FLEXIBILITY IN LARGE SCALE PROJECTS

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Synopsis

Large Scale Projects are invariably the concern of a group of people, who come together for the duration of the development. A number of institutions may have an interest in the project outcome and want to influence its development, consultants may be assigned to contribute expertise to the development and contractors may be engaged to perform implementation roles such as construction.

These participants form relationships which, because of the scale of the project are complex and difficult to define. Decisions are taken and large scale projects implemented but the challenges associated with the development of large scale projects are enormous and error costs are often high. Learning from the mistakes in previous large scale projects has often proved inadequate in meeting the complexity of subsequent developments.

This research approaches the problem by viewing the group concerned with a large scale development as an organisation. The organisational challenge addressed in the research is the provision of functional capacity to support the development and selection of options and the control of implementation. Flexibility is defined as inversely related to organisational constraint, which impedes communication and control. It is the view of this research that when flexibility is lost, functional capacity is reduced and the probability of error increased. As the primary concern is communication and control, cybernetics has been chosen an appropriate background for the development of a conceptual framework.

Application of the framework to a case study has indicated that there is an association between the degree of flexibility as defined and undesirable outcomes during the development of a large scale project.

Key Words: Flexibility, organisation, communication, control, cybernetics.

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Introduction

To view flexibility as a requirement should a system go wrong implies that there should be alternative paths to follow or options to select when error emerges. A large scale project requires a strong commitment to clearly defined goals and by definition, would therefore appear to be highly inflexible. This has been held as a major criticism of large scale developments. Historically they have a poor track record for success and many stand, sometimes incomplete, as monuments to poor decisions made in ignorance. And yet large scale projects do offer major opportunities. Some of those completed have been of great social value, not just in themselves but as spin-offs into other technologies.

One of the major managerial challenges in the development of a large scale project is complexity. This is not merely related to the size of the project but to the number of interdependencies that have to be catered for. Interests views, knowledge and expertise need to be aggregated to focus on the development of the project. It demands an awareness of the situation which has suggested that there would be an advantage in developing a large scale project in preference to incremental change; an appreciation of future opportunities and threats various options would satisfy; and a capacity to control the project through its life cycle. Complexity emerges as a managerial challenge not only because of the number and interdependency of relevant, controllable and uncontrollable variables but also because concern for these variables is usually dispersed into a number of institutions and agencies.

It is in communication and control that the managerial response to complexity in large scale development is found. If flexibility is viewed as an ability to ameliorate threats and take advantage of opportunities in developing a large scale project, it will depend on the effectiveness of the communication channels in aggregating useful information to support decision making and in providing control capacity for the implementation of the decision outcome. Flexibility will be lost when relevant information is distorted, omitted, misunderstood or not integrated when necessary.

Before this research was started I did some work analysing large scale projects that have been viewed as failures. In the majority of cases it had been found, in public inquiry reports etc., that a common cause of failure was attributed to various weaknesses in communication channels. In developing models of the communication systems operating in two project developments, the Westgate Bridge in Melbourne, Australia and the Bay Area Rapid Transit System (BART) in San Francisco, it became apparent to me that many errors, some disastrous, were associated with communication problems.

Consultancy headquarters were sometimes away from the project development area and although they had representatives on site their degree of discretion was limited. Many decisions had to be referred back to headquarters and urgent responses were sometimes delayed. Consultants appeared to be selected because of their international experience but this also meant that they were involved in a number of projects simultaneously and could spend only a limited time considering each one individually. Contractors often complained that they gave information to and requested information from, consultants but received a negligible response and were forced to take decisions with incomplete information, to fulfil schedule demands.

There were instances apparent in the development of BART where interdependencies between areas of design were not catered for within the communication system and designs became increasingly incompatible. Engineers, aware of potential difficulties that would occur in the operation of project outcomes, complained that they were not given the opportunity to present their views and felt subsequent errors were a direct result of this.

Common to both developments was the ineffective monitoring of technical development. Consultants and contractors made many decisions independent of each other and the organisation set up to steer the project development. The initial plans and the contracts formed were insufficient to guide project development. Plans were often general and open to a variety of interpretations and there was little evidence of monitoring of technical development, which would have revealed inadequate technical performance and incompatibility between areas of design and construction.

Initially I was interested as a result of these studies in communication systems in project management and their influence on project success. It appeared that the structure of the communication network was the key to organisational flexibility in steering project development and reducing error cost. After a long period studying project management and organisational design it became apparent that, to steer a project implied more than providing a communication system to coordinate, monitor and control implementation. By developing an understanding of cybernetic concepts and the framework relating these concepts to organisational effectiveness in the viable system model (S. Beer 1979, C.Davies et al 1979), it became clear that it was also necessary for the organisation concerned with steering the project towards a desirable outcome, to have the capacity to learn and adapt. Without this capacity it would not be possible to determine if the unfolding of the project throughout its cycle was continuing to satisfy the interests of those with a stake in its outcome.

It was suggested that it would be useful if the framework developing from this work could be applied to the decision making process leading up to the selection of a particular option. As this was the area many authors felt confirmed the view that a decision to develop a large scale project was a very inflexible one, foreclosing all other options, it seemed particularly interesting. Further support for this approach came during a seminar given by R. Espejo in 1985 when he suggested, another viewpoint could be that organisational structure has far more implications for flexibility than the policy process does.

I then decided to consider how decision making is supported within the organisation. The conceptual framework appeared to be particularly useful in this area. Rather than defining flexibility as the number of options open to a decision maker it came to be defined in the research as the effectiveness of the communication system in providing information sufficient to support the decision making process. Essentially it suggests that organisational relationships provide the capacity for learning and adaptation in the process of formulating options.

Having established theoretically how flexibility can be introduced into the development of large scale projects I gained access to key actors involved in the development of Birmingham Airport to International status. This particular large scale project was selected because it had been developed locally and it was already complete. This has advantages and disadvantages.

All of those interviewed were speaking from memory and Ackoff (1970) found that a project outcome affects actors' perception of both what took place during its development and the decisions that were taken, including those they took themselves. It was possible to cross reference interviews however and support the data with records of meetings and reports at the time. The study of a completed project has the advantage that it permits a complete view of organisational relationships, key events and decisions, the effects each had on the development and their relation in time.

As large scale projects are the concern of one institution only by exception, the conceptual framework for the research has been developed for the analysis of projects developed in a multi-institutional setting. The case study selected appears to represent one such exception, however, although it was the West Midlands County Council who decided to develop the project, there were many agencies who contributed expertise and knowledge.

Large scale projects whether they are the concern of one or more institutions produce the same managerial challenge to develop communication and control mechanisms sufficient to cater for organisational relationships between all participants. This is why the conceptual framework proposes that all participants in one or more institutions and other agencies should be viewed as one organisation, whose purpose is to bring about a successful project outcome. In this way it is possible to analyse organisational effectiveness in developing a large scale project in any institutional setting.

Chapter 1

The Development of Large Scale Projects - a literature review.

1.1 Large Scale Projects

There are few studies on what influences success or failure in large scale projects. P.W. Morris and G.H. Hough (1986) have done an extensive literature review on the topic. Most of the work available is based on project failures and the preconditions that brought about failure (Murphy et al 1974; Kharbanda and Stallworthy 1983; P. Hall 1980; Bignell and Fortune 1984; Rondinelli 1984). Morris and Hough have made a major contribution to the understanding of the preconditions of success and failure in major projects and have gone some way to provide a structured analysis of a number of large scale projects, which they found lacking in previous studies. Their findings on factors which influence project success include, stable and effective relationships within the organisation and a commitment to developing a response, recognition of the effects of external factors and political support. Large scale projects present managerial challenges which must be recognised.

> "Major projects offer major opportunities. Sometimes they cannot be avoided. ....For whatever reason they are undertaken, their special managerial difficulties should be clearly recognised." (Morris and Hough 1986)

The development of large scale projects is invariably the concern of more than one organisation. A concept found in literature which addresses this situation is "organisational ecology". (Stringer 1982, Trist 1977). Organisational ecology is defined as the field created by a number of organisations whose interrelations compose a system which cannot be adequately understood in terms of one-to-one relations between organisations nor as "organisation in its environment". Two characteristics of the circumstances associated with the development of large scale projects have been identified, by Stringer, as the size of projects and the complexity of inter-organisational relationships.

The following review outlines the problems of inflexibility associated with large scale projects and literature which indicates that it is possible to develop an approach to this problem. The research addresses flexibility in two areas of large scale project development 1) Planning 2) Project Management. The literature relating to project development will therefore be presented in these areas separately, although it is accepted that in reality they are interdependent.

In the first area an attempt has been made to combine planning concepts developed by R.L. Ackoff (1981) with a review of planning methodologies by J. Rosenhead (1980). Authors who have developed work related to the planning process will be introduced within this framework. Before studying literature relating to project management there is a section concerned with the emergence of the project organisation. This section is an attempt to outline the organisational developments that have taken place in the last three decades in response to increasingly complex and dynamic environments, which are a hallmark of large scale projects. Finally the chapter includes project management and devices used to steer the project life cycle.

1.2 Planning - methodologies and concepts.

Methodologies	Planning Concepts
Rational comprehensive planning	Preactive
Disjoint incrementalism	Inactive
Mixed scanning	Preactive
Robustness analysis	Preactive/Inactive

i) Rational comprehensive planning - top down, preactive.

This is the term used to describe the planning process as performed by bureaucratic organisations.

> "Options are successively and more tightly constrained with a corresponding reduction in flexibility. This form of planning is taken to require the specification not only of current actions but also of decisions to be implemented at all stages of the plan. The outcome is a slow moving monolithic structure with a reluctance to change from the posture adopted." (J. Rosenhead 1980)

Planning in this type of organisation, described by Ackoff (1981) as preactive, consists of 'predicting' the future and 'preparing' for it.

> "Preparation involves taking steps to minimise or avoid future threats and of greater importance, to exploit future opportunities. ....perhaps the greatest difficulty in preactive planning derives from the fact that the further ahead we try to forecast, the greater the error is likely to be."

He does go on to say however that

> "what corporations 'do' have an effect on their environment"

and to some extent the large scale project can help a corporation to design its own future by influencing change in the relevant environment. In this way environmental change, often not considered desirable by environmental elements, is influenced by technological development.

There is much criticism of this form of planning because of the inherent inflexibility of the process, which may on the one hand incur high error costs for the organisation concerned or on the other hand produce an unwanted technology and/or produce undesirable changes in the relevant environment.

D. Collingridge (1982) takes the view that

> "flexibility is represented in the number of options available to a decision maker on a continuous basis."

He argues that the number of options are rapidly reduced in the decision to develop large scale projects. He agrees with Ackoff that possible futures are difficult to determine with the large time span between option selection and operation.

This view is supported by N. Caiden and A. Wildavsky (1974) who say

> "it is a mistake to encase probable errors in concrete. Large projects represent huge commitments. Resources are tied up not only in the present but over many years required to construct the project

and get it into operation. The scope for error is large but the margin for manoeuvre is small."

ii) Disjointed incrementalism - minimal change, inactive.

Lindblom (1980) in developing this methodology argues that

"coordination between agents with different interests and values is vastly more efficient in the absence of a central coordinator.......decisions should be made with marginal dependent choice, with analysis confined to the marginal differences between the options and between the options and the status quo. This is simplified by restricting the number of options and the consequences of each option considered."

He suggests that there should be

"incremental and remedial attacks on the problem and through negotiation partisans with widely different aims and objectives can come to agree that some policy is in all their interests."

D. Collingridge (1980) advocates this approach as a means of retaining flexibility in the decision making process and uses it as the basis for his criticism of large scale developments.

"incremental mutual adjustment between partisans can be made in a way that keeps options open and limits the costs of maladjustments that must arise from time to time. Because decisions based on incremental change are easier to make, error costs small and the chance to learn increased. .... to retain flexibility it is necessary to develop smaller units."

Relating this to the nuclear power industry he says this would also increase the industry's ability to match capacity with demand.

In developing countries the failure rate of large scale projects has led many critics (N. Caiden and A. Wildavksy 1974, Rondinelli 1983) to conclude that "a large number of small projects with short time horizons greatly increases the prospects of learning, adaptation and correction. Because less has been invested in each individual project it is relatively less expensive to end them."

In his review of planning methodologies Rosenhead admits that
"this approach is less monolithic than rational comprehensive planning but such a process offers only a different type of inflexibility ie. the determinism of the unhindered unfolding of existing tendencies which is inadequate for turbulent organisational environments."

Ackoff describes those who advocate such a methodology as

"inactivists, who advise treating each problem separately, disjointly and doing as little as possible. Some refer to such a strategy as 'muddling through'. Even in an environment that is virtually completely uncontrollable and turbulent, although inactivists may not do well by doing nothing, often do no worse than those who try to do something. Because they act cautiously they seldom make mistakes of catastrophic proportion. When they die, they do so slowly."

S. Zwerling (1974) uses a categorisation due to J.D. Thompson (1967), who described two strategies which could be adopted by a decision maker faced with uncertainty in the future. These strategies can be applied to the two methodologies so far described. The first is a prescriptive approach where the decision maker visualises a future and attempts to realise it.

"The prescriptive technology so dominates and overwhelms the future and to such an extent, that other possibilities are hopefully, precluded. If the decision maker wishes to render the future stable, he will prefer an inflexible technology, one that shapes developments rather than follows them. The comprehensive strategy dictates rigidity in order to make 'error', should it arise, irrelevant. Therefore the greater the sunk cost the better."

The second approach is described as judgemental. It is incremental and aims at an adaptive and adjustable technology.

"The decision maker who adopts this strategy seeks, above all, to minimise the effects of an uncertain future by hedging his bets. Lacking a commitment to a specific vision of the future, he attempts to maximise his chances of being able to meet whatever possibilities the future may hold. He says that the more technology lends itself to incremental change the better. A flexible technology has the capacity for reducing conflict; an inflexible technology has the capacity for creating conflict."

iii) Mixed Scanning - preactive.

This methodology involves initially a low detailed analysis over a wide search area. There is a subsequent elimination of alternate policies till only one remains. This produces a limited responsiveness achieved through bit decisions within the constraints set by the preceding fundamental decisions.

Rosenhead describes this methodology as being

"strongly influenced by the system's approach and a variant of rational comprehensive planning. Flexibility however enters not as a capacity to choose between meaningful strategic alternatives but only as a flexible response which can maintain key structural relationships under perturbations from the environment. The concept of resilience is a recent development in this tradition. The result of resilience is persistence: the maintenance of certain characteristic behavioural properties in the face of stress, strain and surprise. Components of resilience include boundary, restorative and contingency components which imply various mechanisms necessary to bring about persistence."

A system's approach related to the concept of resilience is the cybernetic approach used by S.Beer (1979) in the development of the viable system model. This model presents a framework for organisational design based on functional relationships and concerned with survival. Planning is viewed as an on-going process emerging from stable systemic relationships at multiple levels within the organisation which permit learning and adaptation.

iv) Robust planning - bottom up, sequential, inactive/preactive.

This methodology would appear to be a hybrid of the inactive and preactive concepts. It is preactive in the sense that it does not imply incremental change from the status quo but inactive in the sense that it aims to keep options open which are marginally different such as indeterminate architecture and involves sequential decisions which should be designed so that they can be reviewed as new information becomes available. It represents a departure from preactive planning in that instead of aiming to design a desirable future it produces a set of options which can meet a variety of futures.

To keep options open, the methodology suggests that

> "rather than optimising, a decision set should be selected which are components of a wide range of acceptable decision sequences under most or all of the identified futures. The analysis is expected to proceed recursively with the assessment of the output of later activities in the methodology resulting in amendments to earlier activities." (J. Rosenhead 1980)

This methodology is primarily the work of J. Rosenhead (1980) and J.K. Friend and W.N. Jessop (1976) and is designed to offer a way of handling complex decision situations. Useful flexibility is defined as

> "the number of opportunities for taking future decisions which seem likely to lead to desired states."

The main elements of this planning methodology are that

> "planning should be bottom up in structure and facilitate participation; it should be non- optimising and be based on establishing a set of feasible solutions; it should accept the uncertainty of future states, attempt to keep options open and aim at a loose fit on planned for activities."

The conclusions that emerge from their work are that

> " a) when the monolithic scale of available technology demands an all or nothing decision, flexibility is unattainable b) where the technology permits smaller scale additive implementation, flexible planning is possible."

These conclusions have parallels in the work of D. Collingridge implying that his work has elements of incrementalism and robustness in his analysis of decision making and the inflexibility of planning for large scale projects.

Ackoff (1981) presented four concepts in his work two of which have been introduced. Briefly he views the dominant orientation of some planners to the past, reactive; others to the present, inactive; and still others to the future, preactive. He introduces a fourth orientation, interactive, which regards the past, present and the future as different but inseparable aspects of the mess to be planned for. It is based on the belief that ...

> "unless all these are taken into account, development[1] will be obstructed. It is through participation in interactive planning that members of an organisation can develop."

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[1] Ackoff uses the terms growth and development. Constraints on the growth of a corporation lie in its environment but the principle constraints on its development lie within it.

"The selection of ideals lies at the very core of interactive planning; it takes place through the idealised design of a system that does not yet exist or the idealised redesign of one that does."

"an idealised design of a system should be technologically feasible, operationally feasible and capable of rapid learning and adaptation."

It is the third of these that D. Collingridge would say is not possible in the design of large scale projects because the long lead times imply very slow learning.

This is supported by Ackoff in his outline of the conditions necessary for learning and adaptation.

"the system's stakeholders should be able to modify the design whenever they care to, because relevant information, knowledge, understanding and values change over time."

However he does go on to say that

"the majority of these conditions are met as a result of their efforts to realise the design".

The decision to develop a large scale project implies that a choice has to be eventually made which forecloses a variety of options. For this reason most of the literature presented so far would suggest that a decision to develop a large scale project is very inflexible. There is evidence however that it is possible to improve the performance of large scale projects.

"learning and adaptation is possible in the development of the ideal design if the relationship between the stakeholders permits an integration of the past, present and future aspects of the problem." (Ackoff 1981)

Galbraith (1977) describes several factors that can limit the effectiveness of any large scale endeavour. Among these he speaks of the organisational bottle-neck. He says

"we may possess the knowledge to solve the problem and have the funds to finance the project but may not be able to organise the resources in order to carry out the problem solving effort."

A key factor in improving project performance is recognised by these authors as organisational design. This is further supported by Cleland and King in this comment on information processing within an organisation;

"Problem solving should be supported by the analysis of intelligence information involving the determination of the relevance, credibility, value and appropriate dissemination of intelligence data. Key personnel may have the relevant information but without a formalised intelligence system they have no way of getting it to the right people or of having it integrated with other information to form useful information aggregates."(Cleland and King 1983)

From this quotation it appears that organisational mechanisms for the transfer and aggregation of information are necessary for effective support of decision making. They also refer to the importance of handling environmental uncertainty in the support given to decision making.

"information systems should be designed to attempt to enhance the organisation's capability to handle environmental uncertainty rather than to reduce the perceived uncertainty by default rather than by design."

If it is possible to improve the processing of organisational information and perception of the environment, this would imply that it is possible to reduce error. J.S. Evans (1983) found that the concensus among fieldwork participants in his research on flexibility in policy formation, was that

> "truly unexpected and hence unanticipated occurrences, especially in technology, seldom occur. Those occurrences which caused major strategic disruption were often anticipated; they caused problems because not enough attention was paid to their impact."

Research has indicated that in a complex situation, involving many separated managements and in which uncertainty is high, coordination is best achieved by dispersing decision making power provided that the local managements have sufficient information in predictive form, as to the overall situation. Predictive information being defined as the probabilities of capacity difficulty arising at any given future time rather than as an information system which deals with the history of the recent past or in plans and targets for the future. (Stringer 1982).

This literature indicates that a predictive information system is a factor in the ability of a system to absorb or compensate for disturbances. It presents a probabilistic and adaptive, rather than a deterministic method of planning as more appropriate to turbulent conditions.

The conclusions that can be drawn from this literature survey are that decisions to develop large scale projects are inflexible in that they foreclose a variety of options. However the analysis of organisational structure suggests the support given to decision making can permit flexibility by introducing the capacity to learn and adapt during the development of options. The literature implies that this is brought about by stable relationships between stakeholders, which provide a system for the aggregation of information. It is through effective aggregation on a continuous basis during option development, that learning and adaptation become possible.

Friend and Jessop (1969) see

> "in many problems a conflict between political pressure for commitment and the need for flexibility."

By introducing flexibility into the process providing support for decision making, it may be possible to minimise the detrimental influence of political constraint. Political constraint tends to increase potential error through premature commitment. This is not necessarily advocating extending the time allocated to the planning process but to improve organisational effectiveness in option development.

1.3 The Emergence and Development of the Project Organisation

The project organisation has been described as a temporary organisational structure which is focused along systems lines (Cleland and King 1972, Carvallo and Morris 1978). While large scale projects are not a new phenomenon, the pyramids were built many years ago, there are challenges to be met today which are new such as the complex and dynamic nature of the project's environment. The systems approach has been increasingly applied to general management situations where the basic pressures of size, complexity and time constraints stretch an organisation's capacity to manage. Research concerning the structuring of complex organisations increased during the 1960s.

> " The traditional organisational structures, with their rigid divisions of responsibility and authority and their mechanistic chains of command were too inflexible to meet the needs of the dynamic business environment of the 1960s." (Mockler 1971)

In the late 1960s, a general philosophy of "no best way" to organise caused a shift from traditional organisational patterns to development of individualised and flexible approaches to meet the particular situation.

> " One cannot use a single stereotyped organisational model and meaningfully understand the rich variety of Task and Administrative units within modern complex organisations. One must necessarily speak of variety of administrative systems for coping with different mixes of these model forms." (Delbecq)

The concept of the organisation as a system became recognised in the sociotechnical model. This model together with the cognitive model served as the conceptual antecedents for the "contingent" approaches to organisational design. One of the traditions developing this system concept of organisation was the Tavistock School. Their focus was on how the organisational structure affects and is affected by its members. They recognised that behaviour in organisations is conditioned by such factors as environment, individual motives, values, differences in goals etc.. (Allen and Gabarro 1972)

Contingent approaches are defined by Allen and Gabarro as :-

> "behavioural science approaches which systematically take into account the differences between organisations because of the differences in their tasks and members needs."

Within the cognitive model, the functioning of large complex organisations has been explained as :-

" 1. Cognition - the perceptual and information processing mechanisms of individuals and organisational units. 2. The decision and problem solving process - the sequence of tests and operations that individuals and organisational units go through to structure and solve a problem. 3. The administrative and organisational setting - the way in which tasks have been subdivided and the mechanisms through which these subtasks are coordinated." (March and Simon 1958)

While the sociotechnical and cognitive models are useful and have provided insight into complex organisational behaviour and management of complex tasks their strength lies in explaining the inner working of an organisation and not the management of external forces.

A large scale project often represents the solution to a complex problem. In this situation:-

"Problem solutions will have an equal degree of interdependency and complexity ie. that complex systems have to be designed to solve these complex systems problems." (Cleland and King 1983)

The development of a complex organisation which caters for a high degree of interdependency has been shown in research to be required when:-

" the goals and objectives of an entity require different groups to work together closely;
the environment is complex or changing quickly;
the technology is uncertain or complex;
the enterprise is complex or changing quickly." (Lawrence and Lorsch 1967)

These four features are invariably found in the development of large scale projects. The enterprise may be temporal in nature but it will be complex and change quickly as the project develops through its life cycle. (project life cycle is discussed below)

The complexity of the project organisation is related to the degree of reciprocal interdependency implied by the tasks that have to be performed.

> "Large and complex projects inevitably involve reciprocal (interactive) interdependencies and therefore require more integration." (Morris)

These interdependencies within project organisations are being increasingly catered for by the development of the matrix form of organisation.

The matrix structure is an attempt to maintain the advantage of functional specialisation while taking advantage also of the improved coordination offered by the concept of project management.

> "Though difficult to run and complex to describe, there are good reasons for their growing use: their dual focus of control permits economy of resources and creates a closely coordinated management structure. With their high degree of internal coordination, matrix organisations are one of the most effective forms of organisation available for handling conditions of uncertainty." (Carvalho and Morris 1978)

Galbraith describes the matrix organisation as the final step in the use of lateral relations in the establishment of a mature organisation. He relates it to the decision making process in response to increased task uncertainty. (Galbraith 1972)

The use of lateral relations is seen as a method of decentralising or making decisions at lower levels in the hierarchy. The project manager has responsibility as coordinator and direct control over decision making personnel.

The matrix structure is viewed as the combined contribution of functional and project groups. The term "symbiosis" is used by Cleland and King to describe the relationship between these two components of the matrix organisation ie. the mutually beneficial living together of dissimilar organisms. (Cleland and King 1972).

Research has shown that the Matrix organisation is widely evident in the development of large scale projects and that many of the projects are viewed as successful, eg.Acominas project (Carvalho and Morris 1978), Trans Alaskan Pipeline project and Apollo project (Morris). The matrix is viewed not as a strict alternative to the project manager/coordinator option but rather as a more powerful complex version of it. (Davis and Lawrence 1977)

An important feature of matrix organisations is that they need to grow. Matrices take time to be implemented.

> "The matrix must allow for a swing from functional (during the early stages of the project), to project shared with functional (during the main phase)." (Carvalho and Morris 1978)

For a matrix to work well it has to be logically right. In the Acominas project this was agreed because the project was too big for a functional approach. There also has to be the right climate within the organisation so that people understand why a matrix is being used and how they should work to it. (Carvalho and Morris 1978)

In the concluding chapter of the thesis the application of the matrix organisation to the development of large scale projects will be considered in the light of the research findings.

1.4 Project Management.

Once an option has been selected for a large scale project the next stage is to manage the implementation of the decision. According to Mintzberg (1983)

> "this requires planning and control systems which incorporate mutual adjustment."

From the literature there would appear to be three main stages that can be identified for one-time projects in what is termed the project lifecycle. (Morris and Hough 1986)

i) The Planning Stage

This involves a prefeasibility stage in which there is a more detailed evaluation of the opportunities and constraints implied by the selected option, and a feasibility stage when such factors as the availability of resources and their allocation, and the development of control and monitoring mechanisms for the management of the subsequent stages in the project are considered. Morris and Hough (1986) describe how

"planning should take full account of the future phases of the project; logistics; geophysical, socio-economic and other environmental uncertainties and the interdependency of design and construction. ......The influence of politics cannot be ignored, impacting projects through funding, sponsorship and legislation over fiscal, safety, employment and other matters."

The outcome of the planning phase is a set of objectives and strategic plans for the development of operational specifications in the design phase of the project. Morris and Hough (1986) say that

"unclear objectives are a precondition of project failure. They conclude that a precondition of success must be that organisational arrangements are considered carefully and the fullest authority be clearly given to the project manager."

ii) Development of design.

Development of design for a large scale project involves many areas of expertise. The managerial task is to steer overall design development according to the strategy emerging from the planning process, while permitting technical development in the various disciplines. The interdependencies implied by the development of disciplinary or functional designs cannot be catered for by regular forms of standardisation. Mintzberg says that

"the organisation must then turn to mutual adjustment for coordination. In recent years organisations have developed a whole set of devices to encourage liaison contacts between individuals, devices that can be incorporated into the formal structure. Liaison devices represent the most significant contemporary development in organisation design since the establishment of planning and control systems a decade or two earlier" (Mintzberg 1983).

J. Galbraith (1973) has proposed a continuum of these liaison devices, including liaison positions, task forces and standing committees, integrating managers, and matrix structure. The implications of these devices for flexibility will be discussed later.

> "Organisations that incorporated liaison devices into the planning and control of large scale projects showed a greater degree of success in terms of cost and time overrun, than those who left adjustment between functional groups to chance." (Morris and Hough 1986).

iii) Implementation

The purpose of the planning and design phases is to specify the desired outcome of the large scale project in sufficient detail for management to assess whether operational standard is being achieved. According to Mintzberg (1983)

> "there can be no control without prior planning, and plans lose their influence without follow up controls. To control implementation in the action planning system, schedules and operating specifications are necessary to bring about adequate coordination for the integration of non routine work."

This is contrast to what he terms performance control which

> "aims to regulate the overall results of a given unit and is not concerned with specific decisions or actions at specific points in time. It is found to be effective when there is little interdependence between organisational units."

A large scale project involves a high degree of interdependency in all its phases and therefore an action planning system would seem to be more appropriate. Action planning does not necessarily respect unit autonomy, which suggests that the implementation of a large scale project requires carefully designed coordination mechanisms which permit effective interaction between implementation units.

A precondition of success in large scale projects has been found to be the reduction in the need for mutual adjustment, by the strategic grouping of operational elements to cater for interdependencies (Morris and Hough 1986). It seems therefore it is favourable to the project outcome that the need for mutual adjustment between operational elements is reduced. This is supported by the control problems that arise from

"concurrency, when design and implementation are forced by schedule constraints to develop simultaneously."(Morris and Hough 1986)

In this situation the need for mutual adjustment between operational elements increases because specification is partial. This in turn increases the number of exceptions reaching control and the probability of design changes. Compromise can become inevitable and project performance measured against initial objectives may be reduced.

If planning, design and implementation were sequential it would minimise the managerial complexity of large scale projects. However in practice there is invariably a degree of overlap and the subsequent mutual adjustment necessary can be very costly both financially and in failure to meet objectives.

"The success of lengthy projects is often hostage to significant changes in output prices, demand, regulation, technical developments, changes in government, corporate organisation, staffing policy etc.. They can turn a potential success into a potential failure. All studies on project success and failure have stressed the danger of rushing the initial definition and design development stages of a project."(Morris and Hough 1986)

The size, complexity, technical uncertainty of large scale projects imply a major challenge to develop the coordination necessary to cater for interdependency. Galbraith (1977) recognises that

"if communication to coordinate interdependence during particularly the early phases of a project took place through direct channels the number of channels required would be prohibitively large and if this situation is responded to with a hierarchical design within the organisation, processing capacity may be critically reduced. Each channel has a limited capacity for processing information. An increase in task uncertainty overloads these channels and introduces delays and distortions.The number of exceptions reaching supervisors concerned with new and unique events would overload the hierarchy."

Galbraith suggests that

"in this situation it becomes more efficient to bring the points of action where information exists. When increasing discretion at lower levels the organisation faces a potential behaviour-control problem."

To overcome this Galbraith has described a continuum of liaison devices which cater for the resulting interdependencies.

The range of liaison devices have been described in literature as -

i) Liaison positions - "When a considerable amount of contact is necessary to coordinate the work of two units, a 'liaison' position may be established formally to route the communication directly, bypassing the vertical channels." (Mintzberg 1983)

ii) Task forces and standing committees - "The task force is a committee formed to accomplish a particular task and then disband. The standing committee is a more permanent interdepartmental grouping, one that meets regularly to discuss issues of common interest." (Mintzberg 1983)

iii) Integrating managers - "When more coordination by mutual adjustment is required than liaison positions, task forces, and standing committees can provide, the organisation may designate an integrating manager which in effect is a liaison position with formal authority."(Mintzberg 1983)

iv) Matrix structures - "By creating an integrating force in a program or project office, the matrix attempts to overcome the divisions that are inherent in the basic functional structure" (R. Katz and T.J. Allen 1985).

Cleland and King (1983) offer the matrix organisation as

"a flexible structure, allowing for give and take across lines of authority, with people assuming an organisational role that the situation warrants rather than what the position description says should be done."

This supports contingency theory in suggesting that the best way to organise depends on individual circumstances. They say that

"the matrix design provides a vehicle for maximum organisational flexibility with no one having tenure on the matrix team."

Of the four devices it is the matrix structure which addresses a holistic approach to the problem of interdependence and therefore would seem to offer an organisational solution for the design of a large scale project. However D. Lock (1984) suggests that

"the matrix organisation is suitable for several small projects, each needing a few people for a short time."

"The system demands that people have to spend far more time at meetings, discussing rather than doing work, than in a simpler authority structure. There simply is more communicating to be done, more information has to get to more people" (K. Knight 1976).

Morris and Hough cite one of the factors for success in large scale projects as

"a clear and comprehensible project organisation with one person or group in overall charge having strong overall authority."

This is supported by Lock when he says

"a large project employing many people for a long time requires a project team organisation."

The matrix structure by definition has dual command which introduces conflict, ambiguity and the need for face to face contact. These can be advantageous in a small group, providing flexibility and the opportunity for mutual adjustment but as the scale of the project becomes larger these attributes can be detrimental to the control of the overall project because of the increasing complexity of the resulting coordination mechanisms. A high degree of innovatory design poses a particular problem because it necessitates functional development which is often detrimental to overall project control. However it has been shown through research outlined earlier (Carvalho and Morris 1978) that the matrix structure has been applied successfully to the development of large scale projects. The main feature recognised was that the matrix takes time to grow in this situation but if this is done with the participation and understanding of those involved it can be developed successfully.

Lawrence and Lorsch (1967) describe flexibility as

"the measure of organisational efficiency in absorbing the associated complexity of its environment. Members of a subsystem will develop a primary concern with goals of coping with their particular sub environment. Overall performance in coping with the external environment will be related to there being a degree of differentiation among subsystems consistent with the requirements of their relevant sub environments and a degree of integration consistent with requirements of the total environment. If integrators become concerned with one area to the detriment of another they are dealing with problems at a lower level and effectiveness in meeting complexity is lost. ....The basic pressures of size, complexity and urgency stretch an organisation's capacity to manage. What is required therefore is a more fluid organisational response;"

this can be interpreted as flexibility. Morris and Hough see coordination as a key element in obtaining such flexibility:-

"major emphasis on effective communication and organisational learning as an important mode of coordination."(Morris and Hough 1986)

The major managerial challenge in the development of large projects would therefore appear to be, developing the necessary flexibility to respond to environmental complexity through organisational design.

"Some organisations are able to respond well to these demands; others are less able to respond and continue to use mechanistic, bureaucratic styles of management" (M. Horwitch 1984).

Chapter 2

Flexibility as defined in the research.

In the synopsis, flexibility was defined as inversely related to organisational constraint, which impedes effective control and communication. In this chapter an attempt shall be made to look at this definition of flexibility, as it relates to organisations concerned with the development of large scale projects. Finally it is hoped to show that this viewpoint offers an indication of how flexibility can be introduced into the development of large scale projects, even though literature has suggested that the decision to develop such a project is often a very inflexible one.

Before flexibility can be discussed in the way it is presented in the research, it is first necessary to define the 'organisation' which is to be considered. The first question to be asked therefore is who belongs to this organisation.

2.1 How is the organisation concerned with the development of a large scale project identified?

A large scale project is rarely the concern of one institution or corporation. It is invariably the concern of a group representing participating institutions, consultancies and contractors that come together for the duration of the development. A number of institutions may have an interest in the project outcome and want to influence its development. The expertise necessary to develop a large scale project may be beyond the capacity of the participating institutions and consultants are often assigned to address technical and environmental problems. Finally the business areas which are the concern of the participating institutions will usually not warrant the expertise and manpower necessary to implement a large scale project in the long term, and therefore contractors are engaged to carry out construction work etc..

All of these actors make a necessary contribution to the project development. These participants form relationships which because of the scale of the project are complex and difficult to define. What is clear however is that they all have the concern of the development in common and all have roles to play in producing the desired project outcome. These roles are interconnected to make possible the aggregation and disemination of information necessary for decision making and control during the development. Therefore they can be viewed as belonging to an 'organisation' concerned with project development.

'Organisation' is not used in this research as another word for institution. (see Davies et al 1979) Institution sometimes refers to observable structures in a business setting or as a body which sets the protocol for the activities of a particular group such as RIBA for architectural practice in projects. In the research the 'organisation' is an abstraction, designed to define relationships between relevant structures in one or more participating institutions and other agencies which contribute to the large scale project development. This differs from the definition presented by John Stringer (1982) in that the "organisational ecology" refers to the complexity of inter-organisational relationships. The research views the interactions as within one organisation or system and in this way studies intra-organisational relationships. It is by analysing the relationships that are implied in a particular setting, eg. a large scale project, that the analyst is able to identify the communication and control mechanisms which are or were operational and the organisational effectiveness of those mechanisms.

By functionalising the relevant structures it is possible to consider the relationships between actors, without the restriction of institutional boundaries. This permits a view of the interdependencies implied by the project development, which are not always clear in an institutional setting. Participating institutions and other contributing agencies will usually have additional interests outside the project and therefore relationships implied by the development are not always clear. It is necessary therefore to view this group of participants as an organisation, in order to determine how it develops the functional capacity to meet the complexity of a large scale project development.

Essentially this is the perception of an organisation as a system, with subsystems at multiple levels. The development of large scale projects emerges from interaction between functional groups or systemic functions. The interaction is an attempt to produce the desired outcome, as perceived by participating institutions. It is important to note that it is the participating institutions wanting to influence the project outcome who develop the objectives for that outcome. Other contributing agencies will invariably provide supportive expertise for the development of the project but will have objectives related to their own organisations.

> "The transformation of form into function makes it possible to study organisations instead of institutions. Problems that are not perceived with an institutional logic might be apparent if the organisational logic is used. For instance, the necessary integration and coordination of institutions, which are parts of the same function at the same system level become more apparent." (Davies C. Demb A. and Espejo R. 1979)

Now the concept of an 'organisation' has been established to encompass the relationships between all those concerned with the development of a large scale project, it is possible to consider organisational effectiveness in developing a project which will produce the desired outcome ie. in meeting the related objectives of the participating institutions.

2.2 Organisational Flexibility and Constraint.

When error costs are incurred in the development of a large scale project it is now generally accepted that there is no one cause (Bignell V. & Fortune J. 1984). In an attempt to minimise error costs, it would therefore appear to be necessary to adopt a systems approach to analyse the development of large scale projects rather than by just learning from individual errors of previous projects. This implies that there is a need to view project development from conceptualisation ie. the formulation of options, through to the project outcome. Errors can emerge from anywhere within this range.

While it is useful to consider how many options are available to a decision maker at any one time and how controllable the options will be, it is built on the premise that flexibility is a measure of the capacity for changing options or reversing decisions if error becomes apparent. This is not a very useful concept when considering a large scale project because the selection of an option represents a commitment which can only be altered at a great cost. However a useful contribution has come from R. Espejo when during a seminar in 1985 he said

> "Organisational structure has far more implications for maintaining flexibility than the policy process does."

Organisational structure is a concept to describe the parts and their relationships within an organisation which provide it with the capacity to learn and adapt in an attempt to meet the complexity of its environment. Option selection is the outcome of option development and it is in the informational support given to this process that the research initially addresses the problem of maintaining flexibility in large scale projects. The development of the selected option to the project outcome is a continuation of this process and thus the same approach to flexibility will be applied. Basically flexibility is viewed as the degree to which mechanisms used for communication and control within an organisation are sufficient to permit a desirable outcome.

"Planning is an activity within which development takes place, not merely an activity whose output may contribute to development" (Ackoff R.L. 1981).

" There can be no control without prior planning, and plans lose their influence without follow up control" (Mintzberg 1983).

These two quotes capture the concept of organisational flexibility presented in this research. To be flexible the organisation must have the capacity to develop. Development is brought about through learning and adaptation and this is made possible by the relationships established within the organisation. Flexibility is introduced into these relationships when they contribute to organisational development and reduced when they impede development. It is clear from the second quote that development, or learning and adaptation, consists not only of planning but also controlling the implementation of those plans. They are presented separately for analysis in the research but it should be noted that they are integral parts of the development process.

Organisational flexibility is therefore manifest in organisational relationships and the extent to which they promote learning and adaptation. Attempts to identify the constraints which reduce flexibility can be found in literature concerning organisational design and in studies on large scale project failures.

Galbraith (1977) introduces the organisational bottle-neck as a factor which limits the effectiveness of any large scale endeavour. Cleland and King (1983) stress the importance of an intelligence system which permits key personnel to have the relevant information, and the integration of information to form useful information aggregates. Many sources recognise that information which could have prevented the occurrence of error in large scale projects was often available but its impact was not realised (Eppink D.J. 1978, Evans J.S. 1983).

Factors identified in studies of large scale project failures, have included inadequate informational support for decision making, weak intelligence, poor monitoring, ambiguous control and responsibility, and failure to integrate useful information or perceive false or inadequate information (Hall P. 1980, Kharbanda O.P. & Stallworthy E.A. 1983, Bignell V. Peters G. & Pym C. 1977, Morris P.W.G. & Hough G.H. 1986, Morris P.W.G. interview 1986). All of these are essentially referring to communication problems which reduce the organisation's effectiveness in planning and controlling the development of a large scale endeavour.

It has been shown that the 'organisation' is a useful concept in that, by removing institutional boundaries and identifying functions rather than institutional parts, it assists the analysis of large scale project development by making more obvious the relationships between the actors. It is an attempt to reduce the complexity of the activities implied by the analysis. The strength in this approach comes from the capacity of the 'organisation' concept to capture alternative multi-institutional set-ups, in response to whatever purposes are attached to project development.

The systemic functions related to project development and mechanisms for the transfer of information between them, will be discussed in more detail in chapters three and four. The purpose at this point has been to introduce the relationship between flexibility and constraints within organisational structure and the implications for the effectiveness of project development.

2.3 Areas selected for the analysis of organisational flexibility in the development of a large scale project.

Development within an organisation is dependent on stable relationships, which permit transfer of information in an effective way. Although organisational development is a continuous process there are two organisational roles that can be identified during the development of a large scale project. The first is the development of options to make possible a final selection and the second is a more detailed development of a selected option in order to control the implementation of the project.

Two organisational roles would seem to imply two organisations. However the continuity of the development process can be expressed by viewing the second organisation as a subsystem of the first. In this way it is clear that their roles are different but that they are both part of the same development process. The first organisation is viewed as the global organisation concerned with the total development of the large scale project. In the research this is referred to as the 'General Organisation'. The second organisation concerned with the allocation of resources, relating to a selected option and the control of their use, is referred to as the 'Parent Organisation'.

Members of the General Organisation include those who represent the interests of various institutions wanting to influence the project outcome and agencies contributing intelligence on environmental and technological problems, beyond the capacity of the participating institutions. Members from participating institutions represent their interests by their involvement in the policy formulation process. They contribute to the process by articulating the intelligence of their own entities in relation to the project. The challenge to be met by the general organisation is to form aggregates of useful information, sufficient to support the decision making process.

The key to meeting this challenge is in the development of mechanisms, designed to attenuate and integrate information in a way that reduces the complexity of the information to be considered in the decision making process, without reducing its quality. Mechanisms refer to organisational arrangements for the transfer of information between organisational functions, such as committee meetings, study group reports, physical factors which promote interaction such as shared facilities, etc.. The degree to which these mechanisms exist and are effective in processing information for the support of decision making, is a measure of organisational flexibility. The concept of effectiveness will be developed in more detail in chapters three and four.

The Parent Organisation may be one institution that already exists or it may be an ad hoc structure that is created for this purpose or perhaps some combination of the two. Although the General Organisation and the Parent Organisation have been presented separately here, it may be that the Parent Organisation is concerned not only with the implementation of a selected option but also with policy formulation. If this is the case the General Organisation and the Parent Organisation are one.

Members of the Parent Organisation include those assigned by the General Organisation to allocate resources and control their use in the interests of the participating institutions and agencies who address environmental and technical problems or handle control problems in the use of resources beyond the capacity of those assigned. While these agencies, which may include consultants and contractors, contribute to the development of the selected option by providing the extra organisational capacity required, it is the initially assigned members that ultimately make the decisions and exercise overall control of the project implementation on behalf of the General Organisation.

The challenge to be met by the Parent Organisation is to integrate the information necessary to support the planning process related to the selected option, to develop designs which meet planning objectives and provide time and cost estimates. The effectiveness in meeting this challenge is expressed in the ability of the Parent Organisation to filter information to support decision making and its ability to control and monitor the development of the project implementation towards the desired outcome.

In conclusion it would seem useful to repeat a statement made earlier about flexibility. Flexibility is lost when mechanisms or lack of mechanisms to process information, impede organisational development and flexibility is introduced when mechanisms to process information contribute to organisational development. The research is an attempt to show that organisational flexibility, as defined, can influence project outcome.

2.4 Flexibility in the development of large scale projects - a comparative description.

Flexibility is viewed by many as a requirement should a system go wrong.

> "Since any decision may prove wrong we should favour decisions which are highly reversible or flexible ie. decisions, much of whose invested resources can be recovered and used for some other purpose." (D. Collingridge 1979)

This approach is based on decisions taken with uncertainty, when forecasting is insufficient due to the degree of environmental change possible in the future. Learning is viewed as the very essence of flexibility. We learn from our mistakes and a flexible system is one where mistakes can be remedied cheaply and swiftly. It is therefore related to the degree of choice available to the decision maker.

> "The size of a decision's choice set and therefore its flexibility, decreases throughout the decision process. Initially the choice set consists of some number of alternatives. As time passes a decision's choice set may be reduced as opportunities are forfeited and options expire. Ultimately all flexibility is lost when an irrevocable commitment is made to a specific alternative." (M. Merkhofer 1977)

To retain flexibility it has been suggested that initial decisions should limit the future as little as possible. The aim therefore should be to develop flexible technologies which keep open a number of options such as indeterminate architectural design or the development of small modules that can be introduced as required.

While this approach to flexibility is theoretically sound and is shown to be useful in the policy process, it is limited to decisions that can be changed or offer alternatives, when error occurs or the environmental situation changes. Consequently it indicates that large scale projects must surely be inflexible. Its limitation is because it applies itself to decision making but does not take into account the organisational support given to decision making.

Another viewpoint could be that the degree to which options contribute effectively to organisational objectives is as important, if not more so, than the number of options available at any one time. Therefore while the research accepts the above viewpoint on flexibility and recognises by this definition large scale projects are inflexible, it offers an additional viewpoint that flexibility can be introduced into the organisational structure that develops the information to support decision making.

The argument would still remain that no matter how much organisational flexibility was introduced this would not cater for the degree of uncertainty associated with the development of large scale projects and decisions would still be taken in ignorance. It is true that the future environment cannot be sufficiently predicted beyond a few years and that large scale projects generally take many years to complete. However it has been found that many errors in the development of large scale projects could have been avoided if information that was available at the time had been considered during the development of options. Such evidence can be found in studies on BART, Concorde, Westland Bridge Melbourne, and the Channel Tunnel (P. Hall 1980, P.W.G. Morris and G.H. Hough 1986, V. Bignell G. Peters and C. Pym 1978)

The research does not claim that is possible to predict future environments with any degree of certainty and is not concerned with forecasting techniques. The research looks at how well suited the organisational design and the mechanisms used to attenuate and transfer information are, to learning and adaptation in the development of options. It is the degree to which these mechanisms are effective, according to criteria that will be introduced in chapter 3, that is a measure of organisational flexibility which permits organisational development.

There is supportive evidence that organisational design and the mechanisms used for the aggregation of useful information do influence the development of the selected option. (R. Ackoff 1970, G. Lawrence et al 1984, J.R. Galbraith 1977, A.M. Cyert and J.G. March 1963, L.R. Sayles and M.K. Chandler 1971, D.I. Cleland and W.R. King, P.W.G. Morris and G.H. Hough 1986). The general response to a complex endeavour has been identified as organisational flexibility. Attempts to introduce this flexibility have included liaison devices with the matrix structure as the most widely accepted recent development.

Liaison devices are mechanisms to provide the necessary cohesion for project development. It is clear in the literature cited above that liaison devices do contribute to project success but the devices used vary quite considerably and what may prove successful in one project may fail in another.

The research aims to show that by establishing and retaining organisational flexibility, planning and control can be more effective in bringing about project development with a desirable outcome. This incorporates the concept of liaison devices as mechanisms permitting the aggregation of useful information. The departure from previous work is the study of how well these mechanisms attenuate and transfer information between organisational functions rather than project or departmental groups. This is an attempt, through abstraction, to reduce the complexity of the interrelationships that exist within an organisation concerned with the development of a selected large scale project and thus make them more clear. In this way the effectiveness of the mechanisms used by an organisation to aggregate useful information to support planning and control will be more apparent. This effectiveness will be a measure of organisational flexibility.

Chapter 3

Theoretical Background for the Development of a Conceptual Framework.

In chapter two it was suggested that organisational flexibility contributed to organisational development and that it was introduced through mechanisms designed to aggregate useful information to support decision making and control the implementation of decision outcomes. In systems terms these mechanisms describe the way interactions between systems and subsystems are catered for in the design of the organisation.

The framework is an attempt to relate systems concepts including particularly those developed from the field of cybernetics. A cybernetic approach is being used to express the relationships between systemic parts which support organisational development, because it has been found to be particularly useful in understanding how complex systems behave and how they become effective in the management of complexity.

3.1 Systems Concepts.

Most writers who have attempted to define a system have ignored the subjective element or at least not explicitly recognised it. A widely quoted definition of a system according to J.Beishon and G. Peters (1977) is "a set of objects together with relationships between the objects and between their attributes, connected or related to each other and to their environment in such a manner as to form an entirety or whole"

They themselves use the definition:-

" A system is an assembly of parts where 1. the parts or components are connected together in an organised way 2. the parts or components are affected by being in the system and are changed by leaving it 3. the assembly does something 4. the assembly has been identified by a person as being of special interest."

This second definition is useful if the parts are recognizable to different people in the same way, however it is inadequate in that although it considers:-

"the interaction between entities in the world and those experiencing them, it fails to recognise situations where there are no entities to be recognised, where the key contribution is by those appreciating the situation. ... a system is a way of looking at the world and therefore can be defined as a mental construct of parts or relationships which make up a whole, the whole being that which is captured by the 'name' ascribed by an individual to the particular 'situation' of interest. The 'situation' could be a concept, an object, a problem, a human activity or indeed an organisation." (R. Espejo 1986)

When objects are being observed there can generally be a consensus as to the interaction between them and therefore it is possible to give an identity to the 'whole'. However when the situation is an 'organisation' characterised by ill defined human activities it is difficult to have a consensus on identity, in which case the system will be a construct in the mind of the observer. Even though human relationships may exist independent of the observer, to describe an organisation as a system is to define its purpose according to a particular viewpoint.

" Viewpoints may attach different but equally valid purposes to what appears to be the same organisational situation." (R. Espejo 1986)

To define a system it is necessary to recognise a system boundary.

"The boundary of a system is defined by the variables that a particular viewpoint chooses to look at."(R. Espejo 1986).

It is important when attempting to recognise variables relevant to a situation, that they are controllable by the system in focus and not the concern of a system at a higher or lower level. If the situation is complex and variables selected are beyond the control capacity of the system in focus but important to consider in the situation, then it is necessary to construct a model to express the unfolding of the system to the number of levels that capture the complexity implied by the variables which define the system's boundary.

" For the viewpoint the boundaries of the system are defined by the variables it assumes are under the direct or indirect control of the owner." (R. Espejo 1986)

There will be a set of activities producing the transformation of the named system and each of these activities is a system in its own right whose boundaries can be established in a similar manner, if the situation warrants a more detailed analysis, with reference to their own owners.

Inside the boundary of a system are the variables that have been chosen for consideration. These include direct and indirect controllable variables and monitored variables. These are the input and output of the named system. Outside the system's boundary are variables that cannot be controlled or only partially controlled but which have an influence on the system's output. These variables describe the relevant environment of the named system. In a similar manner these variables will be the concern of systems' controllers at multiple levels, according to the transformations that are recognised at each level.

3.2 Cybernetic concepts

> "Cybernetics offers a single vocabulary and a single set of concepts suitable for representing the most diverse types of system and offers a method for the scientific treatment of the system in which complexity is outstanding and too important to be ignored." (W.R. Ashby 1964)

The context of flexibility in the development of a large scale project is defined in cybernetics by the mechanisms of control and communication supporting or inhibiting the interactions of the participants. The interactions focused on in the research are those within the General and Parent Organisations. To understand how these mechanisms can become effective in introducing flexibility it is necessary to describe what influences their performance. Ashby (1964) introduces three particularly relevant concepts; complexity, management of complexity and requisite variety.

The complexity of the development in cybernetic terms is measured by its variety, that is, by the number of possible states in the development situation. The situation will change during the development of the project and the complexity at any one time will be related to the purpose ascribed to the situation by the named system in focus, such as the General Organisation and the Parent Organisation.

A large scale project is an organisational response to disturbances in the relevant environment.

> "One of the most important characteristics of the environment is its intrinsic complexity. The number and diversity of states and, fundamentally, their interdependencies unfolding along with time account for this complexity." (C. Davies et al 1979)

Environmental change occurs in some objective sense whether or not the system perceives it. There are two distinct ways in which a system may fail. There may be a lack of resources with which to respond to the environment. When projects fail for reasons of this type it is suggestive of insufficient recognition of real constraints at the time when options are being formulated. A second cause of failure is when a system has available the necessary resources but lacks the management capacity to use them effectively.

> "While the number of possible states in any situation can be exceedingly large, any viewpoint can only see a limited number of them. Hence, the situation is, to a larger or lesser degree, a black box for the viewpoint." (R.Espejo 1986)

The managerial challenge of the General and Parent Organisations is to control the black box which represents the subactivities implied by their transformations but which are beyond their capacity to directly control.

> "The complexity which viewpoints perceive is limited by their capacity to discriminate different transformation patterns. This does not imply peering inside the black box. It rather implies seeing the unfolding in time of the output states relevant to the situation. Different managers with reference to the same transformations, will

discriminate a different number of states in the situation. This different capacity to appreciate states implies a higher or lower capacity to discriminate situational outcomes, that is, more or less capacity to discriminate output patterns in time." (R.Espejo 1986)

To be able to regulate a transformation it is necessary for the regulator to have the capacity to achieve acceptable states in the system. With reference to communication, Ashby produced a formal statement;

" R's capacity as a regulator cannot exceed R's capacity as a channel of communication." (W.R.Ashby 1964).

If the number of statements that mechanisms for the emission of information are less than the mental states or statements in the mind of the regulator then some will be lost and never become part of the output states.

In addition if the output states capture the mental states of the regulator but cannot be transfered through the communication channel or cannot be transduced by the target transformation then states will be lost.

This is derived from Ashby's Law for Requisite Variety

"Only variety can absorb variety."

A system is said to be under control if the output is within the target set defined by the viewpoint. Disturbances will tend to influence the transformation so that the output may move outside the target set. The regulator must have the capacity to find responses to these disturbances if he is to maintain control of the system and the output of the transformation remain within the target set. If the regulator is able to maintain control he is said to have sufficient requisite variety.

> "The point of Ashby's law is that while de facto the variety of outcomes in a situation emerges from the intersection between actual disturbances and available responses, there is the possibility of 'engineering' either more response variety or less variety in the disturbances, so that the actual outcomes are limited to those within the target set." (R.Espejo 1986)

The possibility of designing mechanisms to cope with the complexity of the world, permits the regulation of tasks inherently beyond the capacity of the regulator. In order to regulate transformations beyond immediate regulatory capacity the regulator needs to be coupled to external attenuators and amplifiers.

> "Attenuators are all types of structural, operational and informational mechanisms reducing the complexity of the situation vis-a-vis the viewpoint. Amplifiers are all those mechanisms increasing the viewpoints capacity to affect the situation." (R.Espejo1986)

To design mechanisms which permit regulation of a transformation, by engineering variety, so that sufficient requisite variety is established between the viewpoint and the situation, it is necessary to have a model of the situation.

> "Every good regulator of a system must be a model of the system." (Conant and Ashby 1970)

It should be made clear that situations such as the development of a large scale project evolve over time and therefore if the regulator is going to continue to have sufficient requisite variety, it is necessary that the model he holds too evolves with time. Mechanisms designed to permit the attenuation of useful information for decision making and attenuation and amplification of information for control of the decision outcome must be continually updated so that sufficient requisite variety is maintained. Otherwise the transformation output ie. the project outcome may well be outside the target set defined by the viewpoint.

These mechanisms are the means used by an organisation to handle the complexity of the development situation. They are designed to provide sufficient requisite variety between the system and its environment and between the system and its subsystems. A model which offers criteria for effective control and communications within an organisation is the viable system model developed by S. Beer (1979).

3.3 The Viable System Model

Viable systems are those able to maintain a separate existence. If they are going to survive they need not only a capacity to respond to familiar disturbances, but potential to respond to unexpected previously unknown disturbances. This provides the system with the capacity to adapt. This is not to say that the system cannot fail. Catastrophic events may destroy the coherence of the system but viability does lessen its vulnerability to change.

The viable system model has been described at great length by S. Beer(1979) and R. Espejo (1986). The purpose here is to introduce aspects of the model relevant to the introduction of flexibility into the development of large scale projects. Flexibility is a relational problem between the structural parts of an organisation. It is not introduced by increasing the capacity of any individual part but by handling differences in capacity between related parts. This is done by the mechanisms defining interaction between organisational parts which a) attenuate information so that residual variety is matched by the number of possible states that can be recognised by the relevant part and b) amplify information to permit regulation of transformations beyond the capacity of the regulator. It is these mechanisms which provide adequate requisite variety between related parts and thus permit the organisation to work as a whole.

These parts or systems, necessary and sufficient for viability have been described as five functions by Davies et al (1979). Although the organisation concerned with the development of a large scale project cannot be described as viable, relevant functions and relationships can be used to establish criteria for organisational effectiveness. Viable systems seek to discover constraints and opportunities in their relevant environments to permit them to learn and adapt to environmental changes both now and in the future. In this sense they are permanently goal seeking in an attempt to move towards an ideal state. This can be seen in such areas as research and development where organisations develop projects to fulfil certain organisational objectives. The individual goals or responses are realised when project outcomes become operational within the business areas of the organisation.

The operational or business areas of an organisation define the organisational transformation at any one time. This is referred to as system one by Beer(1979) and is described as the Implementation Function by Davies et al (1979). Changes in the Implementation Function emerge from strategic policy developed and controlled by the metasystem to system one. It is in the metasystem that organisational development, that is learning and adaptation, is made possible.

Based on the work of S.Beer, Davies et al have identified three functions which combined are sufficient to permit learning and adaptation. These are the policy, intelligence and control functions.

The policy function of an organisation is discharged by those responsible for the definition of its mission. It is necessary to exercise the discretion of choosing between alternative strategies in organisational development. These strategies are embraced by the selection of alternatives supporting present or future oriented activities which permit adaptation to changing environmental conditions.

From the viewpoint of complexity the policy function has a limited information processing capacity. Therefore they are rarely carrying out the studies of policy concern themselves.

> "There are two crucial sources of complexity for the policy maker; that of the organisation itself in the present, and that of an environment unfolding into a future of threats and opportunities." (R.Espejo 1986)

Most of the time policy makers are deciding on issues that are beyond their capacity to comprehend and yet they need to refer to both organisational problems in the present and anticipated changes in the environment. This implies the need for two structural filters named by Davies et al as the Control and Intelligence Functions.

While from the viewpoint of variety it is necessary to minimise the information needs of policy makers it is also necessary that they maintain their capacity to be in control of the policy processes.

> "Basically, it is apparent that the intelligence and control functions offer two alternative perspectives for the same problem - the allocation of the organisation's limited resources. It is this fact that suggests the need to design the interaction between them." (R. Espejo 1986)

Debates between the two functions should produce informed conclusions which represent the residual variety of their interaction and the concern of the policy makers. The roles of the policy makers are

> "firstly to bring into the debate the relevant structural parts, secondly, to monitor these interactions and finally, to consider alternatives and decide according to their preferences." (R.Espejo 1986)

The effectiveness of the filtering of the two functions depends not only on their individual capacities but on the capacity of the policy function to steer and monitor their interactions. Intelligence and control functions are inherently complex and if there was no interaction between them the policy function would be left with the impossible task of giving closure to all the information they produce. The policy function would then be the only communication channel between them and as the capacity of this function is low in comparison with the other two functions a very large amount of variety would be lost. Potential organisational problems may not be foreseen or opportunities lost. This suggests that the two functions should be highly connected.

"If the two filters are highly interconnected and are of more or less the same complexity, the amount of information loops left for policy attention, that is the residual variety, is minimised. Such an approach is consistent with the intrinsic limited information processing capacity of policy makers. Their role in this model is to look after the interactions and give closure to the information loops which remain after filtration." (R.Espejo 1986)

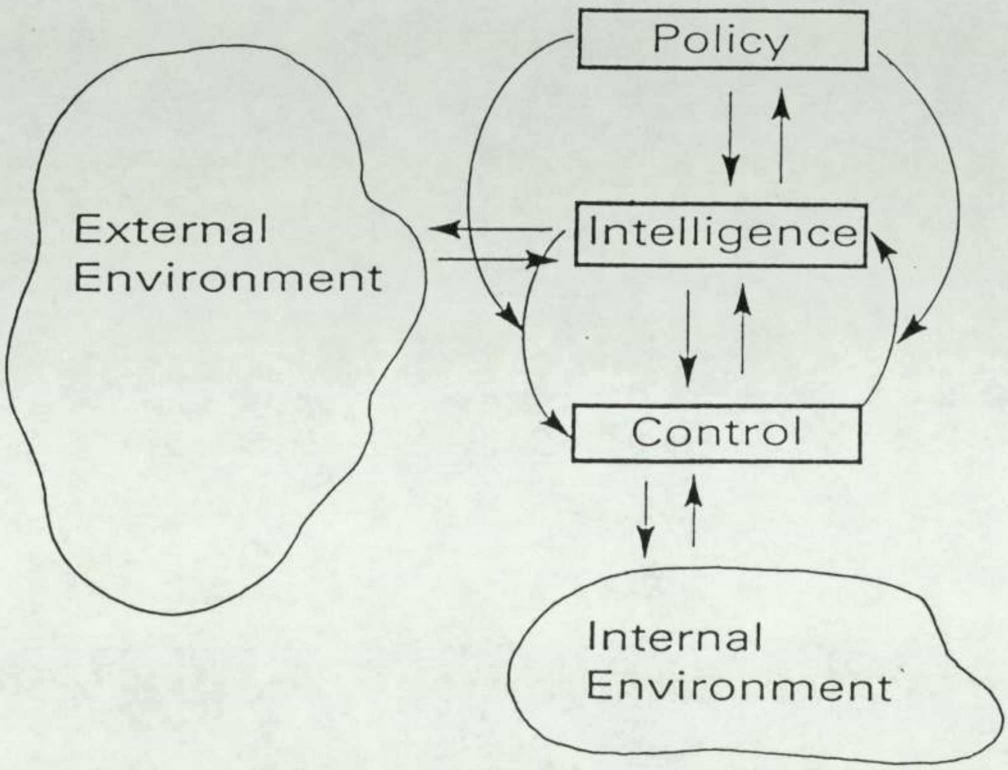
The policy function therefore does not need to have a technical understanding of the of the specific policy issues but it should have a model of how the actual organisational structure works with reference to organisational missions. The model is particularly useful in appreciating the actual communication channels between those concerned and how effective these channels are in catering for organisational relationships.

If the complexity of tasks overload those who are responsible for its implementation, it will tend to be broken down into sub tasks and their management passed to a new structural level. These activities are doing what the higher structural level could not do itself.

Figure 3 - 1

Mechanism for Adaptation

(R.Espejo 1986)



Within the viable system model primary activities are the objects of control for the managers at the immediate level above. Each primary activity is responding by itself to parts of environmental complexity and is striving for its own viability. In this model the primary activities describe the purpose of the system. Therefore in general the objects of control can be viewed as the activities which describe the purpose of the system. In the General Organisation these objects of control will be the operational activities necessary to bring about a successful project outcome. Although these are not primary activities in the viable sense their control implies an appreciation of primary activities the project outcome will influence or create.

Within the general organisation the concern of the control function will essentially be the control of organisational information processing and in the parent organisation the control of project implementation. Again this will be developed in the next chapter. Here it is sufficient to say that the control dilemma of achieving cohesion while permitting a degree of autonomy in the processing of organisational information and control of implementation, is as applicable to the general and parent organisations as it is to the viable system.

Because the imbalance in the varieties of the control function and the activities is natural, it makes no sense to force a balance by increasing the variety of the control function. This is because the more complex the environment the more flexibility is necessary for all structural levels to develop responses.

> "What is necessary is to reduce as far as possible the residual variety that the control function needs to take account of in the primary activities." (R.Espejo 1986)

It is necessary to ensure that the residual variety is properly communicated otherwise there is the risk of losing control. There is therefore a need to validate the information used in transmitting such variety. Minimising residual variety implies increasing autonomy at lower structural levels while retaining organisational cohesion. Without sufficient cohesion the responses developed at lower levels, while satisfying local environmental demands may not be consistent with the development of a global response.

To overcome this tendency towards inconsistency there is a logical necessity for a coordination function.

"The contention is that better interdivisional interactions are more likely to produce consistent responses." (R. Espejo 1986)

Cohesion brought about by the management of residual variety demands a capacity to recognise the true states of the divisions to be controlled. This cannot depend solely on the line of accountability between divisional mangers and the control function as this may conceal their own biases or control problems. The control function therefore needs access to the activities themselves as a cross check from an alternative source. This additional communication is achieved through the development of a monitoring channel. In this way the control function can receive assurances that the responses being developed at multiple levels are consistent with the developemnt of a global response.

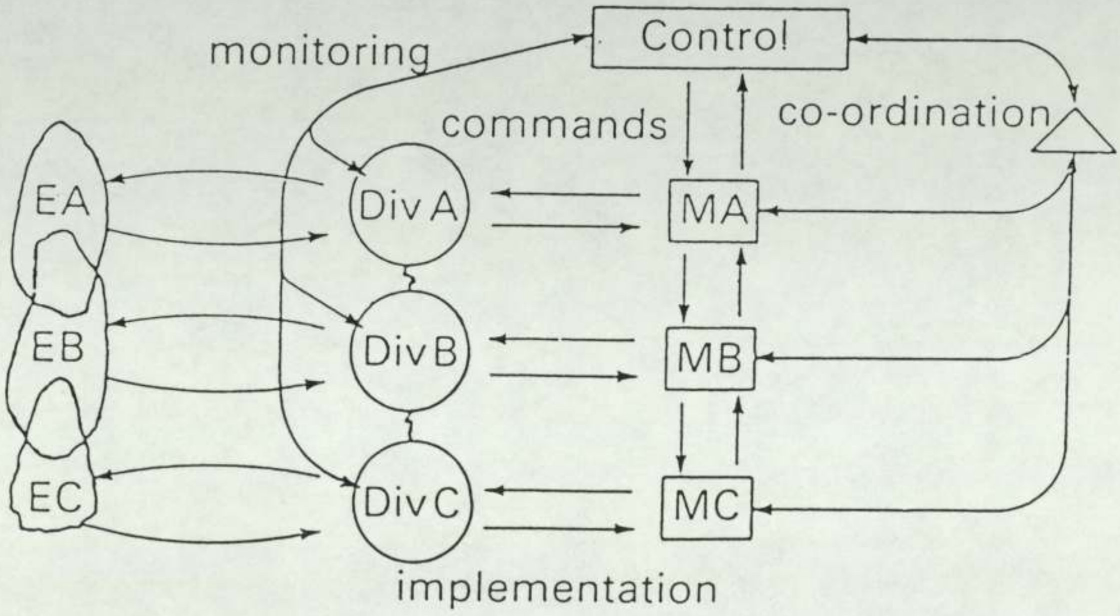
" From the viewpoint of information processing, the capacity of managers carrying out the control function needs to be in balance with the actual information flowing through the three incoming channels." (R. Espejo 1986)

If there is not a balance a response could be to reduce the residual variety still further by developing the coordination function.

Figure 3 - 2

Mechanism of Monitoring - Control

(R. Espejo 1986)



Two mechanisms have been presented here which have been discovered to be inherent to the management of complexity. Their general applicability ie. whether the activities of concern are primary or not, has been discussed. The most powerful insight to the management of complexity was made apparent when these mechanisms were related to the unfolding of complexity at multiple structural levels. Multiple structural levels in this context refers to the concept of recursiveness. Beer in his diagram of the viable system model makes it clear that policy, intelligence and control are not isolated from implementation but rather that they reoccur at each recursive level. Each primary activity within the implementation function is itself viable and as such, possesses the five systems or systemic functions, described above, at the next structural level.

Finally the communication channels that exist between the systemic functions identified at multiple structural levels should have the capacity to carry the variety of information transferred, this is not the same as quantity. The channels should have mechanisms to attenuate and amplify the variety of information so that requisite variety, which permits an acceptable performance, can be established between functions and each function should have the ability to transduce the information it receives and emits. It is the degree to which these mechanisms are effective that is a measure of flexibility as defined in this research.

Beer's principles of organisation underline the organisational requirements necessary to handle variety.

> "First principle of organisation - Managerial, operational and environmental varieties, diffusing through an institutional system tend to equate; they should be designed to do so with minimum damage to people and cost.
>
> Second principle of organisation - The four directional channels carrying information between the management unit, the operation and the environment must each have a higher capacity to transmit a given amount of information relevant to variety selection in a given time than the originating subsystem has to generate it in that time.
>
> Third principle of organisation - Wherever the information carried on a channel capable of distinguishing a given variety crosses a boundary, it undergoes transduction; the variety of the transducer must be at least equivalent to the variety of the channel." (S.Beer 1979)

The description given in this section is based on the application of the viable system to the problem of organisation development and explains how flexibility is related to functional capacity. However it does not take into account the involvement of more than one institution and other agencies, which is often the case in the development of large scale projects. A valuable contribution in this area has been made by C.Davies, A Demb and R. Espejo (1979).

3.4 Application of the viable system model to regional programs.

Cybernetics was said earlier to provide a unified language which could be used to consider communication and control in any system. Davies et al reiterate this claim for their conceptual framework in their application of the viable system model to regional programs, when they talk of system consistency.

> "We are concerned with overall consistency within a whole system to the challenge posed by particular programs. That consistency can be achieved in many ways; the way chosen will be a complex reflection of organisational strengths and policy preferences within a setting." (Davies et al 1979)

The consistency they speak of is the structuring of the organisation into systemic functional parts and the unfolding of complexity to multiple structural levels. Organisational strengths reflect the recognition of structural levels through the dispersal of autonomy or discretion and the mechanisms in use to bring about system cohesion both between structural levels and between systemic functions at each level. The ways in which autonomy and discretion is dispersed throughout the organisation and the mechanisms in use to cater for organisational relationships will reflect policy preferences such as a preference for centralised control.

By using the viable system model in the context of the development of regional programmes they have provided insight into the systemic consistencies which can be applied in this setting. Such a contribution provides a basic input to the complex process of systems design and provides concepts which can usefully be adopted for the development of a conceptual framework for the analysis of the organisation concerned with the development of a large project.

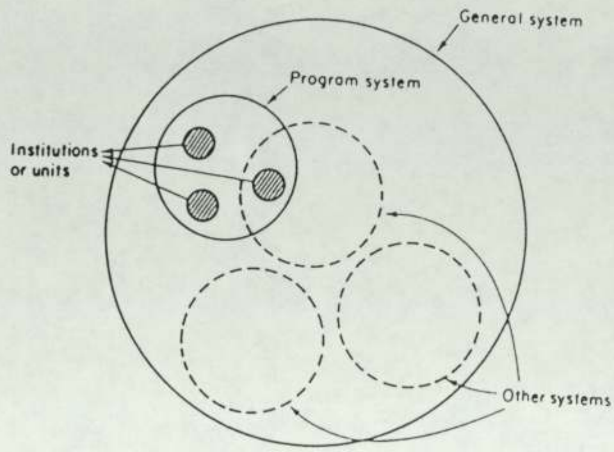
There are two powerful concepts that have emerged from their work. The first is the transformation of form into function, making possible the study of organisations instead of institutions. This is true of the viable system model but the concept is extended here to take into account that more than one institution and a number of agencies are usually involved in large scale developments. The usefullness in this abstraction is that institutional boundaries do not have to be considered and by functionalising in the systemic sense, problems of communication and control are easier to perceive.

> "Problems that are not perceived with an institutional logic might be apparent if the organisational logic is used. For instance, the necessary integration and coordination of organisational forms, ie. institutions, which are parts of the same function at the same level become more apparent. Also a particular institution which is recognised as part of the program system might also be part of another system and this logic might add to the understanding of behavioural conflicts in particular institutional set-ups."

Figure 3 - 3

Institutions and Organisations

(Davies et al 1979)



Assuming that there is functional capacity and the multi-institutional strategy will make its way as a matter of fact, it is proposed that it is possible to make this situation more effective by not sticking to an arbitary definition of institutional forms. This is the strength of the concept of organisation as opposed to institution.

The second concept emerges from the definition of the population of institutions relevant to the program derived from the disaggregation of program objectives and the corollary activities. This population is sorted into categories.

"1. those which are part of the program system, 2. those which are part of the general system."

The first category contains members of the population concerned with the accomplishment of program objectives. The second category contains those who are concerned with the setting of program objectives and in the choice of the program strategy. Their more general goals and policies set the parameters within which the program will be carried out. By contrast the focus of the program system is bounded by program activities and it considers only trade offs between activities within the program.

By applying concepts from the viable system model they say it is clear that the definition of program objectives is done by the meta-system of the program system. The meta-system is that system in which the program system is embedded. The general system is thus an instance of a meta-system.

"The set of institutions or institutional parts structuring, deciding and controlling program objectives define the meta-system and the meta-system itself defines the general system."

The second concept therefore is that of the general system as the meta-system of the program system. This is important because such a concept permits the analysis of organisational flexibilty in the formulation and selection of options which set the program objectives and the implications this has for program effectiveness.

"Functional capacity and mechanisms used by the meta-system to structure and control program objectives have fundamental implications about the effectiveness of the program system.

The general system has three systemic functions by definition ie. policy, intelligence and control functions. Flexibilty can be determined by the degree with which relational mechanisms bring about sufficient requisite variety between these three functions and minimise variety loss in the support given to decision making.

Chapter 4

The Conceptual Framework

The purpose of this framework is to permit the study of the communication and control mechanisms in use, during the development of a large scale project. In general there will be a pool of institutions, although sometimes just one institution, which initiates the development of a large scale project. Those belonging to the pool are the institutions that recognise a need or advantage in developing a large scale project and have an interest in its outcome. The organisation concerned with the development can be viewed as a goal oriented system, made up from the pool of institutions and consultants etc. The inputs to the project development are provided by the pool of institutions and the output should serve the purposes which intitiated the original inputs.

The presentation of the framework will develop through three stages; first the concerns of the general and parent organisations and the activities implied by those concerns, second the systemic functions and their relationship in performing the activities identified and third the mechanisms which introduce flexibility into the intersystemic relationships by minimising variety loss.

4.1 The concerns of the general and parent organisations.

Once the development of the large scale project is initiated by the group of institutions wishing to derive benefits from the outcome, there are two distinct activities which can be identified within the development. The first is to decide on the kind of outcome which will best serve the interests of the participating institutions and the second is to manage project development so that a desirable outcome is achieved. These two activities can be viewed as the concern of a goal oriented system, named in this research as the general organisation. Its task therefore is to cater for the integration between the participating institutions and consultancy agencies, necessary to develop options and select an option which serves the interests of the participating institutions and to provide the management capacity to steer the project implementation towards a desirable outcome. The management capacity is provided by the parent organisation which is generally a subsystem of the general organisation.

If this process is put into a time frame it becomes clear how the development of the activities unfolds.

Figure 4 - 1

Participating Institutions and the Development of the Large Scale Project

```
  --->Pool of Institutions - initiate the development of a
 |      response to serve their interests
 |                         |
 |                       input
 |                         |
 |                         v
 |
 |   ___________________________________________________________
 |
 |   The General Organisation; a Goal oriented system
 |
 |                    - develops policy guidelines for
 |   organisational debate
 |                    - monitors the debate which
 |   formulates options
 |                    - selects a particular option for
 |   development
 |                         |
 |                         |
 |                         |
 |                         v
 |   Parent Organisation; a sub system to the general
 |   organisation
 |                    - develops policy guidelines for
 |   organisational debate
 |                    - monitors the debate which formulates
 |   in greater detail the selected option, presenting
 |   possible  variations within the boundary of the option
 |                    - selects a particular variation of
 |   the selected option
 |                    - monitors and controls the
 |   development of designs which provide the blue-print for
 |   construction
 |                    - monitors and controls project
 |   construction
 |   ___________________________________________________________
 |                       |
 |                       |
 |                     output
 |                       |
 |                       v
 <--------------Project Outcome
```

The General Organisation is concerned with the option development and selection process which should satisfy the interests of participating institutions.

The Parent Organisation is concerned with the management of what is commonly called the project life cycle. The project life cycle, as described in chapter 1, is a string of activities which are usually presented in a sequential way but in practice are iterative to a varying degree and are sometimes concurrent.

This summarises what the general and parent organisation do but to be able to look in detail at systemic functional relationships it is first necessary to outline in systems terms those, who in this research, would be included in the general organisation system and its subsystem the parent organisation. Figure 4 - 2 gives a general view of the relevant actors in the two systems but the number of actors and institutional backgrounds will vary from project to project. What such a model does do is to make clear that the boundaries of the two systems are not related to institutional boundaries and may include participants who are not members of the pool of institutions. A participant is described as someone who contributes to the project outcome, either because they have an interest in the outcome as a member of the pool of institutions and want to influence the development or because they have been engaged to contribute knowledge, expertise etc..

Figure 4 - 2

A System's Map of the General and Parent Organisations

```
 ----------------------------
|    GENERAL ORGANISATION      |
| ---------  ---------------- |
|| Policy  || Managers of    ||
|| making  || existing or    ||
|| group   || intended       ||
| --------- | business areas ||
|           | served by      ||
|           | project outcome||
|            ---------------- |
| ------------  ------------- |
||Consultants ||Study Groups ||
||technical,  ||formed from  ||
||financial,  ||within pool  ||
||environment,||of instituts.||
||planning etc| ------------- |
| ------------                |
| ----------------------      |    --------------------
||   PARENT ORGANISATION |    |   |Project Organisation|
|| --------   ----------||    |   |                    |
|||Steering| |Project mg||    |   |    Designers       |
||| Group  | | Group    ||    |   |                    |
|| --------   ---------- | meta-  |                    |
|| -------   ----------- |-system->|                   |
|||Study  | |Design and ||   to   |    Contractors     |
|||groups | |Construct. ||    |   |                    |
|| -------  |Consultants||    |    --------------------
||           ----------- |    |
| ----------------------      |
 ----------------------------
            |
     metasystem to
            |
            v
 -------------------------
|Institutions or parts of |
|institutions served by   |
|general organisation     |
|objectives               |
 -------------------------
```

Having looked at the systems which describe the activities of, and the participants in, the general organisation and its subsystem the parent organisation, it is now necessaary to describe the systemic functions within the two organisations and the way they are related to perform the activities identified. This will permit the introduction of concepts in the third section, to describe ways in which flexibility can be introduced into organisational relationships.

4.2 The systemic functions and their interactions.

To make clear the organisational relationships that exist within the general organisation, the general organisation and its subsystem the parent organisation will be described separately. The reason for this is two-fold. First the activities carried out at a general organisation level will precede those activities which are the concern of the parent organisation in time, and second the general organisation and the parent organisation exist at different structural levels, with different concerns. As a systems approach requires that the system of interest should be under the control of the owner and because clearly, activities carried out by the project organisation while within the control capacity of the parent organisation, are beyond the direct control of the general organisation, it makes sense to describe the general and parent organisations separately.

The General Organisation

The general organisation is charged with the selection of a suitable large scale project to meet the needs or provide advantages for the participating institutions. In this respect it is similar to the policy function in the viable system model.

> "It is necessary to exercise the discretion of choosing between alternative strategies in organisational development. These strategies are embraced by the selection of alternatives supporting present or future oriented activities which permit adaptation to changing environmental conditions." (From chapter 3)

It was clear in the description of the policy function in the previous chapter, that it did not have the capacity on its own to substantiate issues which invariably require an understanding of organisational problems in the present and anticipated changes in the environment. According to Davies et al. this implies the need for two structural filters ie. the control and intelligence functions. The general organisation can thus be viewed as a metasystem concerned with learning and developing an adaptive response on behalf of the participating institutions. It is not in itself viable but acts as a temporary mechanism to bring together participating institutions, generally with individual organisational capacities to remain viable. The activities of this metasystem will contribute to the organisational viability of the participating institutions in the same way that the metasystem contributes to the viability of the organisation it is designed to serve, by bringing about organisational development.

Figure 4 - 3

The General Organisation as Metasystem to Relevant Intitutions or Institutional Parts

```
                      General Organisation
           ^                                    |
           |                                    |
  monitors effectiveness        provides mechanisms for
   of interaction                      interaction
           |                                    |
           |                                    v
            Relevant Institutions or Institutional Parts
```

The general organisation as metasystem to the relevant parts of the participating institutions, is therefore a mechanism for adaption, in the sense that, it is aiming to increase the response capacities of the participating institutions, to make them capable of meeting future disturbances and taking advantage of future opportunities, together perhaps with a capacity to respond to present threats to their continuing viability.

Figure 4 - 4

The general organisation as a mechanism for adaption

```
--------------  Policy Function-------------
|                                          |
|                                          |
|     -------Intelligence Function-----    |
|----|                               |----|
     |                               |
     ------- Control Function --------
```

Activities Carried Out by the General Organisation.

i) develops policy guidelines for organisational debate.

Organisational debate describes the interaction which takes place between the policy function's two structural filters, the intelligence and control functions, at multiple structural levels. Before organisational debate can be controlled it is necessary for the two systemic functions to have guidelines on what is the purpose of their interaction.

The policy function may actually have a set of options for the development of a large scale project and the interaction between the two functions in this instance will be to develop an understanding of the options by capturing both organisational problems in the present and anticipated changes in the future. In this way the interaction between the two systemic functions permits an appreciation of the potential of each option in terms of taking advantage of future opportunities, meeting future threats and contributing towards the solving of existing organisational problems.

On the other hand the policy function may have only a general idea of the response required but no defined options. In this case, the interaction between the intelligence and control functions will result in the formulation of options, by integrating organisational and environmental studies and filtering out options that warrant the attention of the policy function in support of the decision making process.

In practice the decision makers would select appropriate members of the organisation such as departmental heads to take on particular roles, make clear to them the issues for consideration such as particular options to be studied or options to be formulated, which satisfy the interests of the decision makers. They would also need to determine, perhaps with the assistance of selected organisational members, consultants that need to be engaged and the way they all need to integrate, to provide the information required to support particular decisions.

In the development of large scale projects the decision makers often find themselves in the position of not being able to take a decision even after assigned study has taken place. They just do not have enough support to take a definite decision. If the policy function still feels that the output of the interaction ie. unresolved questions is beyond its capacity to handle, it will need to look again at its policy guidelines.

ii) monitors the debate which formulates options.

The decision makers need to know how well the work is progressing without getting involved in detail. They would do this by making sure that the issues for consideration are being pursued and in a way that the guidelines have suggested. They cannot enter the black box but with effective monitoring mechanisms and policy guidelines, they should be able to establish sufficient requisite variety with the debate.

If the residual variety is beyond the capacity of the policy function, then both the degree of variety balance between the two systemic functions and mechanisms for providing interaction between the systemic functions will have to be reviewed and changes made where the policy function feels it necessary.

For instance it may be that there is a strong control function but a weak intelligence function within the general organisation. Unless this is altered through policy guidelines, by for example the setting up of study groups to consider future opportunities and environmental constraints, then the policy function will receive, unchecked from the intelligence's point of view, organisational information. This will put the policy function in the position of providing the intelligence information itself or taking decisions without this input. Sometimes this results in decisions being delayed, incurring high development costs, as in the development of Nimrod or that a decision is taken with inadequate understanding of the outcome.

On the other hand the systemic functions may be in balance with respect to variety but the interaction between the two may be ineffective. By using the mechanisms designed to monitor the interaction the policy function should be able to determine how effective the communication channels are in catering for organisational relationships. In Figure 4 - 5 the interaction between the intelligence and control functions is illustrated.

Figure 4 - 5

Organisational Debate

```
Environment--->attenuation--->Intelligence Function
                                |           ^
                                |           |
                                v           |
                          attenuated  attenuated
                         information  information
                                |           |
                                v           |
Organisation--->attenuation--->Control Function
```

The policy function needs to know if the information received from one systemic function is understood by the other. This is not merely a problem of different systemic languages but of understanding information from a function with a completely different role and performing different activities. A mere translation would not cater for the complexity implied by the functional roles and there is a necessity for both functions to attenuate the information they have filtered from their relevant areas of concern, in the pursuit of policy directed studies. The attenuation should be made in a way that is meaningful to the needs of the recipient function and within the recipient's capacity to respond. The question is how does the policy function know that all is not well in terms of the interaction between the two systemic functions? This is a question which warrants a great deal more research, beyond the work developed here. In practice in order to determine whether one functional group understands the other, the policy function may occasionally send one of its members to committee meetings designed to provide interaction or they may request reports from meetings or other methods may be used.

The cybernetic framework developed in the research cannot offer a general explanation of how it is possible to detect adequate responses between systemic functions. However certain suggestions can be offered:-

A debate is a two way process and the policy function should attempt to monitor how well each function responds to the other, as the option formulation process progresses. The policy function in monitoring the debate between the two systemic functions needs to be have a system of measurement and compare this with criteria of stability to determine the performance of the debate. What has to be worked out is how to establish the criteria of stability and how to measure the interaction. The criteria of stability in general terms is the ability of each of the two systemic functions to produce an adequate response to a stimulus it has received from the other, adequate that is in the view of the recipient ie. the other systemic function. This is the balance that should be achieved within the organisational debate. To determine if this balance has been achieved the policy function needs to be able to measure the degree to which stimulii produce adequate responses. The policy function need not measure each individual stimulii/response to detect if a balance is being achieved. It would be beyond the capacity of the policy function to do this. All that it needs to know is that in general the debate is operational and that each function is satisfied with the responses it receives from the other function, with relation to the information it has given.

The policy function within the general organisation eventually takes a decision on a preferred option. Its role from hereon will be to monitor the progress of the project development but intervention by the general organisation at this level is usually minimal once the decision to develop a particular option has been made. In fact when there is too much intervention at this level, it is can be to the detriment of the project development.

The problem when considering intervention by the general organisation, is to know how much is necessary. The general organisation wants to make sure its decision becomes operational as intended and therefore it is impossible to have no intervention. On the other hand too much intervention by the general organisation can, for instance constrain the parent organisation to such an extent that it cannot respond to conditions relevant to its activity or bring about change which is costly or jeopardises the satisfactory completion of the project. The role of the general organisation should be a supportive one and intervention should aim only to make sure that the decision to develop a particular large scale project is being implemented as intended and that the outcome continues to serve the interests of the participating institutions. Sometimes it is necessary to abort a project in the interests of those institutions. Methods to determine how much or what kind of intervention is desirable by the general organisation, is another area which warrants further research.

The Parent Organisation

The parent organisation has been described as a subsystem to the general organisation. It cannot be viewed as such until a decision has been taken by the general organisation, to develop a particular option.

The parent organisation is concerned with the management of the project life cycle and therefore can be described systemically as the metasystem to what is commonly called the project organisation. During the project life cycle there are two mechanisms described in the previous chapter which can be recognised. The first is the mechanism for adaptation. The second mechanism is the mechanism for monitoring-control, necessary to steer the project implementation towards a desired outcome. Providing the cohesion necessary to steer project development is not a simple task because usually actors performing implementation activities in the project organisation will not belong to any of the participating institutions ie. contractors, and like consultants, they will have their own institutional interests not relevant to the operation of the project outcome. Contracts are the usual mechanism to control the activities of contractors. If these are made in an institutional setting, it is very difficult, because of the complexity of the situation, to draw up contracts which are flexible enough to cater for the interdependencies between the various activities.

This second mechanism is necessarily used sequentially in a cascading fashion. First there is a need to monitor and control the development of designs which provide the blue-print for construction and second a need to monitor and control the construction. Often pressure is exerted to meet schedule targets and the management of design and construction occurs concurrently. Concurrency is defined as the situation when construction is started before the design phase is complete. This is different to the interaction for adaptation between design and construction which invariably occurs during implementation of the completed designs.

Often difficulties arise in the construction of a large scale project that were not foreseen in the design phase. For example geological problems may mean that implementation of some part of the set designs is not possible and changes have to be made. This is adaptation to emerging circumstances and requires integration between the design and construction elements of the development. This is common in large scale projects and potential difficulties need to be identified as soon as possible to reduce avoidable cost increases or delays. Therefore even when the design phase is complete there is still a need for interaction between design and construction.

Concurrency presents a different problem. Construction in this case is started before the designs are complete. Information is fed a bit at a time to the construction process, fixing in 'concrete' errors that may not be foreseeable at the particular stage in the design phase but could have been avoided if the design phase had been complete. In an attempt to avoid concurrency it is necessary to be able to identify when design is complete. At the moment methods to identify completion of the design phase have not been well developed. However by studying the cybernetics of the problem, the research offers suggestions, in the context of organisational communication and control, why concurrency so often reduces project performance.

The design phase and construction phase are controlled by the same function. They are activities at the next level of recursion with their own management teams. The control function is concerned with allocating resources to the two activities, monitoring their use and providing the coordination necessary to retain a consistency between design and construction as the project progresses. Logically the two activities should be separated in time. In controlling and monitoring design development, the control function is allocating resources to the design activity and monitoring their use. At the same time the control function is also contributing to organisational debate, as described in the adaptive mechanism. During construction the control function is concerned with allocating resources to implement and change designs which have been completed but may need to be adapted as construction problems emerge and monitoring their use.

When concurrency occurs a response is being made operational ie. construction started, while organisational learning is still developing. The degree of capital invested in construction activities will have a tendency to influence decision making, rather than decision making steering construction and may prematurely impose constraints on the variety of organisational responses. Organisational constraints imposed by construction activities will have a tendency to reduce control capacity within the adaptive mechanism, effectively reducing the richness of organisational debate. These constraints may result in options being prematurely foreclosed or potentially avoidable error ie. if the designs were complete, being unforeseen.

Concurrency offers time reductions for project completion and this may be viewed as a real advantage by participating institutions. However is should be noted that any benefits will be at the cost of organisational response capacity. Subsequent inability to respond and/or the making of an inappropriate response are two possible outcomes of overlapping project construction with the contribution of the design phase to the learning process and either can bring about error cost eg. redesign, reconstruction, project abortion costs.

In Figure 4.6 the directional lines between the control function and the design and construction management represent interaction between the control function to each of the management units separately and not to one through the other. This is a convention used in the viable system model developed by Stafford Beer.

One line of interaction between the activities indicates adaptation to problems as they arise during construction after completion of the design phase.

Two lines of interaction between the activities indicates the high variety exchange that is required when concurrency occurs which necessitates self regulation.

Figure 4 - 6

The Control Function and its Systemic Relationships During the Project Life Cycle.

Design and Construction Sequential

```
                  --------- Policy ----------
                  |                         |
                  |    |-Intelligence -|    | (PLANNING)
                  |----|               |----|
                       |----Control----|
                            ^ ^| ^
                            | || |
      |-------------- | || |------|
      monitor                  ||   coordinate
      |                        |v           |
      |--Design------Design<----- |   (DESIGN)
      | Activities   Management   |      |
      |     ^          ^|         |   complete
      |     |          ||         |   designs
      | interaction    ||         |      |
      |     |          ||         |      |
      |     v          |v         |      v
      |-Construct.--Construct.<---| (CONSTRUCTION)
        Activities  Management
```

Design and Construction Concurrent

```
                       --------Policy--------
                       |                    |
                       |   |Intelligence|   |   (PLANNING)
                       |---|            |---|
                           |--Control-- |
                             ^  ^|  ^
      -----------------|  ||  |-----|
      |                       ||        |
     monitor                  ||    coordinate
      |                       |v        |
      |---Design  -----  Design -----|    (DESIGN)
      |  Activities   Management     |      |     ^
      |      ^^           ^|         |      |     |
      |      ||           ||         |partial completed
      |    inter-         ||         |designs construct.
      |    action         ||         |      |     |
      |      ||           ||         |      |     |
      |      vv           |v         |      v     |
      |--Construct.--- Construct.----| (CONSTRUCTION)
         Activities   Management
```

It appears that the control function has two features to be considered when there is concurrency. The first is its reduced capacity in contributing to organisational debate and the second is integrating two activities where one can clearly constrain the other and produce outcomes which although undesirable could be costly to alter or maybe even necessitate the abortion of the project.

When the design and construction phases are sequential, interaction between the activities is concerned with adaptation that needs to be made as problems arise in the construction. The control function shifts ground from design to construction, retaining control over the design activity with respect to adaptation that might become necessary. When design and construction activities are concurrent the control function is concerned with two very high variety activities and the interaction between the activities will be far more complex. The control function does not have the capacity to be the hub of this interaction and therefore it will be necessary to permit self regulation through the design of coordination mechanisms.

Having looked at the systemic functions and the way in which they are related in both the general and parent organisations, it is now possible to consider how these relationships can make organisational learning and implementation control effective.

4.3 The mechanisms which introduce flexibility into the intersystemic relationships by reducing variety loss

The ability to match response to disturbance so that an output within the target set is maintained, has been already described as sufficient requisite variety. If two systems are dependent on each other to produce a combined output within the target set then the situation can be described as one of debate. This of course relates to the organisational debate that occurs both in the general and parent organisations. To understand how to make effective the interaction which takes place between the intelligence and control functions it is necessary to view the debate in the context of requisite variety.

Figure 4 - 7

Organisational Debate - Stimulus/Response

```
                       s
Environment-----------> Intelligence
                        | r       ^ s
                        |         |
                        |         |
                        |         |
                        v s       |r    s = stimulus
                          Control       r = response
                             ^ s
                             |
                             |
                             |
                        Organisation
```

In figure 4 - 7 it is clear that in debate, the response made by one function becomes a stimulus to the other function. However each function is not merely responding to stimulii received from the other function but also to stimulii received from the relevant environment or the organisation. Each function needs to be able to perceive stimulii emerging from its area of concern together with stimulii emerging from the other function in order to make an appropriate response.

It has been accepted that the variety to be perceived in the relevant environment and the organisation is greater than the variety within the intelligence and control functions and it is clear to handle all that variety the two functions need mechanisms to attenuate the information they receive. What is not so clear is that each function needs to attenuate the relevant information it has, in producing the response, which is to become a stimulus for the other function in the debate.

Figure 4 - 8

Attenuation of functional information for response

```
                                 |------------------------|
                                 |    Intelligence        |
            attenuation          |  -----------------     |
Environment---------------------->|environmental    |     |
                                 | |information     |     |
                                 | |      ^         |     |
                                 | |      |         |     |
               attenuation       | |      v         |     |
Control Function----------------->|control function|     |
     ^                           | |information     |     |
     |                           |  -----------------     |
     |                           |         |              |
     |                           |         |              |
     |                           |         |              |
     |                           |     attenuation        |
     |                           |         |              |
     |                           |         v              |
     |                            ----------|-------------
     |------------------------------------
```

The model described in Figure 4 - 8 could also be applied to the control function. This figure suggests that the combined information from the environment and the control function needs to attenuated if it is to successfully act as a stimulus to the control function in the debate. This is because even if the control function has adequate requisite variety with the organisational activities it aims to control this does not provide it with the capacity to perceive states in the organisations relevant environment. Through a continuous filtering of environmental information as it applies to stimulii received from the control function, the intelligence function is effectively attenuating the information it has relevant to the control functions purposes. This attenuated information will be the intelligence function's response directed towards the control function.

The response generated by the intelligence function becomes a stimulus for the control function. If the control and intelligence functions continue to respond to each other's satisfaction, then it is clear that the two functions have adequate requisite variety. In other words they have a flexible relationship, capable of producing appropriate responses to the stimulii they receive from each other. The flexibility of the relationship between the intelligence and control functions is only meaningful if the output of the debate is within the target set established by the policy function.

The policy function requires support for the decisions it feels it needs to make and therefore the relevance of the debate output to decision making is critical. An organisation adapts through the decisions it makes. This is the role of the policy function. However decisions can only be truly adaptive as a result of a learning process. Decisions are thus supported by organisational debate. It is in organisational debate that flexibility can be introduced and it is the monitoring of the debate by the policy function, that indicates areas where mechanisms need to be altered or replaced, to improve the degree of flexibility between the two systemic functions.

Once a decision has been taken to develop a particular option flexibility of choice between alternative options has obviously been removed. However it has been made clear that the effective control of the design phase is important, with respect to the control function's contribution to organisational debate, in the development of the selected option. Its relevancy to organisational debate will now be put aside to concentrate on the management role implied by the control function, which will be essentially the same with respect to both design and construction activities.

Figure 4 - 9

Mechanism for Monitoring-Control during design development and construction

```
  r--------      |------------------s
  |        |     v                  |
  |  s---->CONTROL--------------r   |
  v  |     |r    ^s             |   |
monitor command accountability  v   |
     |     |s    |r          coordination
     |     v     |              |   ^
     |  Design and/or           |   |
     |  construction managers   |   |
     |                          |   |
     |                          |   |
     |->   Design and/or    <---s   |
       construction operations------r
```

Essentially, monitoring provides filtered operational information necessary for the control function to assess project performance. This acts as a stimulus to the control function to bring about change if necessary. The response made by the control function to monitoring, is with respect to changes it feels are necessary in the mechanisms used to monitor the performance of the collective operational elements. It may be for example that monitoring mechanisms are not effective in detecting uneven degrees of development between design or construction areas.

Monitoring and coordination are instrumental in filtering organisational information for the control function and amplifying its response capacity. To this end they do not produce an independent response. The coordination function for example will filter organisational information to produce a stimulus for the control function and amplify reponses made by the control function to produce stimulii for the integration of operational elements. This is why on the diagram in both monitoring and coordination the filtered information from the organisational elements does not produce a stimulus for them but for the control function itself.

Command and accountability are clear examples of stimulii and responses between the control and implementation functions and as such the response from each one becomes a stimulus for the other in a continuous process similar to that described in the organisational debate. The capacity of the control function is going to be less than the combined variety implied by the operational elements and this interaction can only be effective if the control function has the support of filtered organisational information from its monitoring and coordination capacity, which in fact amplifies its response capacity beyond its own variety. In this way the control function achieves adequate requisite variety with the implementation function.

Adequate requisite variety is thus dependent on the effectiveness of the mechanisms used to monitor implementation output, coordinate operational elements and provide interaction directly between the control function and the managers of the operational elements. Communication and control mechanisms used will vary with the project, according to the degree to which the actors are inhouse ie. from the participating institutions with an interest in the outcome; the degree of technological innovation; geographical distribution etc.. Basically however the mechanisms should be designed to establish adequate requisite variety between the control and implementation functions. If adequate requisite variety is achieved and the control function is able to produce responses to stimulii emerging from the implementation function and control the implementation of the responses then organisational flexibility is maximised.

Figure 4 - 10

Achieving Adequate Requisite Variety between the Control and Implementation Functions.

```
                              -----------------
      -----attenuated---> CONTROL <--attenuated--    |
      |    information    |     ^     information|    |
      |                   |     |                |    |
Monitoring                |     |            Coordination
      |           attenuated  attenuated         |    |
      |           information information        | amplified
      |                   |     |                |information
      |                   |     |                |    |
      |                   v     |                |    |
      |                            -------------      |
      |--------------IMPLEMENTATION <--------------
                        self regulation
```

Earlier in the chapter the effects of concurrency on organisational debate once an option had been selected was described. Concurrency of design and construction has an effect too on the control of the project implementation. The variety disposed by the implementation function will be greatly increased. The magnitude of this increase will place almost impossible demands on the control function, unless a way can be found to establish adequate requisite variety between the control and implementation functions. This implies the necessity for the careful design of monitoring and coordination mechanisms. The difference between the variety disposed by the implementation function when design and construction are sequential and when they are concurrent is enormous. The magnitude of this difference is rarely appreciated until the 'business as usual' approach produces unwanted outcomes, often at a great cost not just in monetary and technical terms but also socially, and commitment may be irreversibly lost, at any or all structural levels within the project organisation.

Chapter 5

Research Methodology

The conceptual framework developed in chapter 4 is based on cybernetics and all the work that has been done on the viable system. The methodology is based on the cybernetic methodology developed by Raul Espejo. The aim of the research is to apply the framework to the development of a large scale project, using the cybernetic methodology presented in this chapter. The outcome of the research is to give insight, through a case study, into ways organisational flexibility was lost and compare this with evidence of reduced project performance.

Basic to the development of the research methodology has been the work of Raul Espejo.

" A methodology for problem solving is therefore a set of interrelated activities aimed at facilitating the intervention of analysts in organisational problem situations." (Espejo R. 1986)

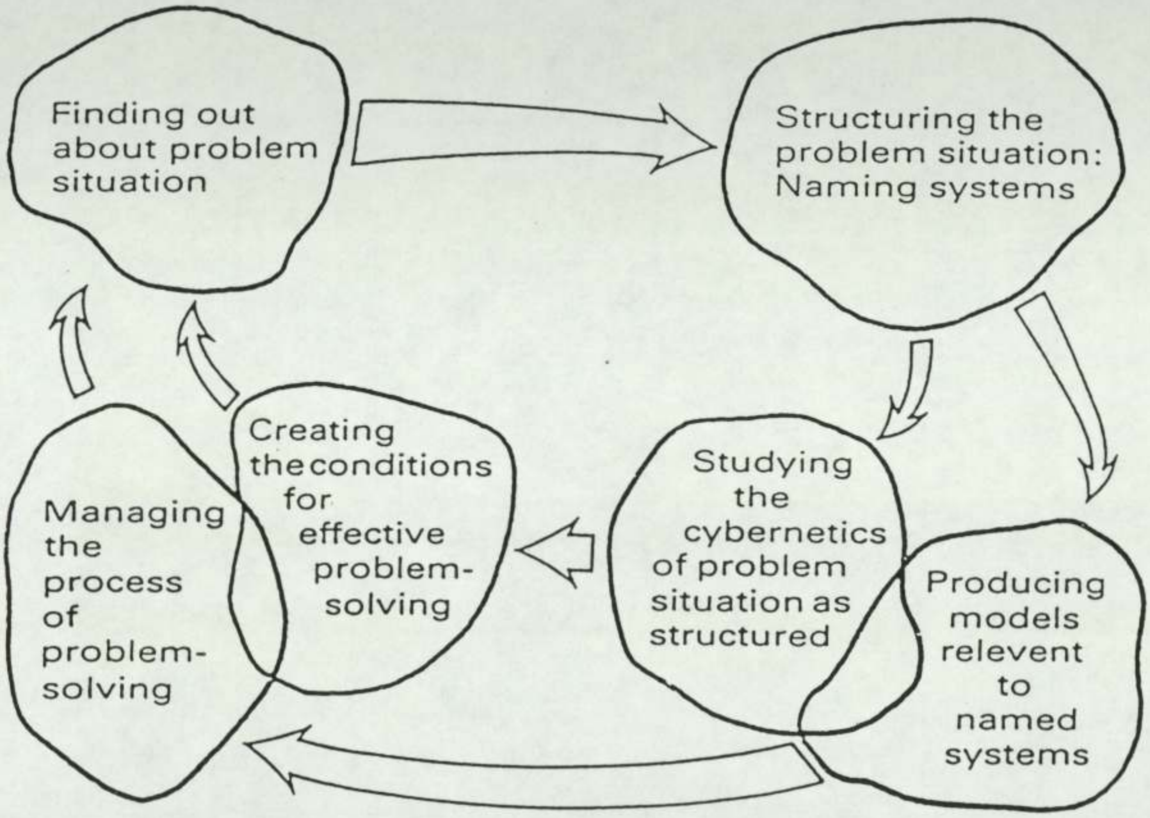
Using to a large extent the approach of soft systems methodology, developed by Peter Checkland and associates at Lancaster University, he develops an alternative methodology, the cybernetic methodology.

" In contrast to the soft systems methodology, this methodology accepts that human activity systems are more than mental constructs in the minds of the participants. The cybernetic view is that these participants are constrained to different degrees by the organisational structures in which they are embedded, and therefore by changes and modifications in these structures it is possible for them to develop different appreciations of a problem situation. Moreover, while some structures are likely to inhibit their appreciations and/or support the production of very poor appreciations, others are likely to liberate their views and make likely richer appreciations of the problem situation."(Espejo R. 1986)

Figure 5 - 1

Cybernetic Methodology

Raul Espejo 1986



The research is not action research in the way the above methodology suggests. The diagram shows an intention to go back to the situation and see how that is altered by the process of intervention. In the research the purpose is to study a situation, working out the context in which this situation took place in terms of communication and control and deriving from there, conclusions showing how adequate or inadequate the process was in terms of flexibility. The research does not use those activities in the bottom left hand corner of figure 5 - 1, which imply intervention or action in the organisation.

Figure 5 - 2

Research Methodology

```
Research----------------> Structuring the case study
hypothesis                (naming systems)
     ^                          |
     |                          |
Studying the outcome with       v
reference to actual       Studying the cybernetics
project development       of the named systems
     ^                          |
     |                          v
Comparing with            Producing models relevant
reference to       <-------to the named systems
criteria of
effectiveness
```

Figure 5 - 2 outlines the methodology used to provide support for the research hypothesis. The process was repeated for each of the named systems ie. the general and parent organisations.

5.1 The hypothesis.

The research problem is to demonstrate the use of the methodology to measure the flexibility of large scale projects and to show that the methodology works. The methodology needs to show that by using the systemic framework it is possible to organise knowledge and understand situations in ways that are not possible using normal procedures. To test the hypothesis a case study was analysed using the methodology outlined in figure 5 - 1 above. This methodology has been developed as an approach to studying organisational relationships and the degree to which they support by their flexibility or restrict by their inflexibility, organisational development. Finally by presenting evidence to establish an association between organisational and project development, support for the hypothesis is sought.

The development of a new terminal at Birmingham Airport was chosen as a case study because it was a local government project, developed geographically near to the area of study. This situation it was felt would facilitate access. Also it was a completed large scale project, permitting an analysis which spanned the whole project development. This posed some difficulties in that those interviewed occasionally could not remember details, particularly concerning early stages in the development. However as the fieldwork progressed it was possible to cross reference interviews and other sources of information to clarify details and fill gaps.

The background to the development will be presented in the next chapter. It is sufficient here to say that the new terminal was a project developed by the West Midland's County Council and the fieldwork was carried out during the last three months before it was dissolved. It was dissolved as a result of the national decision to abolish metropolitan county councils at the end of April 1986. Council officers past and present and airport officials gave their fullest cooperation, being responsive to all requests. Without this help it would not have been possible to gather the relevant data in the time available.

In the general organisation the decision making body was clearly the West Midland's County Council. The articulation of the options was the result of other agencies who were also interested and concerned with the outcome. The problem could have been perceived from the interests of the BAA (major consultants for option development). They would have had their own objectives and perhaps within those objectives, the fact of having a better West Midland's airport was a relevant factor. In the research the study was concentrated on the perspective of one institution the West Midland's County Council, because they were the decision making body. The important point is that the methodology is meaningful only through the viewpoint of the observer. In the research the viewpoint implied that the objectives of interest were those of the West Midland's County Council and the case study was structured from that perspective.

The appropriateness of the case study comes from the scale of the project, the complexity of the task, the ill defined nature of the organisation concerned with the development and the communication and control problems associated with a complex human activity system.

5.2 Structuring the case study.

To establish consensus about a system made up of objects is not difficult. A hard systems approach, used frequently in operational research, is useful when defining such a system. However when naming organisations as systems, viewpoints may differ. As the methodology used in the research unfolds it will become clear that because of the illdefined nature of the systems named in the development of the large scale project, a soft systems approach has been used. The general and parent organisations are viewed as soft systems requiring a variety of participant viewpoints to describe organisational relationships.

It is important to note that the systems, the general organisation and the parent organisation, were named by the research and did not exist independent of that viewpoint. However the transformations implied by each named system and the relationships between participants did exist in the development of the airport terminal. To structure the case study it was therefore necessary to obtain data from participants and relevant county files, to determine for each named system the activities implied by the transformation and the relationships which existed between participants carrying out and controlling those activities.

The soft systems approach to study human activity systems (Checkland 1981) sees the structuring of the problem or the naming of systems as an important aspect of the work of a researcher independent of their particular purpose. He sees the naming of systems in practice as an important methodological problem and suggests the use of 'root definitions' as a means to name systems. He defines a root definition as

> "a concise, tightly constructed description of a human activity system which states what the system is".

Espejo (1986) gives the idea of a root definition a different status than that of a hypothesis concerning the eventual improvement of a problem situation, ie. as a shorthand to describe the real world as perceived by a viewpoint. Instead of talking about root definition he prefers to talk about names relevant to a situation. These he says are the 'names of both the transformation and participants that a viewpoint perceives as relevant with reference to the situation'. Although the system does not exist independent of a viewpoint, the transformation may exist independent of that viewpoint.

In the context of the case study the naming of each of the two systems, the general and parent organisations should make explicit:

Transformation - what input was transformed into what output?

Actors - who carried out the activities implied by the transformation?

Customer - which institutional parts were the beneficiaries or victims of the transformation?

Owners - who controlled the transformation?

Actors, customers and owners are the participants implied by the named system. The initial phase in the data collection was to establish who these participants were. It involved eliciting from different participants the system viewed as concerned with option formulation and selection ie. the general organisation and the system concerned with the development of the selected option ie. the parent organisation.

Initial access was obtained at the airport itself and there most of the names of the key participants in the project development were identified. Other names were added as a result of information gained during interviews. These included airport personnel past and present, West Midland's County Council members and officers past and present and managers of consultancy and construction firms who participated in the development.

The next phase was to determine the relationships that existed between the participants, constituting the general and parent organisation. To do this it was necessary to confirm or establish the role of each participant in the terminal development, the tasks they performed and the communication channels that existed between them and other participants both written and in person, to enable them to perform their tasks.

The interviews were partially structured to acquire this data. In addition personal views were obtained on the way decisions were taken, the contribution individuals felt they had been in a position to make, in both providing the support for council's decision making and controlling implementation, and the perceived causes of events during project development they felt were related to organisational communication and control problems.

Personal views on certain issues produced discrepancies which were eventually reconciled by an overview of all the relevant interviews and by reference to committee and steering group files that were made available. Whenever it became apparent that a discrepancy existed, questions in subsequent interviews were designed to obtain other views, in an attempt to make clearer actual relationships which existed and events which took place. The reasons for discrepancy cannot be determined although there were indications of personality problems between certain participants and instances of self interest. However this goes beyond the concern of the research. It is sufficient to say that by cross referencing interviews with each other and with policy and steering group files it was possible to obtain the data necessary to develop a rich picture of the general and parent organisations as they are perceived in the research.

5.3 Studying the cybernetics of the named systems.

In developing a large scale project the organisation is attempting to achieve a project outcome in the shortest time and at the lowest cost without causing detrimental effects to participants from the experience of taking part in the project. The aim should be to have a system to give people a chance to put themselves into the project without overstretching themselves, participating in the process in a way that people feel they are making useful contributions and not working in a vacuum. These aims are realised through the level of requisite variety each systemic function has with reference to the complexity implied by its organisational role.

If the requisite variety of the systemic functions permits a high level of performance, in their interactions, organisational relationships can be described as flexible, allowing each function to respond to other relevant functions. If the requisite variety of one or more systemic functions produces an inadequate response capacity, then variety in systemic interactions will be lost. Loss of variety could result for example in the loss of opportunities or loss of control capacity.

According to Beer's first principle of organisation:-

> " Managerial, operational and environmental varieties, diffusing through an institutional system tend to equate; they should be designed to do so with minimum damage to people and to cost." (Beer S. 1985)

The tendency to equate is an observation drawn directly from Ashby's law of requisite variety ie. "Only variety can absorb variety." In terms of the development of a large scale project, the named system whether it is the general or the parent organisation will have variety diffusing through it. Requisite variety will exist anyway between systemic functions within the named system and between the named system and its relevant environment. Performance will depend on how well the requisite variety which exists meets the complexity of the situation.

As the first principle of organisation above states, all managerial, operational and environmental varieties diffusing through the named system will tend to equate and therefore the cybernetics of the situation implies that the mechanisms for communication and control between all systemic functions within the named system should be designed to avoid the costs incurred when variety is lost. Wherever variety loss occurs, flexibility of response by systemic functions is lost and logically the possibility of project failure or partial failure with reference to project objectives increases.

The management of complexity, requisite variety and mechanisms for control and communication, were discussed at length in the previous chapter. It is sufficient here to say that once a rich picture has been established of each named system from the data collected it is necessary to introduce these concepts to permit the production of models of the real world situation.

5.4 Producing models relevant to the named systems.

In the context of human activities, models are descriptions, simplifications, abstractions,... of real world situations. The emphasis in describing the two organisations, is in the relationships and not in the parts. Mechanism is defined as any stable form of communication or interrelation between systemic functions that permit them to work as a whole. The structure of an organisation is defined by the systemic functions and the actual communication channels in existence and not by the parts of an organisation and lines of authority formally defined by, for example, the organisational chart.

Producing models which describe the interrelationships between systemic functions implies that it is possible to identify within the model, which systemic function individual participants belong to. This was done by determining through interviews the role of each participant. For example in the model of the general organisation, if a participant was part of a study group created to discover opportunities presented by the development of certain options, then it is clear that he would be part of the intelligence function. Having identified which systemic functions capture the role of individual participants, the mechanisms describing the interaction between functions can be identified by eliciting from the participants their relationship to other participants, such as contact through reports, committee meetings, personal contact, guidelines etc. and the frequency of the various forms of contact.

During the development of a large scale project the roles of participants may change. In the development of the terminal at Birmingham Airport role changes occurred for a variety of reasons. Changes occurred when:- the stage in the development required a change; organisational restructuring or personnel changes brought about role changes; the participant's perception of their role changed.

During the interviews it became clear that there had been changes in the roles of certain participants. As these changes in role appeared to have an effect on communications within the two organisations at different stages in the project development, the occurrence of changes in role and the effects this had on mechanisms used for communication and control, were carefully recorded and taken into consideration when producing models of the general and parent organisations.

There have been two mechanisms described in the previous chapter which are used in the research to structure systemic models of the general and parent organisations as they existed in the real world situation. These are the mechanism for adaptation and mechanism of monitoring -

control. The models are descriptions of the systemic functions and the interrelations between them, which would permit each of the two organisations to work effectively as a whole.

The general organisation is viewed in the research as a system whose purpose is to formulate options and select a preferred option. This is an example of a system which needs to learn and adapt, in order to develop desirable and feasible options with reference to the objectives of the institution/s concerned. It is therefore a metasystem to the relevant parts of the institution/s ie. the parts that have an interest and will be affected by the project outcome. The model of this system as a metasystem will describe the systemic functions of policy, intelligence and control and the interrelations between them.

The parent organisation is viewed in the research as a system whose purpose is to control the implementation of the selected option to steer the development towards a desirable outcome. To be able to steer the project development it was made clear in the previous chapter that both mechanisms are involved ie. adaptation, and monitoring - control. The parent organisation is viewed as a metasystem to the project organisation. The focus of interest will again be on the mechanisms that existed to permit interaction between the systemic parts.

5.5 Comparing with reference to criteria of effectiveness.

Having developed models of communication and control mechanisms as they appeared to work in the general and parent organisations in the real world they are then compared with reference to cybernetic criteria of effectiveness. Mismatches between the 'real world' models and the reference 'abstract' models suggest possible areas of improvement. The real world models produced in the methodology are descriptive models and the abstract models are conceptual models whose purpose is to logically establish the communication and control mechanisms necessary to provide an adequate level of requisite variety in interfunctional relationships. The conceptual model developed in the framework presented in the previous chapter, provides the reference which serves to structure the descriptive model. This is necessary in order that a valid comparison can be made.

Checkland's proposed comparison between the conceptual model and perceptions is similar to the comparison described above but in the research methodology the rich picture is structured within the conceptual framework. By abstraction with reference to the conceptual model, the descriptive model captures the cybernetics of the rich picture and thus permits a comparison of the communication and control mechanisms that existed in the two organisations with the criteria of effectiveness.

Earlier in this chapter it was noted that mechanisms that supported interaction between participants were said to have a high degree of flexibility and mechanisms which inhibited interaction between participants were said to have a low degree of flexibility. Comparing descriptive and conceptual models will suggest areas, where mechanisms for communication and control did not appear to provide an adequate level of requisite variety, to handle the variety implied by the interaction between systemic functions. It is then possible to suggest where flexibility was lost in the organisational relationships and the influence this would have on decision making capacity in both the general and parent organisations and the capacity to control project implementation in the parent organisation.

5.6 Studying the outcome with reference to actual project development.

The focus of the research is to show that the methodology presented can be used to assess how the degree of organisational flexibility influences project development. This refers not only to the eventual project outcome but to system outputs during the development. The aim therefore is to associate areas which suggest that communication or control mechanisms inhibited interaction thus reducing flexibility, with actual events which were viewed by the participants to produce undesirable outcomes. This includes evidence of decisions taken or delayed decisions, which unnecessarily foreclosed options thus limiting opportunities and the emergence of error during project implementation which can be associated with control or communication problems.

In order to make this comparison valid care was taken to restrict evidence to information obtained during interviews and from policy and steering group files. It is a temptation as an observer to form one's own conclusions which neatly support the hypothesis but the analysis of the results, by giving reference to the source of the evidence in each instance, demonstrates that 'fitting' the results to the research did not occur. It should also be made clear that wherever possible evidence is the product of more than one source, to overcome instances of failing memories or wishful thinking.

Chapter 6

The Case Study - A background to the development of the new terminal at Birmingham Airport 1974-1984.

6.1 History of the airport prior to 1974.

Birmingham Airport was opened in 1939. During the Battle of Britain and the remaining war years, Birmingham Airport was used by the government as an airforce base. In 1960 the government handed the airport back to Birmingham and partially in recognition of the airport's wartime contribution, formalised an offer of financial support in the form of a grant towards future capital development. According to the submission of the West Midland's County Council on the Birmingham Airport development, to the Department of Trade in 1977, this grant was to be sixty per cent of all capital expenditure. The possibility of getting the grant ran out in 1981. It was made clear that the grant would be still available, at that final date if a contract had taken effect, even if building was not complete.

During the sixties incremental changes were made to the terminal buildings but during this time the appearance of the terminal deteriorated and when the development of the National Exhibition Centre (NEC) was being mooted in the sixties, it was thought by Birmingham City Council that something should be done about the airport at the same time. Birmingham City Council were concerned with the development of plans for a new terminal and in 1972 they were granted planning permission for the development in close proximity to the British Rail International Station. The plans were for a terminal that catered for up to five million passengers/year. Planning permission expired for these particular plans in 1977.

Looking at the annual traffic growth figures for Birmingham Airport from 1971 - 1972, % increase/decrease, it is clear that at the time Birmingham City Council was developing the plans for a new terminal there was a marked increase in the growth of total terminal passengers. This growth continued until 1974 when there was a noticeable slump of 10.1% compared with the previous year. This slump which has been associated with the oil crisis, coincided with Birmingham Airport being taken over by the West Midland's County Council.

Table 6 - 1

Annual Traffic Growth at Birmingham Airport 1970 - 1974
(%increase/decrease)

1971	1972	1973	1974
+21.9	+11.9	+20.9	-10.1

Table 6 - 2

Passengers Carried at Birmingham Airport 1970 - 1974

1970	1971	1972	1973	1974
686,875	837,171	936,836	1,132,661	1,016,818

Table 6 - 2 shows that at the end of 1970 the number of passengers exceeded 500,000, which was the designed capacity of the existing terminal. The airport was not only losing its appearance but also its

capacity to cater for an increasing number of passengers. The reason Birmingham City Council selected a different site within the airport for a new terminal, was said to be because the positioning of the runways restricted the area available on the existing site. There was just not enough space to build a terminal which would have the capacity to deal with projected passenger growth. In addition it was felt that proximity to the National Exhibition Centre and the International Railway Station would stimulate passenger growth and promote business in the region.

By 1972 it was clear to the assistant airport director that if Birmingham Airport was to compete with other airports such as Manchester, it would have to be in a position to attract more airlines, particularly from Europe. At the time European Airlines were satisfied with their arrangements with other airports, such as Heathrow and Manchester and could not see any advantage in coming to Birmingham, when it was so obviously incapable of catering for the increased air traffic and passenger numbers this would imply. In other words it was not an attractive destination for these airlines. Birmingham City Council influenced by the airport director viewed the airport as a potential gateway to the region and therefore considered ways of making it more attractive to airlines and businesses. They saw it as an integral part of the transport infrastructure which was already well developed with its rail and motorway links.

The success of the National Exhibition Centre was also a major factor which influenced the City Council in its decision to develop plans for a new terminal. Many business men coming to the NEC used small aircraft (General Aviation GA). These used the second runway which followed the direction of the westerly prevailing winds. This second runway would have had to be closed if development had taken place on the existing site, to satisfy Civil Aviation Authority landing area regulations.

The general conclusions of Birmingham City Council were that the existing terminal facilities were unattractive and inadequate to cope with passenger and airline traffic growth; the NEC was having an effect on traffic, suggesting that a terminal with ease of access to the NEC would be an advantage; only by moving the terminal site to the NEC side of the main runway could they develop a terminal to cater for projected traffic growth and retain the second runway. The plans were not implemented at this time because Birmingham City Council could not provide the financial support for the development, even with a government grant. No further progress was made therefore until the West Midland's County Council took over the airport in 1974.

6.2 The emergence of the West Midland's County Council in 1974.

A major restructuring of the system of Local Government in England and Wales took place in 1974. The 1972 Local Government Act had created a two tier system of metropolitan and shire authorities. County and District authorities were created for six large conurbations (metropolitan areas) and about forty urban-rural shires. Four types of independent authorities emerged from this restructuring:- Metropolitan counties, Metropolitan districts, Shire counties and Shire districts.

In line with the new local government act, the West Midland's County Council had fewer statutory functions in its own right in comparison to Metropolitan districts, such as Birmingham City Council, but it had a far more compact area with problems and needs which generally speaking, were far more likely to be common right across the county. The main statutory functions that were allocated to the WMCC, were planning and transportation and public protection. The statutory functions suggested for Birmingham City Council, Coventry City Council, Solihull District Council etc., were development, housing, social services, education, leisure and environmental health.

This allocation of functions between the WMCC and the District Councils serves to illustrate that although the WMCC was particularly well placed to promote and coordinate a total approach to the substantial urban problems in the region, it was powerless to respond independently in many areas. Areas in which the WMCC had discretionary powers to develop long term strategies on a regional basis included highways, transport planning and Birmingham Airport.

The West Midland's County Council was created on the 1st April 1974. The original council members were seconded from Borough Authorities, mainly from Coventry. The Airport Director, who had been up to 1974 the assistant airport director, said that this was a particularly good council with a mix of labour and conservative members. He felt this was good because it created debate within the council which he felt was necessary for the effective development of council policy. In its regional capacity the council saw its major concern as the economic and social development of the West Midlands.

The airport sub committee files in 1977 reflect its regional concerns in the development of a new terminal. In its definition of the role of the project outcome the committee includes:-

" 1. Benefit to the local community - additional flights and an increase in the number of destinations. 2. Beneficial impact on regional economy - the existence of an airport is one of the considerations involved in a firm's decision to locate in a particular area, especially the case where overseas foreign firms are concerned. 3. New airport facilities will to a large extent, provide the final link in the provision of a comprehensive transport network. 4. Additional employment - directly by the development of the airport. A very subjective assessment of the project in a wider context than just the direct use of real resources - the county council is of the opinion that there are very real economic and social benefits related to the development of Birmingham Airport."

Before 1974 the management team at the airport were aware of the limits of the existing terminal in coping with the increasing demands of air transport. They saw the emergence of the WMCC as an opportunity to develop a new terminal which would be competitive with other British airports on an international scale. The departmental structure of the county council placed control of the airport within the Transport and Engineering Department. The airport management therefore communicated formally with the County Surveyor and informally with the airport sub committee, in an attempt to gain Council support for a new terminal development. Council approved the development of project proposals and the county surveyor, head of the Transport and Engineering Department was given the task of overseeing option formulation.

Building a new terminal was an all party decision initially and remained so even though questions were raised by council members at times during the development, on whether a new terminal should be built. Interviews with both the Chief County Architect/Planner and the Airport Director suggest that there was not at any time a serious threat to the development through policy changes. The main threat to project development from council members came from time constraints they imposed to ensure a level of development was complete before election and the DOT grant deadlines. A combined building and civil engineering contract was awarded to J.Laing and construction started within the deadline set, but before design was complete, early in 1981.

The airport director during an interview explained that when he first came to the airport as assistant airport director in 1973, he felt that it gave the wrong impression of the region. As gateway to the Midlands it was a poor image for the Frenchmen, the Germans or any professional people that were arriving, thinking it was a go ahead area. That, he felt was the impetus behind thinking there must be something done about it. Midland's industry was beginning to suffer "the new industrial revolution". It became obvious that it was tourism, the NEC and newer industries that were going to generate growth in the area. Business he felt would grow by attracting money from abroad in a different sphere. This he felt was part of what got the terminal development going. The other part of it was that many of the airlines they started talking to, Lufthansa, Air France, Swiss air, SAS etc. saw no attraction in coming to Birmingham Airport, preferring to use Heathrow or Manchester who had proved their ability to cater for the increased traffic.

He recognised that although his interests lay with the airport, it was part of the regional infrastructure. In pushing the airport in international terms, more could be done through the county council and so in the interests of developing the airport, he became concerned with the regional infrastructure and gained support by speaking to those with influence in the council. He saw his role and that of his team at the airport, as selling the airport development to those with influence such as British Rail, Airlines, NEC, Department of Transport, Tourist Board, Chambers of Commerce and Trade, District Councils and of course the WMCC whose financial support and expertise was required. The airport management team pushed the development as a regional issue because it was felt that only by viewing Birmingham Airport as a regional airport and thinking big, could it develop into valid competitor with other British airports on an international scale.

Council members on the advise of the chief executive made the county surveyor, head of the transport and engineering department, responsible for the formulation of options. This is a departure from the guidelines on the implementation of the local government act, given in the Bains report of 1972. The Bains report suggested that because of the overall responsibility for the region held by Metropolitan Counties and because of the inter-relationship of problems in the environment within which it is set, the traditional departmental attitude within much of local government must give way to a wider ranging corporate outlook. The report put forward the view that the need for a corporate approach is beyond dispute if local government is to be efficient and effective. Derek Hender the Chief

Executive of the WMCC was infact noted in the report as producing valuable articles, supporting this approach when he was a chief officer in Coventry City Council prior to 1974.

6.3 Organisational Structure within the West Midland's County Council

Figure 6 - 1

WMCC Organisational Structure

Dual Management

```
 Committee Structure

                  Council- - - - - - - -Passenger Transport
                    |                        Authority
--------- Policy and Resources------            |
|              Committee           |   Passenger Transport
|                   |              |        Executive
|     ---------------------------  |-----------------------
|     |         |       |       |         |               |
| Finance  Personnel  Land  Performance  Public        Police
|                               review   protection
|            Sub Committees              1)Fire
|                                        2)Consumer
Planning and                               protection
Transport Comm.
|                                            Committees
Airport
sub committee


 Departmental Structure

                   Chief Executive
                         |
                         |---------County Personnel Officer
                         |
--------------------------------------------------------
|         |              |             |            |
Other    County Planner   County      County     County
Chief    /Architect      Treasurer   Secretary  Surveyor
Officers                                            |
(Chief Constable                                Transport
 County Fire Officer                               and
 Consumer Protection Officer                   Engineering
 Waste Disposal Officer                           Dept.
 Economics Officer)                                 |
                                 Airport  ----------|
                                                    |
                                 Highways ----------|
                                                    |
                                 Public Transport---|
                                                    |
                                 Motorways----------|
```

Projects other than the airport development carried out by the council were generally small. The architectural design and planning departments under the one Chief Officer, Alfy Wood carried out projects such as the building of new units for the police station, consumer protection shops and small extensions at the airport. The transport and engineering dept. under the chief officer Stuart Mustow carried out projects such as minor road alterations, traffic management and public transport route design, within the region. The organisation of public transport was the concern of the independent Passenger Transport Authority. Each project according to policy files appeared to be the concern of one or the other of these two departments, who worked with other departments as it was necessary.

Figure 6 - 2

The Transport and Engineering Department

```
                    County Surveyor
                          |
                 Assistant County Surveyor
                          |
   Transport Study------|------Structural
     Group              |      Engineering
                        |
      Civil-------------|------Mechanical &
    Engineering         |      Electrical
                        |      Engineering
                        |
     -----------------------------------------
       |             |              |           |
   Airport   Public Transport   Highways   Motorways
   Director
       |
   Assistant
   Airport
   Directors
```

The transport study group shown in figure 6 - 2 had no airport expertise. Later in 1977 an air transport study group was formed. The significance of this will be discussed in a later chapter. It is sufficient here to say that at the time TED was concerned with the development of proposals for a large scale development, it did not have the expertise to study the regional aspects of air transport. The Airport was in the Transport and Engineering department and the Airport Director who had had the position of Chief Officer in Birmingham City Council, no longer held that position.

Chief Officers from all departments met monthly to discuss with the chief executive, agenda items, structured to discuss project submissions made by individual officers. It was at these meetings that the need for integration between certain departments was decided on. All projects had to have the approval of relevant council committees and it was generally the task of the chief executive to present potential projects to these committees in order that resources could be allocated. On many occasions the chief executive would be assisted by or represented by, the chief officer concerned with the presentation of a particular project to a committee. The policy files show that council committees did not approve any project unless they felt the case for such a development was conclusive.

Small projects including those at the airport tended logically to be the concern of one of the two chief officers mentioned and little interaction between the two departments was necessary. Large scale projects and certainly those connected with airports were beyond the experience of council members.

S. Mustow in an interview described how the early work on the project proposals was the concern of his department.

"The outline plans and proposals were developed in the Transport and Engineering Department TED. When TED had produced their proposals they took them to the chief officers group. Once approved it went from there to the airport committee. From the airport committee through policy committee to the county council, who approved the development in principle. Once that was done the Steering Group was formed. The initial work leading up to the decision to develop the project took place in this department."

The department used outside consultancies including the British Airport's Authority, Alan Stratford and Associates who are air transport consultants and a series of other consultancies to look at the planning data and national government policy guidelines.

The British Airport's Authority were appointed in 1975 as:-

"consultants to advise, in liaison with senior officers of the County Council, on the need for, form of, and location of new terminal facilities. In accordance with the accepted view the BAA were instructed to consider only those sites which were adjacent to the NEC and BR Birmingham International Station." (Submission by the WMCC to the Dept of Trade October 1977)

S.Mustow formed a working group led by the Assistant County Surveyor P. Ronan to work with the BAA, looking at various options for the development. At the end of the study period it was decided what shape the terminal should be, where it should go and then it had to be decided how much it would cost and what size it should be. This exercise lasted for some time until the working group was able to convince the Department of Trade who were giving a grant towards the development, that the development was fulfilling the need and not being over ambitious and that the cost yardsticks were acceptable. Members of the working group other than the head, P.Ronan, included P.Beney Group Architect, E.Entwistle Assistant Airport Director Development, J. Williams the Assistant County Surveyor Transportation and the BAA's consultancy organisation. The group also had contact with the Civil Aviation Authority because they set the ground rules for the airport, and the Department of Trade.

Finance

The project was financed by the sixty per cent government grant, a European Investment Loan and the West Midlands County Council.

Table 6 - 3

Airport development expenditure for the Preferred Option (1977)

Project Cost	£54,438,000
DOT 60% Grant	£32,663,000
County Council Expenditure	£21,775,000

"The balance of the total project cost after deduction of grant would be financed by the County Council. Clearly, a scheme of this size could not be met from the Council's Locally Determined Shemes Allocation. The County Council will approach the European Investment Bank with a view to obtaining a loan at preferential rates of interest." (Submission by the WMCC to the Department of Trade 1977)

The Treasurer's department secured a loan from the EIB for £18,000,000.

The selected option went to public enquiry and the options developed were presented to demonstrate a case for the selected option. Planning permission was obtained and structural changes were made within the WMCC to develop the selected option. In 1979 the Steering Group was formed bringing together as a group the relevant chief officers and the Airport Director.

6.4 Project Management

Figure 6 - 3

Birmingham Airport Development Management Structure

```
                          Steering Group

County        County        County        Airport   County
Secretary     Treasurer     Surveyor      Director  Planner/
Williams      Rose          Mustow        Taylor    Architect
                           (Chairman)               Wood
                               |                      |
                        Project Manager               |
                            Ronan                     |
                               |                      |
        -------------------------------------------------
        |                      |                      |
Civil Engineering         Site Manager          Terminal
and Maglev                   Nixon              Buildings
        |                      |                    |
---------------------          |             Project Architect
|          |         |         |                   Lee
Maglev  Project   Resident     |                    |
<----  Engineers--------->     |        ----------------------
Benussi  Hartley   Horrell     |        |                    |
                               |  Resident     Site Structural
                               |  Architect      Engineer
                               |  Mansfield      Hancox
                               |
          --------------------------------
          |                              |
     Consultants                   Project Support
WS Atkins M&E Services            Valuation&Estates Officer
Silk&Frazier Quantity Surveying       Feather
Ove Arup&Partners Engineering        Treasurers
                  Measurement     Hingley - FinancialPlanning
Henderson-Bushley Maglev          Shelley - Audit
                  Guideway            Airport
R.Simpson    Signing              Entwistle - Development
B.Clouston   Landscape
             Architecture         Maglev Rapid Transit System
                                    People Mover Group
```

The major role changes brought about by the reorganisation include the Maglev engineer, J.R. Benussi, who had previously been head of the Air Transport Study Group formed in 1977; Steering Group Chairman who was also the County Surveyor, head of the Transport and Engineering Department. During the development of the selected option there were three changes of personnel in the role of project architect and interviews show that each saw his role differently.

Briefly, P.Beney the first project architect saw his role as assisting the project manager in developing methods to coordinate and control design development. The second project architect S.Pedlow saw himself in a management role, monitoring the needs of the airport users and using this information to steer architectural design. When problems of incompatability between architectural and mechanical and electrical design threatened the whole project, the first project architect made a brief reappearance in the role. He was brought back from general projects to produce a global design of the terminal, to make possible a closer relationship between the more detailed design work developed by the various disciplines.

The problems of incompatability in disciplinary designs were first noted by John Laing after construction had started. The technical capabilities of P.Beney were undisputed and the architectural designs he produced solved the incompatability problems, however he admits his interests did not lie in management and he found that his involvement in the development of architectural design reduced the time he had available to manage the interaction of the various design disciplines and construction activities which had already begun.

The next project architect was E. Lee and the first task he was given was to design an organisational chart which would make interdisciplinary design for the airport more manageable. Figure 6 - 4 shows the part of the organisational chart which was structured as a matrix. Architects were made responsible for different parts of the airport development and were concerned with coordinating the work of the other disciplines in their particular area.

Figure 6 - 4

The Matrix Element of the Design Team Structure after the development of the global architectural design. 1981

```
Mechanical &
Electrical -------
Engineering       |
                  |
Structural        |
Engineering------|
                  |        Project Architect
                  |                |
Civil             |                |
Engineering------|                |
                  |                |
                  |                |
Maglev-----------|                |
Engineering       |                |
                  |                |
                  |_____________________________________________
                  |           |              |              |
              Terminal     Piers          Services       Maglev &
              Building     Architect      Building       Fire Services
              Architect                   Architect      Buildings
                                                         Architect
```

The project was completed in May 1984. The total project cost was £62,000,000. The West Midland's County Council was abolished at the end of March 1986. "Airport News", in April 1986 shows the annual total of passengers to be 1,758,492 many of which are business travellers attracted by the new facilities at the airport. The number of airlines and destinations has also increased. There is a clear indication that the airport is now a profitable enterprise, catering at the moment for over 40 airlines, serving 80 Domestic, European and Intercontinental points.

The success of the project outcome seems clear but there were lost opportunities and error costs during the development which will be analysed in detail in the following chapters using the methodology outlined in chapter 5.

It is interesting to note that at the beginning of 1988 the Airport Management at Birmingham Airport announced that due to the success of the airport since the development, plans are now being prepared to double its capacity ie. to cater for 5 million passengers a year. This was the capacity of the original airport design, prepared by Birmingham City Council in 1972.

Chapter 7

The General Organisation - A description of the system.

Following the research methodology outlined in figure 5 - 1, the analysis is designed to permit the development of models of the communication and control mechanisms that were in operation within the general organisation. The general organisation being the assembly of all the disparate parts perceived in the research to be concerned with the development of a new terminal for Birmingham Airport. The results of this analysis will then be used in the next chapter to test the research hypothesis.

7.1 Structuring the case study.

Having established the perceived purpose of the general organisation it is necessary to determine who were the key participants, their roles and the channels of communication between them.

Key participants perceived within the general organisation.

West Midland's Council,
policy and resources committee members,
planning and transport committee members,
airport sub committee members,
chief executive, CE

county surveyor, * CS

county architect/planner,* CA/P

county treasurer, * CT

county secretary, * CS

other chief officers, OCO

airport director, * AD

assistant airport director,development,* AADD

assistant airport director,operations, AADO

head of transport study group, TSG

head of air transport study group, * ATSG

assistant county surveyor,structural, * ACSS

assistant county surveyor,civil, ACSC

group architect, * GA

British Airports Authority, consultancy division, BAA

Alan Stratford and Associates, AS&A

Silk and Frazier, S&F

other consultancies.

* Participants interviewed.

The four main departments of concern in figure 7 - 1 are the

Transport and engineering Dept. TED

Treasurer's Dept. headed by the County Treasurer CT

Secretary's Dept. headed by the County Secretary CS

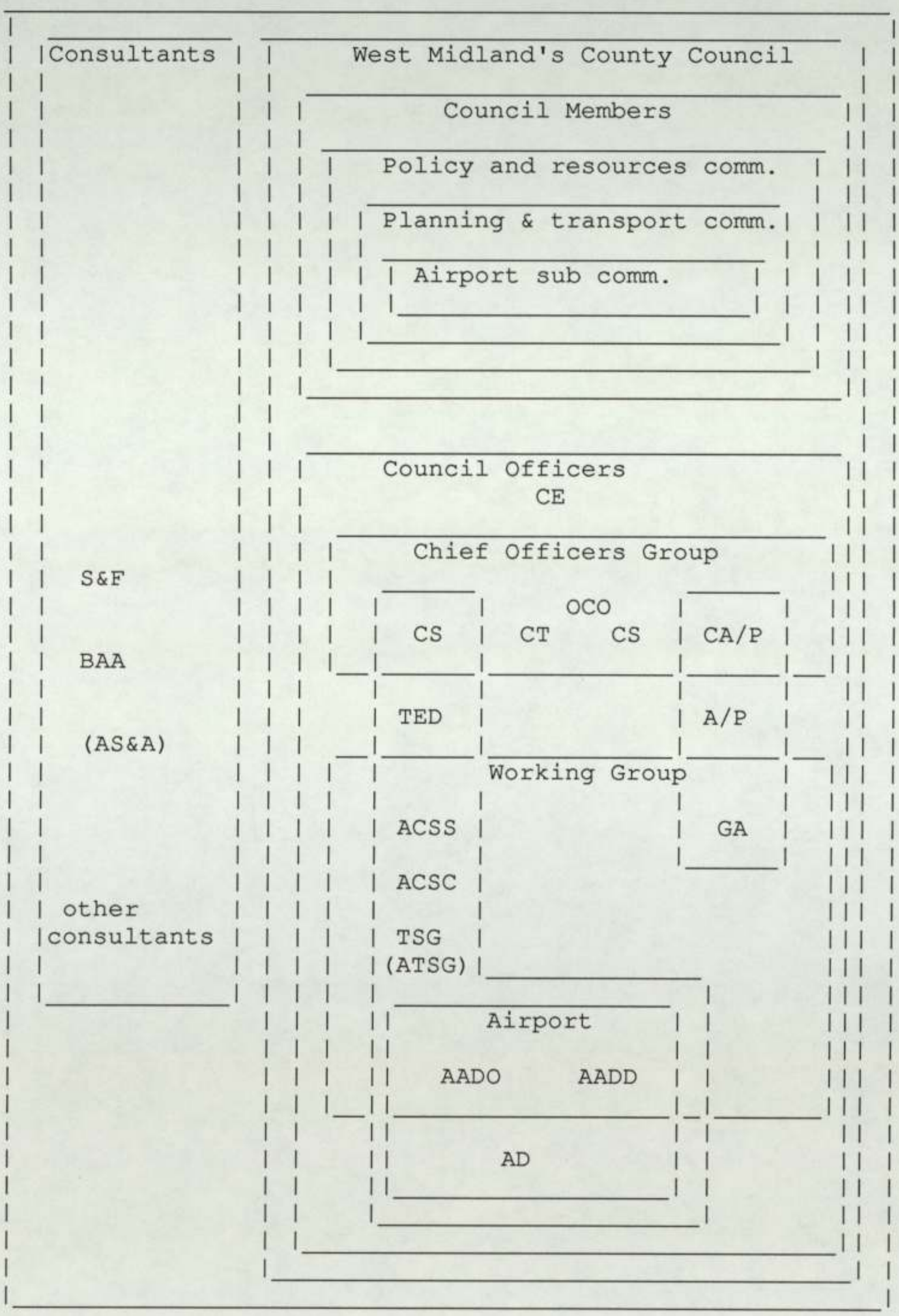
Architectural and Planning Dept. A/P

The initials used in figure 7 - 1 are taken from the list above.

Figure 7 - 1

A system's diagram of the general organisation concerned with the development of the new terminal at Birmingham Airport in 1975.

General Organisation



In 1977 the Transport Study Group was replaced in the working group by its newly created subgroup the Air Transport Study Group (in brackets in figure 7 - 1).

In naming the system, the general organisation, as a system to be responsible for the formulation of options, the council members are viewed as the owners of the problem ie. to formulate option and select a preferred option for implementation. The council officers and consultants are viewed as the actors, who carry out the tasks necessary to bring about the transformation. The customers are viewed as those affected by the outcome of the decision: Council members were given an opportunity to bring about regional economic development; the airport management, an opportunity to develop plans for the airport, to make it competitive with other airports; and council officers were given the opportunity to manage the development of a large scale project, which could add to their personal experience and prestige.

The outcome of the transformation, which is the concern of the general organisation, produces opportunities rather than benefits. Benefits are the outcome of the project implementation. The opportunities evolving from the option formulation and subsequent selection result from the management of the transformation, given the constraints and uncontrollable variables that exist.

Ultimately it was the council members who were the decision makers. They authorized the initial study into the development of a new terminal at Birmingham Airport and the use of financial resources for the engagement of consultants to assist in the study. Finally it was the council members who decided to present the submission to the Department of Trade in 1977, in order to procure the Government Grant available. Decision making within the council passed through tiers of committees. With regard to the development at the airport, it was first the airport subcommittee who made a decision, this was then passed up through the Planning and Transport, the Policy and Resources committees and finally to the council members themselves, to authorise the decision. During 1977, in order to hasten the submission date to the Department of Trade, the Planning and Resources committee and the Airport Subcommittee often met on the same day.

To make decisions the Airport Subcommittee depended on the technical support of the council officers. During the development of options the main channel of communication between council members and officers was through the chief executive. He either presented reports himself, that had been prepared by the departments of his chief officers or chief officers accompanied or represented him at Airport Subcommittee meetings. Policy File Reports and interviews indicate that the majority of the reports were initialled by the County Surveyor or the County Treasurer.

Interaction between chief officers was mainly through group meetings, held monthly. Reports prepared for discussion at these meetings were circulated together with a meeting agenda, to all chief officers prior to a meeting. Any report that was not sufficiently prepared or had not been seen by all chief officers was often retained and developed for discussion at a later meeting. These group meetings involved all chief officers although only four of them and the chief executive were directly concerned with the development of a new terminal at the airport. As a range council matters were considered during the meetings, the relevant officers spent only a percentage of the time discussing the airport development and other chief officers although not directly concerned took part in these discussions. This situation was not detrimental to the involvement of the county surveyor, the county treasurer or the county secretary who had direct contact with the working group. However the county architect/planner, whose only line of communication with the working group was through his group architect (see below), felt that his involvement with the development was severely limited, being little more than the other chief officers who were not directly concerned.

When the council members authorised a study into the development of a new terminal, the county surveyor formed a working group which consisted of members of his own department, the transport and engineering department, with the exception of the group architect who belonged to the architectural and planning department. The head of the working group was the assistant county surveyor structural, and it was he who presented reports developed by the working group to the county surveyor.

After forming the working group, the county surveyor, through the chief executive, obtained permission to approach the department of trade to confirm their financial support. This meeting was held in 1975 and the county surveyor together with members of the working group, the Civil Aviation Authority and the British Airports Authority discussed the possibility of securing a grant. The outcome of the meeting was that permission to develop a new terminal was agreed upon in principle and it was recommended that the BAA should be engaged as consultants in the development of options. The BAA at the time showed an interest in taking over the airport operation but the WMCC decided to retain authority of the airport themselves and restrict involvement of the BAA to that of consultants.

Many other consultants were engaged, one of the major ones being Silk and Frazier, quantity surveyors, who assisted the treasurer's department in developing projected development costs for the various options that emerged. The county surveyor retained direct links with the BAA but in the main, consultants interacted with the working group. The county secretary's department, valuation and estates, was concerned with determining what land was available and considering where compulsary purchasing would be necessary for the development of the various options.

There were six members in the working group. The head of the group, the assistant county surveyor,structural, was concerned with coordinating the work of the other members, monitoring their liaison with the various consultants and the development of reports for the county surveyor. He also considered the structural engineering aspects of the developing options. The assistant county surveyor, civil, was concerned with civil engineering, the transport study group with the integration of the airport and the transport network in the region and the group architect with architectural design. The two members from the airport ie. the assistant airport director, development, was concerned with the day to day operational needs of the airport and future development.

The assistant airport director, development, used his own personal experience and that of colleagues in other airports, such as Manchester and Dublin to provide information on airport operations to develop a design concept. This included the functional requirements for potential airlines and passengers. The information he produced was used mainly by the group architect to develop terminal concepts. Because he was a member of the airport management team with knowledge of the airport situation and its needs, he was selected as a member of the group representing the WMCC in the meeting with the department of trade, to discuss the government grant. He also met regularly with members of the Civil Aviation Authority, Air Traffic Control, Airport Fire Service, Immigration, Customs and Security, to establish regulations which were relevant to the development.

In meetings with the BAA the working group presented the information they had, which the BAA then incorporated into the development of the options. It was the BAA that developed passenger forecasts on which the scale of the terminal was to be based. They used their experience from previous airport developments together with the suggestions offered by the working group to structure the option development.

The Airport Director was neither a member of the Working Group or the Chief Officers Group, however he was very active in generating support for and reducing potential opposition to, the development. The six main groups outside the general organisation with which he was concerned were the tourist board, airport users eg. airlines, local action groups, British rail, local chambers of trade and Solihull District Council.

In 1977 after the BAA had completed the development of the options, the air transport study group was formed. They together with Alan Stratford and Associates reassessed the BAA options and made alterations to both physical aspects of the options eg. size, location, configuration, and future air traffic projections. They also carried out a study on the potential effects the development of a new terminal would have on the region and the opportunities that each option presented.

At the time these options were being developed there was no national airports policy with regard to regional airports ie. categories. It was left to the general organisation to determine the scale of airport operation that would be right for the region. The air transport study group together with Alan Stratford and Associates and airport management assessed the potential type of air traffic that could be attracted to the airport, including domestic internal flights, international routes and intercontinental routes. They did this by approaching the various airlines to determine their degree of interest, considering the source of business interests that could be attracted to the region, both national and international, the degree of passenger growth associated with the NEC and general projected passenger growth to the region. They approached a variety of bodies such as estate agents, chambers of trade etc. within the region and continental and national businesses that already had or were considering having divisions, in the region.

During 1977 the County Architect/Planner was active in overseeing the architectural aspects of the development but the output of the working group as a whole went to the County Surveyor. Plans were prepared within the Architectural and planning department to contribute to the submission to the Department of Trade. In the submission it can be seen that the projected cost of implementing these plans was £54,438,000. This was not acceptable to the Department of Trade and the Architectural and Planning department had to redesign certain aspects of the development to reduce the terminal floor area. The civil engineer within the working group suggested changes such as the deletion of elevated access roads and forecourts. As a result of this work, it proved possible to reduce the cost to £40m. However the Department of Trade was still not satisfied and further reductions had to be made before the government grant of 60% became available. The final submission figure was £29.5m. These project cost figures for the three submissions to the Department of Trade were taken from a report to the Airport sub committee by Stuart Mustow, County Surveyor and Derek Hender, Chief Executive, in 1978. It was made clear in this report that for the purpose of uniform comparison between options the estimated costs were based on November 1977 prices and that they would need to be updated at annual intervals to take into account any changes in building or engineering costs. The report asked the Airport Sub Committee to consider whether they wished to accept the overall project in terms of the 1990 traffic forecasts and approve the third submission to the Department of Trade. Having approved the third submission the airport sub committee were asked to approve the key dates charged for implementation and to instruct the Personnel and Administration Committee to establish and man the necessary posts for the initial project team within the County Surveyor's and the County Architect/Planner's Department, to cover the period up to and until the end of the inquiry stage.

Once the Department of Trade had agreed to the provision of a 60% grant, it was then possible to seek planning permission. The application was subsequently 'called in' by the Secretary of State for the Environment, Mr.Heseltine and the outcome was a public inquiry.

Although this is a brief description of the studies and planning that contributed to the formulation of options, it does serve to outline the tasks performed by the key participants and highlight organisational relationships which existed at this time. To study the effectiveness of these organisational relationships, in a way that provides support for the research hypothesis, it is necessary to look at the cybernetics of the situation.

7.2 Studying the cybernetics of the general organisation.

The council members were concerned with deciding how the terminal at Birmingham Airport could be developed to best serve regional needs. They did not have the knowledge or expertise to take that decision themselves without technical support. They drew the support they needed from the council officers under the leadership of the Chief

Executive. The complexity of the task implies that the council members themselves could not be expected to consider in detail, the formulation of options. To them therefore much of the work entailed in the formulation of options would be a black box and they could be concerned only with the inputs and outputs of the transformation.

In systemic terms as the decision making body, the council committees would be the policy function. They made policy guidelines, instructing council officers to study ways in which the terminal at Birmingham Airport could be developed, to serve the region, according to the role they perceived the airport to have. They monitored the output of the studies and adapted or added further instructions accordingly. For instance in their guidelines the council members requested that options on the side of the runway nearest to the NEC only, were to be considered but later, on the advice of the council officers, they gave permission for two further options to be considered, ie. on the existing site and a split site option.

Figure 7 - 2

The Policy Function - General Organisation

```
                   ----------------
         --------->| Council Members|----------
         |         |   Committees   |          |
         |          ----------------           |
   study output                        policy guidelines
         |                                     |
         |                                     |
          ---------Council Officers<---------
                     Consultants
```

The policy function ie. the council members have far less capacity to handle complexity than the council officers and the consultants and therefore the key issue for the policy function is how well variety is being reduced by the interactions that exist within the group of officers and consultants. The main concern is the attenuation of variety within the high variety side, ie., the group of officers and consultants.

Although the council members require that interaction within the group reduces the variety they have to attend to, they need to be able to influence the issues that the group considers in detail. To determine how the council members influence the activities performed within the group, it is necessary to identify the mechanisms used by the policy function to amplify their policies, which provide the guidelines for the work carried out by the council officers and consultants.

Control of policy implementation is the concern of the chief executive. During the process of option formulation it was he who represented the policies of the council members and controlled their implementation implying a concern with establishing links between relevant actors in the transformation. It is these links that will be analysed in the next chapter, when the cybernetic model of the general organisation will be presented.

The policy function also needs to know whether the debate supporting policy development is being developed as intended. The council members would need to know that the relevant participants in the group were interacting in a way that permitted them to make an adequate contribution to the issues of concern. Within the general organisation it was the chief executive who appeared to monitor the effectiveness of the interaction between members of the group and presented working group and chief officer reports, the residual variety, for the attention of the council members.

The council members did not present options for study but requested options to be formulated in line with their concern to develop the airport to stimulate regional economic growth. Their approval for the study of particular options had to be sought initially and subsequently when council officers perceived a need for developing further options.

To develop a cybernetic model of this interaction and identify the mechanisms used for interaction, it is necessary to determine which roles fit into which of the two systemic functions. The control function ie. those actors who provided organisational information were council officers. This information included organisational capacity for developing a new terminal ie. organisational resources, and the operational needs of the airport to establish its competitiveness with other airports and remove existing constraints. The Intelligence function ie. those actors who provided environmental information were, in 1975, the British Airport Authority. It was their task to project the level of air traffic that could be expected in 1985 and 1990 and to develop options which met their projected requirements and the operational needs of the airport, given the degree of organisation resources.

The main actors who provided the BAA with organisational information were the county surveyor,the county treasurer with the assistance of Silk and Frazier consultants and the working group. In general the mechanism for communication between the two systemic functions were meetings between the working group and the BAA. These meetings were used by the working group to present both operational needs of the airport, as studies made them clearer and policy guidelines as they emerged, to the BAA. The BAA then worked independently between meetings formulating options which incorporated information obtained from the working group. The meetings also provided the working group with the opportunity to look at the developing options. The effectiveness of these meetings as a communication mechanism will be analysed in the next chapter.

The relationship between the two functions clearly changed after the services of the BAA were complete and the Air Transport Study Group was formed. To describe cybernetically, the general organisation, two models will be presented, the first represents the general organisation in 1975 and the second in 1977. This is important because organisational changes altered the mechanisms used for interaction between the intelligence and control functions, and the capacity of the intelligence function, during the formulation of options.

Figure 7 - 3

Cybernetic Model of the General Organisation

```
                 -----------
      --------->|  Policy   |-----------
     |           -----------            |
     |                                  |
     |         ---------------          |
     |        |  Intelligence |         |
     |         ---------------          |
      -----------^         |<-----------
                 |         v
                 ------------
                |  Control   |
                 ------------
```

In systemic terms Figure 7 - 3 is a metasystem and a model of a mechanism for adaption. The general organisation is modelled in this way because it is concerned with learning and developing an adaptive reponse in terms of option formulation and selection, on behalf of the West Midland's County Council. It acts as a temporary mechanism bringing together all the participants relevant to option formulation and selection of a preferred option.

Chapter 8

The General Organisation - an analysis of the cybernetic model.

The task facing the general organisation was to bring together relevant members of the West Midland's County Council and consultancy agencies, in a way that permitted the development of options and brought about the decision to develop a particular option. To do this the organisation had to establish communication links between the participants and endeavour to make those links effective in producing a decision outcome, which satisfied the interests of the West Midland's County Council, for the region. In the previous chapter the key participants were identified, together with their roles and the communication links between them. In order to study how the communication links were made operational and the development of options controlled, the system's diagram presented in figure 7 - 1, will be looked at cybernetically. This will provide a model of the systemic functions and the mechanisms for communication and control that were in operation.

8.1 The cybernetic model of the general organisation.

Flexibility is found in the relational mechanisms between functions which permit them to respond to each other. Response capacity however, does not depend on relational mechanisms alone. The mechanisms catering for the interaction between systemic functions may be more than adequate but unless those functions have the capacity to carry out their roles as policy, intelligence or control, then the mechanisms will be ineffective, no matter how well they are designed. The model therefore represents both the structures or parts that existed in the organisation and the mechanisms for interaction between them.

In 1974, it was brought to the notice of council members in the airport sub committee, that there were operational difficulties at the airport, which were affecting performance. This was presented in a report submitted by the county surveyor, which made clear that there was a need for development at the airport, both to make the airport competitive and to serve the region. The council members had only layman knowledge of the airport and in common with normal practise in local government, they decided to permit a study to be carried out by council officers, to find out if a new terminal was needed and if so where, to what design and what size.

After the Department of Trade had agreed to support a development at the airport, the county surveyor engaged the services of the British Airports' Authority Consultancy service and set up a working group within the council, to develop options. The Council Members agreed that the options to be considered should be situated on the side of the runway nearest the NEC. This decision was taken on the recommendation of the County Surveyor. He was in possession of the plans, developed by Birmingham City Council in 1972, which situated the development next to the International Railway Station and the NEC. They had already determined that further development on the existing site was not possible because of the limited area on that side of the main runway.

Figure 8 - 1

A Model of the Systemic Functions and the Relationships between them in the General Organisation 1975

```
                     POLICY
     reports
     ---------->  Council Members
    |and recommendations
    |
 decisions
    |            INTELLIGENCE
    v
Chief Executive
    ^   ^         Consultants
    |   |
    |   |
    |   |    -------------------------
    |   |   |  Airport Development   |
    |   |   |                        |----
    |   |   |  Transport Study Group |     |
    |   |    -------------------------     |
    |   |-------                           |
    |          |   CONTROL                 |
    |          v                      working group
    |  ---------County Surveyor            |
    | |                |                   |
    | |       ----------------------       |
    | |      |         |            |      |
    | |      |   Assistant County   |      |
    | |      |   Surveyor           |      |
    | |      |                      |      |
    | |      |   Group Architect    |------
    v |      |                      |
  chief      |   Civil Engineer     |
 officers    |                      |
  group      | Ass.Airport Director |
      |      |    Development       |
      |       ---------------------
      |         Airport Director
      |
      |       ---------------------------
      |      |  County Treasurer          |
      |      |                            |
      |      |  County Secretary          |
      |      |                            |
       ------|  County Architect/Planner  |
             |                            |
             |  Other Chief Officers      |
              ---------------------------
```

The policy function considered the recommendations presented by the Chief Executive Officer and it was he who saw that policy decisions were implemented by the council officers. The Chief Executive attended chief officer meetings and spoke to chief officers individually. He selected the officers who he felt were capable of implementing policy decisions. With regard to the airport development the chief executive received his information from the county surveyor either through chief officer meetings or private meetings in his room. When a policy decision was required to carry out a study on the airport development, he submitted the case, that had been developed within TED, to the Airport Sub Committee. When the committee gave its approval to a study, he decided who should head the study. He left it to the County Surveyor leading the study to decide who the participants were to be and how they were to interact.

Figure 8 - 2

Relationship Between the Policy Function and the Participants in the Intelligence and Control Functions

```
            -------->POLICY FUNCTION----------
            |                                |
     reports and                          decisions
    recommendations                          |
            |                                |
            |     INTELLIGENCE FUNCTION      |
            |           ^       |            |
   Chief executive      |       |     Chief executive
            |  |        |       |         |  |
            |  |        |       |         |  |
            |  |        |       v         |  |
            |  |    CONTROL FUNCTION      |  |
            |  |    -----------------     |  |
            |  |---| Chief Officers  |<--|  |
            |      |     group       |       |
            |      |                 |       |
            |--------County Surveyor<--------|
                   |                 |
                   |   Other Chief   |
                   |    Officers     |
                    ----------------
```

The county surveyor thought that there was not the expertise within the WMCC to develop options, so he recommended through the channels indicated in figure 8 - 2 that the BAA should be engaged as consultants to perform this task. The BAA looked into projections of airtraffic for 1985 and 1990 and used their expertise from developing other airports to develop options. As they developed options for the future, they are viewed as part of the Intelligence Function. The County Surveyor gave closure to the two systemic functions by forming the Working Group who spanned the two functions and worked in liaison with the BAA.

The mechanism for providing interaction between the Intelligence and Control Functions appears to be the Working Group. This was made up of five members of the county council headed by the assistant county surveyor. The output of the interaction between the systemic functions was in the form of reports, submitted to the county surveyor. The control function consisted of three members of the county council and the intelligence function consisted of two members of the county council and a number of consultants, the main one being the BAA.

The reports given to the county surveyor by the working group were discussed with other chief officers at chief officer group meetings and then submitted for the attention of the airport sub committee by the chief executive. The chief executive attended most of the chief officer group meetings and assessed the outcome of discussions on the airport, which he passed on to the airport sub committee together with the reports that had been presented by the county surveyor and discussed by the chief officers. Decisions taken by the airport sub committee were then presented to the chief officers during their group meetings.

Although the chief officer group meetings would appear to be the main mechanism used by the chief executive to monitor group discussions on the airport development and present airport sub committee decisions, these meetings only took place monthly and in addition there was a high degree of direct contact between the chief executive and the county surveyor which by-passed the chief officer group. This was mainly because the development of the airport was a large topic for consideration and the time available in chief officer meetings held only monthly and considering issues other than the airport was very limited.

The by-passing of the chief officer group in the consideration of the airport development, caused some chief officers, who considered themselves relevant, to feel that they did not have the opportunity to make an adequate contribution to the ongoing discussions. The Airport Director did not attend chief officer group meetings, making his contribution indirectly through the County Surveyor, who was head of his department.

Figure 8 - 3

Interaction Between the Intelligence and Control Functions 1975

```
                     INTELLIGENCE
 occassional
 ----------------- BAA
| meetings
|      ---- Transport Study Group---
|     |                             |
|     |---- Ass. Airport Director---|
|     |        Development          |
|     |                             |
 -----|                      regular meetings
      |          CONTROL            |
      |                             |
      |---- Ass. County Surveyor----|
      |                             |
      |------ Group Architect-------|
      |                             |
      |------ Civil Engineer--------|
      |                             |
       ----Ass.Airport Director-----
             Development
```

The working group worked as a unit had regular meetings to exchange information but met only occasionally with the BAA representatives. The two members of the working group in the intelligence function were the head of the Transport Study Group and the Assistant Airport Director Development. On analysis their roles did not contribute to the intelligence function because:-

i) the head of the Transport Study Group had no experience in the development of airports. The transport study group was designed to look at transport in general for the region and this involved the study of highways and public transport routes, in an attempt to develop a regional transport framework. It viewed the airport as another link in this framework, seeing access to the railway station and existing road links as a priority in positioning the new terminal.

ii) the Assistant Airport Director Development although a member of the management team at the airport, acutely aware of the operational difficulties which existed had no development department with the capacity to consider future opportunities. This capacity had been seen as necessary within the airport management team but because of the physical constraints, imposed by the position of the existing airport, further development was not possible. To have the development capacity within the airport, would have been superfluous, as future opportunities in this situation were negligible.

It was this inability within the WMCC to look at future opportunities for the airport itself and the contribution such opportunities could make to regional economic development, that influenced the county surveyor to recommend they use the services of the BAA.

The BAA had expertise in the development of airports but little knowledge of the West Midland's region. The options they developed were based on experience they had gained elsewhere and the information they obtained from the working group. The occasional meetings they had with the working group, according to the assistant county surveyor, consisted of the working group making suggestions to the BAA, who then incorporated these suggestions into their formulation of the options.

The information produced by the working group contained :-

operational problems which existed at the airport,
the pattern of passenger growth that the airport had monitored,
potential interest of airlines and other agencies in the development,
CAA regulations for the airport,
the area of land that was available,
the finance that was available,
the structure of the land to take into account the degree of earth moving various options would imply,
airside to landside passenger movement various options would imply,
the positioning of a new terminal to take advantage of the transport infrastructure that already existed,
the opinions of the Airport Director who had developed views on the kind of airport that would project the image he wanted for the airport, to attract new airlines and businessmen to the region.

All this information was assembled initially as a brief for the BAA and elements of the brief were discussed or added to by the working group during their meetings with the BAA. The BAA compared a number of sites and the choice was finally narrowed down to two X and Y (see appendix 2 for the description of these two options). The two options were on the side of the airfield nearest to the NEC and the International Railway Station, as required in the brief.

These two options that were presented to the WMCC early in 1977 were regarded by the County as a basis for discussion.

"It was recognised that neither "X" or "Y" necessarily represented the cheapest or the "best" solution but, rather, were each indicative of the extremes of development option which could be achieved for a given level of cost." (Submission to the Department of Trade, October 1977)

Once the options had been presented by the BAA, the consultancy arrangements with them ceased. The County Surveyor considered that it was necessary for there to be an air transport study group within the Transport Study Group, so that a case could be made for a preferred option. The interaction between the Intelligence and Control Functions then altered considerably.

Figure 8 - 4

Interaction between Intelligence and Control Functions 1977

```
             INTELLIGENCE

   Alan Stratford and Associates
          consultants
              ^
              |
              v
   Air Transport Study Group----
                               |
          CONTROL     regular meetings
                               |
  Assistant County Surveyor-----|
                               |
     Group Architect-------------|
                               |
     Civil Engineer--------------|
                               |
  Ass. Airport Director---------
     Development
```

The major change was that is was a study group within the WMCC that continued the formulation of options with the help of consultants rather than the consultants formulating options. Both the study group and the consultants had knowledge of the region and together they carried out an extensive regional study to determine future opportunities various airport development options presented. Their first observation was that the BAA options were not suitable as they stood to serve regional needs. They were referred to by the head of the air transport study group as "mini-Heathrows" inappropriate to the needs of the West Midlands.

He also made the comment that if the air transport study group had existed when the original Birmingham City Council plans for the airport had been given to the WMCC in 1974, they could have been used, as they appeared to be more appropriate to the region than the options developed by the BAA. If they had been accepted by the WMCC, development could have proceeded in 1974 without the need for further planning permission and the the region would have had a larger terminal, at an earlier date, and at a reduced cost. The Intelligence Function at this time did not find the air traffic projections made by the BAA accurate. This was supported by the Department of Trade, who finally accepted the new figures presented by the Air Transport Study Group.

There was regular interaction between the airport study group and the control function. The assistant airport director, development, provided operational information on the airport and the other members of the control function contributed their architectural and engineering design skills. Five options were eventually developed, two of which were adapted from the options developed by the BAA, an existing site option, a split site option and a preferred option "Z" which was situated part way between options "X" and "Y".

The decision to develop the preferred option was not totally in the hands of the council members because although they approved that option on the recommendation of the Chief Executive, the decision could not be implemented without the approval of the Department of Trade. This was because the WMCC needed the DOT grant to be in a position to finance the project. In total three submissions were made before the DOT accepted that the case for the preferred option was conclusive and that it was cheapest and best. They did on many occasions suggest that cost was not their primary concern but in practice they requested that ways were to be found to reduce the overall cost.

Recommending a particular option to take advantage of future opportunities for the region was the main role of the intelligence function. The control function had to determine how the option was to be developed and find ways of making it as economical as possible. By integrating these two roles during working group meetings a case was developed for the preferred option. To convince the DOT that this was in fact the best option, there had to be a valid comparison between this option and the other four. On the third attempt the DOT was persuaded, that the preferred option best satisfied their criteria and the needs of the region. After this followed a period of convincing the public. A Public Inquiry was held and the WMCC had to persuade the public in the region, that they would benefit from the development, before planning permission was given by the Department of the Environment in October 1979.

8.2 Comparing the Model with the Criteria of Effectiveness.

The comparison of the model of the named system and the conceptual model will be developed by first looking at the interaction between the policy function and the organisational debate, then the capacity of the intelligence and control functions to contribute to the debate and finally the interaction between the intelligence and control functions.

Figure 8 - 5

The Interaction between the Policy Function and the Organisational Debate.

```
         ------->POLICY FUNCTION--------
         |                             |
monitoring                        articulation
         |                          of values
         |     INTELLIGENCE FUNCTION and control
         |          |        ^          |
         ---- organisational debate<---
                    v        |
                 CONTROL FUNCTION
```

The chief executive has been recognised as responsible for monitoring and controlling organisational debate. It is clear from the model of the system that he did not monitor the debate directly. He was in contact with the chief officers but the interaction took place between the working group and the BAA consultants, who were accountable to the county surveyor. It was the county surveyor who assessed the contribution of two functions to the debate. He did this by being aware of the working group meetings and the meetings between the group and the BAA. He checked through working group reports, the issues that were being considered and how the outcomes of studies on the issues were contributory to policy objectives.

The county surveyor was in effect monitoring the debate from within the control function. This is inadequate because the performance of the debate is being monitored from one viewpoint ie., that of the control function. The strength of organisational debate comes from the exchange of stimuli and response integrating the two viewpoints of intelligence and control. Monitoring only from the viewpoint of control is no measure of the contribution made by the intelligence function or the effectiveness of the interaction between the intelligence and control functions.

In terms of the effectiveness of the monitoring mechanism, it is clear that the council members were receiving information from the county surveyor. This information consisted of the progress made in terms of evaluating the cost of developing a new terminal and the operational problems that needed to be overcome, which had been given to the BAA for consideration. However these reports were basically the concerns of the control function and did not include future opportunites the formulation of options presented for the region, which were necessary to fully express the values articulated by the policy function. In this way the policy function was measuring the output of the control function and not the output of the interaction between the two systemic functions. In this situation the policy function could not assess if the interaction between the BAA and the Working Group within the intelligence function, was sufficient to provide the capacity to develop an understanding of future opportunities for the West Midland's Region.

The policy function was only in control of the issues that were to be considered. They had indirect control of who should be members of each systemic function in the debate and the communication mechanism to be used between them. This indirectness of the monitoring and control of the organisational debate, meant that the airport sub committee was not in a position to determine how effectively the options were being produced ie. did they capture future opportunities for both the airport and the region, together with satisfying the operational needs of the airport and the West Midland's County Council?

The positioning of a new terminal, its size and configuration appeared to the county surveyor as straight forward, the individual tasks had all been done before. He felt that the size of the project was unimportant. This comment makes it clear that the concerns of the county surveyor were concentrated on the operational aspects of the development, however as the council viewed the airport as an important gateway to the West Midland's region, it was necessary for the council in making decisions not only to know about the operational and economical viability of the options but also the future opportunities and constraints implied by the options for regional economic development.

Figure 8 - 6

The Intelligence Function

```
Relevant Environment--------> INTELLIGENCE FUNCTION
                                 ^                 |
                                 |                 |
                             attenuated        attenuated
                             information        response
                             from the control       |
                              function              v
```

In developing the two options for the development of a new terminal the BAA worked to a brief developed within the WMCC and met occasionally with the working group to obtain further information from them. Neither the brief not the meetings conveyed to the BAA, regional needs that the policy function wanted satisfying or future opportunities that the region could obtain from the development. They worked out on a limb, using the experience they had gained from previous developments. The relevant environment to them was viewed as the same as previous developments. In effect the options they were developing although formulated to the specifications presented by the working group, were not specifically tailored to the needs of, or future opportunities for, the West Midland's region.

The two members of the working group placed in the intelligence function did not have the capacity to assess the implications of the developing options for the region, as at that time there had been no study of the relationship between the airport and real or potential business growth. The work done by the BAA was attenuated in the form of progress reports they prepared for the working group and in the meetings they had with them. It is not possible to assess how well the working group understood the information presented by the BAA but it is clear that they had very little involvement with the option development.

The Assistant County Surveyor, head of the working group during an interview explained how each member of the working group performed their tasks and brought together a collection of suggestions for the BAA to consider. These were presented at the meetings. It was then left to the discretion of the BAA if and how these suggestions were to be considered.

It would appear that the link between the BAA and the working group was weak. The brief given to the BAA was described as inadequate by the later Head of the Air Transport Study Group and gave them much discretionary power. On assessing the quality of the two resulting options in 1977, he felt they were not developed to capture the regional interests. The County Surveyor had engaged the services of the BAA because it was felt that the council did not have the necessary expertise itself but the brief given to them, it would appear, was inadequate to guarantee that the options developed would serve regional interests. The head of the air transport study group felt that the main problem had been that no-one in the council was able to assess the regional implications of the options the BAA were developing. This in effect reduced the capacity of the intelligence function to filter the relevant environment.

Figure 8 - 7

The Control Function

```
                                 ^           |
                                 |    attenuated information
                             attenuated   from the
                             response  intelligence function
                                 |           |
          Institutional          |           v
          parts affected ------>CONTROL FUNCTION
          by the outcome
```

The institutional parts affected by the outcome were the airport operation and the council itself. The Airport Director wanted an airport that was competitive with other regional airports, capable of attracting international, as well as national air traffic. The Council wanted to stimulate business growth to counteract urban decay and increase employment in the region and also to provide the community with a better service.

The control function was concerned with determining what resources were available in terms of finance, land and the manpower that would be required to implement the project. It was also conerned with studying the operational difficulties implied in the implementation of the various options, eg. how much land would have to be moved, the type of transport that would be needed to move people from the terminal to the regional transport infrastructure etc. These tasks represent the responses made by the control function to policy objectives, to establish the operational implications of implementing the various options. The control function was also concerned with satisfying the airport's objectives. It required to know about operational difficulties at the airport and the relationship between the various tasks at the airport so that they could be catered for in design.

The control function would assemble this information and by attenuating it, contribute to the organisational debate. If the control function in the named system is looked at in more detail it is possible to determine how this information was obtained.

Figure 8 - 8

General Organisation- Key Participants viewed within the Control Function

```
County Arch.-- County Surveyor--County Treas.--County Sec.
 /Planner             |
    |                 |------------------------
    |        Ass. County Surveyor             |
    |                 |                       |
    |    ------------------------             |
    |    |            |            |          |
     Group      Ass.Airport    Civil     Airport
     Architect  Director      Engineer   Director
                Development                 |
                      |                     |
                       ----------------------
```

The group architect, Assistant Airport Director, head of civil engineering and the assistant county surveyor carried out the studies to assemble control function information. By passing this information to the county surveyor it made him the only chief officer in possession of the total working group findings within the control function. Other chief officers received partial information through members of the working group in their department or through occasional interaction with the working group. It was the county surveyor and/or his assistant who decided when interaction with other chief officers was necessary.

The findings show that complete integration of the various disciplines took place at working group level and the involvement of chief officers other then the county surveyor was limited, even though they viewed themselves as relevant to the project. The Airport Director had even less interaction with the working group, communicating only with the assistant airport director development and occasionally with the county surveyor. The relatively high involvement of the county surveyor in the concerns of the control function compared to other officers may not have reduced control capacity within the organisation; it is not possible to assess. What it did do was to create tension between relevant chief officers. This tension developed into departmentalisation of design activities which caused difficulties in integration. These will be discussed further in the analysis of the project organisation and its metasystem the parent organisation.

Figure 8 - 9

The Organisational Debate - Attenuation of Responses

```
Relevant
Environment----->INTELLIGENCE FUNCTION
                     ^           |
                     |       attenuated
                 stimulus     response
                     |           |
                     |           |
                     |           |
                attenuated       |
                 response     stimulus
                     |           |
                     |           v
Institutional---->CONTROL FUNCTION
parts affected
 by outcome
```

The mechanism for communication between the two systemic functions appears to be the working group meeting. If this was so the mechanism would have been sufficient to cater for the variety exchange between the functions. However the members of the working group who were members of the intelligence function, knew little about airport development or how a development would effect the region. The main contribution to the intelligence function therefore came from the BAA and this implies that the OCCASSIONAL MEETINGS between the BAA and the WORKING GROUP was the actual mechanism for integration between the two systemic functions.

Looking at the total mechanism for adaptation it appears flexibility was lost between the policy function and the organisational debate because although the policy function made clear the issues for discussion, it had no mechanism itself, to select members of the control and intelligence functions or request the way in which they should integrate. It also had no mechanism to monitor directly the effectiveness of the debate. Although the policy function did not directly control and monitor organisational debate, reducing flexibility within the mechanism for adaptation, did not necessarily mean that the debate was not effective. The exchange of responses between the two systemic functions could have been working well anyway.

The significant loss in flexibility is to be found in the debate itself. The variety exchange between the two systemic functions, which were both highly complex, was restricted to the meetings between the BAA and the working group and this has been shown to be a mechanism with insufficient capacity for the variety exchange implied by the complexity of the intersystemic interactions. The intelligence function also lost flexibility of response because it did not have the capacity to filter effectively the relevant environment. At the time the BAA were acting as consultants, there were no participants in the intelligence function who had the knowledge or expertise to perceive future opportunities for the region in the formulation of options. These are two instances where the requisite variety that existed constrained the flexibility of functional response.

8.3 Studying the outcome with reference to actual project development.

Flexibility was lost within the general organisation in the way described above. The outcome of the organisational debate in 1977 was two options, that could not be assessed for appropriatness to the objectives of the policy function for the West Midland's region. The fact that appropriate options were developed during 1977 by the newly formed Air Transport Study Group, supports the view that the inflexibility which existed prior to this date did in fact effect the outcome. In 1977 the Air Transport Group provided the intelligence capacity to filter the relevant environment and as the group was a member of the working group, the capacity of the mechanism for response exchange in the organisational debate increased. This in effect increased the support for decision making.

A decision was taken by the Policy Function in October 1977 to go forward with a preferred option. Implementation of this decision could not start straight away because the Department of Trade had to approve a grant and a public inquiry had to be held, to obtain planning permission. However a decision was made at this time by the policy function and implementation of the preferred option was started in October 1979. This interim period can be viewed as the transition time when the logical focus of interest shifts from the general organisation to the parent organisation. There were gradual organisational changes which will become apparent in the next chapter on the parent organisation.

Chapter 9

The Parent Organisation - A description of the System.

The parent organisation is viewed in the research as a system concerned with the management of the project life cycle ie. planning, designing, implementing and bringing into operation, the selected option. It has been described as a subsystem to the general organisation and therefore, although it does have a degree of autonomy, the general organisation still retains a capacity to influence the development if it so wishes. The council members changed as a result of local government elections in 1976 but although the new council questioned the need to proceed with the development, they made no attempt to abort the studies already started. The parent organisation as defined, was formed as a result of organisational changes that occurred between 1977 and 1979, to cater for the managerial needs implied by the development of the new terminal. Temporary staff were employed for the duration of the project and the transport and engineering, and the architectural design departments were placed in physical proximity within the council offices, to cater for integration between them.

The purpose of this chapter is to define the system, the parent organisation, in sufficient detail to permit the development of models of the communication and control mechanisms that were in operation. The parent organisation is viewed as the assembly of all the parts concerned with managing the project life cycle, in a way that satisfied the objectives set by the general organisation.

9.1 Structuring the case study.

The parent organisation is named as a system concerned with the management of the project life cycle towards a desired outcome. The steering group members are viewed as the owners of the problem ie.,to produce a desirable project outcome. The council officers and consultants are viewed as the actors who carry out the tasks necessary to bring about the transformation. The customers, who are not necessarily members of the system in focus, are viewed as those affected by the project development and the operation of the project outcome. Council members, who were not participants in the parent organisation, were provided with an airport operation, which could attract and handle sufficient air transport to encourage business interests in the region and add to their own prestige. The airport management, who were participants in the parent organisation, having a member in steering group and project support, gained the opportunity to develop adaptive strategies, which could advantage of future opportunities and consider future constraints and thus develop a more effective operation. During the previous decade they had only been able to react to air traffic demands as they arose. The local community derived both benefits and costs from the development. Increased employment was provided but many householders close to the airport viewed the development as environmentaly undesirable. Council officers gained valuable expertise by their involvement with the development. The benefits to the council members were short lived as the council was abolished in March 1986. However the region continues to benefit from the new airlines attracted to the terminal, the new routes that are now possible and the growing use business makes of the airport facilities.

Having established the perceived purpose of the parent organisation it is necessary to determine who were the key participants, their roles and the channels of communication between them.

Key participants perceived within the parent organisation.

County Surveyor - Chairman of the Steering Group SGC *

County Architect/Planner CA/P*

County Treasurer CT*

County Secretary CS*

Airport Director AD*

Assistant County Surveyor - Project Manager PM*

Project Architect PA***

Project Civil Engineer PE

Maglev Engineer ME*

Resident Engineer RE

Resident Architect RA

Site Structural Engineer SSE

Site Manager SM

Signing Planner SP

Project Treasurer Financial TF*

Project Treasurer Audit TA

Valuation and Estates Officer VE

Assistant Airport Director Development AADD*

Consultants-

WS Atkins Mechanical and Engineering Services WSA*

Silk and Frazier, Quantity Surveyors S&K

Ove Arup and Partners, Engineering Measurement OA&P

Henderson-Bushley Maglev Guideway H-B

Maglev Rapid Transit System, People Mover Group PMG

Air Transport Study Group. ATSG*

Brian Clouston & Partners, Landscape Architects

* Participants interviewed

*** Participants interviewed who performed the same role at different times.

The subsystems within the project management system are Civil Engineering and Maglev, CE&M; Site, S and Terminal Building, TB.

The initials used in figure 9 - 1 are taken from the list above.

The Air Transport Study Group continued until 1979. The head of the group then became the Maglev Engineer. The person in the role of Project Architect was from 1977 - 1979 the Group Architect, from 1979 -1981 a second person was employed from another council, in 1981 the original architect had the role again for about three months and at the end of 1981 the role was given to a third person, who continued in that role until 1984, just before the project was completed. A fourth project architect took over until the new terminal was operational.

The reasons for the many changes of personnel in the role of project architect have been described in Chapter 6.

Figure 9 - 1

A system's diagram of the parent organisation concerned with the management of the project life cycle.

```
                           Parent Organisation
 ____________________________________________________________________
|  ______________    ___________________________________________     |
| |              |  |                                           |    |
| |Consultants   |  |   Project Council Officers                |    |
| |              |  |                                           |    |
| |              |  |  _______________________________          |    |
| |              |  | |                               |         |    |
| |              |  | |   Steering      Group         |         |    |
| |              |  | |              SGC              |         |    |
| |    WSA       |  | |                               |         |    |
| |              |  | |   CA/P    CT    CS     AD     |         |    |
| |              |  | |                               |         |    |
| |              |  | |_______________________________|         |    |
| |    S&F       |  |                                           |    |
| |              |  |                                           |    |
| |              |  |  _______________________________          |    |
| |              |  | |                               |         |    |
| |    OA&P      |  | |    Project Management         |         |    |
| |              |  | |                               |         |    |
| |              |  | |             PM                |         |    |
| |              |  | |  _______   ________  _______  |         |    |
| |    H-B       |  | | |CE&M   | |   S    | |  TB   | |         |    |
| |              |  | | |       | |        | |       | |         |    |
| |              |  | | | PE    | |  SM    | |  PA   | |         |    |
| |              |  | | | ME    | |________| |  RA   | |         |    |
| |    BC        |  | | | RE    |            |  SSE  | |         |    |
| |              |  | | |_______|            |_______| |         |    |
| |              |  | |                               |         |    |
| |              |  | |_______________________________|         |    |
| |    RS        |  |                                           |    |
| |              |  |  _______________________________          |    |
| |              |  | |                               |         |    |
| |              |  | |    Project Support            |         |    |
| |    PMG       |  | |                               |         |    |
| |              |  | |  AADD  ATSG  TF  TA  VE       |         |    |
| |______________|  | |_______________________________|         |    |
|                   |___________________________________________|    |
|____________________________________________________________________|
```

In 1977 the assistant county surveyor was given the role of project manager. During the next two years the steering group members, who are perceived as the decision makers for the parent organisation, used the working group, which still existed to continue studies to determine:-

1.the capacity of the project council officers to manage the development of design and implementation,

2.areas of management of design and implementation that could be handled by the council if extra personnel were recruited for the duration of the project,

3.the areas of design that would have to go to consultants,

4.who those consultants should be,

5.how interaction between the various disciplines was to be catered for,

6.how project cost was to be controlled,

7.the schedule of tasks for the various disciplines,

8.how the schedule was to be controlled,

9.how construction contracts should be drawn up,

10.who should have the construction contracts.

The steering group members decided that the project manager should oversee cost and schedule control and that technical development within the various disciplines was the concern of the individual heads of the disciplines. The architectural and planning department was moved, to be adjacent to the structural engineers, as they were both concerned with the terminal building design. It would appear from interviews however that, although the departments were situated next to each other, there was still strong departmentalisation and integration did not improve. The county architect/planner was determined to have more involvement in development within his own discipline, for the reasons given in the last chapter. To do this he removed the existing project architect in 1979, who had been involved in producing the information to support the decisions outlined above, back to his role as group architect. From interviews with three of the project architects it would appear that the the county architect/planner did this because he felt that the project architect's strong involvement in the working group, detracted from the contribution he himself could make to the development. He engaged another project architect whose accountability was clearly to him, the county architect/planner and not to the head of the working group, the now project manager. This established a division between structural engineering and architectural design, which remained to a degree, throughout the remaining project development.

The air transport study group experienced a distinct change in the contribution they made to the development, after the head of the working group was made project manager. They continued their studies, to seek opportunities for the region through the development of the selected option, which they felt were an important contribution to the question of design development. However according to the head of the air transport study group, once the project machine was under way, the project manager viewed their contributions as time wasting considerations and blocked information they produced from being passed to design managers and omitted it in the information given to the steering group to support their decision making.

After the successful public inquiry in September 1979, consultants were selected to carry out certain areas of design and support other areas. There were four main areas of design; civil engineering, structural engineering, mechanical and electrical engineering and architectural. Civil engineering design was managed by a council officer, the project engineer. Structural engineering design was the concern of the assistant county surveyor who was also project manager. Mechanical and electrical design was given to a consultancy agency W.S. Atkins. This was a firm based in Epsom, with one of its branches in Birmingham. The person with experience in the development of mechanical and electrical design for airports and responsible for technical development was based in their Epsom headquarters. He was the firm's contact with the council during their bid for the contract but he remained based in Epsom. The managing director who was the firm's representative in Birmingham, was a structural engineer by profession and he admitted, during an interview that he did not have the expertise to assess the level of technical development in the M&E designs and concentrated on time and cost milestones, leaving technical development to his design team. Architectural design was the concern of the project architect who was accountable to the county architect/planner.

The project manager met weekly with the group leaders of the various disciplines.

"I used to have formal meetings once a week with group leaders of the various disciplines and you could say that perhaps they were my team really. They would come into my office if they had any problems, at any other time. When I say problem I don't mean technical problem because I don't see myself as having a technical role. Project Management is dealing with resources, making sure there are enough people to do the job, making sure the time scale is adhered to and making sure we come in on budget." Interview with P.Ronan Project Manager.

The project manager set down the procedures in terms of the frequency of meetings and reports. In this interview he did not mention his involvement with structural engineering but it became clear during another interview, with a member of the architectural department, that he was technically concerned with this area. This is supported by the fact that the organisational chart for the management of the project does not indicate an officer responsible for structural engineering, other than the site structural engineer, who was concerned with the implementation of the structural engineering designs on site.

In 1981 there was a major problem in design development. It was discovered by the contractors J.Laing, that the mechanical and electrical designs were inadequate. As construction had started, to ensure the availability of the government grant, a quick solution to the design development problem that emerged was critical to project success. The project manager had been stringent in monitoring and ensuring that cost and time milestones were being achieved and that council officers had the resources they required yet this crisis still arose.

Civil engineering design was virtually independent of the other three disciplines being concerned with taxiways, road works, drainage and earthworks. Their main interaction was with the mechanical end electrical consultants, who were concerned with runway lighting. The other three disciplines were all concerned with the design of the terminal building. The second project architect, between 1979 and 1981 indicated during an interview that he saw himself as a manager, determining through his interaction with the assistant airport director development, the needs of the airport users and giving this information to his design team to develop the architectural designs. The members of the architectural design team integrated with members of the WS Atkins design team so that mechanical and electrical designs and architectural designs could develop together. When the crisis emerged the consultancy firm accused the architectural team of feeding them bits of information at a time, which was not sufficient for the overall mechanical and electrical designs. During an interview the managing director of W.S. Atkins said that they were unable to get detailed sizes and distribution of mains and pipes because the information given to them did not describe the full accommodation usage.

During the first twelve months of the design phase, the consultancy firm had been responding to the information given to them by the architectural designers and both sides seemed content, until the building contractors J. Laing brought the inadequacy of the mechanical and electrical designs to the attention of the steering group. When the mechanical and electrical engineering consultants said the piecemeal information they had received from the architects had influenced their poor performance, the county planner/architect became determined to put this right. He called for the mechanical and electrical designs to be completely reassessed. The managing director of the consultancy firm during an interview said that assessment of their technical development had not been possible up till that time because of the time constraints imposed by the council. The designs were studied at the firm's headquarters and found to be considerably underdeveloped. They agreed at headquarters that this in part was the result of the architectural designs so far received. The original project architect returned to develop a global design for the terminal, so that the positioning of the various operational units within the new terminal building was clear. It cost approximately #400,000 and many extra manhours, to perform the necessary remedial work on the M&E designs and account for the additional resources, redesign implied would be needed in implementation.

The original project architect had a double problem in developing a global architectural design. First the design had to be completed in a very short time. It took him three weeks. Secondly the structural designs, controlled by the project manager were well advanced and placed considerable constraints on the architectural design. Given those constraints the project architect produced a design that satisfied the steering group and the headquarters of the M&E consultancy firm. The firm then had only three months left to develop the M&E designs which according to both the managing director of W.S. Atkins in Birmingham and the project architect, would have been better done in three years.

During three months of intensive design the M&E consultants and the project architect were under pressure to have the designs developed to a degree which permitted construction to continue. The project architect became deeply involved in the architectural design to a degree, where the discretion of the architectural design team in developing detailed aspects of the design was significantly reduced. As a result of this involvement in the architectural design he had little time left for liaising with members of the construction firm J. Laing and producing reports for the steering group, on the implementation of the project design. He eventually became ill and was replaced by a third project architect who developed the organisational design for the management of the technical development within the project (See figure 6 - 4).

There were many events which took place in the development of the preferred option, which have not been introduced here because, although they are interesting, they do not significantly contribute to the development of models to describe the mechanisms for communication and control within the parent organisation. What this system definition does do is to identify the key participants, the tasks they performed and the relationships they had with other key members in order to perform those tasks. To study the effectiveness of these organisational relationships, in a way that gives support to the research hypothesis, it is necessary to look at the cybernetics of the situation.

9.2 Studying the cybernetics of the parent organisation.

The parent organisation differs from the general organisation cybernetically in that, it is not only concerned with the decision making process, which for the parent organisation is related to the preferred option but also with managing the implementation of those decisions. The analysis therefore implies the use of two models to describe cybernetically the named system ie. the mechanism for adaptation and the mechanism of monitoring-control.

Figure 9 - 2

Mechanism for Adaptation in the Parent Organisation

```
------>Policy Function-----
|                         |
|                         |
|       Intelligence      |
|         |     ^         |
------- v       |<----------
          Control
```

The Steering Group, consisting of the four chief officers identified and the airport director, were the decision makers. The chairman of the steering group elected the project manager to select who were to be members of the organisation providing the support for decision making. This included members of the WMCC who had already been involved in the development, previously viewed as part of the general organisation, new members of the WMCC taken on a fixed term basis for the duration of the project and consultants. Decision on membership was approved in each case by the steering group on the recommendation of the project manager.

The cybernetic model of the real situation will need to show, who were the members of the intelligence and control functions and the mechanisms for communication used between them. It will also need to show what mechanisms were used by the policy function to articulate its values to the organisational debate and to control and monitor the contribution of each of the two systemic functions to the organisational debate.

The parent organisation as metasystem to the project organisation, continues as a mechanism for adaptation to steer project development towards a successful outcome. The planning phase does not stop once the design phase begins.

The policy function in the parent organisation, was concerned with making decisions on behalf of the general organisation. The option to be developed was already selected. The role of the policy function was to decide how this option could be best implemented to meet the objectives of the general organisation. To do this the policy function or steering group, needed the support of the intelligence and control functions. The role of the intelligence function was to seek future opportunities for the region in terms of sub options which could be formulated within the selected option. For example the air transport study group determined that the main runway length had implications for the type of air traffic that could be attracted in the future. To design a minor extension to the runway, it was felt, would provide the airport management with more flexibility of response in the future, to possible intercontinental routes. The role of the control function was to determine how much organisational capacity could be developed in-house and where consultants and contractors, would need to be used to carry out the implementation; to obtain more detailed information on the operational needs that were to be catered for by the new terminal. The control function was supported in its role by various personnel, such as the financial treasurer who negotiated with the European Investment Bank, EIB, to secure a loan to cover the remaining balance of the projected development costs. Without the loan the development could not have proceeded but they had not been in a position to apply for a loan from the EIB until planning permission had been obtained.

Figure 9 - 3

Mechanism of Monitoring-Control, in the Parent Organisation

```
           ------>Control Function-------
          |          ^    |               |
monitoring  resource bargaining  coordination
          |          |    v               |
           ------Implementation<----------
                  Activities
```

The decisions taken by the steering group resulting from the metasystemic activity described above, were implemented during the design and construction phases of the project life cycle. The implementation of these decisions needed to be monitored and controlled to make sure that organisational objectives were being met and to permit an adaptive response to be generated within the metasystem to situations as they arose during the development. Adaptive response may imply the reassessment and amendment of, or parametric change to objectives.

Within the mechanism illustrated in figure 9 - 3, the control function is concerned with the allocation of resources and monitoring their use. Design is the first activity to be controlled. The control function could not control directly all the activities implied by the design of the airport. Therefore departmental heads were responsible for their own disciplinary areas and the project manager with the help of members of the working group, in particular the project architect developed tools to control and monitor the use of resources. Bar charts were developed to determine when design phases should be started and completed, and used to make sure that the various disciplines were keeping within their time targets. He monitored their performance collectively during progress meetings he held weekly. In addition he dispersed decision making on design changes as they became necessary by developing cost ceilings for the various levels in each discipline. If a particular change implied cost increase beyond a certain level, then the decision to make the change was referred to the person who had the authority to take decisions at that level. Outside meetings, the project manager allocated resources as they were required by the various disciplines, by for example, allocating extra staff where needed.

The project manager thus controlled the allocation of resources and monitored progress by the development and cost reports given by the discipline heads during progress meetings. The only technical development he monitored was structural engineering design because this was the discipline in which he had expertise. Coordination of technical development for the terminal building was in the eyes of the project manager, the concern of the project architect. It is not clear if this was his view at the time or in hindsight because at that time integration between the disciplines appeared to exist only at levels below the discipline heads and it was not until after the third project architect was in that position that his role became clearly that of technical coordinator and monitor of technical progress.

The steering group knowing that the WMCC did not have the capacity to carry out the construction activities or control directly, all the construction activities, formed a contract with J.Laing, building contractors, giving them responsibility for the selection and performance of sub-contractors. The control function was concerned with negotiating the contract with J. Laing, providing them with the developed designs and monitoring the progress of their work. The criteria for measuring progress was that agreed construction targets were met to the satisfaction of the site manager, in the specified time and that the budget was not being unecessarily overrun. When construction started design activities were still continuing and the project architect became concerned with coordinating the construction and design activities as well as coordinating the disciplinary design activities and assessing the technical development of design.

In the next chapter the cybernetic model of the situation will be presented. It has been shown here that not only are two models necessary to describe the parent organisation and its relation to the project organisation but also that the mechanism of monitoring-control will need to be analysed more than once to cater for the organisational changes, especially those associated with concurrency, that occurred after implementation had started. Only by looking at each period separately, is it possible to determine the mechanisms for control and communication that were operational and then by comparison with the criteria of effectiveness show areas where flexibility was lost.

Chapter 10

The Parent Organisation - an analysis of the cybernetic model

The task facing the parent organisation was to determine how the decision taken by the general organisation should be implemented to produce a desirable project outcome. The option had been selected at a general level and now the parent organisation was concerned with sub options. The selected option offered a number of sub options within its parameters. For instance although the size and location of the terminal had been determined, the positioning of the various airport operations within the terminal and the length of the runway was still flexible.

10.1 The cybernetic model of the parent organisation

The parent organisation as metasystem to the project organisation (see figure 4 - 2) had to develop the capacity to manage the implementation carried out by the project organisation, in a way that satisfied the objectives of the general organisation and its own sub objectives. Before implementation could begin the questions outlined in chapter 9 had to be answered through decisions taken by the steering committee. Figure 10 - 1 describes cybernetically the interaction between the key participants concerned with formulating in more detail the option, deciding how to increase management capacity to handle implementation and developing mechanisms to monitor and control implementation.

Figure 10 - 1

The parent organisation - planning for implementation.

```
                         POLICY FUNCTION

                         Steering Group
                      ----------------------------
                     | County surveyor            |
                     |                            |
                     | County architect/planner   |
      reports and    |                            |
    ---------------->| County Treasurer           |
   |recommendations  |                            |
   |                 | County Secretary           |
   |                 |                            |
   |                 | Airport Director           |
   |                  ----------------------------
   |
   |
   |            INTELLIGENCE FUNCTION
decisions
   |               Air Transport --------------
   |               Study Group                 |
   v                                           |
project manager<-------------------------> working group
    ^  ^                                       |
    |  |         CONTROL FUNCTION              |
    |  |                                       |
    |  |      ----------------------------     |
    |  |     |                            |    |
    |  |     |     Project Manager        |    |
    |  |     |   (structural engineer)    |    |
    |  |     |                            |    |
    |  |     |     Project Architect      |    |
    |  |     |                            |    |
    |  |     |     Project Engineer       |----
    |  |     |     (civil engineer)       |
    |  |     |                            |
    |  |     |   Ass. Airport Director    |
    |  |     |      Development           |
    |  |      ----------------------------
    |   -------> Valuation & estates
    |                 officer
    |
     ----------->  Finance treasurer
```

The control function also contains all the people who were servicing and supporting the participants identified thus providing amplification of the arguments developed. The figure therefore represents roles within the control function and not the control function itself.

Figure 10 - 1 indicates that the mechanism for communication between the intelligence and control functions was working group meetings. These meetings continued to be held frequently, as they had in the general organisation. As project manager, the head of the working group was given more discretion in assessing the value of the contributions made by members of the working group. The head of the air transport group felt this greatly reduced the contribution they were able to make to formulating in more detail the selected option. During an interview he said that the majority of their suggestions were overruled by the project manager because he thought they unnecessarily delayed the decision making process. One example the head of the air transport study group cited, was their suggestion that the runway should be slightly extended.

The air transport study group found that the extra cost would not be great and the future opportunities such an extension would make possible should be seriously considered. This information however did not form part of the reports submitted to the steering group and therefore was not considered by them. According to the head of the air transport study group, the project manager felt that an extension would require further planning permission and could delay an already tight schedule for project development.

The project manager, project architect, project engineer, valuation and estates officer and finance treasurer each studied their own disciplinary areas and made recommendations to the steering group through the project manager, for additional personnel or support of consultants to develop designs. The chairman of the steering group as head of the transport and engineering department was aware that the council did not have the capacity to develop mechanical and electrical engineering designs and a decision was taken by steering group that consultants should be engaged to manage this area. The selection of consultants for mechanical and electrical engineering designs was done by the project manager and approved by the steering group.

The assistant airport director development had regular meetings with airlines and other airport users to determine the facilities they required. He selected which businesses were to be given, terminal operations, such as the airport cafeteria, and terminal space, such as stationers, banks, car hire etc.. The recommendations he made were passed to steering group by the project manager for approval.

The steering group decided, on the recommendations of the working group, that civil engineering design and structural engineering design was to be the concern of the project engineer and the project manager with the assistance of the consultants they had selected. It was clear that mechanical and electrical designs would have to be developed by consultants and W.S.Atkins were selected on the recommendation of the project manager. Architectural design took longer to consider. The county surveyor supported by the chief executive did feel that perhaps architectural design should go to consultants, as the department in the council was much smaller than the transport and engineering department. The county architect/planner approached the airport sub committee and through their support managed to keep the architectural design of the terminal. This association with the general organisation would appear to show, that when issues could not be resolved within the parent organisation, then decisions were taken by the general organisation.

The project manager and the project architect, together considered how the work of the various disciplines should be coordinated and with the support of the project engineer, finance treasurer and consultants, considered in more detail estimated project costs and time scales for, limited design, detailed design and construction (earthworks, taxiways aprons, terminal and associated civil engineering works). Reports were developed from these studies and submitted to steering group. The steering group approved the findings and the time and budget estimations were subsequently used by the project manager to monitor project development.

When the selected option had been formulated to the satisfaction of the steering group and they had taken decisions which determined the measures of project development and the people who were to be responsible for the various implementation roles the detailed design phase began. It was at this time the county planner/architect decided to replace the project architect with someone he felt would be more accountable to him. This in effect removed the interaction between project manager and project architect which had been operational in supporting steering group decisions.

Figure 10 - 2

The Design Phase - Terminal Building

```
                 POLICY FUNCTION
                                    reports and
                                  recommendations
                 Steering Group<-----------
                                          |
                                          |
             INTELLIGENCE FUNCTION        |
                               reports    |
                 Air Transport--------    |
                 Study Group         |    |
                                     |    |
                                     |    |
                                     |    |
                CONTROL FUNCTION     |    | decisions
     cost,time                       v    v
   ------------------------------> Project manager------
  | struct. eng. design dev.       Finance treasurer    |
  |                                      ^              |
Silk & Frazier                           |           coord.of
(Quantity surveying)                     |            design
  |                                      |          activities
  |                                      |           (design
  |                                      |          schedule)
  |                                      |              |
  |         IMPLEMENTATION FUNCTION      |              |
  |                                      v              |
  |       activity                   management         |
  |                   airport user                      |
  |----- architectural- - - - - -  project architect<--|
  |        design     information                       |
  |          ^                                          |
  |          |                                          |
  |  design information             no interaction      |
  |          |                            _             |
  |          v       little               |             |
  |----- M&E design - - - - - - - M&E engineer<--------|
  |          ^      interaction   W.S.Atkins Epsom      |
  |          |                                          |
  |  little interaction                   ^             |
  |  with above activities                |             |
  |          |                  high interaction        |
  |          |                  with project manager    |
  |          v                            |             |
   ----- structural -------------structural engineer<--
       design
```

Civil Engineering is not included in the above diagram because there was little interdependence between this activity and the other three.

At the beginning of the detailed design phase, limited design had already been developed. This work had gone on during the formulation of options. M&E design consultants had not been involved when the limited design was in progress, as they were not engaged until after the public inquiry, although they had been consultants for air pollution leading up to the public inquiry. Each disciplinary area developed in more detail the limited designs. The architectural and structural design teams having been involved in the limited designs had formed an integrated base to develop the detailed designs. The M&E consultants depended on information from these two areas to develop their designs.

" When you take on a time limit you don't always know the rate other people are going to work to supply information. We could not get detailed sizes and distribution of mains and pipes without having full accommodation usage. We needed to know the areas, spaces and the usage of each particular compartment in the building." (Interview with J. Tagg Managing Director W.S.Atkins.)

On the diagram, the interaction between M&E and architectural design is shown as the exchange of design information. J. Tagg in the above statement shows that M&E clearly requires a knowledge of the total accommodation usage. However the design information they received from the architectural design team was on individual areas, with little indication of how the areas would be related to each other in space.

This interview supports the interview with the project manager, in recognising the project architect was concerned with coordinating the detail of the disciplinary designs and submitting information on design development to the quantity surveyors. This definition of the role of project architect does not have appeared to be adopted by the second project architect. The tasks carried out by the project architect at this time were to determine through the assistant airport director development, the needs of individual operators using the airport and to pass this information to the architectural design team.

His role according to the tasks he described was to transduce the airport user requirements provided by the assistant airport director development, to structure the development of architectural design. The information the project architect obtained identified opportunities to be gained by placing certain airport operations close to each other eg. for security or ease of passenger movement, or allocating more floor space to one operation in preference to another eg. arrivals lounge, cafeteria, duty free etc.. Control of the architectural design was in fact the concern of T. Hart a senior architectural designer. He used the information provided by the project architect to develop architectural designs but did so for independent areas and he did not become concerned with the design of the terminal as a whole.

" I dealt with the client and assembled the brief, dealing with the airline companies, immigration, the police, all the different user groups that are part of the airport. I dealt with that side of things while Terry Hart who was reckoned to be a very good designer was used as the designer of the building." (Interview with Steve Pedlow Project Architect 1979 - 1981)

There was no indication in this interview or elsewhere that he coordinated the detail of the disciplinary designs. Interaction between architectural and M&E design was high within the two design teams and it was two way. The architectural design members supplied the M&E design members with information on the individual areas within the terminal building and they responded by stating, for example, what size ductwork the architectural design information implied. The architectural designs would then be adapted to accommodate the M&E requirements.

"One of the main influences on change of architectural design were the services. The building is almost like a jelly until they have finished their work. We adapted quite a lot because they have constraints on what they can do, whereas our constraints tend to come a long way down the line because they are visual." (Interview with J.Phelps Terminal Piers architect 1980)

Construction was started in April 1981 by J. Laing. It was during construction that it became clear that building would be delayed because a) the architectural designs were still too flexible not indicating how individual areas related to each other b) M&E designs were incomplete and implementation of the designs that had been developed were clearly insufficient to cater for the building as a whole. Any M&E work done at this time would have imposed excessive constraints on any further development in this area and therefore the total M&E design had to be sorted out before construction could continue. It was this situation, brought to the attention of steering group, that initiated the development of a global architectural design which would permit the M&E design to develop to an adequate level.

Figure 10 - 3

Concurrency between Design and Construction
Activities.1981.

```
                POLICY FUNCTION

                Steering Group<-----------------------
                                      |                |
                                  reports           reports
                                      |                |
             INTELLIGENCE FUNCTION    |                |
                                      |                |
                                      |                |
                                      |                |
               CONTROL FUNCTION  decisions             |
                                      |                |
                                      |                |
Site Audit Treasurer                  v                |
     ----------------------> Project Manager     decisions
    |                     |  Finance Treasurer       v
construction(Clerk of  cost,          ^            Project
development  Works)    schedule       |           Architect
    |                 (coord.    accountability  technical
    |                & monitor)       |         development
engineering(Ove Arup)     |           |          (coord.&
performance               |           |          monitor)
    |                     |           |                  |
    |                     |           |                  |
    |  ------------------             |                  |
    | |                               |                  |
    | |   IMPLEMENTATION         resources               |
    | |                               |                  |
    | |Interdisciplinary              v                  |
    | |  Activities              Management              |
    | |                                                  |
    |  -- Design ------------- Project Architect--------|
    |        ^                                           |
    |        |                                           |
    |        v                                           |
     ----Construction--------  J.Laing ---------------
```

Design and construction were monitored separately. Monitoring of design continued as before. Monitoring of construction consisted of auditing construction spending, measuring engineering standards and measuring the rate of development against the construction schedule. Silk and Frazier acted as consultants to the audit treasurer, Ove Arup and Partners were concerned with engineering measurement and the site manager or clerk of works was concerned with construction development.

The project architect had the dual role of design manager and design and construction coordinator. As design manager he had the task of determining how the various disciplines should interact to develop the designs and monitoring and controlling the development. He established interdisciplinary groups relating to the various parts of the terminal building ie., Maglev and fire service, piers, terminal, service building. By dividing the design activities into these four areas he catered for much of the disciplinary interdependence and thus attempted to reduce the involvement he had with technical detail. Each area was the concern of one of the architectural design team. This in theory should have been helpful in reducing the involvement of the project architect in technical detail. However in practice this was not so.

In an interview this project architect said that on the whole, the four architects he gave the task of integrating the various disciplines in each area were just not effective. He accused them of laziness and inability to take decisions but lay the blame for their performance partly on the previous project architect, whose deep involvement in architectural design had reduced the degree of discretion they could exercise. In effect he said the previous project architect had been doing tasks for them and had encouraged a dependence on him which now seemed difficult to overcome.

As coordinator of design and construction activities, the project architect had the task of making sure the design activities did not hold up construction activities. To do this he introduced phases, which made clear to the design team the aspects of design which were to be given priority at any one time and to the construction firm the part of the building program to be developed next. He developed reports on how the two activities were being coordinated directly for the steering group. His only contact with the project manager was during progress meetings which were concerned with schedule, cost and resource allocation for design activities.

Interaction between the design and construction activities was in the form of designs developed by the design team, and personally by a member of each design discipline on site. Site architects and engineers dealt with day to day problems, during any one particular building phase. They were given a degree of discretion in making changes that were under a set cost limit. The four architects concerned with the areas of design met weekly with the project architect, for design meetings to determine the consequences of decisions they had taken and so ensure that the same problem was not being tackled by more than one group.

Once the detailed design phase was established, the air transport study group ceased to have any influence on the project development. The intelligence function ceased to be of significance, in attempts to produce a desirable project outcome. Decisions taken by steering group were generally concerned with changes which involved costs above an agreed limit. These usually did not involve overall increase in project cost, but rather the reallocation of resources. However the decision to allow W.S.Atkins to engage another consultancy group to assist in developing M&E designs at the time of the crisis, and the implications for the need of extra resources for construction, did involve increased project costs. All these decisions were concerned with one particular project outcome and they were no longer concerned with future opportunities associated with marginally different project outcomes.

10.2 Comparing the model with the criteria for effectiveness.

The first stage in the development of a large scale project ie. when a particular option has been selected, is to plan the development of the project. Planning is an activity which is the concern of management, to produce a desirable project outcome. Generally when an option has been selected there still remains a degree of flexibility in determining the form the project should take. This stage can therefore be compared with the mechanism for adaptation. The decisions taken as a result of this activity will both structure the project in more detail and establish the mechanism for monitoring - control, necessary to steer the implementation of the project.

The mechanism for interaction between the two systemic functions was the working group meeting. The project manager decided who should be included in the debate and how they should interact. He was concerned with steering the debate and submitting reports to the steering group. The reports and recommendations presented by the project manager, together with reports produced by the financial treasurer and auditor, at the request of the project manager, represented the support given to steering group decision making.

The county surveyor, in his role in the general organisation, had regarded the contribution made by the air transport group as very significant and as the person who decided the contributions necessary for organisational debate, he always made sure their contributions were included. On the other hand the project manager, in the parent organisation had as his priority getting the project under way as quickly as possible and viewed the contribution made by the air transport study group as relatively unimportant, particularly as the issues they were presenting as a result of their studies implied a provision for debate which would delay the decision making process.

Although the air transport study group remained a part of the working group the head of the working group by placing little importance on the contribution they could make, in effect dismissed their input into the planning process. Support for decision making thus came primarily from the control function, attenuated by the reports developed and presented to the steering group by the project manager and the variety implied by studies within the intelligence function was lost.

One of the critical issues was the selection of people to manage the disciplinary design development. It is this area where many of those interviewed felt errors had been made. Whoever holds the position of disciplinary head, requires knowledge and expertise in the particular discipline relevant to the project. Looking at the four disciplines, the structural engineering design was controlled and monitored by the project manager himself. He did not become involved in the detailed design but ensured that technical development was satisfactory and he had the expertise to do that. Civil engineering design was the concern of the project engineer and he too had the knowledge and expertise to assess technical development. The main problems with technical development arose in architectural and mechanical and electrical design.

Architectural Design

The project architect's role was a complex one. It would appear that the architects, by producing the protocols of the airport were producing an integrating model used by the control function. The project architect was concerned with assessing airport user needs and future opportunities for the airport operation and transducing them into a global architectural design. It was architectural design that provided a comprehensive picture of the whole development. The more detailed aspects of the architectural design bring out the recursive nature of the parent organisation, in that the multiple levels of architectural design represent part of the control function at multiple organisational levels.

The other role the architects have systemically, would appear to be, to offer a coordination system. The development of the detailed work of the protocols into more detailed plans is very much a way of coordinating the work of the other disciplines, together with cost and schedule parameters. Design and construction became concurrent at the beginning of 1981. One of the reasons that created problems was because implementation was started without enough coordination tools to permit the linking of the various activities. The role of project architect as part of the control and coordination functions, rather than a disciplinary head within the implementation function, was not perceived. If the named system is studied, it is clear that none of the project architects handled the perceived systemic role satisfactorily. It would appear that it would have been better to have retained the original project architect, who had insight into global architectural design, and employ other architects to support him in his systemic role. The second project architect was concerned with transducing airport user needs into guidelines for architectural design but failed to perceive the need for the development of a global architectural design. At this time there was therefore no model for the control of design development and no mechanism at this level to coordinate the technical development of the disciplinary designs.

Mechanical and Electrical Design

The project manager assessed the ability of about four mechanical and electrical design consultants and made a recommendation to the steering group that W.S. Atkins should be chosen. His decision was based on meetings he had with a representative of W.S. Atkins, who appeared to have the experience and knowledge to handle the development of M&E designs for a project of this size. He did not appear to take into account that this person was based at their Epsom headquarters and would therefore have restricted involvement in the development of the M&E designs. In an interview the project manager said this consultancy firm was chosen mainly because they were locally based which would facilitate interaction with the other disciplines. It was during other interviews that it became clear that the knowledge and expertise within the W.S. Atkins firm necessary for the development of the M&E design was never based locally.

When the project manager talked of his team which supported him in the design phase of the project he referred to the project architect, the project engineer and representing W.S.Atkins either the managing director or the chief engineer for mechanical and electrical design, both based at the local branch. The managing director of W.S Atkins had no experience or knowledge in M&E design and the chief engineer had no experience in the development of M&E design for an airport terminal. The weekly design meetings chaired by the project manager provided a mechanism for him to assess the degree of development within the four disciplines in terms of cost and schedule but they were not sufficient to determine the level of technical development. The channels for communication existed between the project manager and the disciplinary heads but an assessment of the technical development of the M&E designs was not possible because neither the project manager or the managing director of W.S. Atkins had the experience or knowledge to do so. They were both by profession, structural engineers.

Figure 10 - 4

Mechanism for monitoring-control - early design phase

```
                    CONTROL FUNCTION

monitoring -------- Project Manager---Coordination
 |                          | |                  |
 |-------- Architect.  project -----------|
 |         design      architect           |
 |            |            | |             |
 |-------- M&E         MD. Atkins---------|
 |         design          | |             |
 |            |            | |             |
 |-------- Civil ----- project------------|
 |         design      engineer            |
 |            |            | |             |
  -------- Struct.---- struct.------------
           design      engineer
```

Figure 10 - 4 shows that architectural design was viewed as an implementation activity in design however analysis has shown that it appears this was not the case. Architectural design has been recognised in the research as part of the control function providing a model to permit the control of design development and the detailed protocol to provide coordination between the design disciplines. Without this coordination the design disciplines were not given the opportunity to respond to each other effectively during design development. The mechanism of monitoring - control described in figure 10 - 4 is only concerned with cost, schedule and resource allocation. As it stands there is no mechanism to monitor, control or coordinate the technical development of design.

Coordination between the disciplines was provided by the brief which had been developed for the public inquiry. This brief was of little help to W.S.Atkins because there had been no M&E design input into its development. Coordination of the disciplines was therefore very weak, consisting of a bar chart to indicate when particular tasks were to be started and finished and financial targets, to which all disciplines had to adhere.

Figure 10 -3 shows that the intelligence function no longer influenced the support given to steering group decisions. At this time construction had begun and the situation was to develop the project in the least time and with the least cost. The majority of options and sub options had been foreclosed and therefore looking for future opportunities or constraints was not so significant. The main feature in figure 10 - 3 is the dual monitoring of design and construction and dual reporting to the policy function. The two activities, design and construction were monitored separately in different ways. Design continued to be monitored by the project manager in terms of cost and schedule measurements whereas construction was additionally monitored for technical development by consultants. Technical development in construction was dependent on technical development in design and yet this continued to be measured separately by the project architect.

The project manager and the project architect reported separately to steering group. This in effect increased the complexity of the information the steering group had to consider because it did not cater the interdependence of the three measures ie. cost, time and technical development, in design and construction. The control function was not attenuating effectively the variety implied by the interaction between the design and construction and variety was lost. This could have been overcome by interaction between the project architect and the project manager but they continued to work independently till the end of the project, other than for the design meetings in which the allocation of resources to achieve cost and schedule goals were discussed.

Figure 10 - 5

Mechanism for monitoring-control - concurrent design/construction

CONTROL FUNCTION

```
----> Project manager<-- little -->Project architect--
|             |    |    contact      ^              |
|             v     -----            |              v
monitor       allocate    |         monitor        tech.
1.cost,time   resources   |         tech. dev      coord.
&engineering. for design  |         design         design
performance   & constr.   |         &constr.       &constr.
constr.                   v
2.cost,time             coord.
design               cost & schedule
                   for design & constr.
```

Figure 10 - 5 serves to illustrate how the control function was split. The mechanisms now existed to monitor and control design and construction but they were ineffective in three ways. Firstly the mechanism for monitoring the cost and time of design was separate to the mechanism for monitoring technical development in design. Secondly the mechanism for technical coordination of design and construction was independent of the mechanism for coordinating cost and schedule in design and construction. Thirdly construction was monitored separately for technical development of design implementation and engineering performance.

Comparison of figure 10 - 6 with figure 10 - 4 suggests that flexibility could have been introduced, particularly by increasing the response capacity of the implementation activities to each other.

Figure 10 - 6

Criteria of Effectiveness : Mechanism of Monitoring - Control
Design Phase

```
                         CONTROL FUNCTION
                   ------------------------------------
                   |                                  |
                   | Project Manager(schedule, resources)|
          ------->|   Project Architect(model of dev.)  |<----
          |        |    Project Financial Treasurer     |     |
          |        ------------------------------------      v
   monitoring                   |          ^            coordination
   Financial auditing           |          |           Cost&schedule
   Schedule                     |          |            parameters
   Technical dev.               |          |           Architectural
       ^                  resources accountability       designs
       |                        |          |                ^
       |                        v          |                |
       |---M&E design------ Mechanical & Electrical<------|
       |  activities         design management              |
       |        ^               |          ^                |
       |        |               |          |                |
       |        v               v          |                |
       |---Structural------Structural eng.Design<---------|
       |design activities     management                    |
       |        ^               |          ^                |
       |        |               |          |                |
       |        v               v          |                |
        ---Civil design---- Civil eng.Design<-------------
           activities         management
```

10.3 Studying the outcome with reference to actual project development.

By considering the findings of the comparison of the named system, the parent organisation, with the criteria for effectiveness, it is now possible to identify where flexibility was lost and associate this loss in flexibility with events that occurred during project development. First the planning phase will be considered.

Flexibility was lost during the planning phase because the contribution made by the intelligence function was on the whole, not included in the supportive information given to the steering group. The variety lost as a consequence of this, reduced the flexibility of response by the policy function. The decisions taken by the steering group foreclosed sub options which eliminated potential future opportunities for the airport operation. An instance of this was the omission of studies carried out by the air transport study group on runway length, which could have increased the capacity of the airport to handle a greater variety of air traffic and thus increased the scope of their strategic planning. The runway could still be extended but now it would be at an increased cost and with greater possible opposition from the local community who resist change. At the time of the development it was clear that a large scale project was necessary and it would have been easier to include the case for an extended runway at that time, rather than now when the airport operation appears to be doing well.

The selection of people to manage the development of the various disciplinary designs was based on the presentations put forward by county officers and consultants. Selecting a consultant for the development of M&E designs, with the necessary expertise based in Epsom, reduced the opportunity for interaction. The control function within the parent organisation had very little interaction with the person responsible for the development of the M&E designs and flexibility was lost even though the project manager interacted with the local managing director of the consultancy firm. This loss in flexibility ie. their inability to respond to each other resulted in M&E designs being seriously underdeveloped without either of them realising.

The greatest loss of flexibility was due to the poor coordination of the disciplinary design development. The architectural designs have been perceived systemically, as a coordination mechanism, to permit the other disciplines to respond to each other. The absence of a global architectural design meant there was no effective mechanism to coordinate technical development. Structural engineering design was being developed basically from the original design brief and it was not possible for the M&E design team to respond to structural design development because absence of a global architectural design inhibited their own development. When the M&E designs were eventually fully developed there were many problems associated with attempting to fit services into spaces, constrained by the implementation of structural engineering designs. Supporting structures had to be replaced by wires in some of the floors to accommodate necessary services such as electric wiring and pipes.

Architectural design needed to adapt to the emerging requirements of the other disciplinary designs. This does not imply that it was part of the implementation function, mutually adjusting to the other activities. As part of the control function the project architect would need to monitor the technical performance of the disciplinary designs measured against the control model and listen directly to the managers of the design disciplines. In this way he would be able to assess how architectural design needed to be adapted to provide an adequate mechanism for the coordination of technical development. Unless the mechanism for coordination was adapted in response to poor technical performance or discipline managers' observations, then it would be ineffective and flexibility of response between design disciplines would be reduced.

Flexibility of response by the original project architect when asked to develop a global design was reduced because disciplinary design development had proceeded without this coordination mechanism, which constrained the way it could now be realised. Structural design developed at its own pace, generally independent of architectural design. This reduced the opportunities open to the project architect, in developing the global architectural design. The flexibility of his response was reduced and although he was satisfied with the outcome, he felt he could have done a better job with fewer constraints.

During the later part of the design phase after the global architectural design had been developed flexibility of response to problems of general interaction between design and construction was lost because the project architect became involved in detailed architectural design. He was coordinating architectural design by direct supervision rather than by permitting self regulation. In terms of variety, this created an imbalance between his low variety side and the high variety side of the architectural team. Although the role of project architect has been shown to be concerned with overall design development this was not perceived by him at this time. Even if he had seen interdisciplinary design as within his area of concern, the variety imbalance created by direct supervision of architectural design would have implied a complexity far beyond his capacity to regulate.

Contractors were regularly in a position where they were waiting for information because the project architect was spending to much time overseeing detailed design and the architectural team were unable to respond to perceived problems because the project architect took the majority of the decisions. Flexibility at this time was reduced by the slowness of response and later, when the original project architect was again replaced, by the reluctance of the architectural team to take decisions because they were accustomed to having decisions taken for them. This latter situation did not reduce flexibility in a way that affected project performance but it made the task of the third project architect far more demanding than it need have been.

Finally flexibility was lost because the mechanisms for monitoring and control were inadequate even after the global design had been developed, the M&E designs had been revised and the third project architect had become concerned with the coordination of the design and construction activities. Many of the causes for loss in flexibility had been overcome incrementally, as a result of responding to perceived errors but still the mechanism for monitoring - control was split between the concern of the project manager and the project architect, with little interaction between them. The flexibility of response made by the project manager in allocating resources was reduced because he, personally, did not have a monitoring mechanism for the technical development of design. One consequence of this was that towards the end of the development, cost reductions had to be made and many of the later architectural design features omitted. This may not have affected the outcome of the project in terms of airport operating capacity but it did effect the final appearance of the terminal and the project architect pointed out that most of the cost reduction meant that interior design and fixtures had to be done at a much reduced cost. The appearance he said was inferior to the planned designs and already many features were having to be replaced or repaired as a result of wear and tear, at a cost greater than that implied by the original designs.

Chapter 11

Are Large Scale Projects Inherently Inflexible?

In chapter one arguments were presented supporting the view large scale projects are inflexible but a counter argument introduced was that incremental change is also inflexible because it implies the unhindered unfolding of existing tendencies, which is inadequate for turbulent organisational environments. Robust planning was offered as a compromise, whereby large scale projects are developed in such a way, that the outcome can be adapted to meet a number of possible futures eg. indeterminate architecture. This may be a solution in circumstances where it is possible to develop a flexible design but it does not apply to all problem situations that warrant the development of a large scale project. The Channel Tunnel project and the building of nuclear power stations are examples of large scale projects with complex infrastructures designed to meet particular needs. They cannot be used for any other purpose.

Literature describes well, instances of failure resulting from attempts to develop large scale projects, both in developed and third world countries. Yet large scale projects can be successful, even though the nature of their development implies that options have to be foreclosed when a decision is taken to select a particular option. The critical point in reducing flexibility in large scale projects would appear in literature to be the decision itself, to develop a large scale project with a defined outcome.

11.1 Decision Making and Project Flexibility

The decision is the end of one process and the beginning of another and does not exist in isolation. It is the view of this research that it is not the decision itself which is the main reducer of flexibility but the preceding process supporting the decision and the subsequent process implementing the decision. The support given to decision making influences the degree to which future opportunities are perceived or lost, future threats are perceived or overlooked and organisational needs and capacity are expressed. It is the interaction between these elements which provides decision support ie. organisational debate. Organisational debate and its relationship with the decision making body is where the research addresses the problem of flexibility in the decision making process concerned with the development of a large scale project.

Figure 11 - 1

Focusing Flexibility in Large Scale Projects

```
      ----------- Decision Makers <-------
      |            ^            |        |
      |            |            |        |
   issues and  decision     decision  project
   guidelines  support      outcome   outcome
      |            |            |        |
      v            |            |        |
 ---------------   |            |   ------------
| Organisational |--           -->|  Project    |
|    Debate      |                | Management  |
 ---------------                    ------------
```

It is through project management that the decision outcome is realised. The project outcome is the product of the project life cycle. In project management, future opportunities and threats for the selected option are perceived and the capacity for implementation expressed. Also in project management implementation activities are monitored and controlled to steer the development towards an outcome which satisfies the objectives set by the decision makers. These are the two aspects of project management in which the research addresses the problem of flexibility in managing the unfolding of the project life cycle.

Figure 11 - 1 indicates that although taking a decision, which forecloses all other options, can be considered an inflexible decision, it is only one part of the process in the development of large scale projects. Another view developed in chapter 2 is that organisational flexibility in the process leading to decisions to develop large scale projects and in the management of the project life cycle, is more significant to the success of large scale projects.

11.2 The methodology

The research problem has been to develop a methodology to analyse organisational flexibility which can be applied to the development of large scale projects. The conceptual framework has been developed from Stafford Beer's viable system model and application of the model to program management by Raul Espejo. The methodology incorporating the framework has been developed from a cybernetic methodology for problem solving by Raul Espejo. The particular contribution of this research is the application of a cybernetic methodology to the study of a large scale project, focusing on the analysis of organisational flexibility during the formulation of options and management of the project life cycle.

The purpose of organisational analysis is to improve the effectiveness of organisations or, as in the case of this research, to determine how organisational effectiveness was reduced. Previous attempts to improve the track record of large scale project performance has been to focus on error or failure in projects and associate this with probable causes (Hall P. 1980, Bignell V.et al 1977). A more recent development has been a comparison of a variety of projects to identify preconditions for success or failure in large scale projects. (Baker B.N. et al 1982, Morris P.W.G. and Hough G.H. 1986)

This research is a departure from previous attempts to study project performance, in that the starting point is not events that occurred in the real world but rather an abstraction of the organisational relationships which existed at the time. The methodology is powerful because by developing cybernetic models of the organisational relationships, the analyst is able to capture the complexity of the functional interactions which were operational and through abstraction execute an analysis which is not influenced by real world events. Once organisational effectiveness has been established with reference to criteria of effectiveness expressed in the conceptual framework, the real world situation is observed. Comparison of the conceptual model with the real world situation permits the analyst to find associations between areas of organisational ineffectiveness and events which actually occurred during the development of the large scale project.

The research is meaningful only as long as it is done from the viewpoint of a particular observer. The observer names the systems and, by looking at the cybernetics of the system in focus, captures its complexity. Functionalising the organisational activities makes more clear to the analyst, the interdependencies that existed and permits the identification of mechanisms for communication and control, that were in operation between the organisational or systemic parts.

Are large scale projects inflexible? It is true that the technology selected as the project outcome may be inflexible. The project outcome required in such a case would be a system capable of carrying out a particular process which implied the construction of a complex infrastructure of a set functional size. However this does not imply that the decision making process or the management of project implementation is also inflexible. The cybernetic methodology applied to the case study show that mechanisms for communication and control that existed in the organisational setting did influence the support given to decision making and the management of the implementation of the decision outcome. It would appear therefore that the way these mechanisms are designed has implications for project success.

There are two problems of flexibility in project development addressed by the research. The first is how adequate is the project as a response to changes in the environment? The second is how do we run and manage the development of the project so that we build into implementation, flexibility ie., by providing the capacity for implementation activities to respond to each other? These two problems highlight the role of intelligence and the role of coordination.

The conclusions drawn from the diagnosis of one case study cannot be applied generally but the methodology developed in this research has shown that a cybernetic approach can be applied to the development of large scale projects. A development of this research would be to apply the cybernetic methodology to a range of large scale projects, to assess which aspects of organisational design related to large scale projects are particularly vulnerable to loss in flexibility. These are areas where organisational constraint impedes interaction between systemic functional parts or where functional parts tend to be underdeveloped in comparison with the degree of variety implied by their concerns.

Very often during the development of large scale projects a problem may be solved but others then emerge elsewhere. This is inherent to the complexity of the situation, caused by the interaction between the various activities. The cybernetic methodology developed in this research is designed to handle this complexity in the way described in chapters 3,4, and 5. It uses a systemic approach which permits the observer to focus on a particular level of recursion, such as the general organisation or the parent organisation, which is logically the system in focus for the transformation of interest. If the purpose of the analysis is to assess where flexibility was lost in the decision making process the system in focus would be, in the observer's viewpoint, the general organisation.

It is important to realise that the system in focus is an abstract construct, not an entity on its own. Looking at the cybernetics of the problem situation, implied by the system in focus, permits the development of a cybernetic model of the real world. It is an analytical tool designed to be applicable to an organisation concerned with the development of any large scale project.

11.3 A Cybernetic view of organisational structures in use, to cater for the complex interactions within a large scale project human activity system.

Liaison devices and in particular the matrix structure have been widely used to cater for the interdependencies between activities in the project life cycle. There is still much debate about problems associated with the matrix structure although it has been adopted with a degree of success in many project settings. The main problems would seem to be the conflict created by dual management and the need for many committees to cater for the interactions implied by the matrix structure. Organisational conflict would appear to be a desirable factor within small project groups where personal interaction between all participants is possible. In this situation it provides a bringing together of different viewpoints, thus creating a learning environment. However when the project is large and organisational relationships complex, the opportunity to fully integrate is reduced and conflict can be destructive, such as bringing about a tendency to departmentalise.

"The matrix structure was first developed in research and development organisations in an attempt to capture the benefits and minimise the liabilities of two earlier forms of organisation, the functional structure and the project form of organisation (Katz R. and Allen T.J. 1985).

Project managers whose prime directive is to get the project completed on time within budget are matched against functional managers who tend to hold back because they can always make the project outcome a bit better given more time and effort. When these two opposing forces are properly balanced, the organisation should achieve a more optimum balance, both in terms of project completion and technical excellence. The case study has shown that concern with schedule and budget is not sufficient to measure and control project development. It is also necessary that project management is concerned with technical development.

To manage effectively technical development, it is necessary that project management has a model of the project outcome and has a mechanism to amplify its capacity to control technical development. In the case study it was the architects who developed the model of the project outcome and provided coordination to amplify the capacity of project management, to control the technical development of disciplinary design. This would suggest that project management, as the control function in project development, needs to include functional head/s whose disciplines are able to describe the model of the system which is to be the project outcome. The model can then be translated into designs which provide a coordination mechanism, together with schedule and budget parameters, to cater for the interaction between the other disciplines. Control is then amplified at multiple levels, in the project organisation, expressed by unfolding more detailed designs from the global design.

The cybernetic model presented in the research is not an attempt to provide an alternative structure for the design of project organisations but as a tool to analyse any project organisation to identify where in the organisational relationships flexibility is reduced. Such an analysis permits the observer to identify where mechanisms for communication and control need to be designed or adapted to overcome these sources of organisational inflexibility. Many of the critics of the use of liaison devices say that the cost of interaction is too much for the benefits gained. The cybernetic analysis provides a tool not only to indicate where communication and control mechanisms are inadequate but also where such mechanisms, in operation, may be superfluous to organisational flexibility. In this way interactions between systemic functions can be made more effective and may even reduce the costs associated with providing interaction.

The cybernetic model also permits the analyst to determine the benefits and costs of a particular organisational structure. Organisational structure is designed to meet the complexity of the managerial challenges presented by the development of a large scale project. It is an example of variety engineering which is an attempt to provide management with the capacity to meet the complexity of the human activity system. The project life cycle has been described by Morris as passing through three phases of organisational structure:- centralised, decentralized, centralised.

"The initial, design phase requires unified strategic decision making. During production the volume of work becomes so great that responsibility must be delegated; the organisation becomes decentralized under the project and functional matrix control. Finally, at turn-over, the volume of work decreases while the need for unified integration with operations' start-up creates the need for centralisation once again." (Morris)

Rather than using the terms centralisation and decentralisation for this discussion it is more useful to consider one dimensional and two dimensional structures. When looking at the cybernetics of the situation in a normal one dimensional organisational structure, we talk about increasing coordination by self regulation against increasing coordination by direct supervision as a useful criteria of effectiveness.One of the aspects that gives flexibility to human activity is self regulation (Viable System Model). The organisation concerned with the initial design phase has been described in literature as a functional structure. This is one dimensional and its effectiveness can be assessed according to the criteria mentioned.

During production the volume of work increases and responsibility delegated. At this point the matrix structure becomes fully operational. The structure is now two dimensional but is it flexible? Management is the low variety side and operations the high variety side in the variety equation. Coordination through self regulation amplifies managerial regulatory capacity and balances the equation. However in the matrix structure there is management along two dimensions to the same unit. To avoid contradictory instructions or oscillations in the ways the two dimensions direct this unit, it is necessary to have strong coordination between supervisory units so that cohesion and unity of direction is achieved. It is often said that the matrix structure brings about a proliferation of committees etc.. This is because it is necessary to make clear what each dimensional manager is going to say to the same unit and that puts emphasis in the coordination of the low variety side in this equation. The emphasis in terms of organisational design will be in creating channels of communication etc. for the coordination of the two dimensions which effect the individual units.

In terms of complexity the project side is looking at the different operations from the point of view of their links and implementation as wholes and so perceives particular units and their tasks. The functional side sees all these tasks from a more global point of view but in slices or disciplines. The slices in each of the tasks are pulled together by functional management. Each task will have different problems and situations and therefore it is necessary for the tasks to be seen as a whole ie. through project management, to determine where and when functional resources should be allocated. Functional management needs to look at the individual slices of the tasks to develop ways of coordinating their efforts.

If this coordination effort is done at the centre which is what could be called coordination by direct supervision all the effort of coordination and integration is left at that level. The other option is where people on the ground see their difficulties and progress etc. and find ways of coordinating their efforts. The one based on direct interactions of the participants has very high variety with many people talking to each other but they have the problem that each of them has only a partial view of what is going on. With coordination at the top there emerges a global view but to produce effective coordinations of the actions implies a huge bureaucratic effort of working out the details of the interfaces or the possibilities of oscillations.

The costs and benefits of these alternative approaches usually depend on the cost of failure. If the cost of failure is low then coordination by self regulation makes more sense. As the project grows in size and complexity of infrastructure, the cost of failure is too high and it becomes necessary to accept that more resources need to be put into the control function and accept the cost of removing self regulation ie. reduced flexibility. If self regulation is reduced or not sufficiently developed it restricts the activities of the people at that level. They feel the need to ask for more instructions from the top and the top feels overloaded. The response from the top is often to put more restrictions, by edicts, instructions etc., on the high variety side reducing further their self regulation. This is an example of positive feedback which can quickly lead to varying degrees of instability within the human activity system.

The matrix structure is adopted at a cost. If that cost can be justified then it can be viewed as appropriate to the project. However each project should be viewed independently. Not all large scale projects have complex infrastructures (they may be modular in design). Then it may be that the benefits of the matrix ie coordination between the two dimensions, are outweighed by the costs of bureaucracy. If the large scale project is modular in design, lack of coordination between dimensions may not be as expensive in terms of failure.

The matrix structure would appear to be useful for the production stage of large scale projects where the infrastructure is complex and cost of failure very high, as in the development of a nuclear power station. In this situation it is necessary that there is very strong coordination between the two dimensions, project and functional. It must be accepted however that this is an inflexible structure allowing minimal self regulation of the tasks. This serves to emphasise the importance of the planning phase in the project life cycle. If the swing to a matrix structure is premature the flexibility lost may introduce error which could be very costly and difficult to overcome, due to the degree of reciprocal interdependence between and lack of self regulation within, the tasks. The mechanisms to permit the flow of information, need to be designed before the matrix structure is fully operational, otherwise problems will arise during production.

There is still need for more research into the ways the mechanisms for communication and control should be designed. For example, it is not clear how mechanisms to monitor organisational debate can be designed. The role of the policy function has been described as setting the issues for organisational debate, which give an identity to the organisation concerned with project development and monitoring and controlling that debate to make sure that the support for decision making is well formulated. Setting up of the organisational debate by the policy function involves the clarification of issues, the selection of those to be involved, the creating of a balanced debate ie. having sufficient capacity within the intelligence and control functions, for them to handle the activities implied by their roles and to establish mechanisms for the two systemic functions to interact. It is more difficult to see how mechanisms can be designed to monitor the performance of the debate. To monitor the debate implies a need for a measuring device and a set of criteria to assess performance. The research recognises the importance of monitoring the organisational debate but this area has not been developed sufficiently to indicate how such a mechanism could be designed.

11.4 The development of interactions within the case study Human Activity System

According to the managing director of the M&E consultants, in the implementation of large scale projects, a leader eventually emerges to coordinate design activities. During the development of the Birmingham Airport Terminal, it was the project architect who emerged as the person concerned with coordinating implementation activities. The interview posed the question, if the managing director is correct, why does the concern for coordination emerge in the role of the head of one disciplinary design development and why does it take time for this activity to become formalised? In the case study, construction had started before the project architect actually became concerned with coordinating disciplinary design.

Analysis of the case study suggests potential answers to the two questions. The activities carried out by the various design disciplines were not independent. The actions of one subsystem can make life easier or more difficult for another. Coordination of the subsystems is designed to cater for the dependencies between subsystems in a way that permits them to work towards the objectives expressed by the control function. If these objectives are not clearly understood by the subsystems, coordination is difficult.

The M&E design subsystem did not clearly understand how the objectives applied to it and was not aware of the information it required from the architectural design subsystem. The person with knowledge and expertise in developing M&E designs for airport terminals was based in Epsom and had no direct interaction with the design activities. Had the M&E requirements for global architectural design been apparent at the beginning of the design phase, the project architect would have been aware that the development of such a design was his concern. In this way the interdependency between the two design disciplines would have been more clear. Unless sub objectives are clear, interdependency between subsystems is difficult to define, which might explain why it took time for the disciplinary design developments to be coordinated.

The other question, ie. why the concern for coordination emerges in the role of one of the disciplinary heads, would appear to be associated with the discipline that the majority of other disciplines depend on for information. In the case study M&E design was dependent on information from architectural design. The person concerned with architectural design could have been logically the one to coordinate design activities because it was the architectural design which interpreted airport operational requirements. If this was so the constraints imposed by structural design on the global architectural concept could have been avoided if this dependency on architectural design and the need for the head of architectural design to coordinate design activities had been recognised earlier.

Effective coordination of design activities must influence the technological development of project design and could be a critical consideration in attempts to avoid concurrency. In the case study it was difficult for the parent organisation to know when design was complete because lack of coordination between the heads of the design disciplines made it impossible to assess the level of overall design development. No one queried the technological performance of the design development until problems emerged in construction. Up to that point the project manager and the steering group felt the designs were sufficient for construction to begin.

In the case study the role of project architect appeared to have been a very complex one, which might explain why it took three changes of project architect to complete the design development and coordinate the design activity with the construction activity. Each one carried out different aspects of the role at different times, to respond to the problem situation implied by the role as they saw it. If the activities implied by the role were indeed too complex for an individual project architect to perceive, this would suggest that the project architect needed a team to support him in this role. The complexity of the role of project architect would appear to be the outcome of its involvement in the control function. The project architect appears to have been concerned with developing a model to permit control of the interdisciplinary design development, coordinating the various interdisciplinary design activities through the development of architectural design and controlling construction activities through the use interdisciplinary designs developed from the architectural model.

Figure 11 - 2

The Role Of the Project Architect During Design

```
                         CONTROL FUNCTION

                       Development of Model
              -------->for interdisciplinary<-------
             |         design development             |
             |                 ^    |                 v
    Monitoring                 | instructions    Coordination -
    technical                  |    |           by structuring the
    development       account-      |           interaction of the
       of             ability       |                detailed
    interdisciplinary          |    |           interdisciplinary
       design                  |    v                 design
                       Disciplinary Design
                            Managers
```

Initially it appears the complexity of the role of project architect and its involvement with the control function was not perceived. This could explain why the role was poorly defined and interpreted differently by people attempting to fulfil the role. Each project architect who took on the role viewed it differently according to the situation he perceived. While the project manager and the steering group perceived that problems arising during the development were associated with the role of the project architect, they never viewed him as part of project development control. Had they done so it is possible that he would have been recognised as an integral part of project management and supported in the roles outlined in figure 11 - 2. The activities implied by the role of the project architect in figure 11 - 2 were gradually introduced into the development through the appointment of new project architects, with new directives developed by the steering group, designed to provide a response to problems as they emerged. It is the view of this research that, had the activities implied by the role of project architect been recognised and supported at the beginning of the design phase, errors eg. in the mechanical and electrical designs could have been avoided.

11.5 Authority and Leadership in Large Scale Projects

Two preconditions of project success have been identified as strong authority given to project management and strong leadership (Morris P.W.G. and Hough G.H. 1986). Authority depends on the ability of project managers to perceive the need for change and the ability to bring about change. This cannot be done unless project management has the capacity to perceive project performance. Performance is generally not well measured in the development of large scale projects. Project managers tend to monitor the budget and schedule as in the case study and leave the monitoring of technical development to the disciplinary heads. Unless monitoring mechanisms are integrated project performance cannot be measured effectively as budget, schedule and technical development are interdependent. Although it is recognised that project managers usually have one particular disciplinary background and therefore cannot assess technical performance in other disciplines, this should not be a problem. The control function should be concerned with monitoring the technical performance emerging from the interaction between the various disciplines and not the disciplines themselves.

The control function should also be concerned with coordination of the implementation activities. In the case study, technical interdependency was catered for through the structuring of coordination mechanisms from architectural design development, which should have been supported by accountancy measures etc. relevant to the project. If the coordination mechanisms provided by the architectural design are not supported by these other elements or considered by project management, the capacity of the control function to bring about change is reduced. The project manager continued to sort out individual problems with disciplinary heads. This took up much of his time outside the regular progress meetings which may have been avoided if he had access through interaction with the project architect, to mechanisms for coordinating the design activities.

These two examples of how control function concerns were not integrated, suggest that it is necessary to design the mechanisms for integration between all the managers to establish cohesiveness. The systemic view of the project is to see how all the roles are interrelated and affect each other, rather than look at each role independently. The analysis shows that monitoring, control and coordination activities that were carried out independently by the project manager and the project architect were the concerns of the same control function and were therefore closely interrelated.

Strong leadership can be attained in various ways which may seem equally effective but which may be more or less vulnerable to loss in flexibility. Leadership can be realised through mechanisms used to monitor and control the activities of concern or through involvement in those activities. A leader has to be able to handle the variety emerging from the activities of concern and make clear the guidelines or objectives necessary to steer the activities. In this way he is recognised as a leader and can thus influence project development.

There are two ways he can handle variety and steer activities. He can design mechanisms which attenuate the variety emerging from the activities of concern and amplify his own variety in the steering of the activities. In this way he develops an information space which permits him to monitor and control, without becoming involved in the individual activities. If these mechanisms are effective and remain operational, a change in leadership should not be a problem.

The second way of handling variety and steering activities is to become involved in the activities themselves. In this situation you depend on one person to provide all the bridges between activities and in that sense success of the project is in his hands. This greatly increases the complexity implied by leadership and although perhaps one particular person can handle this complexity, the chance of a replacement in the leadership role being as effective, is very much reduced. When projects flounder after the departure of a particular person, it could be that the complexity implied by his role is too great because by controlling by direct supervision the mechanisms to balance the variety of management and operations have not been developed.

The number of activities and the interdependency between them increases during the development of large scale projects. Even if leadership appears to be strong during the early stages of project development it may become ineffective as complexity of the operations increase, if mechanisms for communication and control have not been well designed. This is particularly true if concurrency occurs. It would therefore appear that effective leadership needs the support of mechanisms for communication and control, in addition to strong leadership qualities in the person concerned.

11.6 Relationship between the General and Parent Organisations.

A third precondition for project success has been associated with the relationship between the systems named in the research as the general and parent organisations. Studies made of past projects have made it clear that organisations concerned with project implementation ie. parent organisations, need support or champions to retain their viability, however intervention by the general organisation into the management of project implementation can bring about project failure. This implies that the parent organisation needs to have autonomy to manage implementation activities and the general organisation should be involved only if decisions go beyond the parameters of parent organisation autonomy ie. if the parent organisation is not implementing the decision outcome as specified or if conditions beyond the control of the parent organisation, need to be attended to, to ameliorate threats to the success of the project outcome.

If project development is deviating from the original decision outcome the parent organisation is accountable to the general organisation and it is they who then decide if objectives should be adapted or if the parent organisation should adopt different management techniques to satisfy the original objectives. If changes in the environment of the parent organisation threaten project performance or the success of the project outcome, it may be necessary for the general organisation to find a response to the threats, in order to protect project development. This may involve taking such measures as negotiating with competitors or groups that oppose the project development and threaten the success of the project outcome. Generally however once a decision to develop a large scale project has been taken the system in focus will be the organisation concerned with managing project implementation.

Intervention between the general and parent organisations should be minimal, if the parent organisation is to have the degree of autonomy necessary to steer the project towards a desirable outcome. Any intervention by the general organisation can reduce the capacity of the parent organisation to respond to disturbances in its environment and can greatly increase the complexity it has to handle, if intervention implies significant change.

It has been noted in literature (Morris P.W.G. and Hough G.H. 1986) that the management of the project life cycle may be very good, achieving the required outcome but the project still fails, or what appeared to be a very good decision is not implemented effectively and the project fails. This serves to illustrate the importance of organisational flexibility both before and after a decision to develop a large scale project is taken. A decision poorly supported is less likely to produce a successful project outcome even if project management is good. A well supported decision which captures future opportunities, organisational needs and operational capacity, is not sufficient. If the parent organisation does not have the capacity to manage the implementation of that decision the project outcome may not fulfil the objectives formulated by the general organisation.

11.7 Conclusions

Large scale projects are sometimes necessary to take advantage of future opportunities and ameliorate future threats. The financial and social costs of not developing a large scale project may, in the future, be far greater than the cost of the project itself. The aim therefore should not be to criticise large scale projects for their inflexibility and the detrimental effects they may have on society but to find ways of structuring the decision making process and the management of the project life cycle to bring about a successful project outcome. Well designed mechanisms for communication and control, capture the complexity of the interactions between the systemic functions at multiple levels of recursion, and create an organisational response capacity which effectively reduces the occurrence of unexpected future environmental changes or errors, improving project performance.

The first principle of organisation described by Stafford Beer, captures the theory behind the conceptual framework developed in the research.

"Managerial, operational and environmental varieties, diffusing through an institutional system, tend to equate; they should be DESIGNED to do so with minimal damage to people and cost." (Beer S. 1985)

Flexibility as defined in the research is a measure of how effective the mechanisms for communication and control, in an organisation concerned with the development of a large scale project, are in bringing about the diffusion of variety without variety loss. It is loss of variety that reduces flexibility in both the decision making process and the management of the project life cycle. If flexibility is reduced in the decision making process, opportunities may be lost, threats unforeseen or a decision may be beyond the capacity of the organisation to implement. If flexibility is lost in the management of the project life cycle unforeseen errors may occur or people may find it impossible to handle the complexity implied by their role.

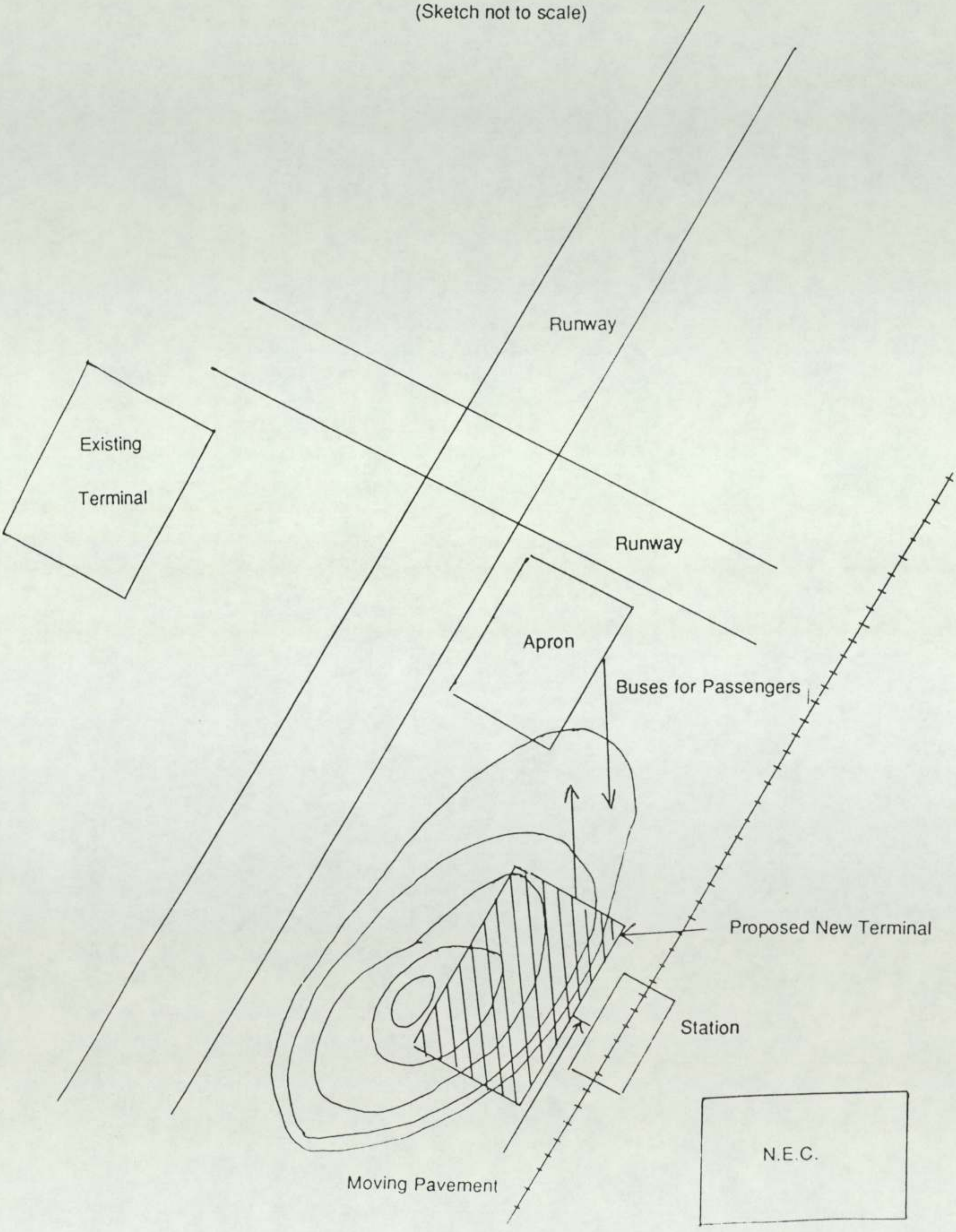
The outcomes associated with loss in flexibility may happen anyway. Future circumstances which could influence the success of the project outcome may be impossible to foresee. However evidence obtained from the case study has indicated an association between flexibility loss and some of the outcomes mentioned in the previous paragraph. The evidence is supported by the work on organisational effectiveness developed by Stafford Beer and Raul Espejo, who have done extensive studies on a number of institutions. Although this research is focused on organisations concerned with the development of large scale projects, the criteria for organisational effectiveness are equally applicable. It is the application of the cybernetic theory to the development of a large scale project which represents a departure from their work.

The purpose of this research has been to show how policy makers and project management can manage better. It is not an attempt to devise solutions. That is done by the managers themselves as appropriate to their own situations. It is a methodology which enables an observer to analyse where organisational flexibility can be improved to help managers to better understand the nature of their organisational problems. The neutrality of the approach used in the methodology and its capacity to capture the complexity of an organisation concerned with the development of a large scale project, gives it strength as an analytical tool. The research has shown that a cybernetic methodology can be applied to the development of a large scale project. The methodology can be further developed by applying it to a selection of large scale projects, and thus become more generally useful. It may also indicate areas in the decision making process and project management of large scale projects, which are particularly vulnerable to loss in flexibility.

Large scale projects cannot be ignored. They are necessary and will continue to be developed. Attempts must be made to meet the managerial challenges implied by the development of large scale projects. The application of a cybernetic methodology to their development is the contribution made by this research, towards achieving that objective.

Appendix 1
New Terminal Plan for Birmingham Airport
by Birmingham City Council 1972

(Sketch not to scale)



Appendix 2
Birmingham Airport Development : Submission by the West Midlands County Council to the Department of Trade October 1977

Contents

1.0 Introduction

The West Midlands County Council (WMCC) inherited a development scheme for Birmingham Airport when it took over responsibility from Birmingham City Council on 1st. April 1974. Shortly after the takeover the Department of Trade (DOT) informed the County that it would like to see a formal proposal for development of a new passenger terminal on the National Exhibition Centre (NEC) side of the airfield. It was suggested that this submission be made during the period of preparation of the Government's White Paper on National Airports Strategy, due in Autumn 1977.

Accordingly the County has considered a number of development schemes, and their financial implications, and this document presents them and the case for the preferred option.

2.0 The joint WMCC/British Airports Authority Study

In August 1975 the WMCC, DOT, Civil Aviation Authority (CAA) and the British Airports Authority (BAA) met to discuss the planning of the proposed new terminal building at Birmingham Airport. As a consequence of this meeting the BAA were appointed as consultants to advise, in liaison with senior officers of the County Council, on the need for, form of, and location of new terminal facilities. In accordance with the accepted view the BAA were instructed to consider only those sites which were adjacent to the NEC and BR Birmingham International Station.

Since the completion of the BAA work the officers of the County Council have looked at other options, expansion on the existing site or construction of a new terminal adjacent to the NEC/ Station for handling international traffic only - domestic traffic continuing to use the existing terminal. The purpose of these studies was to identify the advantages of moving to a new site compared with any cost advantages of developing on the existing terminal location.

3.0 The need for development

3.1 General

An airport with regular and convenient services to the major cities of Europe is of great importance to the West Midlands Region, a point that has been underlined by the Regional Tourist Board, the Birmingham Chamber of Industry and Commerce, the West Midlands Economic Planning Council and the West Midlands Planning Authorities Conference. The importance of the Airport is not just a matter of meeting the travel requirements of Regional commerce and industry but of the broader economic activity the Airport generates, the access to the NEC and the employment that it creates. Birmingham Airport is the gateway to the West Midlands Region and it is essential that its terminal facilities are adequate for the purpose and readily adaptable to meet changing demands The existing terminal building has reached the limit of modernisation without a radical change by way of a major expansion.

At peak periods there is severe congestion and the facilities will be completely overloaded by the summer traffic of the late 1970's.

3.2 Relationship with the National Exhibition Centre

Birmingham Airport has a unique role in that it provides an important means of access to the NEC. The success of the NEC depends, to an extent, on its ability to attract international exhibitions and, in order to do this, it has to be able to attract substantial numbers of foreign visitors. Clearly the provision of appropriate terminal facilities and the growth of the scheduled service network to Europe from Birmingham are important elements in the building of an effective image abroad for the NEC and the West Midlands generally. The management of the NEC and major exhibitors are increasingly placing great value on the convenience which the Airport offers to users of scheduled or chartered air services.

The value of Birmingham Airport to the NEC cannot be easilv quantified but the County believes

in several areas:

a) During exhibition periods in 1976 extra traffic of the following amounts was generated on scheduled international services; Paris 20.5%, Amsterdam 5.5%, Brussels/Frankfurt 16.0%.

b) Much General Aviation (GA) activity has accompanied NEC shows. Coventry Airport has also handled additional GA traffic during these periods, and it appears that some of these visitors do not use Birmingham Airport because of the poor terminal and facilities.

c) Special event charter flights from Europe are becoming established as a regular feature of NEC shows. The charter and GA traffic for 1976 is described in Appendix III.

d) The scheduled service to Heathrow showed extraordinary growth in 1976/1977 and a high proportion of these passengers were visiting the NEC.

The County believes that the NEC cannot be properly supported by the Airport without the development of new terminal facilities and there is much to be said for these being situated reasonably close to it and connected by some form of dedicated link.

3.3 Relationship with Birmingham International Station

The existing terminal site has failed to develop strong links with the Station and it seems unlikely, therefore, that this situation will be changed unless the Airport terminal and Station are more closely connected.

The County has recognised that the situation at Birmingham differs from that at Gatwick and it is not possible to be certain that rail could become a predominant access mode. However, clearly there is an opportunity to make better use of public transport and the national rail network, and British Rail has indicated its intention to promote rail access for air passengers to the fullest extent. For this opportunity to be exploited properly, it would seem to be essential for the Airport terminal to be reasonably adjacent to the NEC/ Station.

3.4 Airline and Travel Industry requirements

There is increasing emphasis on the use of regional airports by airlines and travel industry representatives who have come to recognise the congestion of the London Airports as an unsatisfactory feature of the British travel scene. Birmingham Airport has three important attributes which suggest that it may be attractive, in the future, to those seeking a new access to the industrial heart of the United Kingdom;

a) A catchment area having excellent road communications and containing intense commercial and industrial activity.

b) Excellent access to the Heart of England Tourist Region which contains many prime attractions.

c) Convenient and rapid access to Central London via the inter-city rail link.

The provision of scheduled services as well as charter flights has been an important aspect of the role of the Airport in the past. This has resulted in a broadly-based range of traffic with scheduled services increasing in importance over the years so that they now constitute over 50% of the passenger throughput. The attributes described previously are likely to encourage this trend and the WMCC supports the view that the Airport's most important role is to provide a good range of scheduled services to European destinations.

The cramped conditions in the existing buildings do not allow the airlines either to offer their normal level of service to passengers or to provide adequate accommodation for their staff. Airlines express the view that improved facilities must accompany any expansion of scheduled services.

3.5 Traffic development

In common with every other airport in the United Kingdom, Birmingham suffered a serious interruption of its traffic growth as a result of the 1974 oil crisis. Prior to this the Airport was experiencing considerable growth of all traffic and in 1972 and 1973 achieved better growth on scheduled international services than on inclusive tours and charters.
In 1974 there was a 10% drop in traffic at Birmingham. As might be expected the major traffic reductions were on domestic services and inclusive tours; scheduled international services managed to record a net traffic growth.
In 1975 there was a sign of renewed growth - principally in the inclusive tours and charter field. Scheduled international traffic declined, reflecting the world economic slump in that year.
In 1976 overall growth was again experienced so that the total Airport traffic regained the 1973 level. Inclusive tours and charters decreased in importance but there was a strong upsurge on the scheduled service routes. This pattern is being repeated in the current year.

3.51 Forecast of demand

Based on 1975 survey data, combined with historical trends, the BAA produced forecasts of passenger throughput at Birmingham up to the year 1990. Their forecast of the so-called "natural growth" traffic level in 1990 was 2.8 million. This forecast did not allow for the effects of any initiatives which might be taken by Central Government to bring about the greater regional diversion of traffic than might otherwise occur. A "high test case", in which it was assumed that Birmingham would possess a comprehensive European scheduled route structure by 1990, forecast 3.7 million passengers handled that year. In both forecasts, international charter traffic and inclusive tours were expected to constitute about 50% of the total passenger traffic.
These forecasts took no account of the possible outcome of current investigations into a National Airports Strategy. However, the preferred scheme for development meets the BAA capacity requirements and has the flexibility to meet possible future Government intentions.
Details of the historical traffic growth and the BAA forecasts are included in Appendix I.

3.6 **Conclusion**

a) Birmingham Airport has a well established role in the West Midlands and has demonstrated good growth potential for a healthy balance of scheduled and non-scheduled services.

b) Natural growth will overload the present terminal in the late 1970's.

c) New passenger facilities, linked to the NEC and Station, are required before the Airport can properly satisfy national and Regional demands.

4.0 The WMCC/British Airports Authority Study options

4.1 Introduction

The BAA were required, by the terms of their brief, to consider sites on the NEC side of the airfield only. They compared a number of sites and the choice was finally narrowed to two; "X" and "Y". These, whilst being designed to have substantially similar cost, differed considerably in terms of operating philosophy, configurations and distance from the NEC. The configurations of "X" and "Y" are shown in Appendix II.

4.2 Options "X" and "Y" - operating philosophy

Option "X" allowed a very flexible operating philosophy so that at all stages of development up to 2.8 million passengers per annum, pier service could be provided. Option "Y", on the other hand, did not have this flexibility and required the use of remote stands and "bussing" of passengers at a point well before the throughput reached 2.8 million.

4.3 Link with National Exhibition Centre and Station

a 200 metre footbridge with

order of £1.5m. On the other hand the terminal of "X" was 700 metres from the Station and would have required a transport link to be provided for rail passengers and NEC visitors. The BAA planned a terminal for "X" on the basis of a conventional bus link to the Station forecourt but the County subsequently upgraded the scheme by allowing for a "minitram" type of link. The cost of this - estimated at about £2.1m is included in the cost estimates presented later in this document (but was not included in previously circulated BAA reports).

4.4 General

The two options resulting from the BAA Study were regarded by the County as a basis for discussion. It was recognised that neither "X" nor "Y" necessarily represented the cheapest or the "best" solution but, rather, were each indicative of the extremes of development option which could be achieved for a given level of cost. This level was considered realistic and reasonable for the building of appropriate terminal facilities and was, therefore, adopted as the target order of cost to be aimed at when considering any further alternatives.

5.0 Ancilliary facilities and alternative uses of the existing buildings

5.1 Introduction

The BAA report considered the need for a new passenger terminal and made only brief mention of the wider aspects of Airport development. The County have since given considerable thought to the need for proper utilisation of the vacated terminal area and other types of activity which seem to require attention in any development plan, e.g. freight, maintenance, GA and general commercial activity.

5.2 Freight

The UK air freight industry is orientated towards flying in and out of London Heathrow. The County recognise this and seek only to cater for the proven air freight demand currently in evidence at Birmingham Airport and growth that way may come by way of underfloor loading of new scheduled passenger services.

It is known that Hanger No. 3, which houses the Airport freight complex has a limited life because it infringes runway clearance requirements, and it will, therefore, be important to provide alternative facilities capable of supporting this activity. In the County's view any development plan will have to allow for the construction of an entirely new, if modest, freight handling complex. The existing passenger terminal might be converted but this is perhaps not attractive to airlines or freight forwarders. The County is currently investigating the options open to it and is not in a position to make firm proposals at this stage. This is an issue, however, which cannot be ignored. A sum has accordingly been included in the costs of all the options to cover possible capital expenditure by the County in this field.

5.3 Maintenance

An inevitable result of increased scheduled services will be the demand for more airline maintenance during night stops. Even conservative estimates have shown that within the timescale of the development plan there could be a need to service five or six aircraft under cover. It is unlikely that the County would finance all such facilities but would seek instead to lease the necessary land for development. Some facilities may be required to be provided directly on a speculative basis and a sum has been included. Even with new facilities, however, it may be expected that the current maintenance activity in Hanger No. 2 will continue and no reduction in revenue is expected from this source.

5.4 General Aviation

GA activity at Birmingham cannot be ignored although there can be only a limited long-term future for club flying and the private pilot as airline traffic builds up. Business GA and traffic associated with the NEC will have to be accommodated, fortunately this is one sector of GA activity which might be capable of paying a service related charge. A contingency sum has been included in the cost estimates to provide for any possible expenditure by the County in this area.

5.5 General commercial activity

Whatever else the current terminal may be used for there can be little doubt that it can generate considerable income from the rental of office space. Office space at a developing airport is likely to be at a premium and several companies have already indicated their potential need for large area.

6.0 Alternative development options

6.1 General

In the BAA study it was accepted that a fundemental principle of development should be the location of any new terminal on the area of land adjacent to the NEC and Station. The County recognised that this was an attractive concept but also acknowledged that substantial justification was required when the development options "X" and "Y" were more expensive than any option utilising the existing site. In order to establish the practicability of such an option, the County investigated two schemes not considered by the BAA. One of these allowed for the full development of all new facilities in the area of the existing terminal and the other was a "split" operation in which the international traffic was handled by a new building adjacent to the NEC/ Station and domestic traffic was concentrated in the present terminal.

This outline work established that there was sufficient land available to provide apron and terminal facilities for the first of these schemes to the same level of passenger throughput as "X" and "Y" in 1990.

Pressures building up from consideration of "X" and "Y" determined that the "preferred" site was, in fact, somewhere between the two. Thus a final alternative - option "Z" - was conceived having most of the attributes of "X" and "Y" but few of their disadvantages. These three options are described in detail below and their notional configurations are shown in Appendix II.

6.2 Development of existing site

6.21 General

When considering the potential of the existing site for development great attention was paid to the need to devise a scheme which was comparable with "X" and "Y". To this end the diagrammatic configuration shown in Fig. A2.3 of Appendix II was adopted. This was a solution having the necessary physical characteristics and capacity to handle the forecast 1990 traffic. When defining this option, as with all proposed alternatives to "X" or "Y" the County was careful to ensure that like was being compared with like. Thus as far as possible the three additional options eventually considered; "Existing", "Split operation" and "Z" had costs which represented the investment required in each to handle the same traffic.

6.22 The "Existing" option described

Following closure of the secondary runway a new international terminal was to be located at its western end. The existing terminal was to be given over to domestic traffic and no pier service was proposed for these flights. About 80% of the international traffic was to be provided with pier service - the rest being serviced at remote stands. The entire development, up to 2.8 million passengers per annum, could have been contained within the boundary of the existing Airport area but any further expansion would have required an encroachment on non-Airport land across the A45. The County was satisfied that, for traffic development up tp 3 million the existing site development option was one which would have worked and would have provided a reasonable standard of service. This option would have been about £7 million cheaper than "X" or "Y" but there were serious disadvantages of the scheme and these are described below.

6.23 Loss of the secondary runway

The main runway lies across the prevailing wind and therefore existence of a secondary runway, shorter but correctly aligned, is of importance. It is particularly valuable as a back-up to the main runway and therefore contributes to the safe and reliable operation of aircraft at Birmingham. An analysis of wind speed and direction shows that there is a small loss of usability of the Airport for air transport aircraft if the second runway is closed. There is a more significant loss for GA aircraft that might be attracted to the NEC. The CAA emphasises that combinations of poor conditions would have potentially serious effects on the safety of all aircraft and particularly GA.
Despite this the County recognises that there is no prima facie case for keeping the secondary runway open; the amount of commercial traffic seriously affected by its closure is small. Nevertheless the closure was an unattractive feature not found in any other options.

6.24 **Poor relationship with the National Exhibition Centre and Station**

The importance of this relationship has been discussed earlier in Sections 3.2 and 3.3. With these comments in mind it was clear that the "Existing" option did not offer the prospect of any improvement over the present unsatisfactory position.

6.25 **Location of ancilliary facilities**

If the development of new terminal facilities took place on the existing site then it was clear that the ancilliary activities described in Section 5.0 would almost certainly have had to be located on the NEC side of the airfield. This was considered to be a very unsatisfactory arrangement. A particular disadvantage of the "Existing" option was that it seemed likely to accelerate the need for new maintenance accommodation because its taxiway configuration made necessary the demolition of most, if not all, of Hanger No. 2 - currently used for this purpose.

6.26 **Site constraints**

Perhaps the most serious disadvantage of the "Existing" option was that there was only easy development potential for a terminal handling up to about 2.8 million passengers. Beyond this it was necessary to purchase additional land and it was by no means certain that this would be available. The County believed that this scheme had an inherent defect in that it committed the Airport, more or less irrevocably, to a ceiling of 3 million. Although the County felt this was a currently desirable ceiling it would be unwise to saddle the development with such a rigid constraint.

6.27 **Conclusions**

On the completion of this investigation into the practicability of full scale development on the existing site it was clear that there was a capital cost saving of about £7 million on "X" or "Y" but this was balanced by the disadvantages of the scheme mentioned above. The County considered that considerable dis-benefit would arise from making the terminal building remote from the NEC and Station.

6.3 Development of a "Split operation" scheme

6.31 General

Despite the undoubted attractiveness of the NEC side of the airfield for development, it was felt that the greatest disadvantage of schemes based on this concept was the manner in which the existing terminal facilities were largely abandoned to other secondary activities. Thus there was a duplication of many items, increasing the cost and making it more expensive than any scheme which utilised to a greater or lesser extent the present terminal. Having ruled out full scale development of this terminal a compromise was sought. Accordingly a "Split operation" option was considered in which international passengers were handled by a new terminal adjacent to the NEC and domestic passengers used the existing terminal.

6.32 The "Split operation" option described

In this scheme no development was envisaged at the existing site. Instead the major effort would have been in removing from the present facilities those features not required for purely domestic traffic. No pier service would have been provided for domestic flights. The international terminal was situated on the NEC side and was operated as a separate entity. Pier service would have been provided for about 80% of traffic but, of course, this could have easily been increased with greater capital expenditure. There were few serious constraints on expansion with this option.

6.33 Disadvantages

There was only one feature - cost - which commended this option and in every other respect it was felt to be unsuitable. Specifically the disadvantages were operational complexity and inflexibility when catering for different types of traffic (particularly mixed international/domestic flights).
The airlines and Airport management were unanimous that a split operation would increase costs incurred when operating into Birmingham; these costs would result from the inevitable continuous movement of aircraft, passengers and freight across the airfield between terminals. The CAA advised that they were against any scheme which involved frequent movement of aircraft across an operational runway. It seemed quite clear, therefore, that this was not an attractive solution on operational grounds.
Perhaps more important was the relative inflexibility of the concept in that the proposed new terminal was committed to the handling of one type of traffic. If a change occured over the years so that the international traffic became considerably more important than at present, then it could easily have resulted in the new terminal being overloaded while the domestic facility was little used. In view of the uncertain future at Birmingham it was felt that traffic changes could only be properly provided for by placing all passenger handling facilities within a single terminal complex.

6.34 Conclusion

Despite the fact that the "Split operation" option was about £5m cheaper than "X" or "Y", there were serious operational disadvantages of the option which led the County to believe that it did not present a practicable solution.

7.0 The WMCC assessment of options

The County having completed a review of the BAA options "X" and "Y" and of its own alternative developments which made use of the existing terminal for passenger handling, recognised three inescapable facts.

1. Use of the existing terminal buildings for passenger handling either wholly or partially, resulted in a capital cost saving of about £7 million.

2. Long term flexibility and expansion potential could best be provided by a development wholly on the NEC side of the airfield.

3. The full potential of the link between the NEC, Airport and Station would only be realised if the three were sited so as to form a related development.

In the County's view the disadvantages far outweighed the advantages of any scheme involving development adjacent to the A45. Consequently the County firmly rejected these options and accepted fully the principle of development beside the NEC and Station. It turned its attention, therefore, to assessing the BAA options.

8.0 The emergence of the "Preferred" option

8.1 Introduction

The consultant's reports and working papers whilst presenting two comparable alternatives, made it clear that on balance "X" was preferable to "Y". There were powerful arguments in support of this view; better land-use, better configuration, easier provision of pier service, topography lending itself to a vertically separated terminal. In favour of "Y" however, was the indisputable fact that it provided for easy and rapid movement of pedestrians between Airport, NEC and Station. This was a benefit which could not lightly be dismissed, particularly since the County had placed great emphasis on such interaction when rejecting the existing site development options.
Officers of the County reviewed a possible option mid-way between "X" and "Y". Though, in the BAA assessment, this had always appeared to be unacceptably expensive it was found that the extra costs came from specific sources which could be eradicated.
Access to the NEC/Station had been proposed as being via a pedestrian travelator bridge link in the "Y" scheme. Consequently this philosophy was extended to the original thinking about a mid-way solution since ease of access was considered so important. Such a link, however, was not necessarily the most suitable type of access when the terminal-to-Station distance increased beyond two hundred metres. Thus, although in the previous mid-way solutions the bridge had been extended to its maximum feasible length, this resulted in greatly increased structure costs combined with a terminal frontage forced to lie along Bickenhill Lane - which of course had to be diverted, and an approach road system convoluted to avoid the bridge structure.
To reduce the cost of the mid-way solution it was abundantly clear that an alternative to the travelator bridge link was required which would be flexible enough to allow the line of Bickenhill Lane to remain undisturbed by the terminal location. The alternative proposed by the County was a "minitram" type of small rapid transit vehicle running on a fixed track and offering very low journey times.* Enquiries suggested that suitable systems could be installed at a cost below that of an equivalent travelator. This is perhaps not surprising when it is remembered that the travelator has a capacity far in excess of that likely to be required whereas the minitram can be more or less exactly matched to requirements.

8.2 The "Preferred" option described

Having adopted a "minitram" type of link it was found that many of the previous constraints on a mid-way solution were removed. Nevertheless the County was anxious to capitalise on the BAA work and merely proposed to move the "X" scheme nearer to the NEC/Station. Much of the detailed description of "X" in the BAA report is therefore equally applicable to the "Preferred" option. In the following sections specific aspects of the scheme are described.

* Footnote: It is interesting to note that the journey time over 700m between "X" and the Station by "minitram" is less than over 200m between "Y" and the Station by "travelator".

8.21 The link with the National Exhibition Centre and Station

The terminal frontage is 400 metres from the Station concourse - this compares with the 200 metres of "Y" and the 700 metres of "X". The County considers that a means of direct movement between the two buildings must be provided if the fullest benefit is to be obtained for the NEC and from rail access for airline passengers. The "minitram" link of the preferred option will enable a proper integration to be achieved between the Airport and the NEC/Station. The importance of this integration and the necessity of having a fixed link are considered to be paramount. This vehicle-based link lends itself to be a phased development as traffic builds up, an advantage not available with the travelator. It also allows greater flexibility of levels between Airport terminal and Station concourse as gradient restrictions are less demanding than for a travelator bridge.

8.22 Terminal configuration

The terminal is situated so that the landside road system is wholly contained between it and Bickenhill Lane, consequently the latter is largely undisturbed. There is no encroachment on the land to the east of the Lane and the NEC Western car park and access to it are not affected. The terminal itself is identical in concept and configuration to that of "X" and the lie of the site is such that there is no difficulty in achieving a vertically separated terminal. The greatest difference between the "Preferred" option and "X" or "Y" is the level of pier service attainable. As with "X" but unlike "Y" there is no difficulty in providing full pier service up to 2.8 million passenger levels. Beyond this the "Preferred" option can only accommodate one extra pier, but this would allow the terminal to cater for traffic well in excess of 2.8m without the use of remote stands.

8.23 Apron and taxiway

The apron layout is practically identical to "X" but, on the advice of the CAA, there is a minimum of taxiway in the area of the ILS. The CAA have been consulted on the ILS implications of the "Preferred" option and have confirmed that there is no fundamental objection to it. One benefit to accrue from moving away from the "X" location is that the downgrading of the secondary runway is no longer necessary.

8.24 Environmental impact

There has never been much to choose between the two BAA options on environmental grounds although the County felt they were both preferable to the development of the existing site. Despite this, one reason for seeking the "Preferred" solution was to make the terminal more remote from the Marston Green residential area than was the case with "X".

8.3 Use of the existing terminal area under the "Preferred" option

The preferred option enables the fullest use to be made of the existing terminal area. The potential uses to which this might be put have been discussed earlier and it is sufficient to note here that the selected development option in no way conflicts with the requirements of secondary activities. The CAA has stated its wish to continue using the accommodation it currently occupies for the purpose of Air Traffic Control. A letter to this effect is included in Appendix VI.

8.4 Conclusions on the "Preferred" option

The "Preferred" option represents a compromise solution which has only been made possible by making use of a vehicle-based link between Airport and the NEC/Station. Such a link is an integral and essential part of the scheme.

The terminal concept and configuration follows closely that of the BAA option "X" and this is also the case with the apron. The taxiways are changed but the layout has been approved by the CAA who do not consider that the operational reliability of the ILS will be impaired by the scheme, even should the third pier be constructed.

The development does not affect the NEC western car park and produces an acceptable land-use split between Airport and non-Airport activity. The existing terminal area is made available for development of ancilliary revenue earning activities.

The cost of the "Preferred" option is below that of "X" or "Y" but is above that of the two options which made use of the existing site for passenger handling.

9.0 Financial implications of Airport development

9.1 Capital costs

The development options which have been considered by the County Council all offer the capability of dealing with the forecast traffic, albeit at different levels of service, as has already been mentioned in Section 4.4. Detailed costings for all five options are shown in Appendix IV, to facilitate ease of comparison between alternative developments. A summary of the cost comparison is shown below.

Table 1
Capital costs of development options (all figures are at November 1977 prices)

	Preferred	Option X	Option Y	Split Site Option	Existing Site
	£m	£m	£m	£m	£m
Building costs	26.9	26.9	26.9	23.6	25.3
Civil engineering costs	21.8	23.2	22.0	21.1	18.3
Total works cost	48.7	50.1	48.9	44.7	43.6
Total fees	5.3	5.4	5.3	4.5	4.4
Total land	0.4	0.3	0.6	0.4	–
Total project cost	54.4	55.8	54.8	49.6	48.0

Options "X" and "Y" were developed so that they would come out at a similar cost. The cost of the "Preferred" option is a little lower, principally because of lower costs relating to the perimeter and approach roads. Costs for the "Split" site and "Existing" site options are considerably lower than for the other three. Building works are lower because both of these options have a smaller new terminal. "Existing" site costs are higher than those for the "Split" site because of a link with the existing terminal, and because part of Hangar No. 2 would have to be relocated. The "Existing" site option also has lower Civil Engineering works, primarily because of a significant reduction in earthworks costs.

It should be noted that the total project costs do not include the capital costs of multi-storey car parks or hotels, which would be provided on a commercial development basis. It does include lump sum provision for replacement of freight, maintenance and GA facilities, and work that may be necessary for the existing terminal.

9.2 Capital phasing

The estimated phasing of capital expenditure for the preferred option is shown in Table 2. Bearing in mind the constraints of a probable Public Inquiry and the need to purchase land not currently in Airport ownership, the County has prepared a network for planning and construction of the facilities required to handle 2.8m passengers in 1990. This network represents a practical approach and the phasing of the expenditure shown in Table 2 is derived from it. It has been assumed that a favourable decision to this submission will be given in sufficient time to allow the design to commence early in the financial year 1978/79.

Table 2
Airport development expenditure for the Preferred option (all figures are £000 at November 1977 prices)

	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84	1984/85	1985/86	Total
Total works	5	15	300	6100	15544	12480	12000	2000	300	48744
Total fees	34	1025	1100	1150	820	550	490	110	15	5294
Land	20	150	150	80						400
Project cost	59	1190	1550	7330	16364	13030	12490	2110	315	54438
DOT 60% grant	35	714	930	4398	9819	7818	7494	1266	189	32663
County Council expenditure	24	476	620	2932	6545	5212	4996	844	126	21775

9.3 Financing of development

Capital contributions by the Department of Trade are shown in Table 2 above, in the form of the 60% capital expenditure grant. The Birmingham Airport Municipalisation Agreement, under the terms of which the grant is paid, expires in 1981. However, it will be seen that DOT grant is shown as continuing beyond 1981 until completion of the scheme. This is because it is understood that this will be the case in respect of a major scheme approved before 1981.
The balance of the total project cost after deduction of grant would be financed by the County Council. Clearly, a scheme of this size could not be met from the Council's Locally Determined Schemes Allocation, and a special Key Sector Allocation would be required. The County Council will approach the European Investment Bank with a view to obtaining a loan at preferential rates of interest. The EIB would need to be assured that the scheme had full Government support, and in addition the Treasury would have to provide exchange risk cover

9.4 Revenue forecasts

The development project has been subjected to a detailed financial appraisal by the officers of the County Council, and this is summarised in Appendix V. The appraisal covers the period up to 1990/91 and investigates the future growth of income and current expenditure, and the effect of the proposed capital expenditure upon the Airport's annual surplus/deficit position. The results of the appraisal indicate that there is a reasonable prospect of the financial position in 1990/91 showing a modest surplus. However, the possibility of the Airport still being in a deficit position by 1990/91 cannot be ruled out, depending upon a number of critical factors, of which the following four are particularly important.

9.41 Effect of passenger throughput

The annual income to the Airport will depend strongly upon the actual level of passenger throughput achieved. It was assumed in the appraisal that the annual passenger level would be 2.8m by 1990; this is the level forecast by BAA, and is in close agreement with the DOT's own natural growth forecast.

[illegible]

Any changes in EEC duty-free regulations would have a major effect upon income from duty-free concessions, which would form a significant proportion of the revenue at the Airport.

9.43 Effect of real-terms growth of fees and charges

Real-terms growth in certain types of fees and charges has been assumed, in line with the policy of the Joint Airports Committee of Local Authorities (JACOLA).

9.44 Effect of inflation

The appraisal does of course assume the payment of the 60% grant on the whole of the capital cost of the proposed scheme. The appraisal is at constant prices and the eventual financial outcome will depend upon the relative effect of inflation on the different items of expenditure and income.

Table A1.1

Passengers carried at Birmingham Airport 1970 - 1976

	1970	1971	1972	1973	1974	1975	1976
Scheduled International	69,065	65,380	81,689	111,740	120,281	113,870	107,965
,, Irish Republic	134,935	142,760	119,250	130,693	125,458	130,112	136,047
,, Channel Isles	61,290	58,177	80,743	91,071	92,283	92,350	85,263
,, Domestic	225,773	221,917	220,929	244,382	214,238	209,114	279,756
,, Total	491,063	488,234	502,611	577,886	552,260	545,446	609,031
Non-Scheduled International	192,205	344,557	431,914	551,511	463,225	536,474	502,873
,, Irish Republic	2,677	1,195	58	529	299	51	244
,, Channel Isles	157	590	502	451	71	65	169
,, Domestic	773	2,595	1,751	2,284	963	1,089	2,272
,, Total	195,812	348,937	434,225	554,775	464,558	537,679	505,558
Total terminal passengers	686,875	837,171	936,836	1,132,661	1,016,818	1,083,125	1,114,589

Table A1.2

Annual traffic growth at Birmingham Airport 1970 - 1976 (% increase/decrease)

	1970	1971	1972	1973	1974	1975	1976
Scheduled International	+16.5	− 5.3	+24.9	+36.8	+ 7.6	− 5.3	− 5.2
,, Irish Republic	+15.2	+ 5.8	−16.5	+ 9.6	− 4.0	+ 3.7	+ 4.6
,, Channel Isles	− 8.1	− 5.1	+38.8	+12.8	+ 3.5	− 2.1	− 7.7
,, Domestic	+ 1.7	− 1.7	− 0.1	+10.6	−12.3	− 2.4	+33.8
,, Total	+ 5.5	− 0.6	+ 2.9	+14.9	− 4.1	− 1.6	+11.7
Non-Scheduled International	+31.3	+79.3	+25.4	+27.7	−16.0	+15.8	− 6.3
,, Irish Republic	–	–	–	–	–	–	–
,, Channel Isles	–	–	–	–	–	–	–
,, Domestic	–		–	–	–	–	–
,, Total	+29.0	+78.2	+24.4	+27.8	−16.3	+15.7	− 6.0
Total terminal passengers	-	+21.9	+11.9	+20.9	−10.1	+ 6.3	+ 2.9

Table A1.3

BAA forecasts of annual passengers under "Natural Growth" conditions ('000's)

Year	Domestic	Ch. Isles	Eire	European Scheduled	International Charter & IT	Total
1975	229	100	134	130	487	1080
1980	322	104	171	273	666	1536
1985	343	116	236	453	1034	2182
1990	386	123	326	593	1382	2810

Table A1.4

BAA forecasts of annual passengers under "High Test Case" conditions ('000's)

Year	Domestic	Ch. Isles	Eire	European Scheduled	International Charter & IT	Total
1975	229	100	134	130	487	1080
1980	364	113	189	328	735	1729
1985	408	135	276	571	1224	2614
1990	486	154	407	850	1819	3716

Notes

1. These drawings are schematic and in no sense represent an agreed design for each option.

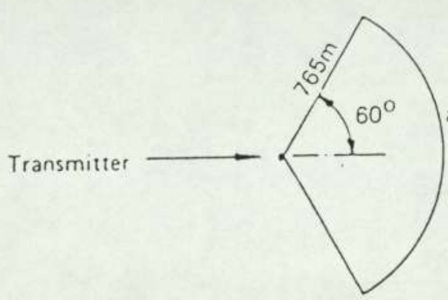
2. Options "X" and "Y" are shown as presented by the BAA. The following modifications to the taxiways have been incorporated within the "Existing", "Split and "Preferred" options:-

a) The taxiway parallel to the main runway located, in "X" and "Y", 195 metres from the edge of the runway has been repositioned in the other options to 150 metres from the runway edge according to the minimum specified in CAP 168.

b) Discussions with the CAA have suggested that the taxiway configurations for "X" and "Y" between the ILS glidepath transmitter and the threshold of runway 33 are undesirable due to the glidepath transmission interference. Hence, changes have been incorporated into the other three options.

c) Chiefly as a result of the repositioning of the parallel taxiway, modifications have been made to the turning/passing areas at the threshold of runways 15 and 33, over those drawn by the BAA for "X" and "Y".

3. The ILS glidepath transmitter is safeguarded by the area shown on each diagram thus:



Note that the lower surface of the area rises radially from the transmitter with a slope of 1 : 50.

4. The "minitram" transit link is shown thus:

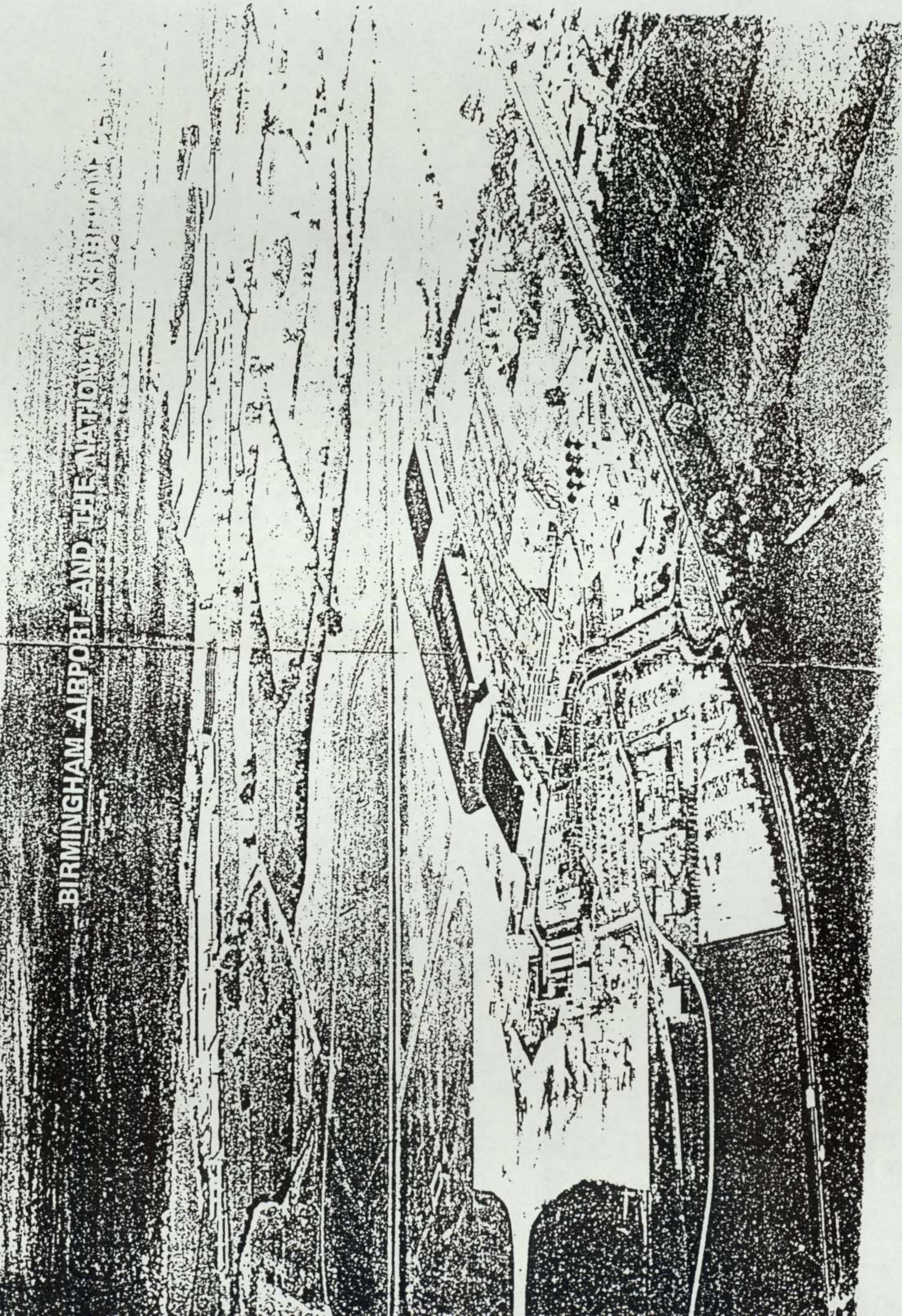

BIRMINGHAM AIRPORT AND THE NATIONAL

Fig. A2.1

Option X

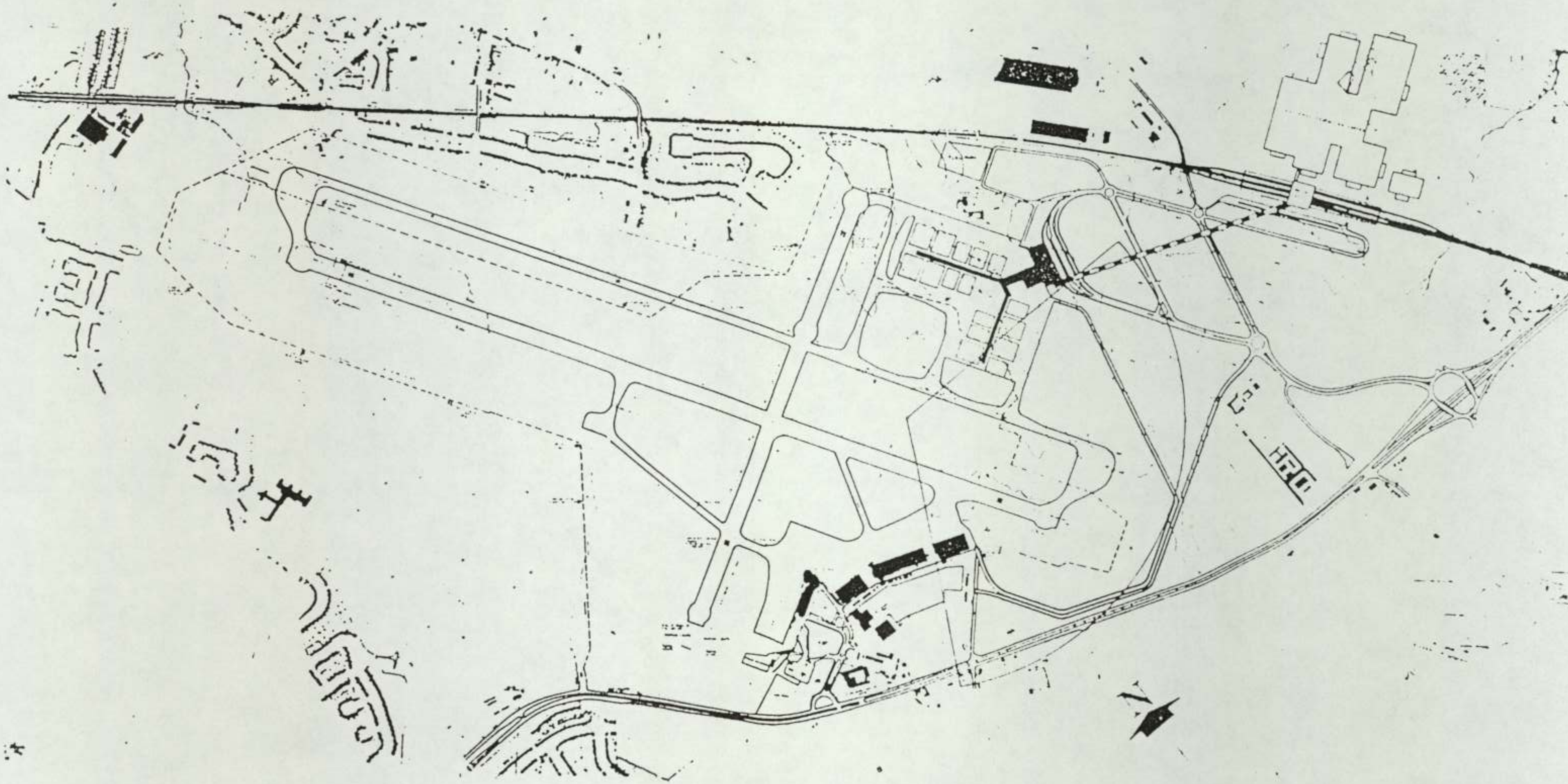
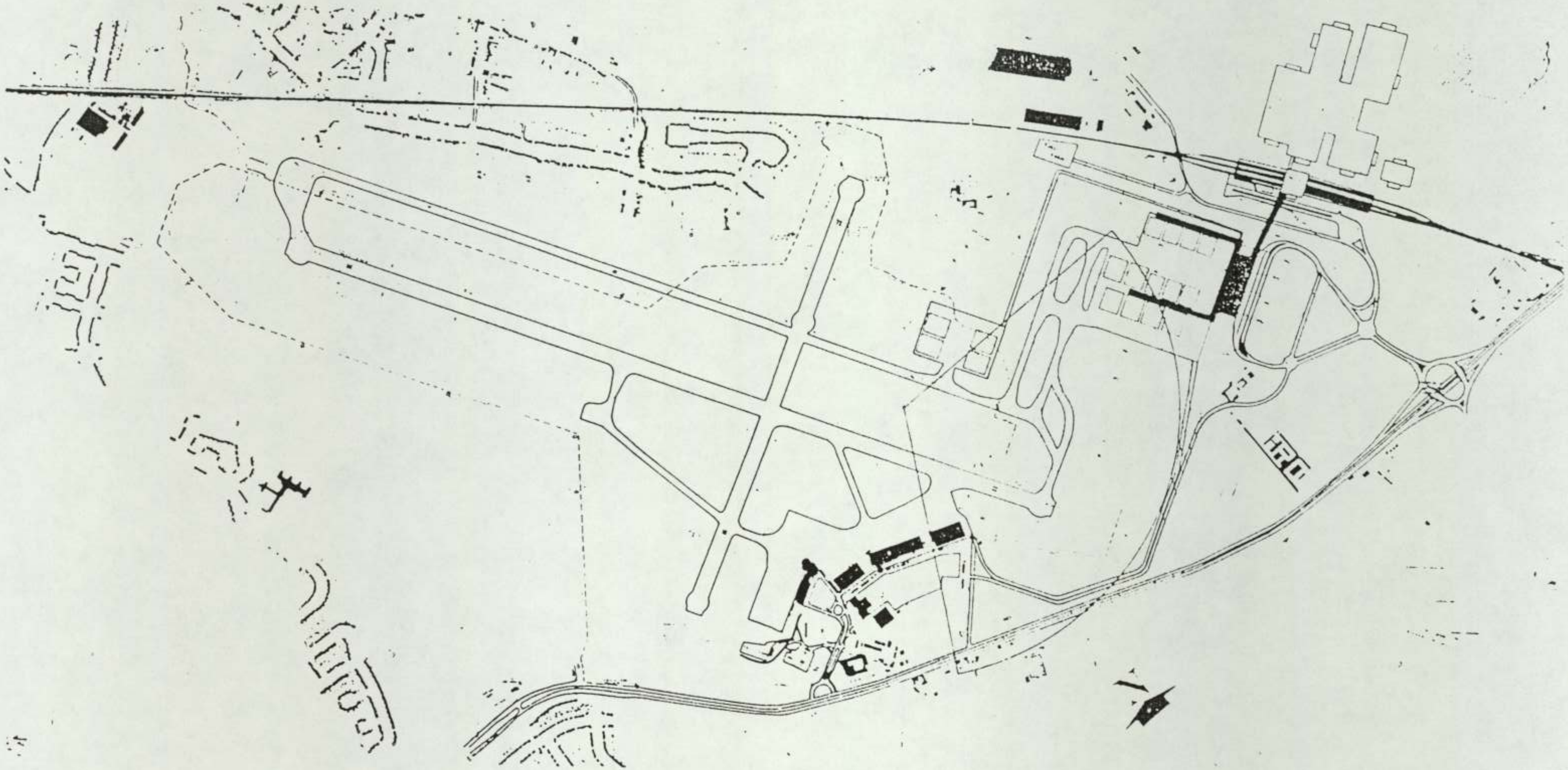


Fig. A2.2

Option Y



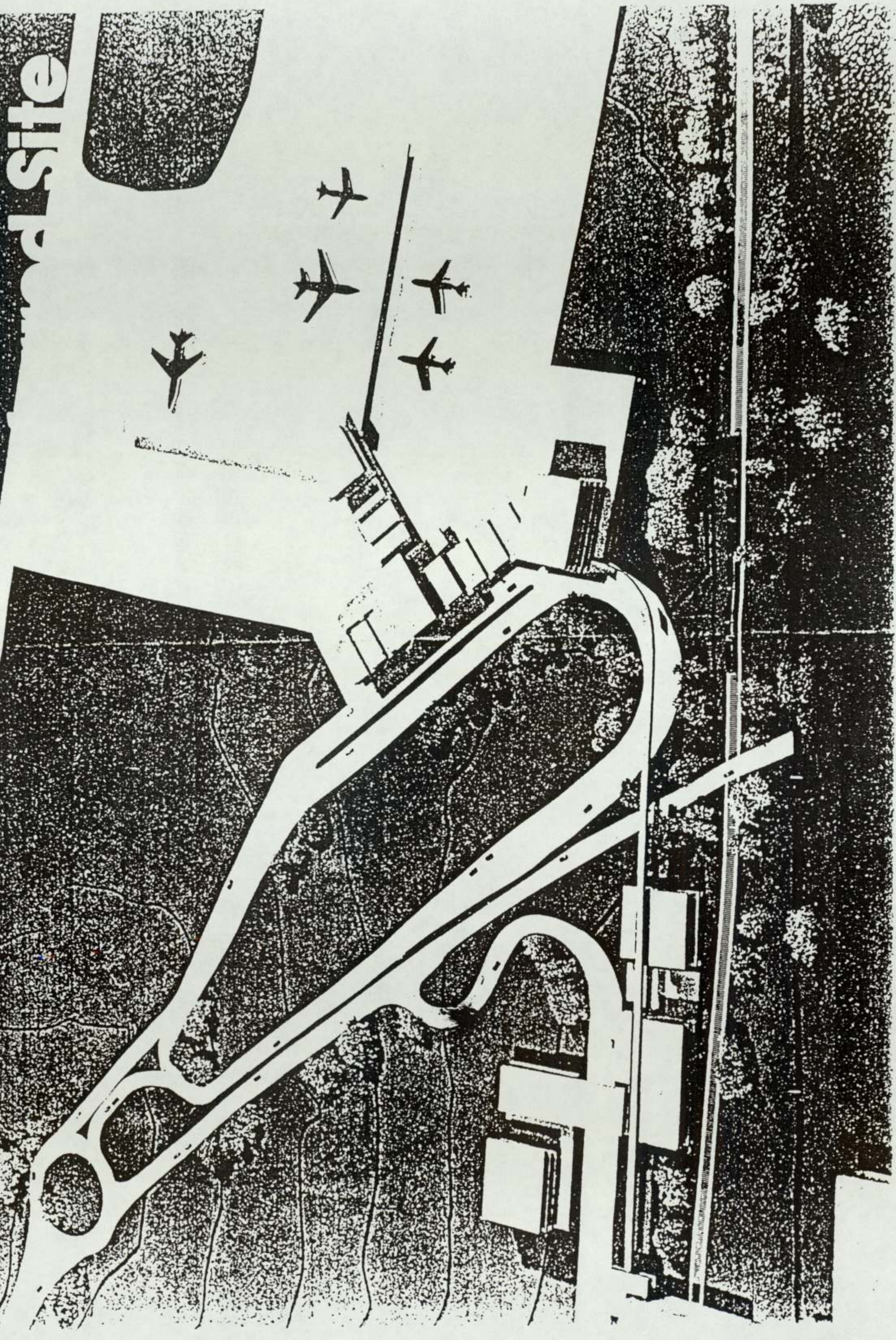

site

Fig. A2.3

Existing Site Option

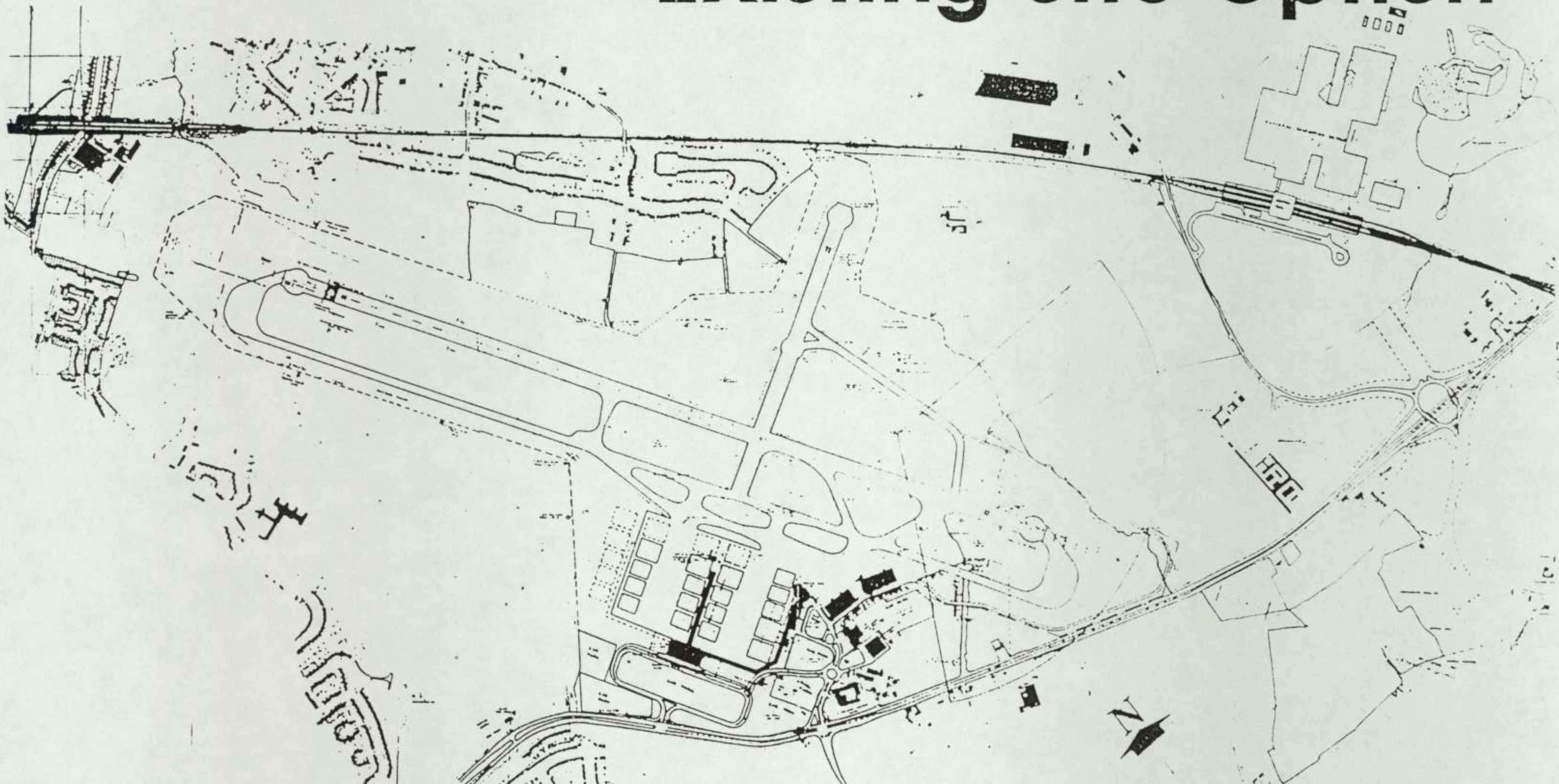


Fig. A2.4

Split Operation Option

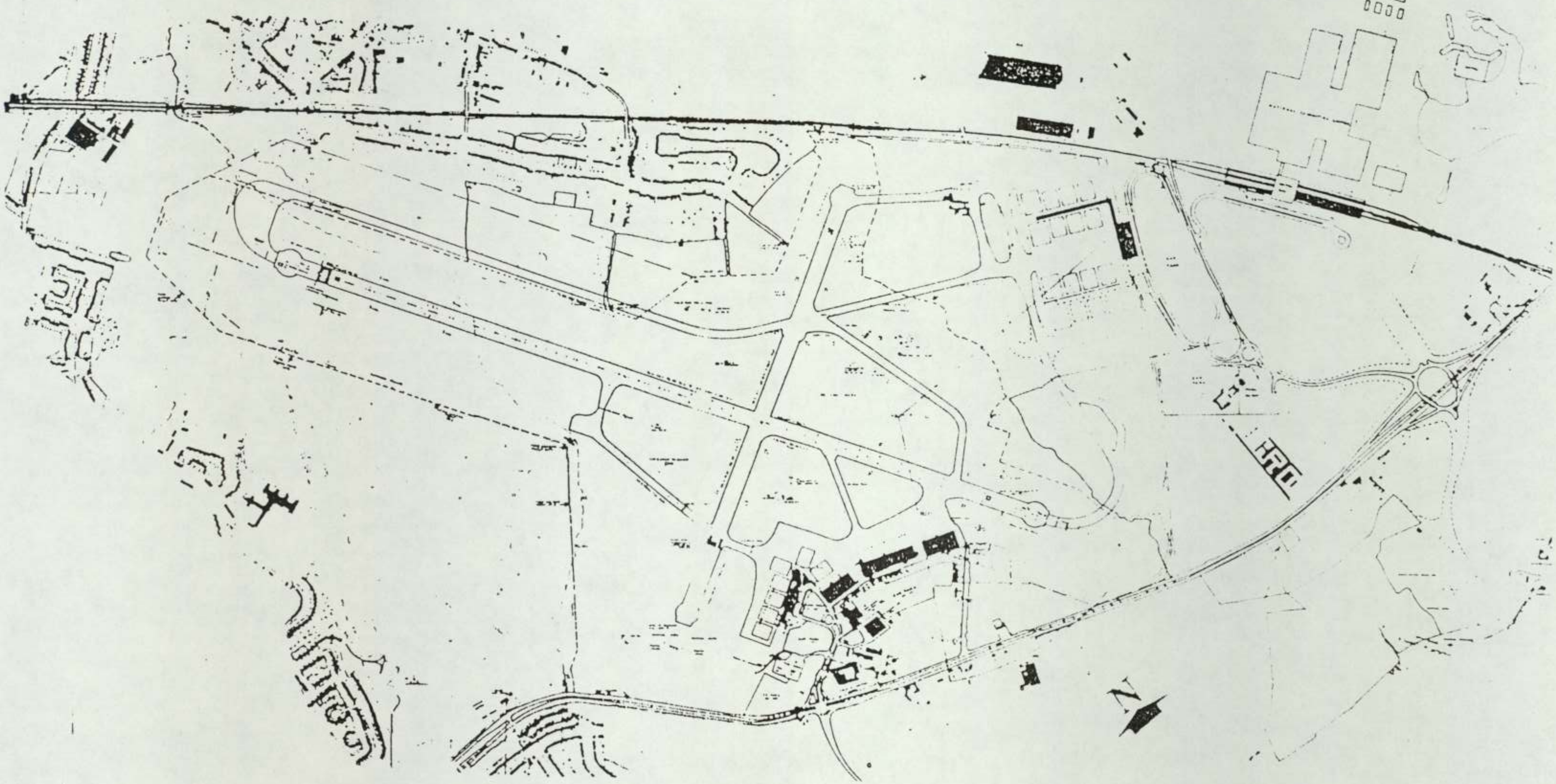
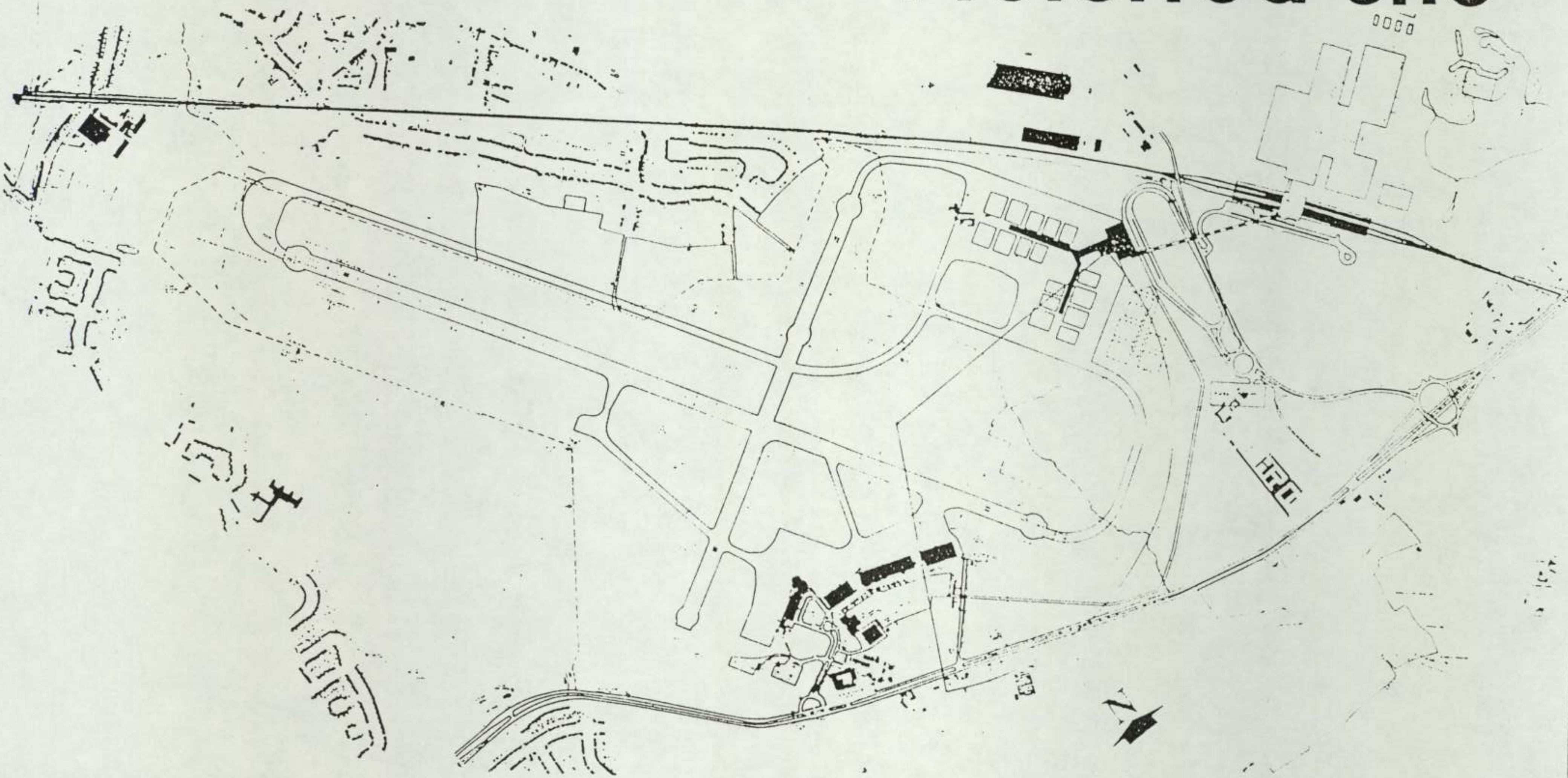
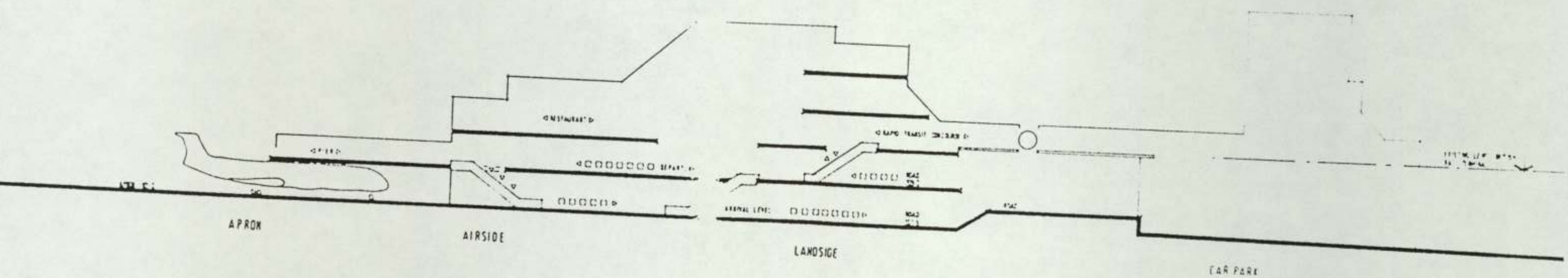


Fig. A2.5

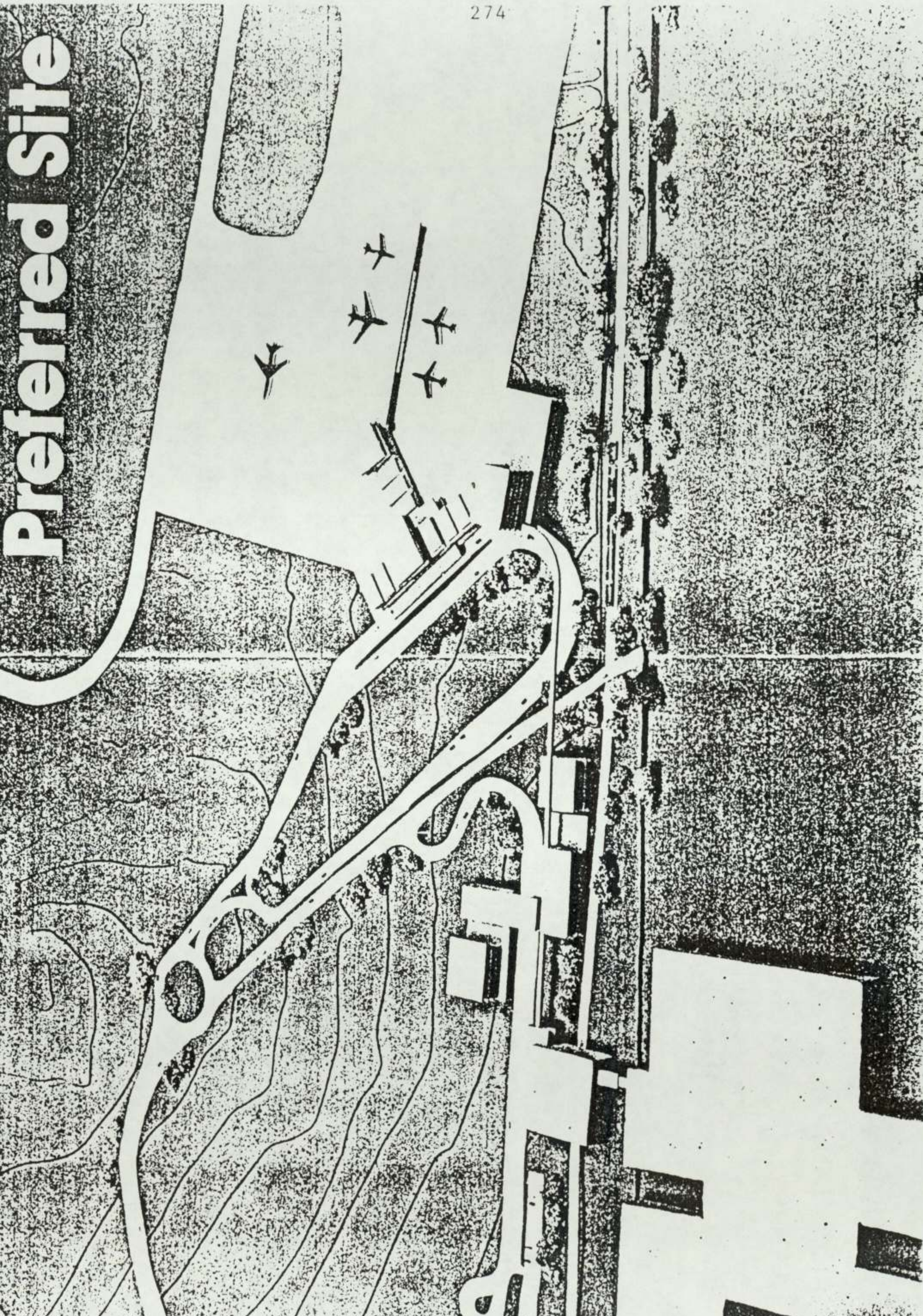
Preferred Site

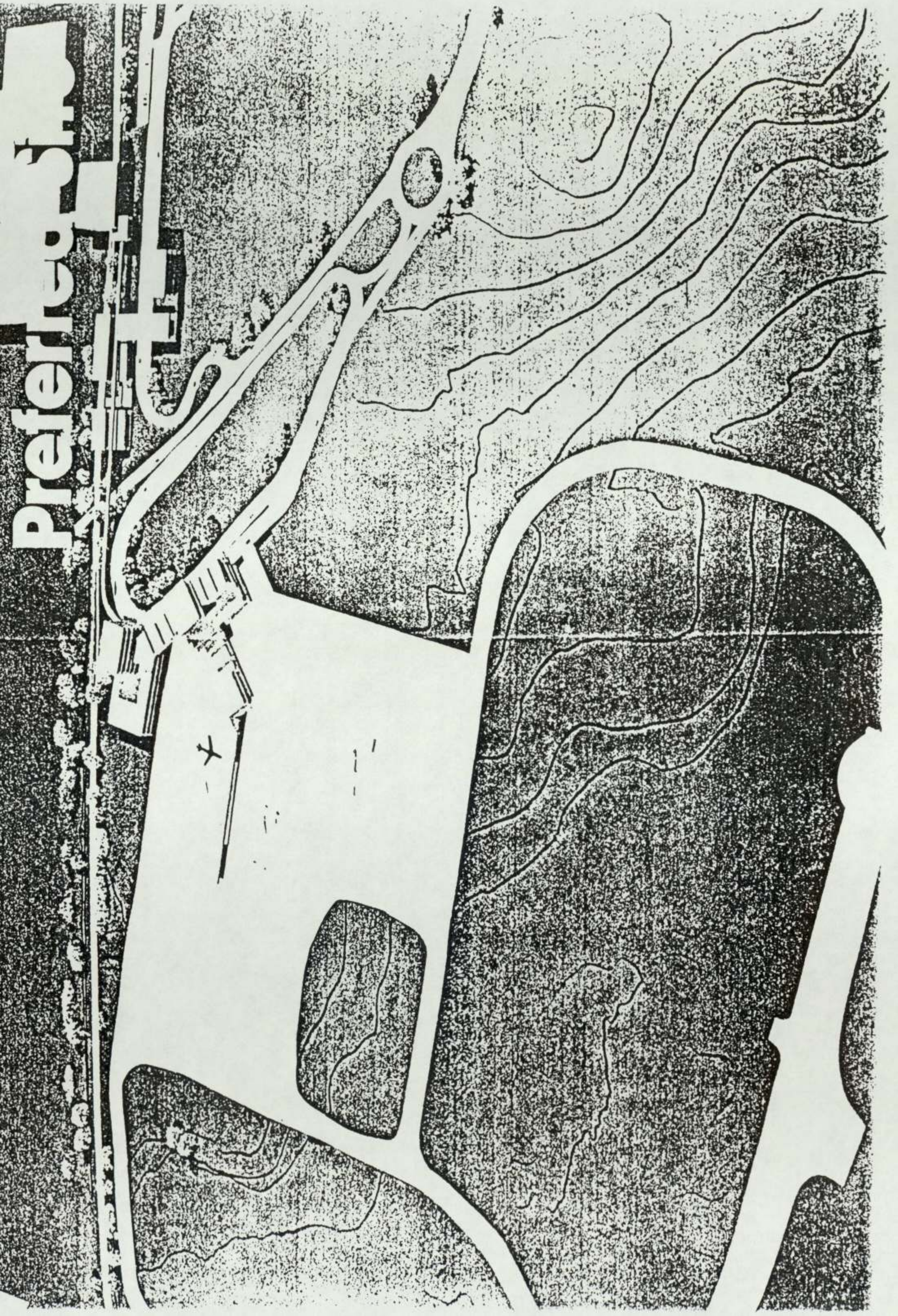


Preferred Site



Section:
Vertical Separation


Preferred Site


Preferred Site

Bibliography

Ackoff R.L. "A Concept of Corporate Planning" John Wiley, 1970

Ackoff R.L. "Creating the Corporate Future." John Wiley & Sons Inc. 1981.

Allen S.A. and Gabarro J.J. "The Sociotechnical and Cognitive Models" in "Organisation Planning Cases and Concepts" eds. Lorsch J.W. and Lawrence P.R. 1972 Richard D. Irwin Inc.

Ashby W.R. "An Introduction to Cybernetics" Methuen and Co. Ltd 1964.

Beer S."The Heart of Enterprise" John Wiley & Sons. 1979.

Beer S. "Diagnosing The System for Organisations" John Wiley and Sons 1985.

Beishon J. and Peters G. "Systems Behaviour" The Open University Press 1977.

Bignell V. and Fortune J. "Understanding Systems Failures" Open University Press/Manchester University Press, Manchester, 1984.

Bignell V. Peters G. and Pym C. "Catastrophic Failures" Open University Press 1977.

Caiden N. and Wildavsky A. "Planning and Budgeting in Poor Countries" John Wiley & sons 1974.

Carvalho R de E and Morris P.W.G. "Project Matrix Organisations - Or How To Do the Matrix Swing", Proceedings of the 1978 Project Management Institute, Los Angeles. Project Management Institute, Drexel Hill, Pennsylvania.

Cleland D.I. and King W.R. "Management: A Systems Approach" McGraw Hill 1972.

Cleland D.I. and King W.R. "Systems Analysis and Project Management" McGraw-Hill 1983.

Collingridge D. "The Fallabilist Theory of Value and its Application to Decision Making" PhD Thesis Aston 1979.

Collingridge D. "Critical Decision Making" Francis Pinter Lt. 1982.

Conant R. and Ashby R. "Every Good Regulator of a System must be a Model of that System." International Journal of Systems Sciences, Vol 1 No.2 1971.

Cyert A.M. and March J.G. "A Behavioural Theory of the Firm" Prentice-Hall 1963.

Davis P. and Lawrence P.R. "Matrix" Reading, Mass. Addison-Wesley 1977.

Davies C., Demb A. and Espejo R. "Organisation for Program Management" John Wiley and Sons 1979.

Delbecq A.L. "Matrix Organisations - an Evolution beyond Bureaucracy" Paper, The University of Wisconsin Press, Madison, p.142.

Eppink D.J. "Planning for Strategic Flexibility" Long Range Planning 11 1978.

Espejo R. "Methods for Problem Solving" Teaching Paper, Aston University, September 1986.

Evans J.S. "Flexibility in Policy Formation" PhD Thesis Aston 1983.

Friend J.K. and Jessop W.N. "Local Government and Strategic Choice" 2nd Edition, Pergamon Press 1976.

Galbraith J.R. "Organisation Design: An Information Processing View" in "Organisation Planning Cases and Concepts" eds. Lorsch J.W. and Lawrence P.R. 1972 Richard D. Irwin Inc.

Galbraith J.R. "Designing Complex Organisations" Addison-Wesley 1973.

Galbraith J.R. "Organisation Design" Addison-Wesley 1977.

Hall P. "Great Planning Disasters" Weidenfeld and Nicolson, London 1980.

Horwitch M. "The Convergence Factor for Successful Large Scale Programs: The American Synfuels Experience as a Case in Point" in 'Matrix Management Systems Handbook' Cleland D.I. Ed. Van Nostrand Reinhold, New York 1984.

Katz R. and Allen T.J. "Project Performance and the Locus of Influence in the R&D Matrix" Academy of Management Journal 1985 Vol 28 No.1, 67-87.

Kharbanda O.P. and Stallworthy E.A. "How to Learn from Project Disasters" Gower, London, 1983.

Knight K. "Matrix Organisations: A Review" Journal of Management Studies 13(2): 111-130. 1976.

Lawrence P.R. and Lorsch J.W. "Organisation and Environment" Homewood; Ill.: Richard D. Irwin 1967.

Lawrence G., Hrebiniak W. and Joyce F. "Implementing Strategy" MacMillan 1984.

Lindblom "Policy Making Process" 1980.

Lock D. "Project Management" Gower 1984.

March J.G. and Simon H.A. "Organisations" John Wiley and Sons Inc. 1958 NY.

Merkhofer M. "The Value of Information Given Decision Flexibility" Management Science 23 716-727 1977.

Mintzberg H. "Structure in Fives" Prentice-Hall International Edition 1983.

Mockler R.J. "Situational Theory of Management" Harvard Business Review, May - June 1971 p.147.

Morris P.W.G. "Project Management Organisation" Construction Papers Vol. 2 No. 1. 1982

Morris P.W.G. and Hough G.H. MRP 86/3 "Preconditions of Success and Failure in Major Projects" Templeton College Oxford 1986.

Murphy D.C., Baker B.N. and Fisher D. "Determinants of Project Success" National Technical Information Services, Springfield, Virginia 22151 USA Accession Number N-74-30392, 15 September 1974.

Rondinelli D.A. "Development Projects as Policy Experiments: an adaptive approach to Development Administration," Methuen 1983.

Rosenhead J. "Planning Under Uncertainty" Journal of Operational Research Vol 31 Nos 3&4 March/April 1980 pps. 209 and 331.

Sayles L.R. and Chandler M.K. "Managing Large Systems" Harper and Row 1971.

Stringer J. "Management Problems of Large Engineering Construction Projects." Working Paper No. 82-005 Australian Graduate School of Management, University of New South Wales May 1982.

Study Group on Local Authority Management Structures. "The New Local Authorities, Management and Structure, Report of a Study Group Appointed... to Examine Management Principles and Structures in Local Government at both Elected Member and Official Levels." Chairman M.A.Bains London HMSO 1972.

Thompson J.D. "Organisations in Action" McGraw-Hill New York 1967.

Trist E.L. "A Concept of Organisational Ecology" Australian Journal of Management, Vol.2, No.2, October 1977.

Zwerling S. "Mass Transit and the Politics of Technology" Praeger, New York, 1974.