A Model for the Design of Project Management Structures

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Introduction

This paper reports upon a research project sponsored by the Institute and carried out at Liverpool Polytechnic. It is an extension of the work which resulted in the publication, by the Institute, of "Project Management: A review of the state of the art"[1] but takes a far more fundamental look at organisation structures for building projects and their benefit to clients.

The objective of the research was to identify a fundamental framework of organisation theory relevant to building projects, the lack of which has been identified[2, 3] as inhibiting improvement in co-ordination and co-operation between the building professions and industry. Such a framework would allow various organisational initiatives to be measured and compared. The determination of organisation structures was pursued as a function of the needs of the process of building provision and was not constrained or predetermined by conventional assumptions. The basic premise is that the design of organisations should follow definition of the process to be managed.

The objective was achieved through the development of a model which was tested against recently completed projects. The model was specifically client orientated and not directed towards the objectives of the contributors to projects except insofar as they affected clients' satisfaction with the outcome of projects.

Whilst it is difficult to condense the research in a paper such as this, the salient features of the model, the methodology and the results are identified and discussed. The theoretical basis is systems theory and its application to organisation. The research draws upon that of Lawrence and Lorsch[4] and Miller and Rice[5] and related systems theory to the building process, as described in an earlier paper[6].

The Model

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 subset of elements is unrelated to any other subset[7]. Systems theory recognises closed and open systems, but organisations can only exist as open systems. An open system has an environment to which it adapts by changing the structure and processes of its internal components. A system's environment is, therefore, 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 state of the system.

The model identifies the system and subsystems of the process of providing a building and identifies the environment of the process and the manner of interaction between the system and its environment. The environmental forces can be briefly classified as political, legal, institutional, cultural, sociological, technological and economic.

Anthony Walker

In 1974 the Institute recognised the need for research into the management of building projects on behalf of clients by sponsoring, at Liverpool Polytechnic, a study of the activities of project management undertaken in practice. This study resulted in the publication, by the Institute, in 1976 of "Project Management: A review of the state of the art".[1] The success of this project encouraged the Institute to sponsor further work at Liverpool Polytechnic in 1977 with the objective of relating organisation theory to the project management needs of clients. This paper is the first report of this work which, as with the first project, was carried out under the auspices of the Institute's Research Committee under the Chairmanship of Mr. Eddie Hall.

If the system is taken as commencing with a start point which is the client's initial need to acquire an additional performance for his organisation and ending with a completed building which contributes to providing that performance, then it is only possible to identify three sub-systems which will be common to all projects, as shown in Fig. 1. Each of these sub-systems will terminate in a Primary Decision which will be taken in response to environmental forces. Fig. 1 shows the decision resulting in a new building being constructed, but other choices may have been made. The information, energy and material imported to the system from the environment determine the choice of outcome of each sub-system. These three sub-systems are called the Systems of Activity of Project Conception, Project Inception and Project Realisation respectively. The conventional design and construction stages lie within the Project Realisation System but the model clearly identifies the two important systems which precede that system. The model is constructed for commercial/industrial clients, but the principles are applicable to other types of client.

Each of these systems of activity will be divided into sub-systems, but it is not possible to identify universal sub-systems. It is only possible to identify their determinants which enable sub-system to be identified for each particular project. In order to reach a Primary Decision, each system of activity will have to progress through 'pinch points', or what are termed Key Decision Points which, when the decision is taken imply a degree of irrevocability. To revoke such decisions would entail the client in loss of either resources already expended or in the future. Key decisions are taken by the client. Each of the sub-systems created by Key Decision Points is further sub-divided by Operational Decision Points. Operational Decisions contribute to and constrain Key Decisions and may be taken by the client's advisors as a result of or in making progress towards a Key Decision. The process of building provision is characterised by discontinuity due to decision points and the resulting incremental nature of the task. Each level of this hierarchy of decision points provides feedback opportunity.

The sub-systems created will be interdependent either sequentially or reciprocally. Sequential interdependency requires that one sub-system must act properly before the next sub-system can act. Reciprocal interdependence occurs when the outputs of each sub-system become the inputs for the others and the process moves forwards through a series of steps in which each step requires interaction between sub-systems. The sub-systems created by decision points will be sequentially interdependent, but in arriving at each Operational Decision the contributors to the project will be reciprocally interdependent. In order to work effectively, the contributors will need to be integrated and the degree to which they are differentiated (and hence the degree of integration required) will be determined by:[8]

(a) The technical demands of the task which determines the way in which the work is divided between the contributors

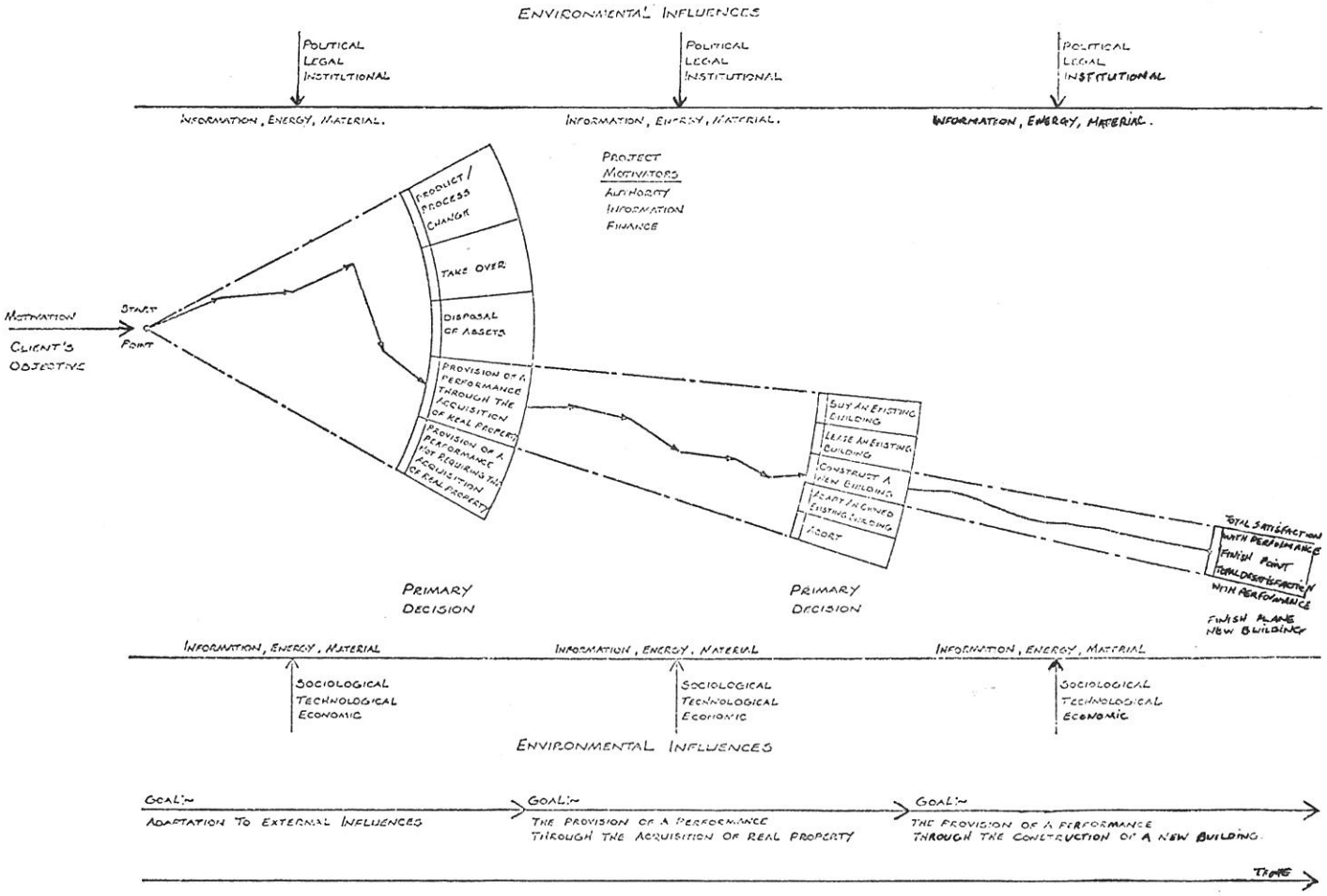

FIG: 1. AN OUTLINE OF THE PROCESS OF BUILDING PROVISION

(Technology).

(b) The geographical distance between the contributors (Territory)

(c) The sequence of activities required of the contributors (Time)

Contributors to a project will, therefore, work in reciprocally interdependent groups in arriving at an Operational Decision which are called Task Sub-systems. Further differentiation may be introduced through sentience. A sentient group is a group to which individuals are prepared to commit themselves and on which they depend for emotional support[9]. In the building process this can arise from the firm or from profession or both and demands additional integrative effort.

The theoretical structure of the system resulting from these propositions is illustrated in Fig. 2.

As referred to earlier, the action of a system's environment should determine the Primary Decisions. It should also determine the Key and Operational Decisions. It is important, therefore, to recognise that it acts on the process of building provision in two ways (as shown in Fig. 3):

(i) Upon the client's normal business activities and hence be transmitted to the process of building provision (Indirect).

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

Where indirect and direct environmental influences act in a conflicting manner, the process of building provision should act to resolve the conflict to the benefit of the client.

As a result of identifying the decision or 'pinch points' in the system, the system model of the process makes clear the major feedback opportunities, which should be used to ensure that the goals of the sub-system remain orientated to the goal of the client.

Fig. 2 provides a conceptual model of the operating system (the system through which the input-transformation-output process is accomplished). The application of systems theory to organisations has recognised that alongside the operating system must exist a managing system (the system which provides the regulating and maintenance activities which keeps the operating system going)[5]. Its application to the process of providing a building identifies the purpose of the managing system acting on behalf of the client as:

(i) Establishing the client's goal.

(ii) Identifying any necessary adaptation of the goal in response to environmental forces.

(iii) Transmitting the goal and any subsequent adaptation to the systems and sub-systems.

(iv) Harnessing and mitigating the influences of the environment on the process of building provision to the maximum benefit of the client.

(v) Contributing to Primary, Key and Operational Decisions.

(vi) Integrating the systems and sub-systems.

(vii) Monitoring the activities of the systems and sub-systems to ensure that they are working appropriately to achieve the client's goal.

(viii) Ensuring that the system and sub-systems have the capability (both quantitavely and qualitatively) to achieve the goal.

The ability of a managing system to operate effectively depends upon an appropriately structured operating system and complementary managing system. The model identifies the elements of importance in structuring organisations and relates them to the process of building provision in abstract terms. The model does not, therefore, contain a rigid proposition for the 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 is seen to be to design the organisation through which it will work in achieving the client's goal.

The Propositions arising from the Model

The model is underpinned by 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 at Key and Operational Decision Points, all

of which identify clear feedback loops.

(ii) The differentiation within the system should be matched by the provision 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 client's organisation and the process of building provision should be integrated.

The model suggests that if a project's organisation subscribes to the above propositions then it should have the potential to mitigate and harness environmental influences to the advantage of the client and achieve client satisfaction with the outcome of the project.

Testing the Model

Having proposed a model it was necessary to test its validity. This was achieved by testing it against three recently completed projects to establish whether the model adequately identifies and explains the outcome of the test projects as a result of the organisational features of each project.

It was important for testing that the projects were for clients who had clear objectives for their projects. It was decided therefore to use industrial/commercial projects for private clients. The projects were similar regarding the type of building and client but used different organisation structures.

The number of projects used limits the conclusions but nevertheless provides a good indication of the model's validity.

The tests match particular organisational features to project outcomes, taking into account project environments. This is achieved initially by testing the propositions arising from the model against the configuration of each project to establish, in principle, their compatability. These tests are followed by more detailed tests which trace the causes of deficiencies in the outcome of each test project to establish whether they can be explained by divergence of the configuration of the project from the model. The model can be considered to be valid, in principle, if the initial tests show compatibility between the model and the test project where the project achieved client satisfaction with the outcome but validity cannot be confirmed unless the detailed tests using the outcome deficiencies give results which are consistent with the initial tests.

The basis of the criteria for the measurement of the projects' outcomes is client satisfaction. 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 with which it had to contend, indicate the performance of the process of building provision. A vector analysis method of identifying the performance achieved by the test projects was devised using component vectors of client satisfaction of Function (including quality), Time and Price and incorporating environmental influences.

Data for the tests was obtained from project drawings, specifications and other formal documents, from project files and, most importantly, from interviews with each of the major contributors covering the design team and the contractor. The data was validated by the contributors to avoid journalistic license. The raw data had to be translated into a form suitable for testing and a technique of Linear Responsibility Analysis (LRA) was developed using the Linear Responsibility Chart[9, 10] as the basis.

An LRA for a project gives visibility to the processes and relationships established. It makes clear the operating system by identifying the tasks undertaken and the differentiation present within the system and the types and degree of interdependency between contributors and their activities. It also makes clear the degree of differentiation of the operating and managing systems and identifies the structure and activities of the managing system.

An LRA is constructed as shown in Fig. 4 by identifying the tasks undertaken and their sequence to which is added the activities of the various job positions of the contributors, including the client. Activities are carefully defined as relationships between job positions and tasks and can be designed specifically for the LRA of a particular project or group of projects. This will

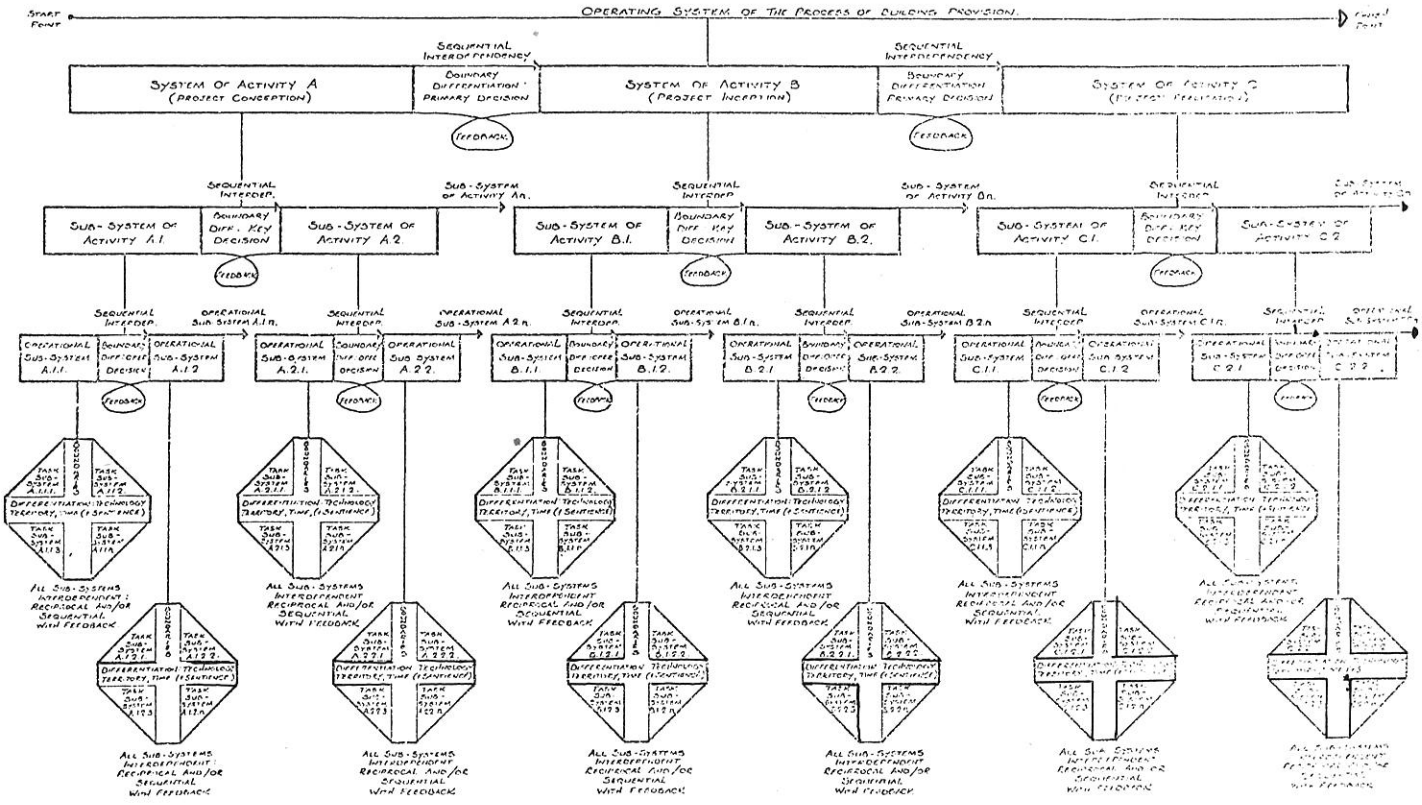

FIG: 2 THE OPERATING SYSTEM

identify those involved in the managing system (the control loops) and in the operating system. The type of differentiation existing between the contributors is then added as shown in Fig. 4.

An interpretation using LRA indicates:

(a) the tasks performed
(b) the task sequence and interrelationship
(c) the job positions and relationships of each job position to each task
(d) the differentiation within the system.

The level of detail of the tasks depends upon the data available, but LRA can operate at a level of abstraction suited to building projects which are invariably of long duration with much aggregation of detailed activities in the project plan. Nevertheless, the test project LRAs each contained about 40 tasks and when drawn to a reasonable scale were each about 2.5 metres long!

Having constructed an LRA, the Primary, Key and Operational Decisions can be located upon it to identify the sub-systems which occurred on the project.

From this detailed exposition of the project, numerical data can be established to show:

(a) the Differentiation and Integration of the Operating System.
(b) the Differentiation between the Managing and Operating Systems.
(c) the Differentiation within the Managing System itself.
(d) the Integration of the Client and the Process of Building Provision.

This data is used for the initial test to establish whether the configuration of the test project is compatible with the propositions of the model. The result of the initial test, the LRA, a statement of client satisfaction and environmental conditions of the project then allow the causes of deficiencies in the outcome of projects to be traced. A high level of compatibility between the model and projects which achieved client satisfaction taking into account environmental conditions, validates the model.

Conclusions

The tests showed that the identification of decision points within a project and hence feedback routes, and the identification of a project's environment, were essential prerequisites of organisation design in order that organisation structures are designed to reflect the process to be managed.

For every test project, some of the deficiencies in the outcome was caused by the effects of environmental forces which the managing system was unable to overcome. Although it is perhaps unreasonable to expect a managing system to overcome the effects of all such forces, anticipation of them can allow the organisation structure to be designed to cope with them. It is insufficient therefore for the manager of the project team simply to receive from the client a statement of the building he requires. It is equally important for the managing system to identify the susceptibility of the client's organisation and hence the proposed project, to change in environmental conditions in order to design an organisation structure with the appropriate

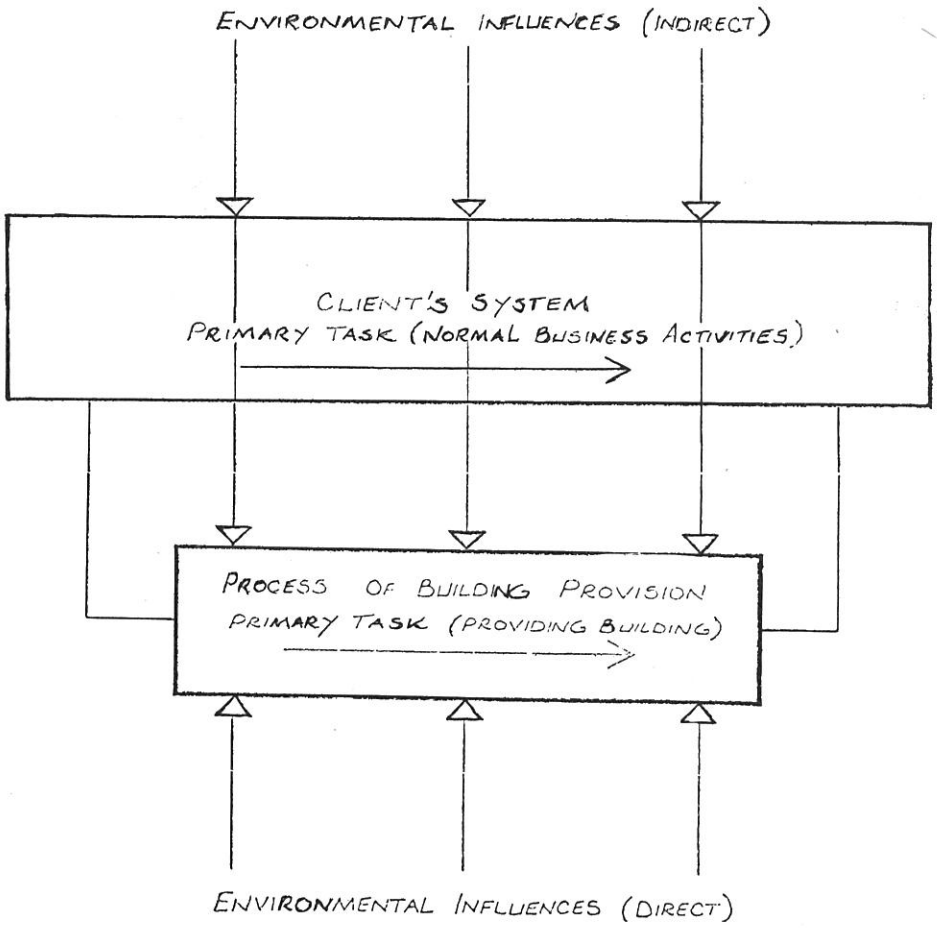

FIG: 3. THE ENVIRONMENT OF THE PROCESS OF BUILDING PROVISION

degree of flexibility. This requires the manager of the project to be involved as near as possible to the start point identified in Fig. No. 1 and also that the client has no preconceived notion of what the structure should be.

The degree of uncertainty of the project's environment determines the ability of the managing system to identify the decision points in a project. 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 identified at the outset and a clearly defined structure employed with precise feedback loops. However, at the other extreme, foresight of decision points will be short and a flexible and adaptable structure needed.

Projects are basically structured by the decision points with a hierarchy of Primary, Key and Operational Decisions which define the sub-systems of the process and create 'pinch points' through which a project's development must pass if progress is to be made.

The Primary Decision Points which determine the Project Conception, Inception and Realisation Systems shown on Fig. 1 were the only ones found to be common to all projects. The type and position of Key and Operational Decisions 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 the client organisation's internal procedures for expenditure or similar approvals. They could include, for example, approval of design and budget proposals and decisions to delay the project. However, if the client's organisation is not responsive to environmental forces, Key Decision Points may be inappropriately identified. They will present major feedback opportunities both within the client's organisation and also for the process of building provision. Operational Decisions, which contribute to Key Decisions and are constrained by them, are mainly concerned with procedural aspects and 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 organisation structure. The extent to which the manager is able to clearly define this process will depend upon the relative uncertainly of the client's environment. 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 planning Operational Decision Points within the framework provided by Key Decision Points.

This approach will ensure that the design of organisation structure begins on the basis of the process for which the structure is required and the environmental conditions in which it has to be achieved, ensuring that structure follows process and that artificial

structures are not superimposed on the process.

The model's propositions regarding the implications for effective organisation structure 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.

The amount of differentiation depends upon the number of specialist contributors employed and their inter-organisational relationships. It is a role of the managing system to identify the skills required and to structure them in the appropriate sequential or reciprocal interdependencies. This process generates the differentiation in the system from which the degree of integration needed can be identified. If this process is not carried out correctly, a false level of differentiation will occur with inter-dependencies inappropriately drawn so that the provision of an appropriate level of integration by the managing system is most difficult, if not impossible.

It was found that generally the managing and operating systems of 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. It was also found that the managing system itself will be differentiated into two parts—one part drawn from the client's organisation and one part from the process of building provision and that each part should be undifferentiated. Disruption of this arrangement can occur when there is duplication of managing activities (e.g. for contracts let on a competitive basis which introduce duplicated managing functions during construction) and when the manager of the project is excluded from the managing system at any point in the process (e.g. due to decisions being taken at a higher level in the client's organisation without consultation).

The quality of integration of the client and the process of building provision (integration of the two parts referred to above) 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 integrative 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 allows apposite and timely responses in assisting the process to achieve the desired project outcome. It is important that the manager of the process ensures at the commencement of the project, that the client has established appropriate integrating devices and it is particularly important that integration is maintained at Key Decision Points.

Postscript

Compared to the application of systems theory to organisation and management in other fields, its application to building projects showed how complex they are in terms of the types of relationships they generate. The organisational independence of many contributors to the test projects and the independence of the client organisations created a large number of the most complex types of differentiation identified by the model. It was found that the corresponding need for a high level of integration was not always recognised by those involved in the process and by clients.

Insufficient attention to the management needs of projects resulting in inappropriate organisation structures and insufficient integration effort in conditions as complex as those found on 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.

There is an often heard plea for a definition of project management which can gain general acceptance and there have been a large number of attempts to provide it[11]. The definition arising from this research is an operational one, that is, stated in terms of what would be observed if project

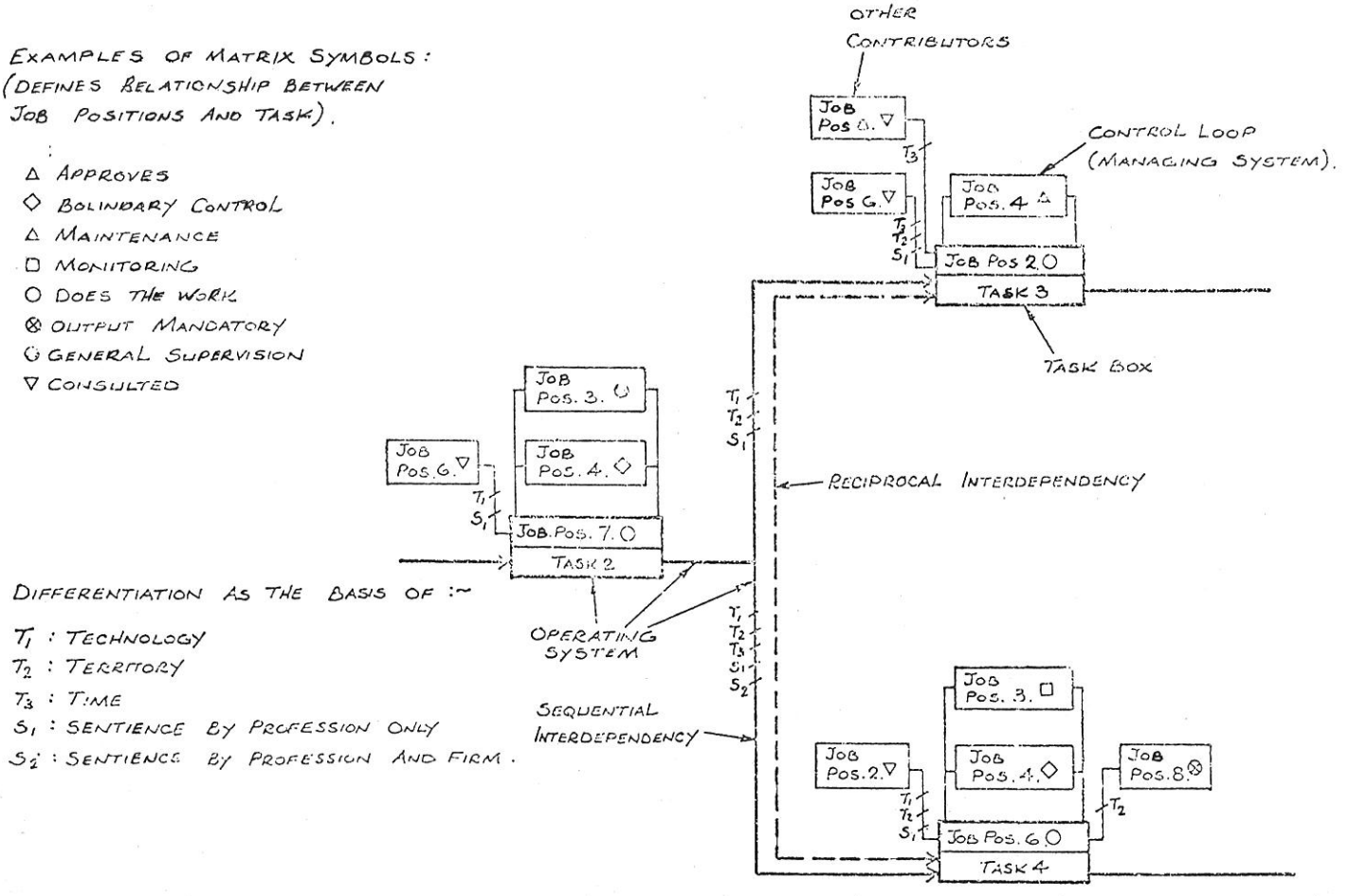

FIG. 4. THE METHOD ADOPTED FOR LINEAR RESPONSIBILITY ANALYSIS

management on behalf of a client was taking place and is:

> '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*, the integration monitoring 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'.

The systems approach, the model and technique of Linear Responsibility Analysis 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 research has highlighted the benefits to be gained by careful definition and implementation at an early stage of an organisation structure appropriate to the particular needs of a project and has provided the tools for its design.

The full research report is available at the Institute and also, through the Inter-Library Loans Scheme, in Liverpool Polytechnic Construction Library.

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

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The Trent Valley Branch very much regret the postponement of this Conference, originally scheduled for 19th March, 1981. This was due to the unavailability of the relevant new documentation.

The Conference has been re-arranged for 21st May, 1981, at a different venue, and further details will be published next month.