At this stage, and although basically descriptive, the model does provide a tool for analysis and a platform for designing organisations. There is scope for more work on the underlying theory and the opportunity for quantitative development now exists.

The systems approach pointed the way to techniques of systems analysis which provided a disciplined and structured method of analysing projects and, in some small way, to quantitative methods of testing the model. The method adopted has shown that techniques can be devised for carrying out rigorous 'post mortems' of building projects which reveal management created cause-effect relationships for the symptoms exhibited in project outcomes.

Unfortunately, it was only possible to test the model against three projects due to the amount of time needed to carry out such tests. Not only does this limit the range of buildings and client types but also limits the range of incidents affecting project outcomes which could be examined, for example on the test projects there were no problems with planning and other statutory approvals. Yet, such is the nature of the building industry that each project tends to be unique, with its own particular set of problems. Additional testing of the model on other projects will, therefore, provide further insight.

The research achieved its objective in so far as it has shown that it is possible to identify valid abstract concepts of significance to the management of building projects for clients and embody them in a model which is a useful basis from which to design organisation structures. It has also shown how little theoretical work has been done in an area of vital importance to the building industry. A major benefit of the research is, it is suggested, the provision of a springboard for further research arising from the broad perspective adopted. This framework could provide the basis for co-ordinating a range of research programmes into project management and for demonstrating the interrelationships of future pieces of work whether they adopt a holistic approach or examine a particular part of the system.

The major finding of the research is the need for flexibility in the approach to organisation structures for building projects which is contrary to the most commonly adopted approach in practice which assumes that there is only one method of structuring project organisations, i.e. with the architect as designer/project manager and the contractor appointed by competition after the design is substantially complete. The research has confirmed the hesitant developments in practice of adopting new approaches to project organisations, and has provided a framework against which they can be judged. In particular, it has shown that the environmental context of a project and the nature of the task to be undertaken should determine the organisation structure adopted and has identified a method of doing this.

The results challenge the professional institutions to re-think their ideas and attitudes to project organisations in order that they and the building industry can serve their clients in the best possible manner. The flexible approach to organisation structures suggested means that far more research is required in this area than has been carried out in the past if we are to extend our understanding of the most suitable match of organisation structure and project environment and task. The traditional assumption that there is really only one way to structure project organisations has inhibited research in this area and little theoretical work has been undertaken, since the need for it has not been recognised. It is hoped that this research will act as a stimulus for others to pursue research in an area which is in its research infancy but which will eventually provide significant benefits for the building industry's clients, its members and, ultimately, national economic performance.

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