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A METHODOLOGY FOR PROBLEM-FORMULATION

A thesis submitted for the degree of Doctor of Philosophy

by

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A METHODOLOGY FOR PROBLEM-FORMULATIONABSTRACT

The process of operational research is traditionally described by a list of sub-processes, starting with a description, definition or formulation of the problem. Explicit methodology for this formulation is sparse. Earlier research on the nature of conflict and its resolution produced a diagrammatic notation, which seemed capable of extension and use as a problem-formulation 'language'.

This thesis examines a wide range of methodology, directly or peripherally related to problem-formulation. It then argues the case for carrying out research to develop the diagrammatic notation as a medium for communication between an operational researcher and his clients, in order to establish in detail what their 'problem' is and perhaps to monitor the process of resolving it.

The notation, and rules for its use, are developed and described in detail, and then used to help decide how the problem formulation process itself is to be managed. The difficulty of 'proving' a methodology is examined and the principles and purpose of experiment in this context is discussed. A suitable group of people with a shared problem was approached, and agreed to an experimental consultancy. The methodology was thereby tested 'successfully', in the sense defined in the thesis.

The consultancy is in abeyance, but a start has been made with the use of the methodology in a study in support of a hospital accident and emergency department; it is also to be used in a study of decision-making in higher military commands. Further applied research will also be needed to find out how best it can be used to enhance the early stages of systems practice (Checkland), the analysis of options (Radford; Howard) and hypergame analysis (Bennett).

Present evidence suggests that the procedures and practice described in this thesis are consistent with and complementary to these and other methodologies.

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FOREWORD AND ACKNOWLEDGEMENTS

This thesis has been written over the period November 1979 to mid-1983. Almost all of the references have been studied in detail over this period, although the broad nature of the content of some which predate this period was already known.

Where ideas have been 'borrowed' from colleagues, either from hitherto unpublished material or from correspondence in the course of research, permission to use them has been given and the sources are acknowledged. In one case, my reinterpretation of another's research ideas have been discussed in detail with her (Janet I. Harris).

Some relevant unpublished conference papers of my own have been included as appendices. Two of these were written during the research study period, and although pertaining primarily to other areas of involvement these were also seen as relevant background thinking for this research (appendices A and B). Two summary papers covering the work reported here have been published and offprints are provided.

My thanks are due firstly to the Principal and the Department of Mathematics of Royal Holloway College, University of London. They accepted me, after my retirement from the Ministry of Defence, as an Honorary Associate, and so provided me with a suitable base for following my research interests. Since October 1981, I have been Visiting Professor of Operational Research, and while this has lengthened by a year the time taken to complete this thesis, it has enhanced my opportunities to plan applied research in continuation. In particular, I must thank Professor M.R.C. McDowell. His interest in my work on conflict and games in the mid-1970's initiated a co-operative study of research games (1976-1979) and this in turn led to his support for my post-retirement plans.

Secondly, I am indebted to the Leverhulme Trust for a research grant to cover travel, secretarial and literature expenses for the first three years of research and for my general professional activity.

Finally, I acknowledge the debt that I owe to many colleagues over many years. Not all of their names appear in the references or elsewhere in the text since I have sharpened my ideas in discussions in a variety of forums, formal and informal. Some part of all this must have come from those encounters.

CHAPTER 1TOWARDS A METHODOLOGY FOR PROBLEM-FORMULATIONIntroduction

This is a statement of the ideas behind a research programme. It will argue, in the first place, that the problems with which operational research helps are not satisfactorily posed in general; and, indeed, that the problems stated and analysed are often not sufficiently relevant to the decisions that those who own the problems have to make.

Secondly, it will examine what methods are used, or are being proposed for use, in carrying out the problem-formulation stage of the total decision-process. It will be accepted that this stage is not necessarily the starting point of a linear process, although it is a key-area of an iterative process. In particular, it will consider what constraints there may be, at present, in applying existing methods to the decision-process in large (e.g. governmental) organisations.

Finally, it will consider the proposed direction of research: why it is seen as relevant to the development of a problem-formulation methodology; why it should provide a sound basis for negotiation between operational researchers and their clients; and why it should be complementary to and not an alternative to other methods which in part or in whole have similar purposes.

The Philosophy and Methodology of Operational ResearchAckoff's principles

Not everyone sees the aims and procedures of operational research in the same light, a comment that can be taken as an understatement of the current state of operational research and one that demands a statement of my personal philosophy. This is based on long experience as an operational researcher, as a manager of operational research, and as a researcher into techniques and methodology. It is also influenced in a major way by the ideas and experience of others.

Some of this experience and influence will be outlined later in this paper. The immediate statements summarise, in broad terms, my current beliefs.

In essence, they are in very close agreement with those recently stated or restated by Ackoff; a paper which I presented to a one-day conference arranged by the OR Society in December 1979 to debate Ackoff's views, and which is at appendix A, states why I am in agreement with him. This agreement has developed over a period of ten years through personal exchanges and study of his books and papers, in relation to my own research and to my former advisory role, as Head of Research of the Defence Operational Analysis Establishment, Ministry of Defence. In a paper written as a basis for discussion of OR in Defence (Third International Discussion Conference on Operational Research), I summarise the difficulties facing OR in doing relevant supporting work on major problems (appendix B).

For the present purposes, the principles which Ackoff expounds and follows start with his perception of the problems of major concern to decision-makers as 'messes', sets of interlinked and interactive problems. He sees the need for taking into consideration a very wide environment, which may include many organisations, many purposeful systems, with complex and often inadequately explicit aims and goals and with similarly ill-defined values which govern the behaviour of each individual who affects the total system behaviour. This alone raises enormous difficulties. I have commented on some of these elsewhere (Bowen, 1975a and 1979) - see also note 1.

Central to his concept of planning, for which the operational research and decision-making are required, is the idea of ideals, outcomes that can never be obtained but can be pursued and approached without limit. This idea not only comes into the initial statement of purpose, but into clarification of what is meant by objectivity and into the process of idealised design. Constraints on the eventual resolution of the 'mess' through the planning and implementation processes are introduced only as a conscious practical limitation on present progress towards the ideal.

The total involvement of those who plan and those who are planned for is another ideal. It affects operational research in the sense that

analysis should not be attempting to solve problems for people, but facilitating their efforts to resolve their difficulties for themselves. Additionally, it calls for operational research commitment to the total problem and not to some conveniently chosen part of the problem which appears to be amenable to some standard analytical treatment.

This is far from being a full treatment of the logic which Ackoff has developed over many years of teaching and practicing OR (which he calls Social Systems Science). Even the references given in appendix A are only a part of the whole story. Nevertheless, it is perhaps sufficient to make a few simple points which are very relevant to the purpose of my research.

- a. Because of the nature of messes, it is very difficult for anyone to state clearly a problem for resolution, and it is impossible in principle to solve a mess. Every change made to a system can only be looked at as a step towards the elusive ideal.
- b. Because of the interaction, in a mess, of many systems which contain many people, a host of variables which will be difficult or impossible to quantify have to be considered.
- c. Because standard OR procedures can model certain sub-systems (primarily mechanistic ones or ones that are so treated), there is no prior reason to believe that the analysis of these models will provide a decision-maker with information that he will perceive as relevant to his choice.
- d. Only when the total problem (mess) is sufficiently clear to those who own it (see note 2) can they and their supporting analysts specify what further data and data-processing they may need in order to move towards a better framework for choice. It may be that no detailed analysis, other than that of clarifying the issues and their relationships is then needed, in some cases at least.
- e. The perceived nature of the mess and acceptable courses of action to reduce its discrepancy with the ideal, may change in major ways as inquiry proceeds and as time passes. Even statements of the ideal to be pursued may change.

- f. Any statement of the stages of a decision-process must recognise that a procedure that is followed in linear fashion must be weak, in that it should be an adaptive process: in Ackoff's philosophy the planning process should be ideal-seeking which requires a capability for self-monitoring and self-adaption. In particular, the stages of problem-formulation and implementation must be linked: it is of little value to have a proposed 'solution' which is found to be unworkable in practice.

Decision methodology

Ackoff's principles are demanding and comprise a framework of methodology for the whole OR process. Nevertheless, except in brief accounts, guidance as to how to operate within this framework is not available. To assimilate Ackoff's philosophy is hard; to work within it requires a discipline and style similar to his own. It also requires clients who are willing to participate in the ways his approach demands, and it has to be remembered that it aims to offer such support that is required to enable people to resolve their own problems. Ackoff has the advantage that he is free to refuse to work for those who want him to behave in ways other than those which he believes to be desirable.

What else then is on offer, that can help operational researchers who, even though they may accept his principles as a sort of ideal, find themselves at this moment forced to accept severe constraints imposed by the situation in which they work? I am thinking of those in groups within large organisations, and consultants who work for such organisations under normal economic constraints which do not allow them to pick and choose their clients. Particularly, in the area of problem-formulation, what structured procedures and techniques are there?

There is not much in the OR literature that gives a coherent picture of a methodology or methodologies for operational researchers to follow. This should not be taken to imply that they do not exist. There are many very good operational researchers and operational research teams who have done excellent work on complex and intractable problems. Few have attempted to give coherent accounts of the personal rules and procedures that have guided them. A recent paper (Tobin et

al, 1979) is one exception: interestingly it is linked with the debate that followed Ackoff's controversial statements (Ackoff 1979a and 1979b). Two other papers (Mitchell, 1980; Tomlinson, 1980) provide more general statements of methodological belief based on long personal experience. There are many reasons why more such papers are not written: time; the reluctance of some employers to have organisational problems aired; and the difficulty of making explicit processes which have developed through experience (for example, how to manage people) in a way that could help others to follow.

Only one book exists that explicitly covers the total OR process (White, 1975a). This I have studied closely, and I have strongly recommended it (Bowen 1976 and 1977a). However, as the author admits, it is limited. It contains some guidance on the factors that must be taken into account in the problem-formulation stage, but, it says little about the linked stage of implementation, the process of communication, the nature of the decision-making system and the conflicts within it, and, generally, it avoids behavioural issues. Its strength lies in the treatment of modelling and analysis, which are the conventional expertise areas of operational research. It illuminates the range of secondary decisions which the analyst has to take in assisting with the primary decision, but, in the problem-formulation stage, these are decisions which are necessary to translate the problem into a manageable shape for analysis. In my 1977 review, I said "... the reader is awakened to the fact that finding the problem is a major study area, lacking at present any clear methodology."

There are few good accounts of what OR is done in large organisations, how the tasks are negotiated, and how the place of OR in the organisation helps or hinders the analytic and communication processes. It is important for the problem-formulation stage that a partnership between OR and management should exist; it is also important that management should see its role in the wider environment of its organisation, and, indeed be prepared to evolve this organisation accordingly. Without such organisational characteristics, OR as Ackoff would have it will operate under severe constraints. Two organisations have produced literature which indicates that these aspects of decision methodology are not universally ignored: there are undoubtedly others (see, for example. Tobin et al, 1979) although I have not seen explicit

documentation. The Swedish National Defence Institute (FOA) has described the central role of OR in policy formulation and planning at the highest level and traced the development of its activities prior to and after the crucial decision in 1973 to give OR this wider responsibility (Jennergren et al, 1977). The treatment of the subject in a series of essays on different aspects, is well-worth reading (Bowen, 1978a). More recently, the National Coal Board has produced a document which, although it concentrates more on the work carried out, gives a similarly encouraging message of success through co-operative endeavour (Operational Research Executive, 1979).

The latest argument for a new approach to methodology comes from Rosenhead (1980a and 1980b). This urges a move away from rational comprehensive planning and from incrementalism, both of which are seen to fail in turbulent environments, the first because it posits too rigid a policy, the second because the continuity in the nature of the problem which it requires is rarely forthcoming. Rosenhead proposes a methodology based on robustness analysis which he believes will provide for flexible planning and practical application. It is too early to judge the full merit of his claims, but it is inevitable that the problem-formulation and implementation aspects of the total decision or planning process will require very careful and explicit attention.

There are, of course, numerous case histories in the literature. Almost without exception, these ignore how the problem came to be seen, to what part of the overall problem the analysis was relevant, and what success there was in implementation. There are a few recent gleams of light in the prevailing darkness. Stainton (1979) has deliberately rewritten an earlier case-history (Stainton, 1977) to throw some light on the way in which management and analysts operated together to improve the operations of a steel firm in cutting bars of rolled steel. Williams (1979), in a paper that won the first PROSPECT award, discusses a productive planning problem emphasising the involvement between the OR team and the client shipbuilding organisation. Although, as yet, there is not enough material of this sort to offer more than "the beginning of a rationale for problem-formulation" (Bowen, 1980a), more of the same is badly needed.

There is, then, evidence of need for something to be added to the written methodology of OR, and, in particular for something to guide the phase in which analyst and client jointly wrestle with the task of deciding what it is that is worrying them and what they have got to take into account in any changes that may be made to the system they control. The next few sections examine what research is already underway that shows promise of offering something towards this goal.

Some Current Research Studies

Radford's approach to complex decision problems

In dealing in general terms with policy problems and the decision processes related to them, Radford (1977) introduces the Analysis of Options. This approach is based on the study of metagames; the problem to be analysed is viewed as a game situation and the procedure in essence seeks a stable resolution through reviewing the metagames derived from the game situation and the metaequilibria of the metagames. Radford is concerned with the perception of the participants of their own possible strategies and the possible responses of others, the perceptions of others' perceptions and so on. I have no doubts about the value of his work as an orderly, descriptive, explicit form of representation of the conflicts that militate against a simple preference decision. It can provide insights into the needs for more data and more communication and the nature of these needs. It can provide more coherence for the judgement of alternatives, and for negotiating and bargaining procedures, once the broad decision has been taken to regard the problem in a particular way.

Radford refers to limited information leading to those involved having "... a sense of incompleteness in their understanding of their problem" (page 4) and regards "the gathering of information and preliminary appraisal of the problem" as the first step (page 1). He also says (page 2) that "In many ways formulating such a problem and resolving it are one and the same thing." Again, on pages 36 to 38, when he discusses in more detail the first steps, namely information gathering, it is as if the problem is taken as known; indeed, if this is not so, what is guiding the information gathering? In all

this discussion, I would prefer the word "data" rather than "information"; the latter word, to me, contains the assumption that the data is in fact relevant for the purposes of inquiry and for the related secondary, or the eventual primary, decision.

In his chapter 5, Radford looks at the communication, negotiation and bargaining between participants. There is no mention of prior procedures which might have helped towards an avoidance of the more malevolent and non-co-operative relationships that may exist. He does, of course, deal with the full spectrum of possible co-operative and non-co-operative stances, but, as with the "problem", there is a situation which is deemed to exist and be, more or less, understood.

All this does not seem untypical of real situations. Whenever we come to recognise a problem's existence, we take our perception of that problem at that moment, and we take the situation, as it is, to be the environment in which the problem exists. There must be a starting point and to some extent it must be arbitrary. Nevertheless, there is some choice and it would be nice to make that choice before positions become too entrenched.

In his chapter 6, Radford does draw attention to the way the problem develops in time, and his statement of the information gathering stage is now somewhat different since it is part of a continuous development of understanding leading towards a resolution. But "the problem" seems still to be prejudged. In the accompanying illustrative case-history to expand the facilities of the Toronto International Airport, which gives a fine descriptive analysis using the analysis of options, the final decision, forced by events, was 'Do nothing'. As in the case of the Third London Airport, the anguished process might at least have been alleviated if a much wider framework for the original problem-formulation had been accepted.

It is this aspect of the total decision-process that is a problem in its own right. It may be that the Analysis of Options can in fact be used on this meta-problem. But even if it can, some earlier work needs to be done to start from a very wide environment of a set of linked, or possibly linked, problems, as Radford accepts (pages 155-158); there will be a need for another sort of negotiation, between analyst

and client, to decide on the choice of problem within this environment.

It seems that Radford's procedure will allow the problem to change in degree and, particularly, for the strategic complexity of the problem to be differently perceived. It will not allow it to change in type, until at the end of a long and perhaps bitter struggle something like a 'Do nothing' policy is achieved, despite the fact that the need for some sort of change may still be required.

In my experience of defence problems, there are many worrying features that occur. Linked problems are certainly not always analysed together. When there is a search for a weapon system to fulfil a certain task, one will be chosen, although later events and negotiations may force a cancellation for reasons which might have been considered even if not predicted. Studies to prepare for possible future military actions, and spend resources accordingly, take precedence over studies that seek a spending on facilities that should reduce the probability of such future actions being called for (Bowen and Harris, 1978). Grainger (1980), in a private communication, has drawn attention yet again to the interesting fact that, no matter how the world changes, the UK defence vote remains obstinately divided, like Gaul, into three more or less equal parts: he too is concerned that analysis carried out seems insecurely linked to decisions.

My conclusion is that Radford offers a most helpful means of improving the later processes of problem reformulation and implementation but does not provide a sufficient methodology to ensure that the ball is started rolling in the right direction. It may also be that he offers techniques of communication and debate that can be integrated with new approaches to their benefit. In a later book (Radford, 1980), he does add more description of how the problem is formulated, but my general impression of a gap here is unchanged.

Bennett's theory of hypergames

The work that was seminal in producing Radford's ideas (Ackoff et al 1968; Emshoff and Ackoff, 1970; Howard 1970, 1971, 1975) has been developed in a different, but probably complementary, fashion at the University of Sussex. Neither of these approaches have yet had time to produce published applications, other than illustrative post-hoc

analyses. Nevertheless, hypergames also merit study with regard to their relevance to the problem-formulation process.

In brief, I believe that they have the potential to extend and improve Radford's concepts of analysis of conflict situations: they did in fact stem from a conflict research programme (see Bowen and Harris, 1978) which used game-theoretic and gaming approaches.

The underlying idea of hypergames is that the several participants in a conflict are playing different games. They will not necessarily have correct perceptions of the strategy sets being considered by others, nor similar perceptions of the preferences of outcomes. Hypergame theory examines the stable and unstable solutions of the linked games - the hypergame. Details of the analysis of hypergames are given by Bennett (1977), Huxham et al (1978), Bennett and Dando (1979), Giesen and Bennett (1979), Bennett (1980), Bennett et al (1980), and Bennett (1980b).

Perhaps the most interesting feature of this series of very interesting and stimulating papers is the increasing caution that is expressed. Even in post-hoc analyses the uncertainty as to whether the analyst has the full problem or the full context of the problem becomes more explicit. Huxham's work on the shipping crisis is referred to by Bennett (1980b) as "a case in which the great 'width' of a problem precluded any great 'depth' of analysis with the available resources." It is also stressed that there should be no attempt to produce a single model that is claimed to be a complete picture of what is happening. As with Radford, a process for disentangling some of the complexity of reality is being sought.

Once again, there seems to be a need for an earlier stage of problem exploration, before a hypergame (or an analysis of options) technique is used (see Bowen, 1981a). Perhaps however the logical framework, the language, of hypergames may be valuable, as may the language of the analysis of options in the earliest stage of problem-formulation that can be systematically carried out.

It will be clear by now that the whole problem of looking at messes is bedevilled by never-ending adaptive loops and by a bewildering procession of infinite regresses: we go round and round; there is no clear starting point and no clear end; every problem contains many

secondary problems and is enclosed by many meta-problems. The eventual choice of how far to probe will be a decision about how to tackle at least the first metastage.

Work at the University of Bath

In the long run, a problem-formulation which is satisfactory has to be one that is acceptable to those who own the problem (see note 2). If those involved participate to the utmost, the whole process is necessarily eased. In particular, values do not have to be measured artificially or imputed (see Bowen 1979 and 1981b). Behavioural studies seem to be increasingly moving towards techniques in which interactive modelling enables the participants to control and understand their own decision or judgemental behaviour and such measures of their own subjectivity that are used (by them) in analytical support (Kaplan and Schwartz, 1975 and 1977). I have studied such work not because, for the present purposes, I wished to use the models being developed but because I needed to know what processes of later analysis were available to which any framework of problem-formulation should relate. I have referred elsewhere (Bowen 1981b, 1980b, 1980c) to particular interest in the work by Hammond and by Kaplan on Subjective Judgment Theory and Information Integration respectively, although I cannot yet be sure what their impact might be on the research I carry out.

Eden and his colleagues at the University of Bath have gone a stage further (Eden, Jones & Sims, 1979 and 1982). They are engaged on what I see as major research on, and application of, a very special problem-formulation technique. Their inspiration comes not from the ideas in OR and management science but from the areas of the social sciences, notably that of clinical psychology. Their concern is not so much with the 'solving' of problems but rather with helping their clients to understand, in their own language, the relationships and influences of the mental constructs from which they perceive their problem to be built (see note 3). They use a directed graph-theoretic technique, backed by an interactive computer program which enables people to enter into a dialogue with their own ideas and those of collaborating others. Their process ends when their clients no longer need their professional support in the inquiry that the clients themselves

make. The problem of values is eased because these are subjectively included, and questioned, by those who own them. The problem of language (or jargon) is set aside since the study is carried out in the language, or sub-language, that is natural to the individual. It is an impressive process, researched by using co-researcher clients and 'proved' in practical success with other clients. Why should I wish to seek further?

There are two main reasons. The first is that the process used in getting things going is one which I describe as counselling. It has many of the features which, in other fields of counselling, limit the numbers of those who can successfully engage in the task: it is not a question of knowing rules, studying them and having a serious intent to do well, but it is a question of having a suitable personality and an ability to both emphasise and at the same time remain detached from the analysis development. The qualities that provide a good operational researcher with a sufficient neutrality so that his own values are not unwittingly imposed upon the problem studied, may not be enough for the carrying out of Eden's methodology.

The second reason is the commitment required from the client and the time he has to devote to make this commitment fruitful. Since it is, generally, a client group rather than a single person, this difficulty is magnified. From experience, I cannot, in general, see the clients in large organisations having, yet, the confidence in the ability of their analysts to be willing to get the process of inquiry underway. There may be antipathies to the central role of the computer, however interactive and responsive this may be, but this is not seen as too serious an issue.

I believe that as a step between existing (or non-existing!) practice in problem-formulation, and the development of an environment in which Eden's work can be widely used, there is a need for a less-ambitious, more prescriptive methodology with a flexible but impersonal language. It should, however, be consistent with, and not preclusive of, any methods of potentially general application which are closer to the ideal; cognitive mapping as used by the University of Bath team is certainly close to my ideal.

Hildebrandt's view of implementation

Hildebrandt uses the word implementation in a special sense. In a discussion of the analyst's role (Hildebrandt, 1980), he describes it as

"the actual use of OR output by managers, a use that influences their decision processes"

In a paper that won a prize at the 1979 Norwegian OR Conference, he deals specifically with implementation so defined (Hildebrandt, 1980b). He does not, however, stress the importance of problem-formulation, perhaps because he did not find it to be of special concern to the OR community whose writings he discusses.

Nevertheless, in a summary of one analysis of the problem of OR implementation (Ginsberg, 1975), Hildebrandt quotes "mismatch between problem and solution" as the first in a list of major difficulties that Ginsberg perceived. Not only this, but all the other difficulties listed, stem in part from the inadequacy of problem formulation, e.g.

"failure to handle the manager/analyst interface adequately" is inevitable if a problem is inadequately formulated and the model building is not based on the concepts of problem which the manager has;

"poor criteria for problem selection and solution evaluation" is a result of the preceding failure; and

"environmental factors which affect the ease or difficulty of implementation" also seriously affects implementation as I have used the word - a change to a system as a result of decision stemming from analysis - and I have already drawn attention to this at the end of my comments on Ackoff's principles.

Implementation must, in both senses, be a factor in problem-formulation. In particular, environmental systems which might introduce constraints on potential actions must be seen as part of the problem, as of course must any internal behaviour which operates against possible changes.

Hildebrandt does not examine how Eden's work might serve to overcome the problem of getting OR accepted, or getting the OR process properly used. This was, I think, because at the time his paper

was prepared, the most relevant descriptions of that work (e.g. Eden, Jones and Sims, 1979) had only just been published: certainly Hildebrandt is well aware of Eden's research.

Per Agrell, of the National Defence Research Institute, Sweden, in a private communication, draws attention to the fact that implementation may be used of many aspects and phases of the total decision process, and that, therefore, the concept of "implementation" has to be defined, implicitly or explicitly, in the separate contexts in which it may be used. I comment on this again in chapter 5.

Systems thinking

Within systems thinking (Emery, 1969), there is a great deal that I view as essentially a part of operational research. In addition to Ackoff's work (appendix A) I would stress the relevance of cybernetic modelling (Beer, 1972 and 1975) and of systems developments by Checkland (1972, 1977, 1980, 1981). These researchers deal with the total process of "problem-solving" from their own special standpoint. Neither, however, provide the language that I seek for problem-formulation. If I feel more comfortable with Checkland's methodology than with Beer's, it is because the former provides a more coherent view of "process", the time-varying elements of the overall system studied, as opposed to "structure", which, by comparison, changes only very slowly.

In his stress on "root definitions", which establish the essence of systems relevant to the "problem", Checkland addresses an issue of central importance. His approach is a verbal one. My "language" will have to be capable of coping with the necessary root definitions and be instrumental in helping to obtain them. In statements on problem-formulation itself, Checkland (1977) sees the essence of his new systems analysis as lying in the debate that it generates about ill-structured problems.

It is towards a systemic procedure for conducting this debate that my own work is directed. I shall return to a more thorough discussion of Checkland, 1981, after I have described my own methodology and its application in practice. I shall also then comment on the claims made for a System Dynamics approach to problem-formulation.

Conway's study of the OR process

Before moving on to discuss my own earlier research and why I believe it can lead to a useful methodology for problem-formulation I want to make a few comments on a broad research study (Conway, 1979), the aim of which is examine the actual process by which problems for investigation by OR are generated, understood, structured and solved, culminating in implementation of recommendations.

Conway started this work in 1976 and it is still in progress. It contains an invaluable analysis of the many different (but similar) models of the OR process that have been offered, and considers what aspects, seen in actual processes, are missing from what, generically, is seen as the classical model. (The variants are not seen by Conway to have essential differences). Among other aspects, he finds identification of the nature of the problem as perceived by individuals in the management structure to be missing, and also the importance of the co-existence of several interacting projects.

In his search for a suitable language for discussing the dynamic model of the OR process that he has developed, he has discussed several language approaches that are in the literature (Boothroyd, 1978; White, 1975a; Ackoff and Emery, 1972; and my own work based on conflict which I discuss in the next section). In all cases, he sees the concepts limited to a single independent project, and has sought his language elsewhere.

This is important because I shall need either to show that this limitation is not true of my own 'language' or I must develop it to remove such limitation. Conway's comments were based on the then limited documentation of my ideas, but they are not made lightly and I cannot ignore them. I shall comment on the close similarities between my approach and that of Boothroyd's concept in the next chapter.

The Conflict Approach

The key words which have recurred in the foregoing are 'conflict', 'language' and 'perception'. In the earliest published work on the research studies into conflict (Bowen and Smith, 1976), which I initiated in work for the Ministry of Defence, it was made clear

that misunderstandings of language and different perceptions of situations and actions were fundamental and had to be overcome if conflict was to be avoided or resolved. In this paper, a new logical diagrammatic notation (largely developed by David Smith) was introduced. With minor changes, it is the language which I propose to develop and use for the study of problem-formulation. It is systems-oriented and set-theoretic in principle. Basically any system is a set containing sub-sets (or sub-systems) and is contained by some set which can be defined as its environment (in some sense). Sets which are separated within a common enclosing set represent systems which are likely to be in conflict: there may be a third set in the same environment which is capable, potentially, of controlling any conflict, but this is not always the case (even in organisations that normally come under some central control).

The full detail of the notation will be given in the following chapters. For the present purposes, three quotations from the original paper are important.

"Anyone who is advising on a problem has to choose suitable methods by which he defines, interprets and models the problem and provides information in a suitable form for ultimate decision and implementation. The fact that there is a problem, means that there is conflict..." (page 165)

"The models which have been described are useful, not only for the purposes of problem-definition, but also for structuring and enquiring into the interaction both between the analyst (in his subsequent advisory role) and the decision-maker, and between the decision-maker, when advised, and those whom his decision affects." (page 165)

"...it would be valuable, even to those experienced as advisors, to have some type of logic to apply directly and systematically to any new problem ... to work out afresh for each problem, in its own language, a procedure which may already be known is a wasteful and an inefficient way of doing business." (page 166)

The first two show that even in 1972, the idea of a problem-formulation use of the notation, introduced to help understand the way in which conflicts arose and developed, was foreseen. The third, in the light

of much more knowledge, particularly influenced by Eden, showed an enthusiasm that was rash, although as I have stated above, perhaps the language can help in the current modified aim of getting part of the way.

Since then, only a few documented uses of the notation have been published, although I have used it informally in my own work and in advisory work, particularly that which involved intervention in conflicts at a managerial level. In a paper for a Conference on Systems and Informatics (Bowen, 1975b) the basic diagrammatic notation was described very simply: the interaction notation (arrows connecting boxes or sets, or systems) was shown to be optional and only necessary to emphasise what seemed, to the analyst or for the purposes of communication, to be more important: the rules of the notation defined interactions between contained and containing sets. The use of various notations for emphasis of particular interactions was also introduced, although I have since abandoned these. There is also in this paper an important discussion of the way in which the passing of time makes for difficulties in stating the problem in the context of its ultimate implementation: this may prove to have links with Rosenhead's methodology.

Before the conference took place, the notation had already been used to examine the OR process itself, and the interaction between analyst and decision-maker in particular; the paper was in fact presented somewhat differently. The new ideas were included in a later paper (Bowen, 1975c) and were further extended and presented at an OR Society one-day conference (Bowen, 1977b). Because these last two are not published in very accessible form, the second one is reproduced at appendix C. It is this work (which discussed the case of a single OR problem) that motivated the critical comment by Conway referred to above. The earlier work (Bowen 1975b) does, however, indicate, albeit very briefly, something of the nature of interlocking problems.

Additionally, and perhaps very importantly because of the relevance of the game-theoretic ideas of Radford and Bennett, the notation has been used to illustrate and develop concepts of conflict games (Bowen, 1978b). This, largely the work of Janet Harris, also introduced new 'arrows' into the notation to specify purposeful interactions and pure

communication links (purposeful and otherwise). Finally, there were notes (primarily by Janet Harris, with contributions by David Smith and myself) which were not even in an informal document. These dealt specifically with a search for the implications of the different perceptions of systems in conflict, and also made some, very tentative, suggestions for dealing with the time dimension. They will be referred to again in the next chapter.

As a basis for a language to describe and develop problems, the notation has the advantage of logical simplicity and visual neatness and compactness. It enables both physical and conceptual systems to be described in the same sort of way (the former may be seen as defined sets, the latter as fuzzy sets). It can compress a lot of data into a small space, it provides a diagram to guide thought and communication, and particularly to offer, partially, a common language for the latter. It avoids, to a large degree, the snaking connecting lines of typical system diagrams. It imposes a discipline by forcing attention to systems which contain and systems which are contained: this includes systems which properly belong within an individual, being his concepts. It does not accept overlapping systems: either systems must be broken down and give new sub-systems labels or systems must be drawn as at a particular time or stage to identify changing states or shifting roles.

It has the potential to interface with other methodologies. This is very important both because of the adaptive nature of the OR process and because it may not be easy without a linking methodology, to ensure the carrying through of the logic of methods which only deal with part of the total decision process. It seems desirable also to concentrate attention on the broader aspects of problem-formulation, and not to try to deal with detail that may be better studied by other methods. It will, therefore, be necessary to keep the level of description at a low and balanced level until a clear need arises to introduce complexity: further, it will be necessary to check the extent to which the notation can deal with the underlying concepts of the other methodologies discussed.

Like any other language (see Eden, Jones and Sims, 1979 and 1982), it must be accepted and understood by analysts and clients. It must

therefore be natural, or if a specialised sub-language, it must be simple. There may be difficulties with those who prefer words to diagrams; fortunately, those working in large organisations are becoming more and more familiar with graphic methods, particularly computer flow charts, and this will aid any new learning process.

The Research Programme

To complete my account of why I have stayed with this conflict-based idea, I should revert to the statement made at the end of the section on hypergames. The infinite regresses and the endless adaptive-loop processes that I refer to have always been accepted, indeed a natural feature, of my research on conflict. My early collaborator, David Smith, and I saw clearly that we ought to be able to use our own process of modelling to monitor our own processes of inquiry into conflict: in work, that unfortunately cannot be quoted, David Smith did just that, albeit in a loose subjective fashion. Accordingly, I should, if the methods to be developed are to be sound, be able to model the problem of problem-formulation. It is an idea which is also possible in the University of Bath work; Eden and his colleagues do indeed use their own mapping techniques to study their research processes. In the same way, a good OR methodology that enables the modelling stage to be carried out in a reasonable formal way should provide a methodology for the choice of models. (Bowen 1975d and 1976). How far I can get towards my ideal is debatable, but, in principle, the method proposed has the important potential of being self-reflecting. That is a desirable criterion.

My own experience in using the notation in professional discussions, and in seminars for University and Civil Service College teaching is encouraging. It has been readily accepted, has stimulated ideas, and has helped to co-ordinate discussion by identifying more clearly the relationships between the concepts being used. The diagram of appendix C has been invaluable in drawing attention to the difficulties that face any operational researcher.

The research programme, as at appendix D, was prepared before this chapter was written. Despite a great deal of further reading and discussion of available methodologies covering the OR process, nothing

arose which made me wish to change direction. The research that followed was to put a belief into more formal terms; to develop the ideas that had been useful to me into ones that could be generally useful; and to demonstrate this in practice. In short, it was to show that, in Ackoff's phrase, I had "an idea whose time has come".

Notes on Chapter 1

1. There is work going on in France (Moscarola, 1980) on the process (not the moment of time) of decision, which relates directly to and is in broad agreement with issues discussed in Bowen (1979). I cannot yet judge the relevance of this research to my main theme of problem-formulation, since the questions raised about values and beliefs have been primarily oriented towards other parts of the total decision-process.
2. On the notion of ownership of a problem, Professor W.R. Buckland commented that, while he was not sure what meaning I intended, he was sure that it would be confusing to a manager who, generally, would describe his situation as one of responsibility for, and not ownership of, a problem. Two points arise.
 - a. I find it a useful notion, but I must define it for my purposes, and I must not use it in communication with clients unless they come to 'own' my concept as I intend it.
 - b. In my language, an individual owns a problem if he accepts it, as defined in words, as recognisably the problem perceived by him (i.e. it is part of his world-picture); and if, also, he is concerned with, and in some part responsible for, its resolution. A group which does not have (or own) a common perception of a problem will have difficulties in the joint attempt to resolve 'it'.

I would also note, in the context of Buckland's comment, that 'decision-maker' is a term which worries people, since there are usually several involved in a decision, while the prime function of "the man at the top" is his taking of responsibility. Elsewhere (Bowen, 1979), I refer to Shubik's advocacy of "responsibility-taker".

'Owning a concept' is a phrase that I have borrowed from Eden and from Ackoff: it was not previously in my vocabulary but I now own it. Eden is concerned (Eden, Jones and Sims, 1979) that the problem studied by an adviser is so expressed that it is recognised by the client as 'his problem' - he owns to having that problem (see pages 148-151 of the reference). Ackoff has a particularly nice thought on ownership (Ackoff, 1974, preface,

page viii)

"I do not claim authorship of any of the ideas presented. I am sure others have had each of the ideas I treat as my own. No idea can mobilize a large number of individuals into action unless most of them can treat it as their own. My hope, therefore, is that in this work I articulate what many others have thought and desire to claim as their own"

3. Dr. Sue Jones, of the University of Bath, in a private communication, referred to

"... the need to pay attention to the problem definition before any attempt to find solutions - assuming that [these solutions] can be found [and that] the process of problem definition itself does not result in a dissolving of the problem".

CHAPTER 2THE CONFLICT NOTATIONIntroduction

In the early 70s, with a colleague, David G. Smith, I initiated a research study on conflict. The initial intention was application to military problems. I was conscious that, in modelling situations for defence studies, it was customary to assume that war had started and that two sides were 'lined up' in a particular way. The unstated and unanswered question was how affairs had developed towards this undesirable state and in what ways would this development affect the initial conditions for combat. It was the precursors to war that were of interest to me: it seemed that the deployment of resources of all kinds to aid a move away from war should be an important issue for defence, yet, in OR studies, nothing had yet been done to analyse such deployment.

It soon became clear that descriptive models of the process of conflict were required; also, that such models should help to identify critical points, particularly the crisis point when a move from 'peace' to war became an accepted, because necessary, policy. As our study advanced, it appeared likely that, if basic elements of the process could be identified, these should be relevant to conflicts of all types, and provide a basis for concepts which might be useful for understanding conflict situations. It was also recognised that conflict could be benevolent, and as such was an essential element of progress. What we wished to study was malevolent conflict, or a loss of control of conflict that could, if it remained benevolent, be useful. When conflict led, or might lead, to the acceptance of non-preferred policies and actions which, at an earlier stage, would not have been deemed acceptable at all, we wished to know what facilities (including means towards understanding) could be improved or added to so as to reduce the future likelihood of such degeneration of a situation (note 1).

The results of our work were presented at a social sciences seminar at Edinburgh University in 1972, and reported in due course

in the proceedings of that seminar (Bowen and Smith, 1976). In repeating here, for convenience, the essence of the notation and models developed, I have made changes in order to bring the material into line with my current practice. This includes tentative rules or conventions for the use of the original and extended notations.

The Conflict Models

Model of interaction

Figure 1a shows a model of interaction in its most simple and basic form. X and Y are two purposeful systems which interact in a common environment. This environment of the X-Y interaction will be defined as a system which may have sub-systems, other than X and Y, which are of particular relevance to the interaction. The total environment contains everything. Arrows are shown which imply changes that system and sub-system produce in one another; it is not essential to show these since such changes can be understood, by definition, to take place. With separated sets, X and Y for example, changes that they produce in one another are, in fact, made through changes to and by some common environment, although the changes are more commonly perceived as direct. For example, if an individual X speaks to another individual Y, X's voice modifies the intervening space by producing sound waves in it and Y receives these. Even if X hits Y, there is, physically a process of transfer of energy that requires the environment to be there. In more complex situations, X and Y will interact through their observations of how the other affects other sub-systems of the common environment, although again they may perceive a "direct" mutual involvement. If it is necessary to emphasise such a relationship, this is done by a double line (not arrowed). It is between such separated systems that conflict may occur at some level of intensity, desired or undesired.

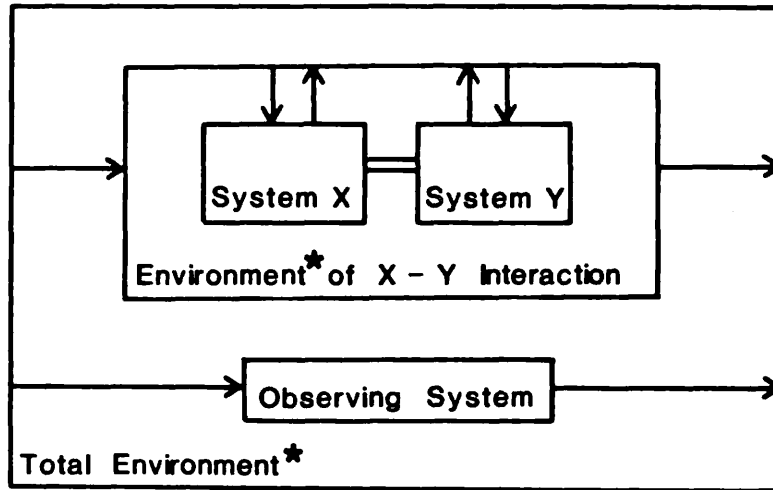


Figure 1a. A model of Interaction (neutral observer)

*Ackoff defines environment in a way that excludes the system whose environment it is. This leads to difficulties in notation and, generally, in language. In my notation, my own environment would include myself.

The double lines therefore indicate potential conflict, although there is normally conflict, benevolent or otherwise, between two such interacting purposeful systems. Indeed, the way in which a diagram is drawn itself indicates where conflicts are perceived to be possible. Any diagram is someone's perception, perhaps a perception of another's perception. Someone else may wish to change the placings of systems in the diagram, or to add systems, in order to draw attention to other conflicts or direct influences, which are seen to be descriptive of the matter under consideration.

I illustrate this by considering the observing system (figure 1a), which I have depicted as observing the X-Y interaction from outside the environment which primarily affects the interaction. Although, through the total environment, the observing system must, in however small a way, affect the X-Y interaction, it is not here perceived as doing so in an obtrusive way. Consequently, no direct interaction is shown between the observing system and the X-Y interaction.

Importantly, this implies no conflict.

However, if the observer were within the X-Y interaction environment, there would be potential conflict with both X and Y (figure 1b).

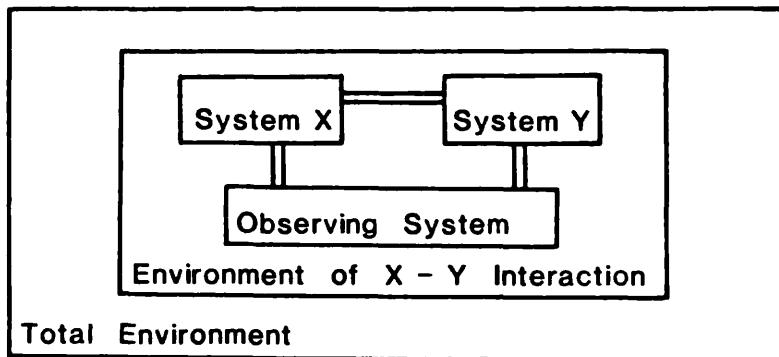


Figure 1b. An Interfering Observer (arrows implied)

Such an observer would be far from neutral and would himself be an important part of what he was trying to observe. Such non-neutrality is clearly an undesirable state, never totally avoidable. Indeed, it is often a feature of an observer-cum-consultant's problem that has to be accepted and allowed for. I shall return to this important theme in the next chapter.

The final comment that can be made about figures 1a and 1b is that the changes brought about by interactions may be affected by errors of omission, commission and delay. There will be a need, in some cases, to draw attention to the distortion of what is intended by purposeful action: this will be discussed later in this chapter.

Model of an adaptive system

Figure 2a shows how a purposeful system (X) adapts. Essentially, X has a means for obtaining data, for storing them, for processing them into information for decision, and for giving effect to decisions.

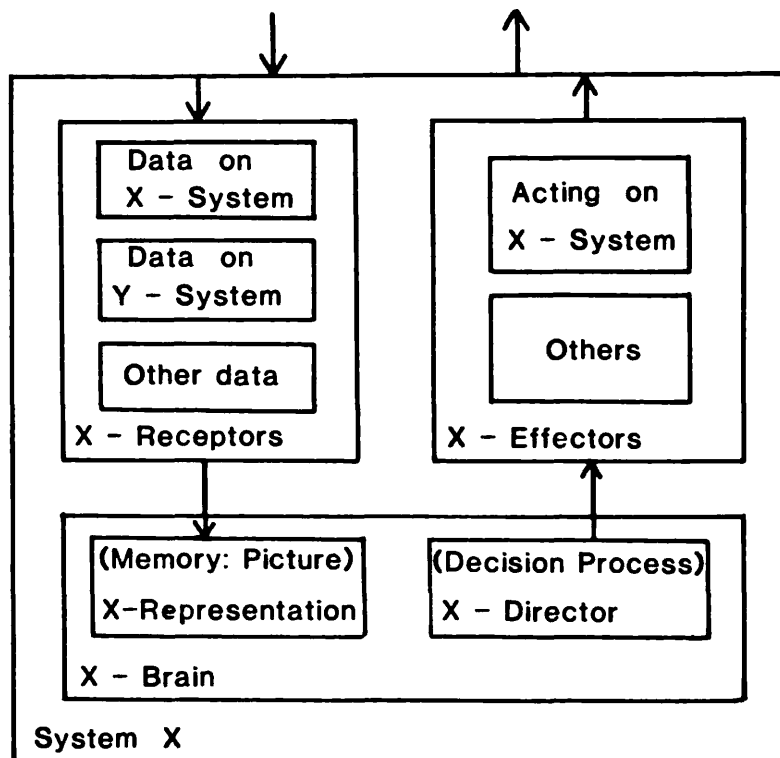


Figure 2a Model of an Adaptive System

The receptors are shown as handling data from different parts of the environment, including, importantly, system X itself. All data may feed into the X-Representation, which is sampled in a purposeful manner by the X-Director (the decision-making function). Appropriate orders then go to the X-Effectors. One "set" of effectors are responsible for changes to X itself: these changes come back to the X-Representation via the receptors which deal with the system itself. This closes a loop between X-Representation and X-Director

(together, the X-Brain) and provides the consciousness and internal adaptive behaviour of X. The other effectors provide for external adaptive behaviour in the same way.

Alternative processes could be assumed and shown. For example, 'automatic' processes could link receptors and effectors 'directly'; the rules for decision could be shown as a sub-system of X-Director, as could rules for sampling from the X-Representation. In another context, the whole or part of the process could be seen as taking place, by definition, without explicit diagrammatic description (in particular, receptors and effectors will always be assumed to exist within any sub-system that accepts and acts upon data). It is neither desirable nor possible to show everything, and only what is essential for the purposes for which a diagram is being used will be shown. The fact that there are other features being assumed must, of course, be clearly understood.

There is a logical sequence in which an adaptive process works, subject always to errors and delays. The influences on X must be received by the receptors and the actions of X must be put into effect by the effectors. In such a case, we must show the influence arrows to and from X and (exceptionally) influence arrows directly from receptors to brain and brain to effectors. Later, I shall introduce other conventions of this sort which can be added to the minimum notation rules illustrated by figure 1b.

The scheme in figure 2a is also drawn as if for an individual, but it can equally illustrate the working of an organisation. In such a case, the X-Director and X-Representation will be purposeful systems of people and machines with someone in control. There is no intention to lump together the distinct mental frameworks or brains of all people in the organisation, although documents or understandings may exist that imply an intended common frame-work for operation. There are certain to be some conflicts ("I have data; why aren't you using it?", or "I can't make a decision with what you are giving me"). Such struggles also go on within individuals (who, as will be discussed later, have to carry out many roles), and we can speak of internal conflicts. Similar remarks to these on Director and

Representation also apply to the interaction between Brain and Receptors or Effectors. In such cases, we may wish to indicate conflict by double lines, or to indicate, as in figure 2, a relatively orderly and harmonious working by using influence arrows.

To summarise, it will not always be necessary to show all the sub-systems of X which makes it adaptive, nor is it possible, except in a particular case, to say whether influence arrows, conflict double lines, some mixture or nothing, is appropriate to the diagram. The selection is a matter for the judgement of whoever is producing a diagram, and it must reflect his purpose.

Indeed, there is a complexity in choosing notation which was hidden in figures 1, but, nevertheless, it is often possible for such simple diagrams to suffice. Since the environment influences the systems it contains, and vice-versa, there must be means by which this influence is received and transmitted (receptors and effectors of some sort). Figure 2a can therefore be simplified into figure 2b, as has already been implied.

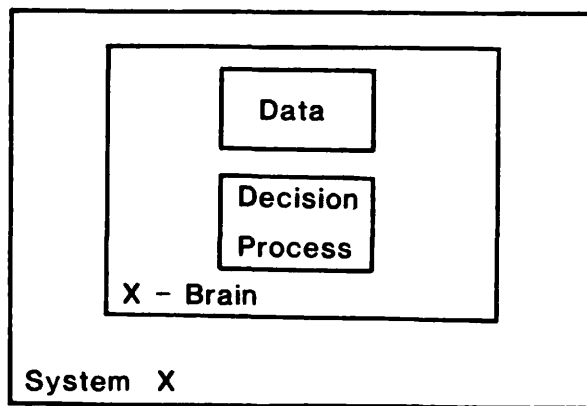


Figure 2b. The Adaptive System Simplified

What has happened is that the receptors and effectors have been subsumed into the influence arrows (not shown) that would indicate the influence of X on X-Brain, and vice-versa (a similar approach could be made to representing the interaction between X and its environment).

Only for more detailed statements will diagrams like figure 2a be required.

Model of the decision-process

The decision-process of system X, albeit over time with consequent continual influences from within and outside system X, take place within X-Brain. Figure 3 shows the basic subsets which form ideas, operate on them and lead to action, in relation to a presumed interaction (conflict) with system Y.

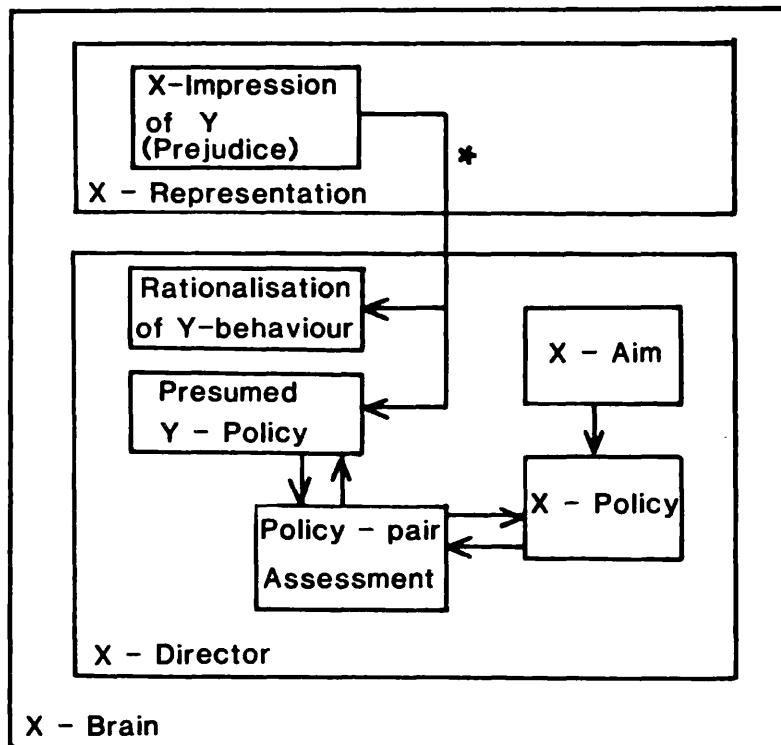


Figure 3. Model of the Decision-Process

*The arrows that link subsets of separated sets operate strictly as in figure 1a; here they are shown, for emphasis, as direct links (a similar emphasis was used in figure 2a, but not mentioned there).

X has an aim which he perceives to be potentially adversely influenced by Y's behaviour. He has a number of policies which he

could follow to meet his aim, one at least of which he hopes will be satisfactory. If none are satisfactory, he may be prepared to adjust his aim and seek new matching policies. If he knew Y's policy for action, he could make a suitable assessment. However, in general, he can only acquire a presumption about this policy after rationalising Y's behaviour: in this process, his prior stored and processed knowledge of Y is all-important. Dependent on past history and on the nature of the current interaction, his impression of Y might be far from benevolent and far from accurate: he may well impute to Y reasons for behaviour which are untrue. Part of his picture is his impression of Y labelled prejudice: this word is not used here in its emotive connotation but in its precise sense, acknowledging that pre-judgement invariably enters into the assessments of the purpose of others. Without close empathy and/or co-operation, X is likely to make a poor estimate of Y-policy and, consequently, choose an unsatisfactory policy (if he can find one at all).

The sub-sets shown in figure 3 are fuzzy in the technical sense - it might be more correct to say fuzzier than those dealt with previously. They are mental constructs, although, in some cases, they may be made explicit outside the mind of an individual, and then used as information by other purposeful systems. As shown in figure 3, they are implicit concepts within the X-Brain. For an organisation, they represent more complex combinations of ideas, with more explicit representation, however inadequate this may be. Nevertheless, the ideas still exist and are developed separately, and inevitably differently, within the minds of individuals comprising the organisation's 'brain'. The complexity of group decision-making is apparent: there will be conflicts between individuals with some sort of joint responsibility for decisions, due to different individual perceptions of the situation faced. However, what is being attempted is still something like figure 3.

There is no clear sequence in which these sub-sets operate in the decision-process. What goes on is continuously fed back to the representation and influenced by the changes that take place there. Figure 3 contains what I believe to be the more important sub-sets for the present general discussion. The particular influence of

'prejudice' has already been stressed.

More complex structures can be created. Sub-sets can be included to emphasise such concepts as values and beliefs. Various logical processes and sub-sets of data available can be included. It is worth noting that one way in which this can be done is by using graph-theoretic approaches similar to those of Eden and his colleagues, as discussed in chapter 1. There may, indeed, be many approaches to deal with particular complexities for particular problems; it is not yet possible to generalise any approach, and it may well be dangerous, theoretically, to do so.

Additions to the Notation

Uses of the notation

The notation has been used, since 1972, for a number of purposes rather different from those for which it was originally devised. It had, however, always been realised that it should be relevant for describing important aspects of many situations for which conflict and crisis management were not generally perceived as central features. The original paper offered tentative views on this. In particular, it seemed relevant to any attempt to plan and control the OR process itself; some work on this has already been mentioned (appendix C, and chapter 1).

Individuals and their roles

In this examination of the OR process, I used an idea introduced by Janet Harris in work on games (I shall return to her other notational additions below). This was the simple device of using a circle, rather than a rectangular box, to represent an individual (the most basic purposeful system): in particular, the circle is placed in the top left-hand corner of a box to represent an individual within a system who is the controller of that system. In this role, the individual is, potentially, a resolver of conflicts. In figure 4a, sub-systems Y and Z controlled by B and C respectively may be in conflict. If their immediate environment, system X, is controlled by A, his task includes keeping B and C in order.

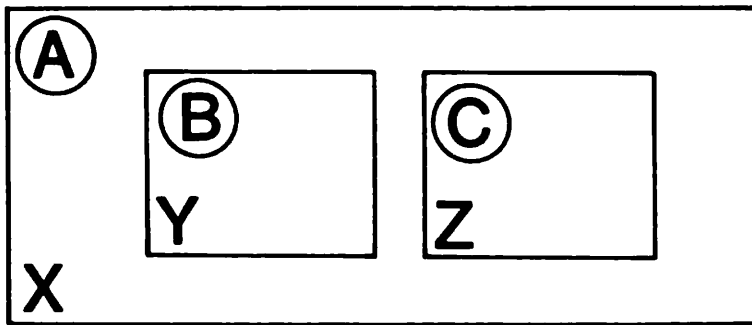


Figure 4a. Individuals in Control of Systems

A is successful in preventing serious conflict between systems Y and Z.

Even in the wider context of large organisations, there may be, by agreement, some purposeful system in their common environment which plays a similar role (e.g. the United Nations, however limited its powers, in world affairs; or a joint union-management committee in an industrial organisation).

Difficulties arise when an individual operates in control of a subsystem (or subsystems) of the system which he also, nominally, controls. Such an individual plays conflicting roles, and it may be impossible for him to mediate satisfactorily in a conflict to which he is an active contributor. To indicate multiple roles, the individual is shown in hatched circles: at any moment in time, he attempts to play one role but this must be affected by the knowledge and ideas (prejudice) he has from his other role (figure 4b).

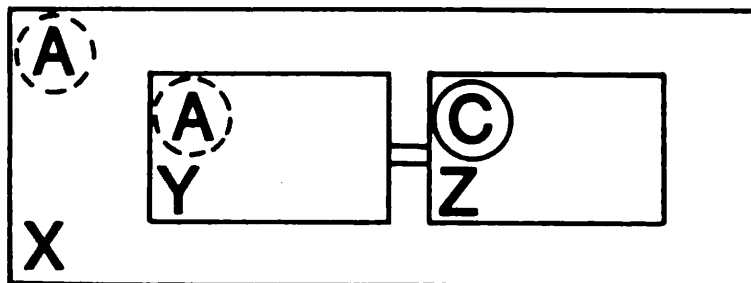


Figure 4b Individuals in Control of Systems

A is unable to control a conflict to which he is a party (note 2).

In annex C, role-playing is discussed in relation to the hoped-for neutrality of an analyst. Since one of his roles, in regular discussion with his clients, is as part of the decision-making system, he cannot in his neutral-analyst role be wholly disinterested. A similar situation would occur if a parent was employer of one of his children in a business: roles of parent and employer are not compatible in practice. Even worse would be a situation in which a child employed a parent.

If the roles which an individual plays outside the organisation (system) of immediate concern are perceived as relevant to his behaviour as part of the organisation for a given problem, the systems in which he plays these secondary roles must be included in the environment of the organisation when formulating that problem. It is in this context that it will be necessary to take account of Boothroyd's 'action programme' concept (note 3). I believe, however, that this can be treated as part of the wider concept of conflict rather than as the central feature of 'articulate intervention'.

Purposefulness and communication

In her work on conflict games (Bowen, 1978), Janet Harris introduced additional arrows into the notation. The need for these arose in emphasising communication and purposeful action. In addition, she found it necessary to indicate that what happens may not be what was intended. As mentioned earlier, distortions due to errors of various kinds, and due to delays, will arise. When the likelihood of such distortion is recognised, and is seen as important to the description of a problem (or some part of a problem), this should obviously be emphasised.

Figure 5 shows the arrows used. A solid triangular arrow denotes purposeful action: it should start from a circle (an individual) - whether there might be merit in allowing such an arrow to start from a more general purposeful system still has to be examined; it may not be important to stress the individual responsible for the

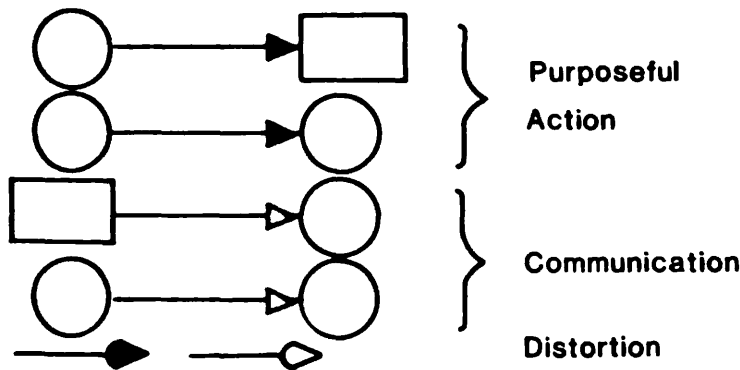


Figure 5. Purposefulness, Communication and Distortion Arrows

action and yet important to label the purposeful nature of the action.

Some purposeful action may be primarily communication, but communication can also come from systems which are not themselves purposeful. Communication is always to an individual, and the empty triangular arrow, stressing communication, should end on a circle (again it may be that communication although actually received by people within a system, is more appropriately shown with the arrow ending on a rectangle). Automatic transfer of data, from machine to machine, is not itself purposeful nor is it communication: purpose (from an individual) may control what data is passed and extracted from a machine store, and so may lead to communication for an individual, but black boxes are just black boxes.

For both types of arrow, distortion is shown by rounded arrow bases.

The simple arrows (\rightarrow), as well as those of figure 5, were used in the work on conflict games to emphasise any important influences between systems and subsystems. In particular, they were used* to indicate a direct influence between subsystems of separated systems; they are so used in the diagram of figure 3. All other arrows may be used in such ways, subject to the rules for their initial and terminal points.

*This had not been general practice before, although David Smith had found it useful in some of his conflict studies.

Communication is sometimes the intention underlying physical action (e.g. destruction of some physical object may be a means of passing a message which has no direct connection with the act of destruction). Communication from one person to another is generally purposeful. It is not intended to develop special notation for such cases. In general, the context in which a diagram is being used should obviate such need. Also, the description required and the sets actually defined should be enough to determine when and where communication and purposeful arrows are required.

Conversely, if a diagram seems to need some special additional notation, it may be because appropriate sets and subsets have not yet been introduced or satisfactorily related. It is important that the 'language' remain as simple as possible and not develop piecemeal into sub-languages, since this would reduce the effectiveness of the methodology developed. This will be further discussed in chapter 3 on Theory and Methodology. In particular, I would not at present wish to press the ideas on intensity of interaction which were suggested in an earlier paper (Bowen, 1975b).

Non-Overlapping Sets

In set-theoretic terms, the sets (systems) that will be acceptable will be those whose intersection is either the null set or that set which is contained by the other. In diagrammatic terms, sets will not "overlap", i.e. $A \cap B = \emptyset$ or $A \subset B$. This restriction is imposed in order to maintain a clear and orderly notation: although overlaps will in principle occur and have to be dealt with, this may be done in a number of ways.

For example, consider the resources (R) of a system (X) which have to be allocated in part or in whole to a number of subsystems (X_1, X_2, X_3). The most direct way of showing this might be (if the restriction were removed) as illustrated in figure 6a.

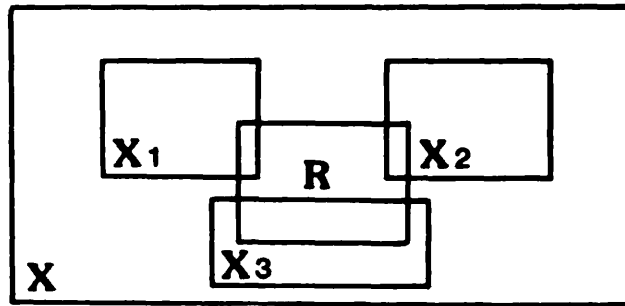


Figure 6a. Sharing Resources

The total demand for resources might of course be more than was available, a fairly common occurrence. Conflicts arise between X_1, X_2, X_3 and X has a problem of supply and allocation. This can be more usefully demonstrated as in figure 6b.

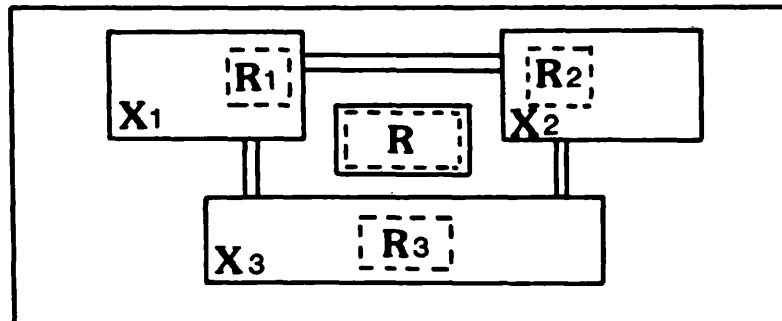


Figure 6b. Conflict over Allocation of Inadequate Resources

Here the X sub-systems are seen in conflict. R_1, R_2, R_3 are either the resources planned to be allocated ($R_1 + R_2 + R_3 \leq R$) or the demands ($R_1 + R_2 + R_3 > R$). Expanding this, we could enclose R in a subsystem which was the supply subsystem (S) and X 's job (more precisely the

job of the controller of X - the individual circles are not shown here) would then become that of the resolver of conflicts between S and X_1, X_2, X_3 . To examine the problem, we would start to look at ordering, manufacture and so on, eventually expanding beyond X itself. Even at a simple level, we might well begin to identify organisational or policy limitations. As with people (see earlier remarks on roles) hatched lines can be used as in figure 6b to indicate that, over time, subsystems change roles (or simply change) and become part of other systems. Indeed, the example of roles is a case of overlapping sets if the rule of 'non-overlaps' is not imposed. I am a member of the sets {RHC academic staff}, {RHC students} and {RHC staff cricket club} as well as of a large number of sets, professional and social, outside RHC: fortunately, few of the problems I encounter are due to conflicts of roles, and I am almost always in a clearly defined role at any moment of time. To monitor my own life, it would certainly not be very useful to me to picture it through diagrams with overlapping sets.

Simple cases of overlap may be overcome by relabelling the intersection and removing parts of the original sets. More complex cases of overlap may best be dealt with by separate diagrams for the different aspects of systems interaction that need description and analysis. It is fairly evident in any case that a single diagram would soon become too complex to take in: each diagram should be related to the purpose of drawing it, although the relationships between diagrams and their mutual consistency must be given attention (note 4).

In particular, different people's perceptions will need different diagrams, even though they may be describing the same 'reality'. Such diagrams are in effect 'dimensional slices' of whatever 'reality' is. I do not find the concept of reality very useful, except in so far as it may be a measure of the convergence, or possibly some kind of summation, of individual perceptions (for my present purposes at least). I stress again, that all diagrams in this chapter are my perceptions of illustrative situations that I hope will help the reader to understand my outlook, and perhaps formulate objections and differences (note 5).

This problem of perceptions is introduced here because confusion about perceptions often leads to a concept of overlapping systems because they are being looked at from two different points of view. The process of seeking appropriate ways to avoid overlaps in the diagrammatic representations will often shed light on the concepts being used and will aid understanding. It may be, for instance, that, in attempting to cover a period of time over which a system is changing, overlaps will occur which have to be removed by describing time-slices separately. It may however be possible, when the structure of a problem changes only slowly, that time passing will bring new systems (concepts) into the description: in such cases, there is a possibility that successive environmental systems can be defined as time-sets. A simple example is given in appendix E which summarises unpublished notes of 1975 (mainly work by Janet Harris) on the interactions and perceptions of analyst and decision-maker in the total OR process.

Perceptions

There are other comments on perceptions which seem useful as a tail-piece to this chapter on notation. One of the intentions of my study is to develop diagrams which can provide explicit bases for communication, inquiry and shared understanding. Although I am primarily addressing the broad problem-formulation stage of the OR process, it is necessarily a part of this to consider what later analysis may be needed, and be feasible, as the analyst and decision-maker jointly move towards practicable implementation of relevant change. They may need to go through some of the thinking which appendix E examines from different perceptual stand points.

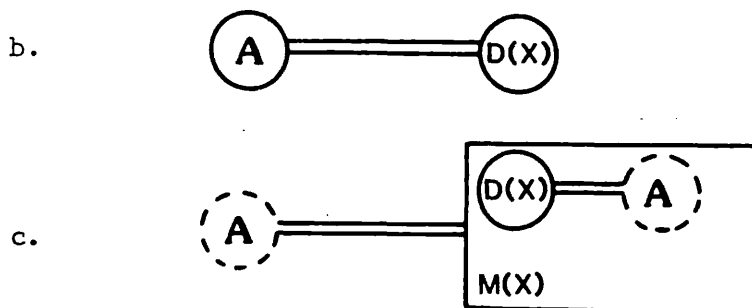
Another importance of perception lies in its relevance to conflict. Conflicts that are perceived by an individual may not be 'real' in the sense that they result from misunderstanding or lack of information; nevertheless they are real for the progress of events. A may see himself in conflict with B, but B may see no conflict. B's responses to A's actions may then be as difficult for A to appreciate, as are A's actions for B. I offer three examples to illustrate the ways in which problems arise and can, in principle be resolved (note that 'problems' and 'conflict' are near-synonyms).

Example 1

Individual A requires some work done on a faulty installation carried out by system X. He identifies D(X) as the relevant actor and forwards his complaint. He receives a formal notification that his complaint has been noted and will be attended to. Nothing happens. However, D(X) is totally unaware of the problem: his management system provides the formal temporising replies and, unknown to him, there is a pile-up in the system. A's best hope was to see D(X), but as implied above this never came about (I usually put this in the context of a particular nationalised undertaking, since the story is partly a true one). Figures 7a and 7b show the actual and desirable situations. In a., A is in conflict with M(X), D(X)'s management system (M(X) is aware of A's frustration but is too tied down by rules to act usefully, and does not really perceive conflict since A is too polite to attack junior staff). In b., which is the desired solution, A breaks through the M(X) barrier and is able to resolve his conflict with D(X) directly. c. is an alternative form of b. which shows A in two roles, formal and informal, in relation to the typical business hierarchy: this also contains an implied time dimension.



M(X) contains people (juniors) other than D(X). It is they who create the A-M(X) conflict.



A, in M(X), becomes, in effect, part of the management system for a period of time.

Figure 7. Conflict with a Bureaucracy.

Example 2

This second example is not put in diagrammatic form because it is a simple story and the diagrams needed are rather space-consuming for my present purpose. It concerns a military force (X) in readiness to move but situated diplomatically, well away from the potential enemy (Y) border. Y is not contemplating aggression, but carries out manoeuvres close to the border as a normal sort of contingency-plan exercise. X knows that Y does this sort of thing, but this is a new area for exercises and Y has failed to announce publicly what he is doing. X-intelligence reports an aggressive move and X takes up forward positions in accordance with his contingency plans. Y-intelligence reports this and Y is instructed to abandon the exercise and take up a defensive stance against the presumed X-aggression. The two defensive stances degenerate into open war. Preconceptions of the underlying attitudes of each party are seen, in this example, to affect disastrously the interpretation of the data received. Lack of awareness of the potential effects of prejudice, lack of a procedure for examining carefully all possibilities, and lack of direct communication are important aspects of this sort of development of conflict. In an analysis of the most recent Egypt-Israel war, an even more bizarre example is quoted (Shlaim, 1976). The Israelis had firm intelligence of impending attack but disregarded it: they had already decided that Egypt could not succeed in an attack, that Egypt knew this, and therefore Egypt would not attack. Changes in organisation and in monitoring of intelligence are necessary to avoid such misperceptions.

Example 3

This must be regarded as hypothetical, although it arose from the study and rationalisation of obscure communication between conflicting groups, which appeared to do nothing to reduce conflict and much to enhance it.

Three trade unions together formed a joint negotiating team (JNT) to sort out difficulties with the Board of a nationalised undertaking. Unfortunately, there were two very distinct perceptions of the negotiating system.

The three union representative groups saw themselves, at the negotiating table, as independent negotiators albeit with some external discussion and procedural agreement as a JNT, prior to meetings with the Board. They also saw the Board as representatives of Government (figure 8a).

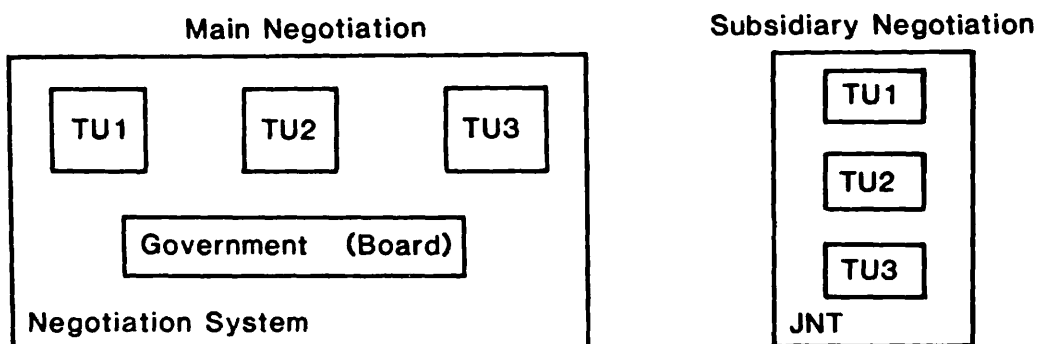


Figure 8a. Perception of the Trade Unions

The Board, particularly its Chairman, saw itself faced by an organised entity, the JNT. It also saw that the negotiation would be directly influenced by the expressed and presumed policies of Government. They had necessarily negotiated earlier with Government to see what constraints they could avoid and what they still might have to face (figure 8b).

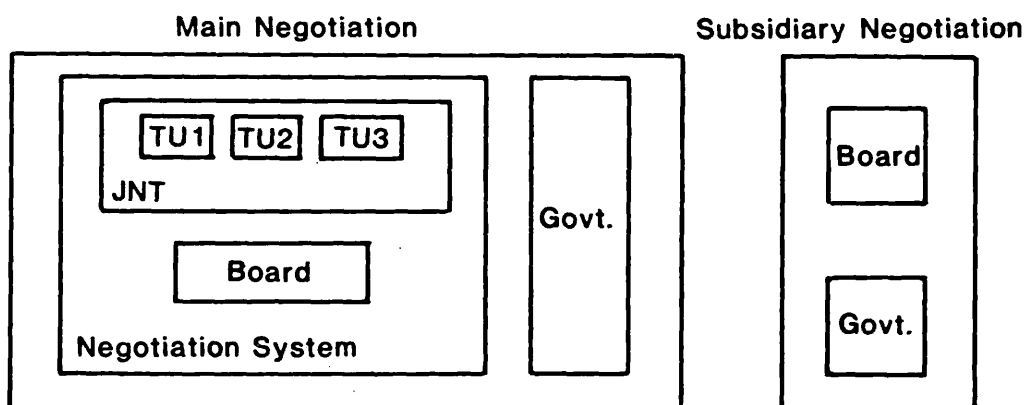


Figure 8b. Perception of the Board

The result of these different perceptions came out clearly in confusion over pronouns! When the Board Chairman said "we" he meant the Board, but the unions read "we" as the Government. When the Board chairman said "you", he addressed the JNT, but got conflicting responses from the union representatives. When a union representative said "we" he meant his union, not all three (JNT) as the Board thought. When he said "you" he meant the Government and was duly surprised when already overt policy was denied by the Board, who were not trying to support, or even were actively trying to subvert, Government policy that they saw as harmful.

I believe that a few explicit diagrams, available to all, might have made a world of difference! (note 6)

Final Comment

In all problems, conflicts that exist or that might be generated are important aspects which are all too often disregarded until implementation of decision is seen to be impossible or to result in consequences undesired and unforeseen. Identifying these conflicts is part of the problem-formulation process: perceptions of potential conflicts and the nature of these conflicts are essential aspects of a full appreciation of problems and their possible resolution.* I do not of course imply that formulating the problem solves it, although the ideal is to move in this direction: even though we may include options for implementation within the problem statement, later processes of analysis may change the list of options and, indeed, the whole nature of the perceived problem.

The conflict notation is seen to have potential to describe and clarify many of the difficult concepts that lie within the idea of problem-formulation. It provides a possible language to make complexity explicit in a simple manner and on a relatively small area of paper (a characteristic of any good diagrammatic illustration): it provides a discipline which forces certain inquiries that should be relevant

* Appendix F describes one use made some years ago of the notation. It is based on work carried out by D.G. Smith and J.I. Harris and includes an interesting set-theoretic treatment by the latter (not previously published).

and fruitful; and, being based on notions of conflict, it centres itself on aspects of problem which, if absent, imply that no problem exists. It is consistent with Ackoff's philosophy in being holistic and being concerned with all systems that may in some way contribute to the existence or the resolution of the problem.

The next chapter will discuss some of the philosophical issues that surround the concept of simplicity and examine the notation as a means for describing the problem that faces me in producing and 'selling' the methodology sought.

Notes on Chapter 2

1. Dr. Sue Jones of Bath University raises an interesting point which, in effect, asks whether it is always desirable to move away from conflict (e.g. war) when the alternative might be perceived as worse (e.g. a long period of suffering for oppressed people while a slow and not necessarily successful negotiation process goes on). Would such a war be "malevolent conflict" in my sense of the term? This is a very complex subject and my brief statement here must necessarily be only an indication of how I would treat it.

It may be, in such a case as is indicated above, that war is not a totally unacceptable policy, whereas letting the status quo go on for much longer is unacceptable. There are no constraints on what people or groups of people may select as policy orderings and preferences at any stage. However, even if such a serious move into conflict is made wittingly, it would be recognised that the process leading to the situation prevailing had not been successfully controlled at some earlier stage. One aspect of the original conflict research was to study precursors to conflict and seek ways of avoiding such situations occurring again (see my phrase, "future likelihood").

Conflict is potentially useful, in this context, as an indicator, at an early stage, that policies and actions may be leading inexorably, unless there are facilities (including willingness) that can change attitudes to possible compromise or co-operative futures, to a conflict that would be described as malevolent. There would be no policy for the party perceiving malevolent conflict that could resolve it "peacefully" and sensibly; although a "successful" war might eventually result in resolving conflict, one would prefer there to have been satisfactory alternatives.

2. Figures 4a and 4b do not imply that, in the former, A can easily remain neutral towards the conflict between the X and Y systems. Control is always limited: only mutual acceptance implies a lack of conflict. Some discussion of mediation in conflicts will be found in chapter 3 that add to the simple models offered here.

Professor M.R.C. McDowell interpreted figure 4b in a manner which I did not intend, seeing the role shift as movement (of A) from one set to another. Accordingly, he suggested that a directed dotted line should be introduced between the two hatched-line circles, to indicate a role shift for some purpose, e.g. communication or, more specifically, conflict resolution. It was, however, not my intention to imply that A physically moved into Y to deal with conflict nor that his presence in Y was a special cause of it. The point being made is that A's necessary concern with X, in which he is superordinate to C in Z, would not allow A to play the role of a missing B without risk of conflict, in this role, with C. If such conflict occurred, A, as a direct party to the conflict, would have great difficulty in playing his primary role as conflict-resolver.

Nevertheless, the idea of a notation to imply, when appropriate, some ordered sequence of role-playing may be useful. I do not, at present intend to add such a notation, since diagrams are more likely to be representing near-simultaneous playing of multiple roles and frequent switching between them. Work on actual problems should indicate whether, how, and when, the sort of added notation proposed might be of value (see however the brief comment on a hospital study, chapter 6, where the patient moves from subsystem to subsystem).

3. In correspondence with Hylton Boothroyd, I offered an "Ackoffian" definition of his concept of "action programme".

"An action programme is the totality of states, actions and concepts of a purposeful system over a period of time, the purposeful system being a set of individuals (maybe only one) and facilities they control, not necessarily in concert, for a broadly defined purpose."

He was reluctant to accept this since to him "purposeful system" sounded like a solid slice of space and/or time, and he saw within my definition a concept of "common purpose" that is not a prime characteristic of what can be identified as "programmes". He offered a tentative definition as follows:

"An action programme is any set of past, present and future actions that an observer both chooses to regard and chooses to regard as a whole, together with the known, unknown and implicit

cognitions of the actors" (my underlinings).

I commented on the phrases underlined.

- a. I aim to deal with past, present and future actions in terms of existing data and prejudices: what is or is seen to be; and what is intended by self and others, the latter imposing constraints on acceptable policies. I am conscious of all the possible actions as basic to the existence of and resolution of problems, and regard implementation as a vital aspect of problem-formulation.
- b. "chooses to regard" is important. Every system diagram will be the choice of its owner: it may represent his perception of the "diagram" of another. A diagram does not necessarily represent a fact and it will put together systems, of all kinds, in an idiosyncratic way.
- c. "chooses to regard as a whole" is important to my problem-definition process, which following Ackoff is to be holistic, as close to the ideal as possible.
- d. The "cognitions of the actors" are precisely what I hope to make explicit, or at least less vague, through my diagrammatic structuring.

On this basis, I regard our processes as closely similar: although there is still much room for debate, I prefer to wait to see whether application of my ideas will, in practice, encompass the concepts that Boothroyd provides. Certainly, I do not think of a purposeful system as other than changing (evolving) in time and space, and, with the emphasis I place on misperceptions and misunderstandings and the barriers of language, I do not recognise "common purpose" as other than an ideal, even though such a concept may be perceived. My treatment of roles is an important part of my recognition of "action programmes".

4. I am aware that not everyone will prefer my insistence on non-overlapping sets. If, in the process of disentangling overlapping sets, ideas become clarified, this should lead to acceptance of my "rules" for the purpose of a common language for problem-formulation. There is nothing to prevent people using their individual 'languages' for their own purposes. If the process is

not found useful, I shall obviously have to make changes, but these must be done in the context of the whole process that I outline.

5. It is implicit in this chapter and in appendix E that conflict is a perception of an individual. As stressed in a diagram by double lines it is the perception of whoever owns the diagram. It does not follow that conflict is perceived by either or both parties to an interaction, even though it is perceived by a third party. Nor does it follow that if A perceives himself to be in conflict with B then the reverse is true. It is also important to stress that conflicts between large systems are perceptions of some individual(s).

I have tried to avoid the need for an explicit definition of conflict because, paradoxically, it seems always to provoke a lot of argument. Broadly speaking my perception of the concept is covered by the statement:

"Conflict between X and Y is perceived to exist if X's (or Y's) actions are seen as inhibiting Y's (or X's) courses of action now or in the future: the perceiver may be any individual - the one who draws the diagram - including X and Y."

6. I have kept the diagrams of figures 7 and 8 as simple as possible for the purposes of illustration. It has been pointed out that a use of the arrow notations of figure 5 might have improved their message. I accept that this might be so. However, as may be seen in appendix E, and will again become apparent in chapter 3, the use of the arrows involve certain complexities in the diagrams (particularly the inclusion of individuals, to or from whom some of the arrows must go) that I decided to avoid here. In a practical application, as will be seen, the added complexity becomes inevitable and acceptable.

CHAPTER 3METHODOLOGY, THEORY AND EXPERIMENTIntroduction

The purpose of this research into problem-formulation is to provide a coherent and usable methodology. The use of whatever is produced will necessarily be pragmatic and in no way prescriptive. There will be no theory as to how problems are or should be formulated.

Nevertheless, there are aspects of methodology development which necessarily parallel those of theory. In particular, it must be shown that the methodology can be used and is useful, other than by stating the purely subjective view of the author that it is useful to him. Also it must be shown that there are some rules of procedure that are generally applicable and that the pragmatism does not go so far as to make each application a special case, despite the fact that there are bound to be some special feature and limitations with each problem.

This implies a number of things. Firstly, the notation or language for the formulation of problems must be kept simple, in some sense; it will be undesirable to extend it to cope with special difficulties without ensuring that such extension is compatible with comparable difficulties that might arise elsewhere. Secondly, it will be necessary to be able to identify ways in which the methodology, at any stage of its development, is producing indications which are wrong, inadequate or misleading, and to be able to hypothesise changes which will redress the errors of the earlier work. Thirdly, in order to be useful, the methodology must be acceptable to those to whom it is offered, and this problem of communication should be capable of being addressed by the approaches proposed for problems in general.

All these issues will be discussed provisionally in this chapter. It is possible to make a few brief initial remarks before going more deeply into principles. The issue of simplicity was intuitively accepted in the earlier work on conflict. The mode of thinking about conflict as a generic process was also tested subjectively, on a

range of conflict situations, military, political, social, religious and personal. Any changes that seemed worthwhile were retested in contexts the same as or similar to those already used to ensure that the language was not becoming specialised. This not only sorted out errors, but it ensured simplicity by limiting statements to those which seemed to be generalisable across contexts; at the same time, it provided a means of getting deeper into each problem by the new light which was thrown on it by the transfer of ideas from apparently very different problem areas. Simplicity and testing seemed to go hand in hand.

The use of the methodology to explore its own relevance to the many problems inherent in problem formulation was touched on in chapter 1. It is not possible without experimenting with a problem owned by a client or a client group to say whether the methodology can be used to monitor and aid the acceptance of the methodology. It is possible however, to attempt to use it, as it so far exists, to explore the problem that I have of considering how to present it and how to conduct, or how to lay down some principles of conducting, experiments to establish that a workable methodology has been created.

There will necessarily be difficulties in establishing criteria other than the subjective ones of acceptability. It will be enough if I can achieve the confidence to say "it works" and to have independent support for this.

Some Comments on Theory

My philosophy concerning theory and the methodology underlying theoretical development seems to be close to that of Karl Popper. I do not imply that my views have been developed independently, although on reading Popper (1977) for the first time, I found my ideas were coherent within his framework which did not seem a surprising one, although in its totality it was an impressive and powerful statement. What seems to have occurred is that, indirectly through communication with Ackoff, Boothroyd and others, many of Popper's ideas had become incorporated in my own thinking. I now find that Popper makes precise, or at least logically argued, what I thought I had thought but had never expressed explicitly.

Theory, as Popper regards it, must be falsifiable. It must consist of strictly universal statements (such as "all ravens are black") as opposed to strictly existential statements (such as "not all ravens are black"): the latter can be verified in principle, by finding a white raven for example, but cannot be falsified, while the former can by the same process be falsified in principle but never verified. Theory must divide the class of all possible basic statements into two non-empty sub-classes, those with which it is inconsistent - the potential falsifiers - and those which it permits. It will be falsified if a reproducible effect is discovered which refutes it. Basic statements have the form of singular existential statements which result from observation of a specific event, or which are testable by observation of appropriate events. Some permitted basic statements may be false.

It is necessary to be clear what potential falsifiers there are. The easier it is, in principle, to destroy a theory, the more satisfactory will the theory be: provided that many falsifying hypotheses have been tested and found wanting, confidence in the theory will be high. If basic statements contradict a theory it should not be abandoned unless they can be held to corroborate a falsifying hypothesis (reproduceability - see the above paragraph - is of importance here).

Popper accepts that, in the search for scientific knowledge, there must be methodological rules. These can only become accepted by custom and by the satisfaction of those who use them. One such rule of particular importance here is that if a theory (a system of statements) is threatened, one should not try to save it by any kind of conventional strategem: that is by adding auxiliary hypotheses to deal with the particular threat. Not only will the universal statements on which the theory was based be weakened, but the degree of falsifiability will generally be diminished. Only if this latter is not true will the theory perhaps be 'saved'; for example, by limiting the class of objects or the class of circumstances to which the theory applies. Falsifiability and the universality of the theory will often only be affected by the more constrained, but still general, universe to which it applies.

It would also make theory less 'simple' were it to be surrounded

by conditional disclaimers for specific singular statements of many kinds. It would become increasingly difficult to identify falsifying hypotheses, and increasingly likely that self-inconsistency would arise without being observed. Nevertheless, certain disclaimers are always necessary to make clear what the theory applies to:

"... a theory is not just a set of hypotheses, verified or unverified. A theory has to be more than this, and it has to be used. Indeed a theory should include a specification of its uses." (White, 1975b)

It is the last sentence to which I draw particular attention. Such a specification of uses, which might be the form of disclaimer I refer to, is, of course, part of the process of identifying the two sub-classes into which theory divides the class of basic statements.

The other part of the above quotation that is important is that theory, to be theory, has to be used. Many so called 'applications' of theory can be seen to be statements of potential application. It is evident that, if a theory contains statements of application, it can be falsified if application fails in appropriate tests. It would be methodologically unsound if such potentially falsifying tests were not attempted, although the status of theory could, protem, still be properly claimed (that is if it were clearly intended to carry out the tests).

Popper discusses the preference that should be given to those theories which can be most severely tested, a statement that he derives from a methodological decision to seek always universal laws and casual explanation for events which can be described. He gives an example of four possible natural laws.

- o All orbits of heavenly bodies are circles.
- o All orbits of planets are circles.
- o All orbits of heavenly bodies are ellipses.
- o All orbits of planets are ellipses.

Of these, the first has the highest degree of universality and precision; if it is true, so are the others. It is more easily falsified than the others; one should not go to theories of lower universality or precision unless tests make it necessary to abandon the preferred ones. In this way, one starts with the hope of being able to make simple

statements and only introduces conditions and qualifications when this is inevitable.

Methodology

Although I am not trying to develop theory as such, I am seeking a process through which knowledge can be 'improved', however subjectively this improvement may be assessed. It is therefore worth examining what the above aspects of theory have to offer to methodology development.

In what sense, for example, might the methodology proposed in earlier chapters be said to be falsifiable? This depends on the statements which can be made about it which have the form of, and can be interpreted as, strictly universal statements. There are some intuitive tests that I have used in the development so far. For example, inferences and insights will come from the diagrammatic structures which were not in my mind, or at least never explicitly formulated, before (see, for example, the discussion of the diagrams in appendix C and in appendix E): unless this happens, the methodology fails. That it will not necessarily happen with some individual client is not particularly important, but the methodology would be deemed by me to have failed if such an outcome could not be obtained with a co-operating client or with a sufficient number of clients in a true consultancy activity.

Also, what can be said about a problem in words must be capable of encapsulation in diagrams so that words can be used in less explicit and precise ways once the diagrams are there to direct and formalise discussion. Thus, if the meanings of diagrams remain primary causes of argument, rather than enlightening the confusion created by earlier verbal statements, the methodology will be discredited.

My theory, if I have one, is that people in general will be helped by the methodology and will wish to use it - not all people (human nature being what it is!) but some people and by "some" I must necessarily mean a considerable number. Clearly, if I cannot help myself, I fail (subjectively, I have already passed that test); going a stage further, I fail if I cannot help a co-operating client. In the latter case, it may not be the methodology per se but the way of introducing

or teaching it that is at fault. It is proper perhaps to remove this distinction by including the way of introducing the process in the methodology, that is to say that the methodology must eventually include a statement of the procedure for the application of the methodology.

It may seem that I can, after a certain number of successful experiments or client applications, claim that the methodology is proven. In a sense, yes; at the least, it would be very encouraging. However, the important feature of any testing should be potential falsifiability. As I proceed, failure with a new client, or a different type of client, should point to methodological aspects that need reappraisal. One problem with OR methodology in general has always been that, as problems become more difficult, the profession keeps running out of relevant techniques. Theories are eventually replaced; methodologies must be continually reassessed and reinvigorated.

Within the ideas of the conflict notation, there may be another important, unstated "theory": that the process of interaction and conflict as defined is universally applicable. This implies that the concept of problem can be built up by using no more than the basic 'bricks' of interaction between systems and of certain emphases which are indicated by the notational arrows and by what systems and subsystems are or are not included.

If this view is taken, then the methodology is capable of falsification along the lines indicated by Popper. More importantly, a theory of this sort is both simple and of a high degree of precision and universality, and it is consequently capable of more severe testing. Were it to be hedged with 'ifs' and 'buts', it would introduce the very semantic problems, in deciding whether it were applicable or not, that the diagrammatic language seeks to avoid.

From this brief argument, I draw a number of tentative conclusions to guide the move into experimentation and application.

- o No auxiliary notations should be added for any specific problem without testing the relevance and consistency of these in other (as different as possible) situations.

- o If there is evident lack of success the source should be sought in the fundamental systems and conflict concepts and in the rules of the methodology, rather than in the detail of the notation used.
- o The extent to which the logic and structure of the problem can be outlined, rather than the extent to which the totality of a problem can be expressed should be taken as a criterion of satisfaction.
- o The methodology must work for me, including enlightening my perception of others' problems, and it must work for me in helping to provide, and later develop, a methodology of practical application.

The rest of this chapter will look at two important aspects already touched on: firstly, the use of the notation to define and illuminate the task of devising a satisfactory methodology, and, secondly, the type of experimental procedure that can be followed to test and develop the methodology.

The Problem of a Language for Structuring Problems

My problem is to develop and 'sell' a language for structuring problems. I use the word 'problem' rather than Ackoff's word 'mess' for simplicity and because this is the language a would-be client will most likely prefer: the process of study will soon make it apparent whether the problems are indeed complexes of problems. I must do two things at the outset: explain my notation and give some rationale to encourage a client to use it (initially, the second of these may be made easy by taking a willing and co-operative client, although the co-operation must not be allowed to degenerate into a supportive conformity). It might be helpful to use the notation to describe what it is that the methodology is intended to do.

Consider figure 9, which is by no means the first such diagram that I have tried on myself.

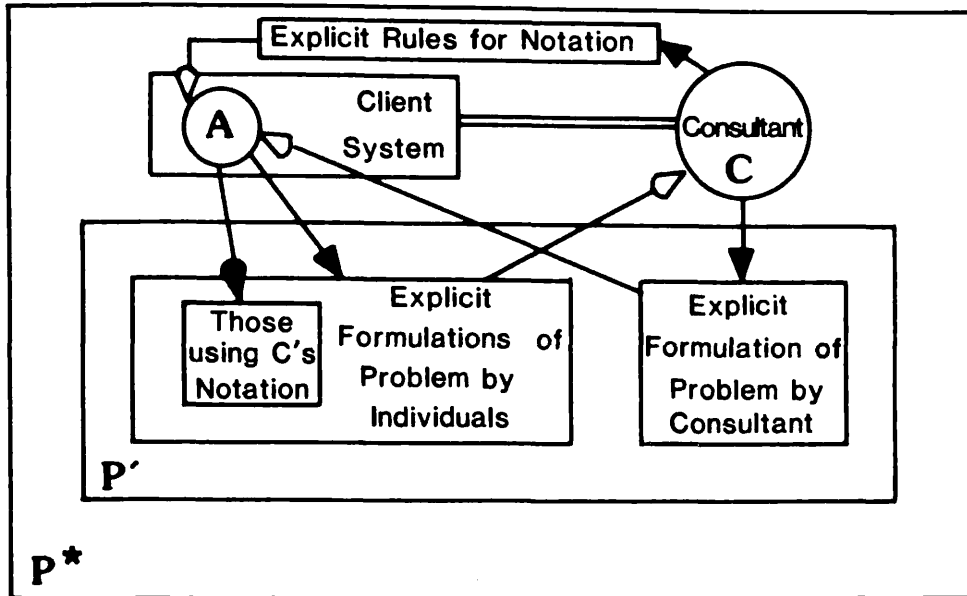


Figure 9 The Problem of Structuring a Problem

There is a problem which is 'observed' and formulated by a number of individuals who jointly own the problem (client system X of which A is a particular individual). P' is the set of explicit representations produced by X and by a consultant C . These representations (problem-formulations) change both in time and in nature as will be discussed in a moment.

The clients and consultant may or may not include some picture of themselves in P' . As I would generally draw a perceived problem P , they would be part of this problem (see the diagram of the OR process in appendix C); however, they are present in a rather different way during the problem-formulation stage. Indeed they are part of P^* which includes P' (which could be drawn as part of P), and P^* is the problem of how to set about establishing what P is. Their role in P^* is not the same as their role in P , once a satisfactory P' ,

representing P, has been established.

In P* what process does C follow? He formulates the problem for himself using his notation. This is an imperfect and incomplete representation but he may pass it to X as a starting point for discussion. It seems likely that there is conflict between C and X at least in the early stages, and how and at what rate communication proceeds is a matter for judgment in each situation. Certainly the representations passed initially will be misunderstood, and communications and purposeful actions will suffer distortion. As the communication process goes on, the consultant will continue to feed back the descriptions he receives, translated into the notation, with amendments, additions and questions.

I will assume that the process does not founder and that eventually the clients will begin a serious use of the consultant's language. Why should this occur? I believe that this will occur because of obvious and interesting differences in the separately perceived pictures, and because of the questions raised by the consultant (especially by his inclusion of systems that are not at that stage perceived by the clients as relevant to the problem).

I have stressed in figure 9 that the diagrams are purposefully constructed. The purpose is not immediately, nor necessarily, made explicit. This seems important. A learning process is to go on and (ideally) no one should be attempting to provide prescriptive statements (although in part they will do so!). Naturally, as time passes communication is expected to become more complete and error-free as a mutual understanding is created.

The consultant would, in principle, be better off if he could preserve a sort of neutrality, so that his clients are, and see themselves as, in control of the problem-formulation - their problem defined in their way - and also in control of the resolution of any disagreements between themselves. If the consultant is seen as 'interfering' or 'taking over', he will risk rejection. He needs to minimise the chance of conflict becoming malevolent between him and his clients.

Any reluctance of individual clients in opening their concepts to each other, and to the consultant, is undoubtedly a problem which may prevent the overall problem from being fully formulated. It implies conflicts, which may be hidden, but which are part of the problem until they are resolved. I think one has to accept this, remain aware of it, but be prepared to fail if co-operation is at too low a level. Also the consultant must be prepared to interfere and to translate to the best of his ability, i.e. he must sometimes consciously depart markedly from the ideal neutral stance.

Conflict Resolution

To consider what neutrality involves, I cannot do better than refer to the Third Party Consultation process which Burton (1969) and others have used. In particular, there is an excellent account by Fisher (1972) of various methods of this type proposed for the study and resolution of conflict. Figures 10 and 11 encapsulate the sort of "controlled communication" seen as essential to the conflict-resolver's role. At appendix G, these figures are compared with Fisher's summary of the common features of the methods he describes.

Figure 10 is the basic interaction model (see figure 1a, chapter 2), and shows a conflict between two systems X^* and Y^* . the observing

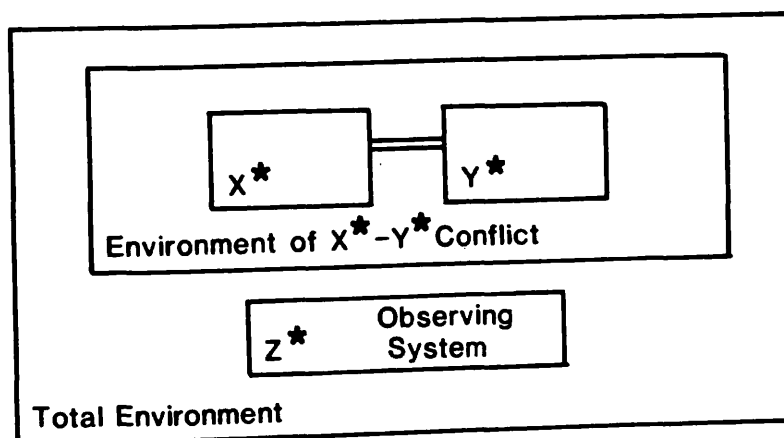


Figure 10 The $X^* - Y^*$ Conflict

system Z^* offers a third-party consultancy to help resolve the conflict. In figure 11, X and Y are individuals, perhaps leaders of a small team, chosen as negotiators for X^* and Y^* . Aided by a team of consultants from Z^* , led by Z, they communicate with each other. The aid is in the form of neutral models about conflict and related to the particular problems that Z perceives them to be troubled with.

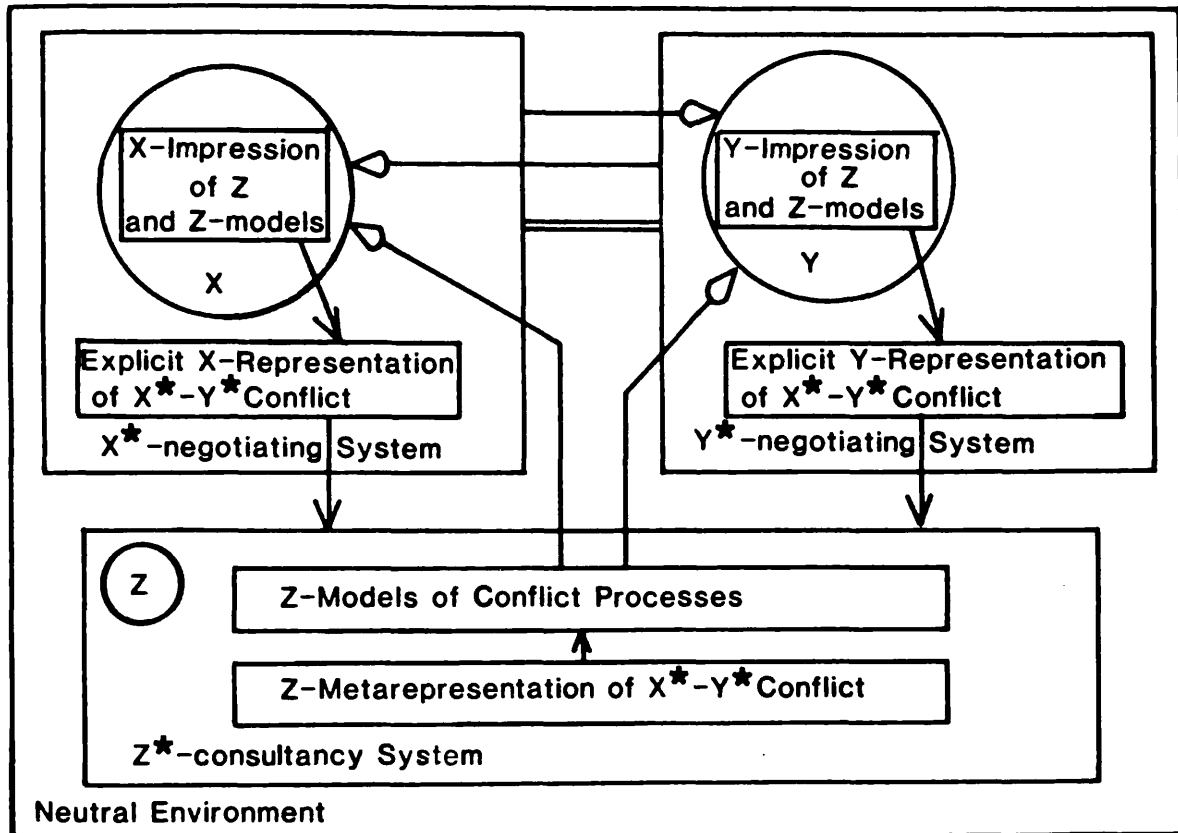


Figure 11 The Third-Party Consultation

There will be, from time to time, additional direct communications, outside the primary form of the consultancy, for information and advice. These would generally be shared communications as in figure 12.

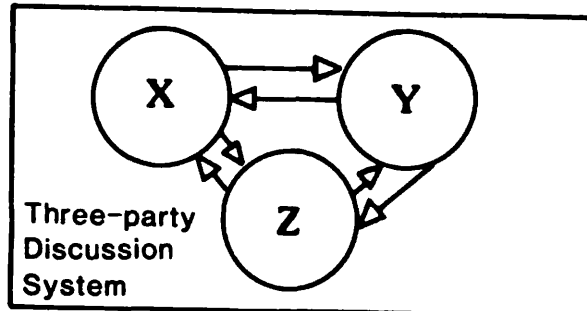


Figure 12 Direct Communication

Ultimately, as confidence in each other's intentions increases, it is intended that there will be co-operative sessions of direct communication between X and Y with Z as observer (figure 13).

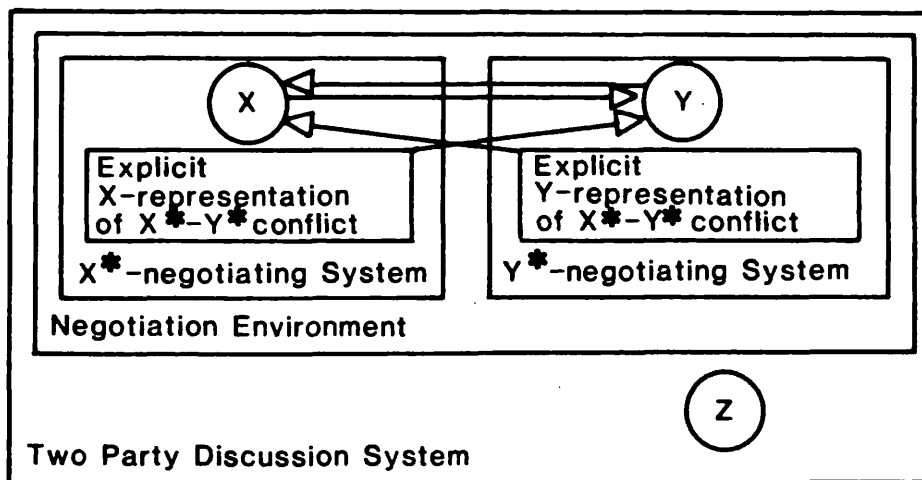


Figure 13 Moving towards Conflict-Resolution

In figures 11, 12 and 13, the 'boxes' can in several cases be regarded as rooms. In figures 13, there may be separate phases where the Negotiating Systems operate separately or together in face to face communication. There may also be an iterative process in going from figure 11 to figure 13. The principle is that as communication starts to flow so conflict yields to co-operation.

That the process works, I have to take largely on trust since confidentiality has prevented the publication of case studies. However, I have never doubted its applicability since it is an extension and a formalisation of typical counselling work: for the same reason, I was always confident that Eden's research would succeed.

Referring again to figure 11, Z's models of the process of conflict could well include figure 11 itself since this relates to the purpose and process of conflict-resolution consultancy. There may be an initial perception by X and Y of conflict with Z, his processes and his models, and it is important to resolve this so that Z is accepted. Even then, this acceptance may need to be reinforced, even re-established during the consultancy process. In doing this rapidly and unequivocally, the permanent display of and constant reference to diagrams such as figure 11 could be more effective than words.

Burton and his colleagues have concentrated in their work on preserving acceptability through neutrality: they have found, in some cases, that it can even be helpful to know very little at first about the detail of the conflict so that they do not have prejudices, except of course about what they learnt from their clients.

Going back now to the preceding section, concerned with my problem of a language for structuring problems and how to employ it, I am very conscious of the attraction of the Burton process (and also the Eden process) because of the close attention to a neutral stance. However, as I have already indicated (chapter 1), such processes make great demands of, and require great commitment by, the clients. Provided that the process used maintains an awareness of and a conscious analysis of conflicts (note 1) between analyst and clients, I believe that it is wise to be able to compromise between neutrality and

expediency (both in terms of a busy decision-maker's time and of a familiar way of working - the diagrammatic language alone will be a large enough hurdle).

It will therefore be necessary to have figure 9 as a constant reminder of the conflict that potentially (and initially inevitably) arises due to the imperfect neutrality of the consultant's stance and of the imprecision of the interpretation of communication. In principle, the communication should become increasingly meaningful to all parties as the problem-formulation process goes on.

The First Experiment

Having argued that there is a process of interaction with clients which can be suitably described and illuminated through the notation with particular emphasis on the problems of conflicts that may arise, I now want to examine what sort of initial experiment would be suitable to examine the applicability of the methodology so far outlined.

There are a few principles, which I will list and discuss, which will aid my choice (or, because I have in fact already been through the arguments before writing this, explain how I intend to choose).

- o The problem should be a real one in process of study by those who have perceived it as a problem.
- o The owners of the problem should be amenable to a systems approach to problems.
- o They should be known to me and I to them and a mutual respect should exist.
- o Their problem should be broadly understood by me, but I should not be personally committed to a particular style or type of resolution of their difficulties.
- o They should know, or quickly be able to get to know, the nature and principles of my methodology.
- o They should be critical, seeking to use the methodology but unwilling to accept it unless it was seen to go deeply into their problem and to steadily enhance their perceptions of

how they might best formulate it.

The first of these principles I take as self-evident. The next four are principles which ease many of the difficulties of communication and conflict for a first experiment. It is not an adequate confirmation of the methodology if all goes well, but it will clearly be necessary to make drastic changes if the reverse is the case. It might be argued that falsification would be achieved more quickly (if the methodology is misconceived) with a tougher test, but there are many practical aspects of the methodology that still have to be learnt and developed (how to increase the detail of problem representation; how to recognise whether one has gone as far as possible; how to actually carry out the stage-by-stage arguments about different problem-perceptions; and so on). In other words, I have to resolve my problem (figure 9) in the process of resolving that of others.

The last of the six principles stated is of particular importance, and it raises the question of how to maintain the clients' concern that the methodology should be critically tested. It is made of more consequence by the fact that several of the other principles implicitly introduce risks that polite and supportive responses might replace the required harsher tests of critical assessment.

The co-operating clients would be more suitable therefore, if they had a vested interest in there being such a methodology as I intend, and if they also had a requirement for its having a general (rather than a specific, own-problem oriented) validity. Such clients might be of several types. They might be people who are aware of past difficulties in being confident that they had the right problem; they might be conscious that internal or external conflicts implied that their problems had been far from mutually agreed; they might recognise that their problems had been of many different types, but that some systematic process of formulating them would be of value (i.e. they would see the value of generalised and therefore more repeatable and controllable approaches).

The strongest motivation for critical appraisal that I can think of would be that the lack of a suitable problem-formulation methodology was in fact a part of their problem. This lack is a problem that, as

a practicing operational researcher, I have been concerned about for some time, and that is why I have set about the research task of resolving it. But what sort of operational researchers might be suitable clients? Most 'good' practitioners (see chapter 1) seem to have methodologies of some sort, not necessarily unsound or seriously lacking but not explicit, and therefore very difficult to impart to others except through a long apprenticeship.

Teachers of operational research (OR) do in fact teach something about problem-formulation in this way. But what they can teach is limited. Indeed, the methodology of OR as a whole is accepted to be very difficult to teach usefully, except through experience (on-the-job-teaching). An inquiry into this problem, instigated by the NATO Science Committee was carried out by an Advanced Research Institute (Bayraktar, B.A. et al (eds.), 1979) and it has been variously debated since. Teachers are without doubt very keen to increase the range of explicit theory and methodology of OR that can be taught.

My preferred clients would therefore be a teaching group who wish to increase the generality and methodology content of their education in and for OR. Such a group would be one of which I was not a direct part but with which I had a reasonably close relationship. The next three chapters deal with the experiments, subsequent considerations of methodology, and conclusions (note 2).

Notes on Chapter 3

1. My use of 'conflict' may create adverse reactions in the minds of clients who would see it as connoting a critical attitude to their organisational behaviour: like 'prejudice' and 'misperception', it could lead to a lack of trust, a feeling that they were 'on trial'. (Dr. J. Kidd, Aston University). I am conscious of this risk and am prepared to use other language if necessary.
2. This and the two preceding chapters complete the first and part of the second stage of the research study as outlined in appendix D. The time scale was met: just over a year was spent in producing this material. It includes a number of ideas (not originally related to problem-formulation) which existed in informal, unpublished notes by myself and former research colleagues. What was not originally mine has been acknowledged; in its present form, it is mine (in Ackoff's sense) and no responsibility attaches to others for any shortcomings or errors in its presentation. Similar remarks apply to comments made by several colleagues on earlier drafts which I have included as notes on the chapters.

CHAPTER 4THE ASTON EXPERIMENTIntroduction

On December 3, 1980, after a period of discussion with Dr. Raul Expejo of the Management Centre, University of Aston, I forwarded the following statement for consideration by the teaching staff of the Management Centre's Operational Research and Systems Analysis Group.

"RESEARCH IN PROBLEM FORMULATION

I have devised, from earlier work on conflict resolution, a systems-based diagrammatic notation to assist in the description of and communication about problems. I wish to test the applicability of this in practice. Following discussions with Raul Expejo, I wish, in particular, to become an analyst/consultant (unpaid) to the client group composed of those involved in the OR/SA teaching at the University of Aston.

The problem that I perceive, at this moment, is the problem of "developing and maintaining an integrated MSc OR/SA course in the Management Centre of the University of Aston." This is, of course, a totally inadequate statement to give a basis for action.

With those who are willing to become my clients, I propose to act as follows, to a time-scale governed by the time you can afford.

1. Early in January, 1981, I shall send copies of a short paper outlining the notation, and the rules for its use. Raul has more detailed papers.
2. I shall also send a very rough diagrammatic indication of how I perceive the problem.
3. You are requested to respond, using the notation and/or any other 'language' (basically English!) giving your own individual or joint perceptions - preferably individual because this will produce richer detail of problems within 'the problem'.
4. I shall respond with queries, new diagrams, etc., to each one

of you. I shall not, without permission, refer your views to others.

5. When I have 'sufficient pictures', I shall request a joint meeting at Aston to discuss implications of the findings to date. At this stage, your individual views will need to be expressed by you, with me in the role of an incompletely neutral mediator. If you are willing to exchange and study explicit views produced independently, before such a meeting, so much the better.
6. The process iterates but with close group participation. At some stage we shall, I hope, be using a common notation modified as necessary from the initial one: the 'problem' should be 'better defined'.

Be critical. If we succeed you will have something of value for planning and teaching. If not, I must return to the drawing board."

On December 12, the statement was considered at a departmental meeting and on December 16, Dr. Espejo wrote to tell me that "(it) was indeed well received", that "all members of the group are keen with the idea", and that he expected that I would "receive all the necessary support".

In anticipation of a favourable reply, I had already drafted the paper on notation and rules. It was a 12-page summary of the essential elements of this larger document. It had a second role as an invited paper for the 1981 International Federation of OR Societies' Conference in Hamburg, and was published in the Proceedings of that Conference (Bowen, 1981c). It does have minor additions, such as a comment on the transfer of aim to policy to aim, and so on, down a hierarchy, and a reference to work on communication distortion (Laing, 1980) but these will not be enlarged on here. The dual purpose of this document did not involve any compromise since the message for the Aston Management Centre was always intended to be fairly general and not overly-prescriptive, a document for information and discussion.

The First Phase

Procedure

On January 26, 1981, I sent to all eleven members of the University of Aston's OR/SA teaching group the rules of the notation and six

diagrams. The data on which these diagrams were constructed were taken from a formal document prepared as a statement to the Science Research Council's Mathematics Committee, from notes that I had made during discussions, primarily with Dr. Espejo, and from informal internal documents.

I asked that I be informed of where individuals differed from or did not understand my treatment of the as yet incompletely defined problem. I suggested that they might wish to indicate to me their personal problems within the overall course development programme or how they saw such problems arising in the future.

I stressed that 'conflict' was not intended as a pejorative word. I noted that there would be many constraints imposed by individual styles, beliefs, needs and so on, and these could develop into more difficult situations unless conflicts could be controlled or phased out.

It was intended that individuals responded to me in their own way and in their own time. At that stage they had current teaching and examinations to cope with as well as planning towards a very different course and its integrated teaching.

The initial diagrams (note 1)

These are provided, together with those that followed, in a pocket inside the back cover of this thesis (attachment 1). The 'rules and notation' (Bowen, 1981 c) and a second published paper (Bowen, 1983) which is a short version of this chapter are also there - attachments 2 and 3. Diagrams 1 to 6 show the picture that I had so far gleaned.

Diagram 1 showed the management system and its main environment: individuals were named but this detail has been omitted here.

Diagram 2 was a very incomplete picture of the proposed course and I commented also that it was clearly subject to conflicts and constraints.

Diagram 3 showed communication and purpose and drew attention to primary potential conflicts (as currently perceived by them).

Diagram 4 showed resource allocation and associated conflicts. I drew their attention to the inadequacy of this diagram and said that their views were particularly required.

Diagram 5 dealt with personal aims, policies and values. I noted that it would be useful, eventually, to have explicit aims, policies, and so on, for each individual.

Diagram 6 dealt with the monitoring of the programme. Its relation to the other diagrams are indicated, as shown, by the footnotes.

The responses

Because of my own involvement in other work, namely studies of the use of analysis of options and hypergames in the examination of problems and their resolution (Bowen 1981 a), and because of my clients' pressure of work, there was a lull in our interactions. Since my hopes of written responses were clearly not going to materialise, I arranged for a series of one-hour interviews at the University. Two members of staff were away, including one of the senior lecturers who was to be on sabbatical leave for a year, and I was also unable to see the Acting Head of Department.

The eight interviews took place in May, and my analysis of these was forwarded to the Acting Head of Department in June. Diagrams 1, 3, 5 and 6 (first revise in each case) show the changes made to diagrams 1, 3, 5 and 6. The following paragraphs summarise these changes.

The management system (diagram 1, first revise)

The senior lecturers were not perceived by themselves or others as a management group. Policy was determined by departmental staff meetings and might be implemented, as appropriate, by any member of staff particularly by those with named roles (e.g. course organisers; admissions tutor). Apart from the Head of the Management Centre, and the Dean, both of whom, it was said, should be concerned with ORSA relations with external organisations, the Director of Post-Graduate Studies was seen as the focal point, both for publicity and administration. A minor change was the disappearance of a link

with the Mechanical Engineering Department which was not seen as of any importance, despite a specific reference to it in the original SRC document. Other changes reflected staff movements.

Communication and purpose (diagram 3, first revise)

The main changes reflect changes already made to diagram 1. Communication between the Acting Head of Department and the main Course Organiser is now stressed: there is a somewhat strange and dual hierarchical relationship between them which will be referred to again in discussing other aspects of the problem. Another important feature is the Admission Tutor's need to have good contact with potential students prior to their joining.

Aims, policies and values (diagram 5, first revise)

No further comment is necessary for this revision of diagram 5, except to point out that the Course Organiser becomes potentially the arbiter between individuals with regard to their personal aims and policies. This puts a responsibility on him which is outside the natural administrative hierarchy, and his formal and informal relationship and communication with the Acting Head of Department is critical.

Monitoring and co-ordination (diagram 6, first revise)

Changes made here are major ones. Here the Acting Head of Department (AHD) is seen in his natural role requiring, in particular, information from the Course Organiser, who is at the hub of day to day course development activity, so that he (AHD) can check whether the course's purpose for which he is responsible is being reasonably met.

Discussions with the Acting Head of Department

The letter which accompanied these diagrams, spelt out many of their implications in detail. In particular, it suggested

- a. the need for a description of the course with regard to
 - (i) the relationships between its parts; and
 - (ii) the relationship of these parts to an explicit and detailed statement of the ideal aimed at, implying a major development of diagram 2;
- b. the development of a programme for monitoring the teaching programme with particular emphasis on individual roles and values, implying further extension of diagram 6, first revise and the other diagrams which extend its understanding; and
- c. in due course, when the new teaching programme was underway, a proper development of diagram 4 to deal with the sub-problem of resources stemming from shortages of time for staff to do what, professionally, they needed to do.

In July, I met the Acting Head of Department to obtain his reactions to what had emerged. It was agreed that he would provide a more detailed statement of his intentions for the course, including the minimum concepts necessary in the teaching to make students aware of the nature and practice of ORSA. He would also try to give me a fuller description of the intended teaching programme based on the draft syllabus planned to come into operation in October, 1981.

His general reactions were remarkably similar to those expressed by those who participated in an exercise at Royal Holloway College (Bowen, 1981a) to examine their problem of the cuts in University finances. Namely, he found nothing "new" in what my diagrams said (not surprising, since they merely reflected what he and his staff told me), but he did feel stimulated into action: in particular, he agreed that explicit systemic models must be available for monitoring and co-ordination (indeed he started to develop ideas based on diagram 6 revised, although we had insufficient time to develop these together).

The Second Phase

In August 1981, I received the papers dealing with the aims and objectives of the course (due to start in October). The first paper gave the learning objectives (L.O.) in a provisional form, and this is included with the diagrams - attachment 4. It was intended to

use it as a pilot evaluation device, getting students to respond, at the end of each term, to questions about how they felt the objectives had been met for them. The second paper was "a crude attempt at an overall map relating a set of named skills or knowledge topics to the course modules" and I was asked if I could design something more complete without the diagram's disappearing "under a spider's web of interconnections".

At a meeting (for another purpose) on September 3, I provided a questionnaire for students based on the L.O. (this questionnaire is not given here, since it was in the event never used in a systematic manner) and also obtained some reactions to a first draft of a diagram linking the L.O. with the course modules as described in the syllabus. On September 7, I forwarded an improved diagram (diagram 2, first revise). I took the syllabus document to represent the best information I had on the "desired programme" (see diagram 6 first revise) while the L.O. similarly represented the "explicit espoused values". I drew attention to the fact that I was aware from the September 3 meeting that the syllabus as then perceived by individuals was clearly not what had been written nor was there agreement on exactly what it was. I also raised the following points.

1. The questionnaire, based on the L.O., could provide a direct communication route from students to the Course organiser and the Acting Head of Department, with statements of satisfaction or dissatisfaction with learning progress. If this was done an appropriate link should be added to diagram 6, first revise.
2. I suggested that the teaching staff should examine the L.O. periodically to enable them to comment systematically on what teaching they have intended or been unable to include, and on what they perceived others to be providing.
3. I saw diagram 2, first revise, as part of the control and monitoring facilities, for use as the course proceeded. I stated that it should be redrawn as necessary by those teaching the various parts of the course.

In the new diagram 2, the arrowed links between 'boxes' implied that the teaching in one box should enhance the learning related to the L.O. numbers in the box to which the arrow went. I stressed that there were bound to be some conflicts of opinion between staff on these, and of course, that my perception was merely a starting point for discussion and debate.

Once the course started, and many of the issues implicit in all the diagrams became real problems, the pressures on the teaching staff became such that they had no time in the first term to think about precisely what they were doing - all their energies went on the doing! If I had been an in-house adviser (and I realise, in retrospect, that I had always thought about my methodology as a tool for such an adviser), it would perhaps have been possible to work with individuals in their 'spare moments', as well as to observe directly what was going on. However, such actions were not practical.

It was not until late February, 1982, that I was able to meet with the Acting Head of Department (and others) to be briefed broadly on what had transpired and to plan the next interaction. The following questionnaire was prepared, it being made clear that any confidences would be respected if things had to be said which could not be fed back to the group as a whole.

QUESTIONS

1. Do the Learning Objectives (L.O.) represent adequately your perception of what the Group aims to teach and should be teaching?
In particular,
 - a. are any of the objectives clearly wrong?
 - b. are there objectives which you would like to have added?
 - c. are any of the objectives too idealistic?
2. Which of the objectives, in part of whole, will be broadly met by the courses you teach?
3. Which other courses (which others teach) do you see as important to the same objectives as these in 2?
4. Have you any comments (further to the above), on any of the

courses, that imply discrepancies between intentions (as presented by the learning objectives) and likely results? [For example, there may be personal attitudes to material that individuals wish to teach; limitations on what individuals are able to teach; and constraints such as time, facilities, student attitudes and abilities; and so on.]

5. Have you any disagreements with my statement (figure 2, first revise) other than those implied by your answers above.

I received responses from the Acting Head of Department, the Course Organiser and the five main teachers, during visits which took place in April 1982.

Sorting out what I learnt was a complicated and time-consuming task. Diagram 2, second revise, was forwarded in August 1982 with a wealth of comment (see note 1); nothing was added by me to what was told me except in the form of separate questions and observations for the next interaction, and nothing was omitted except by generalising some statements to preserve confidentiality. The following summarised what was done.

1. I listed the stated views on the CORE teaching, both those of satisfaction and those of criticism and self-criticism.
2. I listed general comments on the L.O. and then comments on each L.O. in turn. (These provided a rationale for my new interpretation of the placing of numbers in the second revise of diagram 2.)
3. I gave an account of views on the integration of teaching across the course.
4. I noted that there were no basic disagreements with the first revise of diagram 2 as a format for information although there were many modifications required. One teacher had had difficulty in understanding what was implied, but this seemed largely due to the inherent complexity of the course. Another saw such diagrams as essential steps in the understanding of what was going on. The Acting Head of Department referred to the structuring as "a stimulus to our thinking".

5. I provided notes on their comments which implied the need for second revisions of diagrams 1 and 5.

My suggestions for the next stage were as follows (actions by them):

- a. to discuss rewriting the syllabus to be more like what is taught (note 2);
- b. to discuss rewriting the L.O. so as to make them more easily understood (free of jargon and woolly phrases) and acceptable as reflections of what is taught;
- c. to discuss whether diagram 2 now represented present reality and how it should be changed by modifications as above;
- d. to examine resources of time and people, related also to needs outside the MSc course;
- e. to consider student reactions to the course and other opinions (for example, those summarised by me); and
- f. to look at my comments on diagram 5, first revise, which I saw as important to both the course development function and the monitoring and control function.

This last was concerned with differences of opinion on the relationship between the Course Organiser and the Acting Head of Department.

It was suggested that the latter was not a main channel of communication with the former, and that the diagram did not reflect the informal structure of planning and implementation. Diagram 5, first revise is concerned with the personal attitudes of teachers and links with diagram 3, first revise: course development is covered by the latest diagrams 1 and 2.

I pointed out that there were pressures on teachers. I accepted that, normally, negotiation between the Course Organiser and individual teachers would be informal and amicable. However, should there be a clash, the Acting Head of Department should be situated so that he can be the resolver of conflict. I believed that I had faithfully reflected his view: if not there might also be a need to reconsider "Monitoring and Co-ordination" where he is seen clearly as superordinate.

The Third Phase

The next phase of our interaction turned out to be very much related to the last of the issues just discussed, although the others entered into the particular situation which arose. Important differences of opinion about the direction in which the course was progressing and the way in which other university pressures and duties has affected the intended open communications had led to management difficulties. In retrospect, I observed that the earlier analyses had foreseen this possibility, but insufficient emphasis had been placed on organisation to prevent or minimise it.

For reasons of confidentiality, no detail can be given relating to the discussions that took place in October, 1982. My analysis of the situation, through discussions with the eight people primarily involved was forwarded on November 8, 1982. I later wrote a summary of the whole experiment, (Bowen 1983, an offprint of which is included with the diagrams), which went through an editing and approval process with my clients. I do not therefore wish to include more about the third phase here, but I draw attention to the section of the published paper that deals with the use of the notation for representing the actual process of communication within the group.

Despite the fact that I would have liked to continue this study, it seemed likely that I had got what I needed from the experiment. In February, 1983, I wrote to the Acting Head of Department:-

"... While 'the problem' looks very different now than it was a year ago, experience has made it better known. It is suggested that I have said what people already 'knew': it was always my hope to make explicit what you all 'knew'. I shall never know whether my interventions helped this knowing ... It was never my intention to propose solutions, merely help identify problems as perceived, as part of the process of my finding out how my methodology would help me in doing this. I would like to look at some of the specific questions now arising if you and others wish me to, but I would first want to know what areas of your problems need clarification ..."

Conclusions

The findings and conclusions of the experiment are given in the published paper (Bowen 1983). Again, because of my responsibilities to my clients, I do not want to add to or change the words that they found acceptable. More general conclusions, covering the whole study, are in Chapter 6.

Notes on Chapter 4

1. It is not possible to make the diagrams fully self-explanatory in this thesis. In diagram 1, for example, there are organisations shown whose relevance and purpose were fully interpretable by the client-group. In particular, diagrams 2 (first and second revise) cannot be understood in detail without an intimate knowledge of the ORSA course: the important features of these diagrams are their inherent complexity, the interlinking of 'separate' subject areas and the differences between them. It is necessary to realise that I was presenting what I understood my clients to be saying about their problem, and that the diagrams formed an explicit background for a continuing communication between us: both sides shared, albeit imperfectly, a common fund of detailed knowledge. Some notes for readers are given with the diagrams.
2. Primarily, this would deal with major differences in the CORE teaching between what the syllabus implied (diagram 2, first revise) and what the teachers intended and implemented (diagram 2, second revise); part of the difficulty lay in adhering to normally acceptable formats for a course syllabus for the purpose of getting the course approved. Secondly, there was no clear linking, in the syllabus, between what was in one module and what was necessary for leading into other modules; some essential elements, in the event, remained untaught. Thirdly, there was more in the syllabus than could be taught explicitly with the time and staff available. The use of a "gradual learning process" also led to different students learning different things, depending on their insights. Additional comments are made in Bowen, 1983.

CHAPTER 5FURTHER THOUGHTS ON SYSTEMS METHODOLOGIESIntroduction

One of the difficulties of concluding an inquiry of the type undertaken here is that new literature appears faster than one can fully assimilate it. There are conflicting risks as one's own ideas become more clearly formulated: on the one hand, there is the problem that the development of ideas that one has are incompletely carried out because of the influence of the half-digested, possibly mistranslated, ideas of others; and on the other hand, there is the danger of rejecting new material because it disturbs the stability of an established personal view (Huxham and Dando, 1981).

I decided to study Checkland's book in more depth when the work described in the preceding chapters was almost complete. The idea was to criticise it and my own work together and to seek reasons for any apparent discrepancies, particularly because my discussions with those who had studied and used his ideas, implied a need to argue more completely my feeling that problem-formulation was not sufficiently structured in Checkland's methodology.

I also comment, albeit more briefly, on the potential of System Dynamics in the problem-formulation phase.

Checkland's Systems Thinking

Although it is the second part of the book (Checkland, 1981) that is more important to my thesis, a few remarks on systems thinking as Checkland interprets it are relevant. In commenting on methodological and scientific aspects, I concentrate on matters directly or indirectly related to the problem-formulation process, or, as I believe Checkland would call it, "understanding the problem situation".

Had we differed in our underlying philosophy of science and in our appreciation of how and why thinking about systems (other than 'hard' or physical systems) must depart from the norms of science, there would be little point in any comparison of my practice and his.

However, there is a great compatibility, all the more interesting because our research programmes have been quite independent, bearing in mind, of course, that the influence of others, directly and through reading, makes true independence of ideas unlikely.

There are six aspects of his teaching that I wish to stress.

1. He sees the need to use his own methodology to study "the client-consultant temporary system ... one which needs to be engineered, not left to chance communications" (see my figure 9, and the discussion of it, in chapter 3).

2. He examines the problems of testing a methodology and comes to conclusions very similar to those of chapter 3.

3. He reinforces my decision to follow Popper's thinking and gives reasons why he does not see a conflict between the accounts of science given by Popper and by Kuhn. Despite pressures from colleagues, who perceived such a conflict, to study Kuhn's philosophy (e.g. Kuhn, 1962), I had already come to the conclusion that Kuhn was not relevant to my purpose. Checkland says: "Kuhn's account stems from an historical study of how actual scientists have behaved in the past: Popper's account concerns the logic of this activity". It was the logic that I wanted.

4. He uses, on occasion, set theoretic diagrams and influence arrows in a manner similar to mine, although he has not developed his ideas and so they lack consistency, discipline and definition. Indeed, he is quite deliberately not prescriptive of his use of notations and is prepared to select as appropriate for his purpose (note 1).

5. He calls for methodology which is flexible enough to incorporate or be compatible with the ideas and processes of other methodologies. He is not anxious to claim that his is the definitive methodology (I also avoid such a claim).

6. He is willing to use 'hard' systems approaches for parts of study if they have logical merit, namely when the problem can, at least for the time being, be assumed to be clearly posed. I would agree, provided that problem-formulation is seen to be thorough.

These few comments do not, of course, do justice to the very clear and informative account of systems thinking that Checkland provides. They do, however, underline important areas of agreement.

Checkland's Systems Practice

Despite such agreement on systems thinking, there are marked differences in my approach and Checkland's in practice. I believe that these stem largely from different views of the role of an analyst in relation to his clients.

I wish to avoid, as far as possible, any imposition of my ideas on the clients: it is my intention to help them to express the problems situation through their weltanschauung (W). This W will be changing over time, and will be involved with all the value judgements and conflicts that they perceive themselves and others to have. Eden and his colleagues would go further than I in seeking to preserve neutrality. Checkland, correctly perceiving, as we would all agree, that absolute neutrality is a myth, moves in the other direction. He becomes a co-owner of the problem-situation and an active participant in its resolution. In his terms he is an Actor in the situation and affects it through his own W (note 2).

I do not believe that there is yet enough knowledge available to say what is best. One methodology will be handled better than another by a particular analyst, and will be received better by a particular client. However, there is one constraint which Checkland imposes that creates a difficulty, in the sense that I cannot accept it absolutely. It concerns the problem-situation.

Expressing the Problem-Situation

In considering how to go about expressing the problem-situation, Checkland refers to:-

"... recording elements of slow-to-change structure within the situation and elements of continuously changing structure and forming a view on how structure and process relate to each other ..."

He says that this stage of analysis should not be pressed in systems terms and that one should not, at the initial stage, impose a structure. I do not see how one can define in the model world, any relevant system, without some conception of the part it has to play in alleviating concern over the current situation: this requires a framework in which to imbed it. In the end, this framework must be a systems one, since a later comparison phase between the 'now' and a possible future has to be carried out: the systems language of the conceptual new system has to be compatible with that of the description of the present situation (note 3). There is also a difficulty in setting up root definitions of systems of concern unless there is an adequate framework.

I accept, of course, that there will be a gradual process of movement towards a more structural and more acceptable framework. Perhaps 'impose a structure' implies a 'hard' approach: my systems would not be seen by me as 'hard' and they are expressed as the client sees them. It is certainly possible to deal with "roles, norms and values" within my framework: indeed, I am forced to consider these and to see them to be as important as Checkland indicates. "Power", or, as I prefer to see it, influence of various kinds, is also necessarily taken into account.

There is almost certainly some problem of language here. Checkland is properly insistent on avoiding 'hard' approaches to 'soft' problems. He speaks of "recording ... structure" and there should be no reason to avoid systems language here, whatever constraints he may wish to impose on descriptions of process. He may, however, already use some looser systems statements in describing the problem-situation, and so may be prepared to accept my initial structuring, for communication purposes, as a reasonably 'soft' approach. Much of the hardness, that seems to be inherent in a technique, vanishes if the technique is used in a less ambitious mode - even statistical method can be applied without imputing to numbers the rigour that their normal usage would imply.

Reactions to Other Philosophies

Checkland and I have similar reactions to the ideas that underlie the philosophies of Vickers (1965) and Churchman (1971) and find them broadly acceptable within our own. In the case of Churchman, I would perhaps interpret him somewhat differently, for example, his statement "I am often inclined to put implementation questions first i.e. can anything be changed" (Churchman, 1979). I take this to be equivalent to my insistence that implementation and problem-formulation are closely related: the problem cannot adequately be explored unless there is an understanding of what can and what cannot be changed, at least with the time-scale being considered. Checkland, however, sees it relating to the relevance of changes that are actually being proposed to a system and would work back to establish a case for the existence of such a changed system. Both of us are perhaps reading our own philosophies into Churchman's words.

Our attitudes to Ackoff's methodology are fundamentally different however, and words may again be getting in the way. Checkland reacts against the 'hard' terms used in Ackoff's language, and particularly the goal seeking model of human behaviour. I take this model, in Ackoff's framework as an 'as if' concept. In Checkland's conceptual models, purpose (goals) is necessarily stated in the root-definition of the relevant system. This system is a mental construct and I see all of Ackoff's methodology as dealing with such constructs. Similarly, Ackoff's ideals are even more desirable systems or states, known to be impossible to achieve, but nevertheless setting some perceived direction of pursuit. It is very important to accept that Ackoff is not proposing to resolve people's problems, but to offer ideas to help them to take what is, for them, appropriate action to assuage their concern with the present.

Towards an Integration

Broadly, I can see a modus vivendi between my approach and Checkland's. What I am doing aims to provide what Checkland admits many analysts want, namely, more help with the process of gathering a rich impression of the problem-situation. I try to do this with an

absolute minimum of prescription - despite my addiction to Popper and to Ackoff. I also wish to display the situation so that potentially relevant choices can be revealed - the question that is insistent is: "Is what we are doing what we intend it to be, and is it getting what we want?" My comparison process, conceptually similar to Checkland's, is aimed at keeping this question in the forefront of the clients' minds: it is the changes that take place in the clients' actions, values, W's, and so on, that move the process towards their realisation of what they must do. Then they might seek help in stating alternatives, in how to choose, and how to implement, but these are not the parts of the total decision process with which I am primarily concerned. However, if they are stated as problems in themselves, there is no logical reason why the problem-formulation methodology should not form a part of the help given with them: the whole of the decision process applies to the choices inherent in the part of that process, a fact which too many operational researchers have ignored (this applies of course to "implementation" which I refer to in the section on Hildebrandt's view of implementation in chapter 1).

In general, I find most of Checkland's procedures to be most helpful, although I might use them slightly differently. CATWOE, the specification of:

- Customers of the system
- Actors responsible for the
- Transformations provided by the system;
- Weltanschauungen (world pictures) which control the way the system
is perceived.
- Ownership of the system; and
- Environmental constraints,

is relevant for ensuring that all these are explicit, or suitably implicit, in the system structure that states the problem. The Workbook is a sort of check list, invaluable as an aid for setting any study into motion: it is an excellent example of the sort of thing that might be a means for aiding decision for use by clients as opposed to analysts.

Finally, there is the concept of the root-definitions of systems of concern. This is an attractive idea as a complement to a diagrammatic structure. As it is put forward by Checkland, I have two reservations: it is not clear what guides and stimulates their formulation, nor whether they have to be acceptable in principle to the owners or potential owners of the systems, or whether they can be simply models used by the analyst for his purpose, at least initially. My equivalent process is implicit in the focussing of attention on separate parts of the problem structure as it develops: in both cases, there is an iterative process which includes the comparison process which I have referred to already, although the purposes of the two iterative processes relate to different stages of the total decision-process. (See note 4.)

System Dynamics

It has recently been claimed (Wolstenholme, 1982; Wolstenholme and Coyle, 1983) that the notations and procedures of System Dynamics offer a generic problem-formulation process. The later paper may be said to be much less forceful in its claims than the former. The full technique description of this systems methodology is given in Coyle (1979).

There are two main reasons why I cannot see System Dynamics as a basic methodology for the purposes, and with the required scope, that I have discussed. Firstly, it was not designed for such a process. While there will undoubtedly be problems for which system dynamics modelling is appropriate, these are more likely to be 'hard' systems problems in Checkland's terms. Some of Checkland's arguments also imply that the use of a technique, developed for a class of 'defined' problems, is inadequate for the messes that require understanding of what problem situation is being addressed.

Secondly, it seems to me that the technical language and diagrammatic notation of System Dynamics may well hinder rather than aid communication. In general, both reasons will tend to mould the problem to the technique, or the principles of the technique. In Checkland's methodology and in mine, the arguments start from the nature of the problems to be tackled.

Nevertheless there are attractions in system dynamics procedures. Eden, Jones and Sims (1979), for example, state:-

"We constructed a computer simulation model which could be used to demonstrate ... how [a] qualitative and subjective model could form the basis for the construction of a qualitative model ... not dissimilar from a Systems (sic) Dynamics model (for example, Coyle 1977) except that, since it was based upon a model of the world as the client group saw it, then it could be seen by them as a simplified representation of their reality".

Again, they say (Eden, Jones and Sims, 1982) in a discussion on "coping with quantity":-

"It is important ... to distinguish between influence diagrams in Systems (sic) Dynamics modelling as they are typically used, to model the underlying structure of some 'objective' reality and cognitive maps which are intended to represent, using his own language and theories, the 'problem-reality' defined by the client."

They do not imply, in using a system dynamics model, that it is "the only appropriate form of quantitative model", but do stress that "it enables the important dynamic consequences of perceived feedback loops" to be dealt with.

Wolstenholme and Coyle (1983) return the compliment by their use of directed graph techniques, similar to those of Eden. I am left with the feeling that because there is all too little available to choose from to help formulate messy problems, it would be wise to watch what developments take place in System Dynamics. However, I have not found anything so far which makes me wish to change or add to the methodology that I have presented.

Notes on Chapter 5

1. Checkland encourages people "to use any map-making methods they want in providing a 'rich picture' of the problem-situation (never of the problem) and to be more coherent for systemic diagrams later on in the study". His paper "Techniques in 'Soft' Systems Practice, Part 1: Systems Diagrams - some tentative guidelines", Journal of Applied Systems Analysis, 6, 1979, University of Lancaster, addresses this point.
2. He does, however, expect those in the problem-situation to do the study with the help of systems analysts.
3. Checkland states that, since he deals with "models relevant to ..." rather than "models of ...", it is not inevitable that systems discussed are part of a potential future reality. He also notes that a conceptual model can be compared with the real world without any assumption that the latter is a system. I think I would find these subtle distinctions hard to make, and to maintain, in continuous interaction with clients.
4. It would seem that root-definitions can arise at any stage once the problem-situation has been adequately studied and a rich picture obtained. They might therefore appear either as a consequence of or as a precursor to my diagrams. It is probably wrong, in principle, to refer to "stages" of the decision-process, since it will always be necessary to judge whether the problem-situation has become well enough understood for a root-definition to be formulated: difficulties with definition might well lead to a need to modify any diagrams that had so far been produced.

(These comments follow communication with Peter Checkland. They have been added at the last moment, without there having been time for me to do more than offer an initial reaction. His statements quoted, or implicit, above were made on an early draft of chapter 5.)

CHAPTER 6COMMENTS AND CONCLUSIONSWhere to Go from Here

It is necessary to be clear about what is still to be done since 'the end' does not arrive in this sort of research. As work progressed, there were changes of direction and emphasis, although the original research programme, appendix D, has been followed more or less.

The first stage of formalisation of the diagrammatic notation, and its extrapolation from earlier conflict studies to the task of problem-formulation has been thoroughly covered. There have been extensions of notation and development of rules, both of which have been discussed, both in principle and through examples. A brief account has been published (Bowen, 1981c).

The second stage of looking at documented problems (of conflict) through the use of the notation has only been done in part. Firstly, it was found that there was insufficient detail to be worth going too far along this road; and, secondly, it seemed more important to study broad methodology to see what else was available that related to problem-formulation, and to establish a logical basis for the research as a whole. This has been done in chapter 1 as a preamble to the development of the notation (chapter 2).

Future tasks that may be considered as possible extensions of this second stage are:-

- o the use of the methodology to enhance the initial statements of the problem for both hypergame and metagame studies (see Bowen, 1981a);
- o a more detailed examination of the compatibility of the methodology with that of Eden (Eden et al, 1979 and 1982); and
- o further study, on practical problems, of its relevance and possible integration with Checkland's methodology (Checkland 1981).

These will be referred to again in looking at future developments of the third stage.

This third stage consisted of the consideration of an experimental framework (chapter 3) and the carrying out of an experimental consultancy (chapter 4). In these chapters, a satisfactory testing of the robustness of the notation and its use for communication is described.

However, this alone is not enough, except to encourage me to take practice further in actual consultancy. There are two current research studies in which such advances can be made.

A Hospital Study

For a local hospital Accident and Emergency (A & E) Department, others at Royal Holloway College have developed and are putting into service a computerised data-base with extensive detail on the reception, diagnosis, treatment and follow up of each patient. This has been done not only as a convenient filing and reference system for the Consultant Surgeon, but as a basis for research into his problems and his interests in various associations between treatments and consequences, information and diagnosis, and, for example, between prescriptive drug use and driving accidents. (It was an interest in this, as a result of other College research on road traffic behaviour, that initiated this co-operative study.)

It would be foolhardy to use such a data base for random statistical analyses to find out what correlations might be determined. What are required are hypotheses, stemming from beliefs born of experience. In simple terms, we require to know what ideas and problems are of concern to the Consultant Surgeon and we want to know the context in which these problems arise.

The intention is to formulate (or reformulate) these problems in the full context of the A & E subsystem of the hospital system. We require, among many things, a picture of the communications, the medical staff and equipment, and the flow of patients through the hospital system. We hope to be able to examine financial and organisational problems as well as medical problems as our understanding and experience develop.

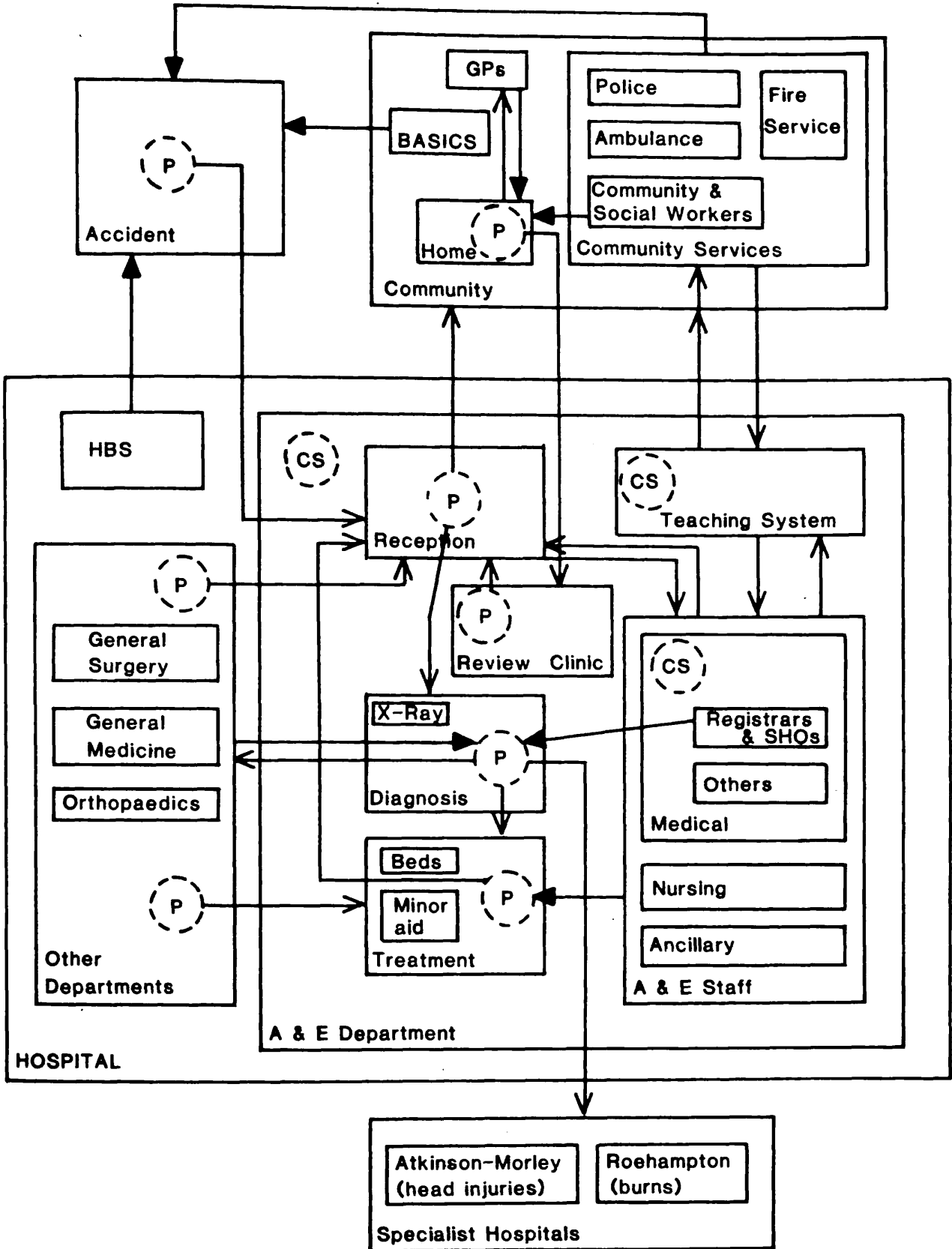
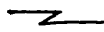


Figure 14 Diagram based on data in a lecture given by the Consultant Surgeon entitled "The New Specialty of Accident and Emergency"

Two aspects only will be referred to here since the work has hardly begun. Figure 14 represents the essence of the Hospital system as described by the Consultant Surgeon (in papers and in discussion with us). It uses an idea, previously suggested by me to a colleague who was developing a game for Ward Management (Hicks, 1976) namely to regard the patient as an essential body of information flowing through the system. Also, this provides some impression of the time dimension. Only one change, asked for by the Consultant Surgeon, has not yet been added to this diagram: namely, that he would wish himself to be part of the Diagnosis System, although his superordinate role in the Medical Staff and overall A & E systems implies his availability. His perception indicated a concern that his presence was very important, at least for the more serious cases. My own perception is that it may indicate an unwillingness to leave sole responsibility to his Registrars with the danger of some inefficiency in his absence.

The second aspect relates to other diagrams produced by a colleague who finds a need to express time delays for which he is using a sign,  on the arrow line. It is too early yet to say whether identification of reasons for this, plus some indications of something like a "patient queueing system" might make such an addition unnecessary. However, it was implied in Bowen and Smith, 1976, that "errors" of omission, commission and delay might occur in any interaction: the first two in effect are dealt with by the round based arrows, and it could be that the third needs its symbol also.

A Data-Information-Decision Study

Another research study to which the College is committed is that of examining decision-making in high military commands. Again, we are only at the beginning of the inquiry, but it seems likely that my methodology, Checkland's and Eden's will all have a part to play. This should provide an excellent opportunity to examine the last two of the three "future" tasks referred to in the opening section of this chapter. The other one may also arise, particularly since the analysis of options (metagame) technique, extended through the hypergame perspective

could become an important part of a method of studying the effectiveness of staff co-ordination within a Command and Control System.

Other early impressions are that control of such a difficult research area, largely unexplored, may itself need the same methodologies. The subject is a sensitive one (and I mean in a personal and organisational not in a security sense). Not only do senior officers not take kindly to suggestions that their expertise may be questioned, but those who sponsor the study, because it has important bearings on their equipment development, for action and for training, are aware that any infelicities in the handling of such research could have repercussions on their freedom to undertake it. It may well be that appendix E will become relevant in this context.

As I have indicated before, problems, wherever they occur, have the same generic form, including potential conflicts. and should be amenable to the same methodological attack. It is expected that my methodology and others will play a useful part in controlling the program of analysis and communication with the immediate clients and others who are actors in Checkland's sense.

Tentative Conclusions

For reasons already mentioned, it could be rash to draw definitive conclusions. Some of the lessons learnt from the experimental consultancy have already been stated in chapter 4, and in a paper presented originally to the Fourth European Congress on Operational Research (Lausanne, July 1982) and later in final form (Bowen, 1983) to a 3-day International Discussion Conference (IFORS & ORS) at the Management College, Henley, May 1983. I will not repeat those lessons here.

What seems appropriate is to state what I believe I have achieved:-

- o I have devised a "language" which is simple and understandable; a diagrammatic form of communication which can be used in discussion about the problem and, ultimately, for its formulation.

- o I have provided rules which impose a discipline on the preparation of diagrams and which force attention to certain aspects of systems (acquisition of data for decision, implementation of desired actions, multiple roles, communication and so on).
- o I have made the elements of the notation (and the rules) few in number, so as to avoid dealing with aspects of a problem in an idiosyncratic, specific problem, oriented, manner (Popper's principle of simplicity - see chapter 3).
- o I have developed the methodology for the specific purpose of problem-formulation: it is not a technique taken off the shelf and used for a purpose for which it was not designed - its genesis in conflict resolution studies is hardly surprising since problems and conflict are inextricably interrelated.
- o I have examined it against various ideas (not necessarily problem-formulation methodologies as such) without finding it in more than minor disagreement with these; and I have observed that it can be used as complementary to many of the wider ranging methodologies.
- o I have tested the methodology on my own problems in a very general way; I have used it to describe what I am trying to do and to help me to do it; and I have carried out experiments over a period of about 18 months, as a consultant to a teaching group.
- o I have not yet encountered any serious difficulties in expressing what I wished to express, despite the simplicity of the diagrammatic facilities. Although I have not yet had others (except in the current work described briefly above) using the notation to state their ideas, I have had useful reactions on the basis of diagrams which I offered as representative of those ideas.

With regard to this last statement, it is important to appreciate that the notation is not the methodology, but merely my choice of a means for developing the methodology and using it. There must be many other notations which others might prefer. However, I would

regard it as essential that any other notation be simple, communicable to a wide range of people (i.e. not be restricted to specialists as a set-theoretic or graph-theoretic mathematics would be), and generally capable of expressing the same ideas and concepts which are the methodology.

Finally, I do not claim that I have provided a proven methodology, since this would be a contradiction in terms. I do, however, claim that what is offered here shows great promise for practice and that it is a useful stepping-stone for advance. The river is wide and deep. Those who attempt to follow are advised to make sure that they can swim.

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What Ackoff is proposing for the practice of OR
and why I think he is right

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A paper presented to the OR Society Meeting on
"The Ackoff Proposals - Is the Debate Over?"

held at the Royal Society

10th December 1979

The purpose of this paper was to set the background of the debate by a summary of and comment on two papers by Ackoff presented at the ORS Annual Conference, York, 1978, and published in 1979 in the Journal of OR. It is printed here as it was delivered except that quotations and listings were presented visually.

References have been added - see reference list at the end of the main text.

Mr. Chairman:

This house, in which we hold our conference, belongs to a Society which had its genesis in Oxford, through the multidisciplinary interests of such men as Christopher Wren and Robert Boyle. It is not inappropriate that I, once an Oxford pure mathematician, now working in very different subject areas, should be speaking here in support of the ideals of Russell Ackoff - a man trained as an architect and whose philosophy seems to encourage combustion.

Despite the title of my address, I am not the opener of a debate. My aim is to help to close the existing debate, so that we can all, in our own very different environments, push on with improving and extending the practice of O.R. My personal belief is that what Ackoff says makes good sense; it coheres with the way in which I have done O.R., researched in and advised on O.R. and, from time to time, taught O.R. It has not made good sense to all, and it has angered some.

I shall try to clear away some of the misperceptions about Ackoff and his work. I do not expect this to lead you all to follow, precisely, the Ackoff trail. I do want you to see that his framework, and his use of it is flexible and capable of integration with many others, to the advantage of all.

There are many dimensions of the problem of O.R. which is a mess, a set of interrelated problems, as Ackoff defines the word (Ackoff, 1974). You will see that Ackoff's philosophy helps to decide how to do O.R. and how to teach O.R. It does not tell you what to do but it will help you to think about what you want to do.

Let me go on to some important words that Ackoff uses and defines, starting with an Ideal.

In 'On Purposeful Systems' (Ackoff and Emery, 1972), he defines it first in the technical framework being developed, and then restates his meaning as follows:

"(It) is an outcome that can never be obtained but can be approached without limit. In this sense we can say ... of some scientists that their ideal is to obtain errorless

observations. Even though ... an ideal can never be obtained, we can speak meaningfully of (its) pursuit."

There are two important observations that I want to make. Firstly, because of the pejorative implication, especially in debate, of the word 'idealist' (one who seeks to attain an ideal state) we should avoid that word today. Ackoff's purpose is 'ideal-seeking', in the sense of setting a course towards, and continually striving to get nearer to, a state which he desires but can never fully attain.

Secondly, therefore, he fully accepts that, because of the near-infinite complexity of the world he seeks to change, his philosophy is itself expressing an ideal. He does not expect that either he or others can fully effect the principles that he expounds. Because of this, the goals and objectives that may be set for O.R. practice, in any given environment, at any given time, may be far short of any ideal that Ackoff states. However, his judgement of some O.R. practice would be that it is not ambitious enough and, more importantly, that it is counter-productive to the acceptance, and the future, of O.R. as a valuable contribution to the decision-process.

I shall return to ideals in discussing idealised design of systems. So, a few words on 'systems'. I don't see Ackoff as being tied to any hard systems theory but to systems thinking in the sense of synthesis.

"... a thing to be understood is conceptualised as a part of one or more larger wholes, not as a whole to be taken apart.

Then understanding of the larger containing system is sought.

Finally the system to be understood is explained in terms of its role or function in the containing system." (Ackoff, 1979a)

He goes on to make an important distinction between knowledge and understanding (see also Ackoff and Emery, 1972, pp 46 to 53). In a simple sense, knowledge speaks of how something works; understanding speaks of why it works that way. If we intend to change a system it is understanding, not knowledge, that is essential information for our decision.

It seems to me that, while systems thinking, in a restricted sense, could shut off whole areas of the total relevant picture, there

is no logical reason why it should be so restricted. Indeed Ackoff says (and I also stressed this at an earlier meeting on methodology - Bowen, 1977b)

"There are no physical, chemical, biological, psychological, sociological or even Operational Research problems. These are names of different points-of-view, different aspects of the same reality, not different kinds of reality. Any problematic situation can be looked at from the point-of-view of any discipline, but not necessarily with equal fruitfulness."

(Ackoff, 1979a)

Bryer has attacked the Systems Approach as he sees it (Bryer, 1979) but in my view he wrongly interprets the work of Ackoff and Emery (1972). He seems to see it as a procedure for gaining knowledge, whereas I see it as an attempt (and offered as no more) to provide a framework within which knowledge can be ordered and co-ordinated in the search for understanding. No doubt, we shall be able to develop arguments on this issue, later in this meeting.

And now I come to objectivity.

Insofar as scientists, or any others, wish to take into account as much information as they can, honestly, truthfully and without bias, no one should be opposed to their intent. If, however, they claim to be unbiased, or to understand and correct the biases of others, they are claiming a god-like status, an ideal. Certainly, in the study of messes, as Ackoff defines them, the biases that exist in individuals' perceptions are real factors that influence events: they cannot be wished away because they are illogical or irrational in the personal value framework of an analyst.

Some will wish to help others to change their ideas (if the latter so wish): much of operational research as I have known it, involves activity to this end. But such help cannot be given if analysts offer their wares as objective in contrast to the more subjective approaches of their clients, even when this is true. There is no doubt in my mind, from my personal experience in defence O.R., and from my observation of what has happened elsewhere, that the "we, they"

attitude, where it exists, has seriously degraded the potential of O.R. and has made it both unacceptable and static.

Ackoff does not deny the ideal of objectivity, he merely argues that, unless it is understood, it will be misinterpreted and misused.

"Objectivity is not the absence of value judgements in purposeful behaviour. It is the social product of an open interaction of a wide variety of subjective value judgements. Objectivity is a systemic property of science taken as a whole, not a property of individual researchers or research. ... it is an ideal that science can continually approach but never attain. ... It is value-full, not value-free." (Ackoff, 1979a).

Ackoff's discussion of this is central to his thesis on the demise or near-demise of O.R. in many places. It is coupled with three other aspects: his emphasis on the differences between optimisation of the solutions of models and the search for acceptable real-world choices; his emphasis on the importance of all those who are not involved in the decision process but who are affected by it; and his concept of O.R. as not only dealing interactively with a wide range of discipline but also providing a framework by which this interaction can be made fruitful.

It is this last need that drives me to want this discussion to be integrative and not divisive.

I now come to a concept which is very important to Ackoff's philosophy. When he speaks of producer-product, he is emphasising that there are things that are necessary for the production of some object or property of an object. In open systems, these are infinite. Only in closed mechanical systems can we attribute a clear cause-effect relationship. Particularly in interactive systems at successive moments in time, the producer-product concept is important: a may produce b and b in turn may be a producer of a later form of a.

Ackoff is not, as was suggested at an earlier meeting at Bath, preferring Singer's concept of producer-product to the concept of cause-effect in order 'to stand everything on its head'. Such a mischievous procedure could enlighten, it could amuse and it certainly

could be a valuable debating trick. But as Ackoff argues, producer-product is a wider, containing concept, generally applicable and not restricted to mechanistic systems. Whereas cause is necessary and sufficient for its effect, producer is only necessary, not sufficient, for its product. Producer-product is an essential concept for the wide-ranging employment of the systems thinking that enables what he calls the humanisation, self-control and environmentalisation problems to be seen as embedded each within the next.

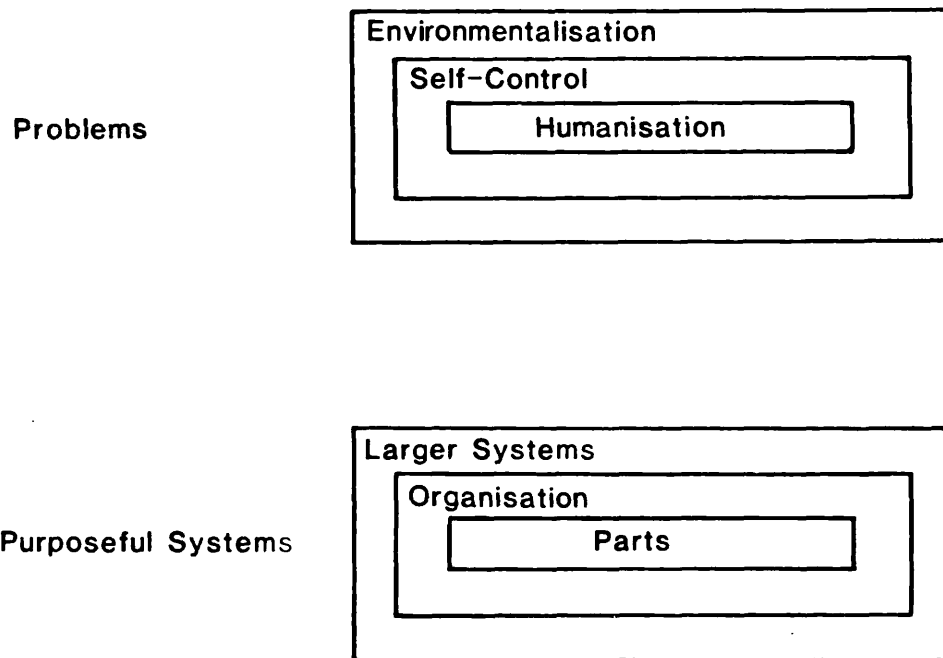


Figure A1. Problems and Systems relevant to the Concept of Producer-product

These deal, respectively, with the problems of the purposeful parts; the purposeful organisation of primary concern; and the purposes of the larger systems of which the organisation is part. It is essential to appreciate that Ackoff's philosophy is thereby insisting on attention

to the many unquantifiable and difficult-to-understand aspects of individual and group behaviour.

So far, I have discussed primarily and all too sketchily some of the important principles of Ackoff's thesis as outlined in his first York paper (Ackoff, 1979a). If he exhibits anger there, it is anger with what he sees as an almost total refusal by the United States O.R. Establishment to develop O.R. to meet the bigger challenges of the day. He in no way decries the importance of the many O.R. techniques which help with problems of a mechanistic nature. He does inveigh against a refusal to get involved with more complex social problems, and against the stupidity, if such involvement is accepted, of using classical O.R. techniques to tackle issues for which they are largely unsuited. Insofar as he includes the U.K. in his general attack, he recognises that in many areas people are pushing forward in ways that are not his style (and he has stressed that there is an obligation in any study to take style into account). Nevertheless, there is U.K. O.R. work which he sees as consistent with progress towards his ideal. He perhaps under-emphasises his disclaimer.

In examining his second paper (Ackoff, 1979b), we must accept any detailed extension of his philosophy as a personal approach (both possible and acted upon in the environment in which he works). It is an approach to the mess that is O.R. practice. It is neither the solution, nor can it ever be a solution. It can only be an attempt to move forward, and it can only be tested by results. Ackoff would claim that the results are not discouraging, although he admits that so far he has only managed to make small impacts on very messy messes. He is both a realist and a humanist: to regard him as being distant from sociological and psychological problems as they affect individuals, and to be concerned only with a cold theoretical structuring of such problems is quite absurd.

So - on to the ideas of resurrection of the future of O.R.

With regard to interactive planning Ackoff offers three principles.

1. The principal benefit of planning comes from engaging in it.
2. Planning should be continuous.

3. Every part of a system and every level of it should be planned for simultaneously.

The first of these is the participative principle. It was thoroughly debated at our Oxford conference, and I gained the impression that, despite the undoubted difficulties, it commanded wide support in principle. The second is, in effect, asking for deep involvement right through to implementation and control of the new system, something which many O.R. workers have sought, but few have attained. The third stems from the interactive nature of the systems we deal with; we all know the frustrations of providing analysis which proves to be irrelevant to those we serve because of changes in systems other than the one on which we, often without choice, have concentrated.

I suggest that, while it might be interesting to discuss how to overcome obstacles to the application of Ackoff's principles, we have no reason to deny their relevance and desirability.

His concept of an idealised design for the system planned for seems to me to be equally desirable, but very much misunderstood. It is the constraints placed on this design that are all-important. Firstly, the design should be technologically feasible and I do not intend to discuss this further. It should also be operationally viable. It is this latter constraint that makes a conceivable reality of what would otherwise be a pipe-dream: it would encompass the incrementalist approach and draw attention to what increments were possible.

One particularly important feature of idealised design, indeed of the conceiving of ideals in general, is this. Initially, one is not bounded by constraints other than those that, for some personal reason, confine one's thinking. For example, it may be that a decision-maker is likely to have strong antipathy to certain options: if neglect of such options is likely to constrain the idealised design, there is a new sub-problem - to get him to understand how and why such options might be better included.

The idealised design will not be achieved in any easily definable sense, because the test of its viability in the various stages of planning will subject it to continuous change. It will take into

account the many value judgements of those concerned (those who plan and those affected by the plan who should also be involved in the planning). It will take into account the many conflicts that will occur and, by its process, assist in resolving these. It will facilitate participation and motivate those involved to work for the future they desire. It will encourage creativity and direct its purpose, and it will widen the horizons of what is deemed possible.

How far one can go in practice is a matter of conjecture: all depends on the vision and persuasiveness of those brave enough to follow the logic of the principles. The hardest nut to crack is the further concept of a system designed to be ideal-seeking, having an ability to monitor its environment and adapt to changes. It is not that we do not all accept the importance of flexibility in this context: it is that conceiving the sort of flexibility that should be designed into the system is very difficult.

On the practice of O.R. Ackoff makes three points. I will do little more than state them, because I hold them to be self-evident.

We should undefine O.R. For a long time, O.R. has been, for me, what I do to help those who seek my involvement with their decisions. I hope that eventually we can usefully define it, but the definition must be adaptable under the pressures of the changing tasks to which it might be applied.

We must take interdisciplinarity seriously. I believe that it is not important to regard all the members of an O.R. team as doing O.R. The essential O.R. people are those who can shape those of many disciplines or expertises into a team capable of addressing the task in hand.

Finally, those who are concerned in any way with the decision, should be members of the team in some sense. We are back to the principle of participation. I would only add that the constitution of the team, in ability and in spread of skills, must be a factor in deciding what sort of idealised design is worth aiming for: it will not be operationally viable if it is not efficiently planned for.

In Ackoff's comments on the role of the Society, I don't see anything controversial. What he calls for, I believe our open society

has striven for, although our success to date has been limited. We also now have, although not initiated by the Society, a U.K. journal (the Journal of Enterprise Management), the aims of which are in sympathy with Ackoff's call for improved communication between O.R. people and managers. I shall watch its future development with interest. It is certainly not enough to talk to ourselves. I have often quoted an article, which I thought excellent, which bemoaned the lack of interest by operational researchers in occupational psychology. It was printed in the Journal of Occupational Psychology (Gregson, 1962), as if to advance its own argument by minimising the probability that operational researchers would be motivated by it - since they would be unlikely to see it.

I also believe that we discourage contributions to journals by too strict a refereeing standard of what is O.R. I know many, who see themselves, or are willing to see themselves, as doing O.R., who feel shut out. I am with Ackoff in urging our publications to be ever more adventurous; if controversy results, I believe this to be beneficial, provided it can be controlled - I suppose that such publications would be ideal-seeking and designed accordingly.

In his section on O.R. education Ackoff does two things. He puts forward, as an example of an O.R. education programme, designed to follow the principles outlined earlier, his own (S³) programme at Pennsylvania. He also comments on the 1978 Presidential address (Simpson, 1978).

Regarding the Pennsylvania education programme, he does not offer it "so much as an example to be followed, but to show how completely the educational paradigm that O.R. uses can be redesigned." He also states that "the product is far from ideal but it is systematically ideal-seeking and subject to continuous experimental modification." Since any educational programme must have many features which are personal to those designing it, whether an idealised design or not, I can see no purpose in describing again here what is clearly and factually described by Ackoff.

His so-called criticism of Professor Simpson, is important if only for the fact that Ackoff has been accused of rudeness, of comment

inappropriate to an occasion when the President was presiding. I find it difficult to find support for these accusations: Ackoff started by saying that he was not taking issue with the President, but with a concept of teaching that he shared responsibility for in the 1950s and 1960s. He then proceeded to say why he thought that this model for teaching, which was still being used, was no longer what was needed. I believe that the 'offence' taken on the President's behalf was a rationalisation of a refusal to listen to a view that might shake confidence in present methods of teaching. I hope Mike was not himself offended, however surprised he may have been. (I learnt after this paper was given that S knew beforehand of A's intentions, and raised no objection.)

When I heard the Presidential Address, I would, had it not been a privileged occasion, have taken issue, in principle, with some of the arguments that Ackoff finds unacceptable. I worried particularly about some of the statements on formal courses in mathematical techniques, because I believe that the relevance of these to the essence of large-scale problems is marginal. I would accept that they have a major role in dealing with the more technical or mechanical systems; I do not agree that we can attribute some general conceptual content, relevant also to complex purposeful systems, to standard mathematical models.

Let me now wind-up. I am not, as I said, intending to make debating points. Over the years that I have listened to, argued with, and read the ideas that Ackoff puts forward, and which he changes in accordance with his principle of idealised design, I have accepted much of his philosophy as my own. I have done this, not because it looked good, or because it was the best available, but because he formulated what, in some way, I had thought but had never made explicit in a way that satisfied me. So anything I have said today is my belief, and my interpretation of what Ackoff says. If you disagree with me you may or may not be disagreeing with Ackoff.

I have, for many years, wanted a new direction for O.R. I did not find the continued reflections on what is wrong with O.R. voiced at the Stirling conference, disturbing. I would perhaps have been disturbed if nothing had been said, although I would have

preferred to have heard more of what people were doing to advance the state-of-the-art towards their ideal.

I hope that any meeting that follows up today's discussions will put before us accounts of what individuals and groups are doing to improve the process and the image of O.R. At present, there are many doing good O.R. in Ackoff's sense, but their principles are incompletely expressed and not available in a form that gives a blue-print for others. I would also like the Society to provide a Peking Poster facility, for those who want to offer unconventional ideas, not yet accepted as O.R., but relevant to the challenge that Ackoff sees in major social and organisational problems.

For our present purposes, I hope we can stay close to the arguments put by Ackoff at York. We cannot easily recall the context of statements made long ago: those who argue for a sociological base for O.R. will perhaps agree that we would have to know the sociological background that produced the statements, before we could interpret them in the context of today.

Finally, I ask you to accept that the problem of doing O.R. is a mess: it may even be called a meta-mess. It is not a problem amenable to classical O.R. and it is not enough to say, what we prefer managers not to say, "I know what to do: it is my expertise.". If we do not follow Ackoff, we must find an equally coherent and well-argued philosophy to guide our footsteps.

Here are my requests in a nut-shell.

From Individuals

1. Explicit formulations of his or her philosophy and principles of 'good' O.R.
2. Acceptance of or alternatives to the principle of idealised design.

From the Society

1. A Peking Poster facility for unconventional (even incomplete) ideas.
2. Less strict definition, by referees, of what is O.R.

For this Conference

1. Stay close to the arguments of the York papers (as far as Ackoff's views are concerned).
2. Accept that the problem of doing O.R. is a 'mess'.

Operational Research's Contribution
to the Problem of Defence

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A paper prepared for the Third International Discussion
Conference on Operational Research, organised by the
Universities of Sussex, Lancaster and Pennsylvania,
at the Dudley Hotel, Hove, 12-16 May, 1980.

Introduction

The 1939-45 war gave great impetus to the involvement of scientists in the study of military operations and created a new subject, operational research. Many believe that the early methodology has been lost: that OR then was "good" and that, somehow, it has become "less good". I would argue against this. Systems were then so underdeveloped and so little understood that great improvements could be made with the help of quite simple models. Problems were so many that it was possible to do a great deal by concentrating on the easier, generally tactical, ones. The close co-ordination of scientists and decision-makers was natural and readily accepted in the circumstances prevailing. Perhaps most importantly, experimentation and testing of ideas was possible in actual operations. In all, the environment was very favourable towards the success of OR, as it was, for similar reasons, in industry in the 1950s.

The intention at this conference, however, is to look at the present day and to the future. So we are concerned with current and future spending on defence, and how OR can assist in its economic application to systems whose improvement or development will have the greatest pay-off for the security of our various countries. There are several reasons why our task of assessing the value of defence OR is difficult.

Security. Details of successful OR studies of recent date are not openly available. We can, however, try to identify areas in which we believe that OR has been of value for decisions on resource allocation or operational efficiency.

Identifying the influence of OR. Relating the findings of analysis to policy decisions is far from easy. Sometimes the two seem to be incompatible, and when they are not, proof that the decision was greatly affected by the analysis is rarely possible. Also, because of the time-scale of equipment introduction into service, many changes of policy take place, without further analysis, and the relevance of the earlier work is often far from clear. We can perhaps judge OR's value indirectly:

- o has it affected the mode of thinking and judgement of those who are, or will be, responsible for decisions?
- o is it still being required in major defence studies?
- o has it provided any tools for management use and at what level?

Peacetime and Wartime. We do not have a fully operating system and cannot measure directly even today's effectiveness, if we regard success in war as the main criterion of the defence system. We may, however, see deterrence and political impact as a main criterion. If so, are studies done which give measures of such a criterion? Can we identify peace-time operational facilities or processes which are important for deterrence, and say how OR has helped to introduce or improve these?

Prediction. Future operational environments are very uncertain. Has OR found ways of identifying facilities needed which are reasonably independent of environment. If models are based on "likely future wars", can they deal reasonably with the initial conditions (the states of the systems when war starts), and, in reaching these conditions, can the effects of interference from systems over which Defence has no control (e.g. potential enemies and international organisations) be taken account of?

I have stated these aspects of defence OR and its assessment as if they were peculiar to defence. This is not entirely true. Commercial and political security hides from open publication many of the things we would like to know when judging the success or failure of OR in other areas. The time-scale of industrial and social system projects can also be as long as 10 years, a figure broadly applicable to major defence equipment developments. Again, planning studies in the civil field often deal with new systems which will introduce operational problems of which there is no prior experience. Finally, prediction problems abound in economic studies, and they are just as complex as those faced in defence OR.

If I am right in saying that defence has the characteristics of the general class of socio-economic problems, there is an importance

for our discussions. There are many such problems being studied and OR, although not necessarily by that name, is involved in most of them.

Discussants, whether or not they have worked in Defence OR, should have experience of value to help assess whether OR in defence is doing the right things in the right way.

National and Alliance Contexts

I hope that our discussions will not be limited to the defence OR of nations whose defence budgets are large in absolute terms. There is a strong tendency in discussion meetings of this type for the US or British environments, or both, to predominate. I would like to get a wider picture, across nations and alliances of nations, of what defence OR is done (or not done) that is (or would be) appropriate and valued in its particular context. It will be of interest to know, for each nation:

- o at what level in the hierarchy are OR departments or units situated
- o to what level of decision do its studies relate
- o what organisational factors operate for or against the implementation of OR-derived ideas
- o what are the aspects of defence problems that are most difficult to deal with (either because OR does not have the tools it needs or because OR has inadequate access to data - including in the latter case barriers which say "that is none of your business"!).

I know, for instance, that Sweden has a very different defence OR set-up to that of the UK and that its priorities for study are also different (Jennergren et al, 1977). I know that the small nations of NATO have very different national criteria for defence effectiveness to those they adhere to as part of the NATO alliance. From time to time, nations have priorities for internal security, which demands OR support more akin to the wartime OR of 40 years ago.

With those complications, added to those of security, and the limited time at our disposal, our discussions will probably be more useful if they are conceptual and general, rather than technical

and detailed. We should certainly try to establish whether there is "good OR" being done by one country the nature of which can be generalised for the benefit of others. I do not imply that specific cases cannot be described, but I do suggest that description be limited to what is essential to establish where Defence OR stands and where it might be going.

I will end this introductory discussion paper with my own views on UK Defence OR. You may take these as necessarily biased. However, I have been for the last ten years a methodology researcher, outside the main-stream activity of advising the MOD; I have had to take a critical look at what we (including myself) had done in the past, as well as what changes were taking place. I have tried to reflect carefully on my judgements; they will still be only one man's view of a very complex area, and fallible. Perhaps, however from the accidental sample we acquire, some consensus and some useful ideas for the future will emerge.

Defence OR in the UK - A Personal View

My own involvement in operational activities has spanned 40 years, although I can only formally label my work as operational research over the period from 1954. I have worked in a Research and Development (R & D) Establishment as an analyst of the potential operational performance of naval equipment under development. I have worked as a scientific member of Naval operational groups, including a period serving afloat, on the Staff of the Commander-in-Chief, Home Fleet. I spent five years with the Department of Naval Operational Studies, within the MOD, examining the immediate problems of the Naval Staff. Finally, I was at the Defence Operational Analysis Establishment as a manager of project teams working on maritime problems and more recently as a researcher and in-house consultant; in both these roles, I have been involved with a wide range of problems including major resource-allocation and operational planning studies, where the customer is at high level up to and including the Secretary of State for Defence.

From this background, I will comment both on the organisation of OR and on its performance, and state what I believe to be its weaknesses as we move into the 1980s. I start by listing some areas where there has undoubtedly been success, albeit varying in degree.

Logistics. Defence OR has taken over methods developed in industry for improving stores handling, repairs, ship building, aircraft and vehicle maintenance, and so on. Inventory and stock control, reliability theory, queuing theory, critical path analysis and many statistical techniques have been put to good use. By improving control systems, lower costs and increased efficiency have resulted.

Tactics. Using similar methods to those of wartime, tactical studies have been a continuing OR commitment, seeking better ways to use, in wartime, what we have. This has been carried out, in general by small groups working with operational units sometimes at operational headquarters, sometimes less directly from R & D Establishments. Service officers are closely associated with these, as with most other OR studies, and are often integral members of the OR team.

Equipment R & D. Operational studies, of limited scope, are carried out alongside research and development. They help in making choices between alternative developments and in enhancing equipment performance in operation. There are elements of sub-optimisation in such work, but links with studies which examine the same and other equipment in wider contexts exist. I believe these links to be far from satisfactory due to the organisational structure and to the different criteria of "goodness" that are inevitable in different parts of a large organisation. Nevertheless, there is excellent work done in this field.

Communications Networks. Many important studies have been carried out to help in the design of communications systems, particularly to ensure that networks have appropriate capacity and are robust against interference and breakdown. The larger question as to whether data provided by communications systems is properly matched to the information extracted for decisions is of continuing concern, but as yet little progress has been made.

Movement and Redeployment. Military strength measured in terms of ships, tanks, aircraft and weapon systems is of little relevance unless things can be in the right place at the right time. Strategic movement studies can be carried out, to a large extent, without the complications of battle interactions which reduces performance in ways difficult to assess. Many valuable studies of this type have been carried out and well received; linear programming and other programming techniques have been admirably suited to the purpose. One such study has been reported in the open literature (C.N. Beard and C.T. McIndoe, The Determination of the Least Cost Mix of Transport Aircraft Ships and Stockpiled Material to Provide British Forces with Adequate Strategic Mobility in the Future, 1968 Operational Research Society Conference Edinburgh). Studies such as this are among the few that have offered planning aids as well as the advice needed for major decisions on strategic concepts and equipment procurement.

This is not a complete list, but by omission it serves to draw attention to an important area of defence OR that consumes a large part of the resources available, large-scale battle and campaign modelling. This complex task must be attempted if help is to be given to the tasks of planning for major weapon systems through an understanding of their interactions and their separate and joint capabilities. One cannot but admire the technical skill and professional understanding that has been deployed. Often both analysts and senior military staffs have been pleased with what has been done, on other occasions there have been serious reservations. I am wary of the early enthusiasm of the customer because I do not see the follow-up actions as being clearly related to the analysis received: I am worried by the frustrations that result from non-acceptance of analysis, and even more worried when analysis is accepted but the reservations made by the analysts are ignored.

One success that can be attributed to large-scale modelling, although I could not prove it, is that everyone involved is learning a great deal about the systems studied and about the environment. They are understanding better the relationships of the many variables, controlled and uncontrolled, that are used in the models. But relating

the findings of analysts, to the decisions that are to be taken is very difficult. Because they should be part of our concern in debate, I will list some of the reasons why I think OR needs to assess success with large-scale modelling with great care.

- o Many factors, whose importance is not questioned, are omitted from these models. Morale is one such factor: "command and control" is another. The latter has recently been the subject of study in a land-battle context (D.W. Daniel, "What Influences a Decision? Some Results from a Highly Controlled Defence Game".) Information-decision games have produced results which do not give confidence that actions will be as smooth and satisfactory in their response to situations as most modelling would suggest.
- o Monte Carlo simulation models are difficult to control, in the sense of understanding the reasons for consequences, given the input data and the rules. The need for parallel analytical models and the use of variance reduction techniques is increasingly realised, but the model-worlds are still as bewildering as the real one.
- o The models do not seem to represent the world as the customer sees it, judging by his responses. Why this is so is not easy to determine, and it seems to depend on the level of decision involved. Sometimes, the issues that decide military resource allocation are far from the "natural" military context. Economic, political, and even industrial, pressures which the decision-maker sees as realities are not in the models, nor do the outputs relate easily to these. There are associated unrealities and lack of explanation of results as discussed in the two preceding statements.
- o Increasingly, defence analysts engaged on work for the Central Staffs of MOD have become more distant from the realities of warfare (as have their military advisers) and from the operational systems with which they deal. The first is due to a long period of relative peace. The second is due to a combination of two factors: the pressures of many

demands on a small number of analysts; and the less frequent opportunities to work with the Services, particularly in major exercises. The net result is that the development of models increasingly emphasises the technical at the expense of the operational.

- o If there is a need for analytical mathematical models, the available expertise must be better balanced, away from computer programming skills and towards logical-mathematical skills. It is important also to realise that good mathematical modelling, because it has to simplify descriptions of systems, has to be backed by good operational insights.
- o Whatever types of model are deployed, statistical skills in data handling are increasingly required, both in handling "dirty data" that determines inputs and model generated data. Defence OR is not alone in lacking such skills - where do statisticians go?

The Future of Defence OR

If my concern about defence OR in support of major decisions is justified and it is desired to continue and improve this area of work, we should discuss what is needed in the future. It is clear that, in less taxing areas, the successful use of OR is a logical development of the type of OR that created our subject in World War II and in the industrial post-war era. In the more difficult, high-level, decision areas, a further extension of this OR approach is an uncertain way forward.

We could make changes in various ways, for example:

- o we might offer large-scale models in a form suitable for learning by those who have to take decisions, rather than attempt to use such models to obtain results on which we believe decisions should be based;
- o we might use them solely for our own learning to help us construct simpler models as aids to decision;
- o we might try, more consciously to set our models in the

wider framework of the decision-making process, perhaps using non-quantitative approaches;

- o we might pay a great deal more attention to an analysis of our own decisions concerning the selection and use of our models.

In what I have said, I neither decry what has been done in the past, nor do I despair for the future. Even in the areas of greatest difficulty I am impressed by what has been achieved; but I am not satisfied that those who have responsibility for decisions are getting the value that they expect or that the immense efforts of analysis would imply.

There is one final difficulty that I think should be discussed. OR has the reputation of being restricted to highly numerate problems, and clients tend to avoid non-numerate aspects. On the other hand, most OR workers are reluctant to adopt qualitative methods that might be more appropriate (Bowen, 1979). Even if the door is partly open, OR is not pushing very hard in order to get through.

The Process of OR - A Systems Approach

K.C. Bowen, Defence Operational Analysis
Establishment, Ministry of Defence

A paper presented to the OR Society meeting on
"The King is Dead: Long Live the King"?

held at the University of Aston

December, 1977

This was one of six papers discussing the future direction in which OR methodology might develop. It is given here unchanged except for the style of referencing.

Introduction

When a systems approach to the study of a large scale socio-economic problems is put forward, there can be a misunderstanding of what is involved. In the language of the physical sciences, from which operational research has drawn its main strength, systems are considered in a mechanistic way, with fairly rigid rules for interactions and for the effect of variation of system parameters. Seen in this way, a systems approach can be said to be inadequate for dealing with sociological, psychological and other behavioural factors, which are clearly important for the types of problem with which OR is increasingly concerned.

It is, of course, all too easy to be critical of OR as it is. All is not well with OR, but, sometimes, this criticism can be unfair. Many writers have damned OR on the basis of work done on the Third London Airport study, which used a cost-benefit approach to bring complicated value-systems and social attitudes into line with money measures. But this study was not carried out as an OR study; indeed, the analysts had little or nothing to do with problem-formulation and the identification of options. On the other hand, examples can be found which can be used to praise OR, again with limited justification. The Docklands Redevelopment Team (led by a former Defence OR man) did what is, to many, a fine piece of OR work. Yet it was not carried out by an OR team, but by a top-level planning group, which did not use generally accepted OR techniques.

It is not part of my argument that particular techniques are good or bad. They can only be judged by their use. I am concerned with the lack of a framework for problem-formulation, within which appropriate analysis methods can be chosen for the particular problem of concern, so that the process of OR can proceed sensibly. Such a framework may be provided by a systems approach.

Systems and Subsystems

My concept of systems generally follows that of Ackoff and Emery (1972), apart from defining the environment of a system as including that system, and treating it in turn as a system (a containing set).

Necessarily, in a short presentation, precision of definition is impossible, but will I hope, be sought from the various references by those who wish to go further than reaching a broad understanding of the direction in which my arguments lead.

A system is a set of two or more interacting elements, existing in an environment which influences the system and is influenced by it. In general, it is difficult and unprofitable to examine what a system is doing in isolation from its environment. We are interested first in a purposeful system which can operate on its subsystems and, via a common environment, on systems which it does not control. We need to define and place all the essential subsystems of the systems we discuss, and then deal similarly with the subsystems until the total problem is exposed.

Some of the subsystems will be in the minds of people - their ideals, goals, objectives, aims, value systems, world pictures, prejudices, beliefs and so on. Indeed, once purposeful systems are introduced as essential parts of a problem, the roles of people (singly and in groups) must be of concern. Ackoff and Emery offer a starting point for the introduction of behavioural factors into a systems framework. My own work on conflict and OR methodology has been influenced by theirs.

The notation that I use is based on Bowen and Smith (1976), but is simpler. In essence, a system is drawn as a rectangular box and will contain others which are its subsystems. Containing boxes will indicate, for example, environments. Interactions take place between any system and a system directly containing or contained by it - lines indicating interactions need not be included except when emphasis is required. Conflict potentially occurs between distinct systems in a common environment, provided that these systems are purposeful. Human systems, regarded for simplicity as individual people, are shown as circles. They may be in control of the system that contains them, i.e. they represent its purposeful nature.

I shall not in this paper deal specifically with the systems-structuring of what is in people's minds. The paper already referred to gives an indication of what can be done, if the diagrams representing

the adaptive and decision processes are interpreted as representing individual behaviour. Another use of the notation is also given in Bowen, (1978b): it is applied to the roles and activities of people in games played for research purposes and is primarily the work of Janet I. Harris.

What follows is a treatment of the OR process itself. It was first presented in Mexico to underline some of the points made in a written paper (Bowen, 1975b) and was then included in a paper presented in India (Bowen, 1975c). In these two countries, major social problems are being faced, and I thought it important to emphasise the difficulties of the OR process and the overriding importance of good problem-formulation and of a clear understanding of the decision-making system. Indeed it seemed to me then, and still does, that more help is likely to be given in this way than by large-scale modelling of those parts of the problem that are able to be described by numbers and by mathematical relationships.

The advantage, if I can use such a term for a perceived limitation of analysis as at present developed, is that, since relationships are described in logical but not numerical terms, all factors, whether sociological, psychological, or physical, can be included. But one warning must be sounded. The systems description is as perceived by those who create it, or at best it is how they perceive someone else's perception. A number of such diagrams, ostensibly of the same systems, are needed to describe "reality" effectively. In the discrepancies between such diagrams lie the major difficulties that face those who have the task of making decisions, including the analyst who must face clearly the problem of what approach to analysis should be made.

The OR Process

Fig. C1, then, describes, in a simplified form, the OR process as perceived by me, for the purposes of the discussion which follows. Insofar as different perceptions are held by those reading this paper, they will be alerted to possible reasons for different attitudes to OR and to the likelihood of difficulties of communication resulting. Certainly, if such a diagram is used to help in deciding what analysis,

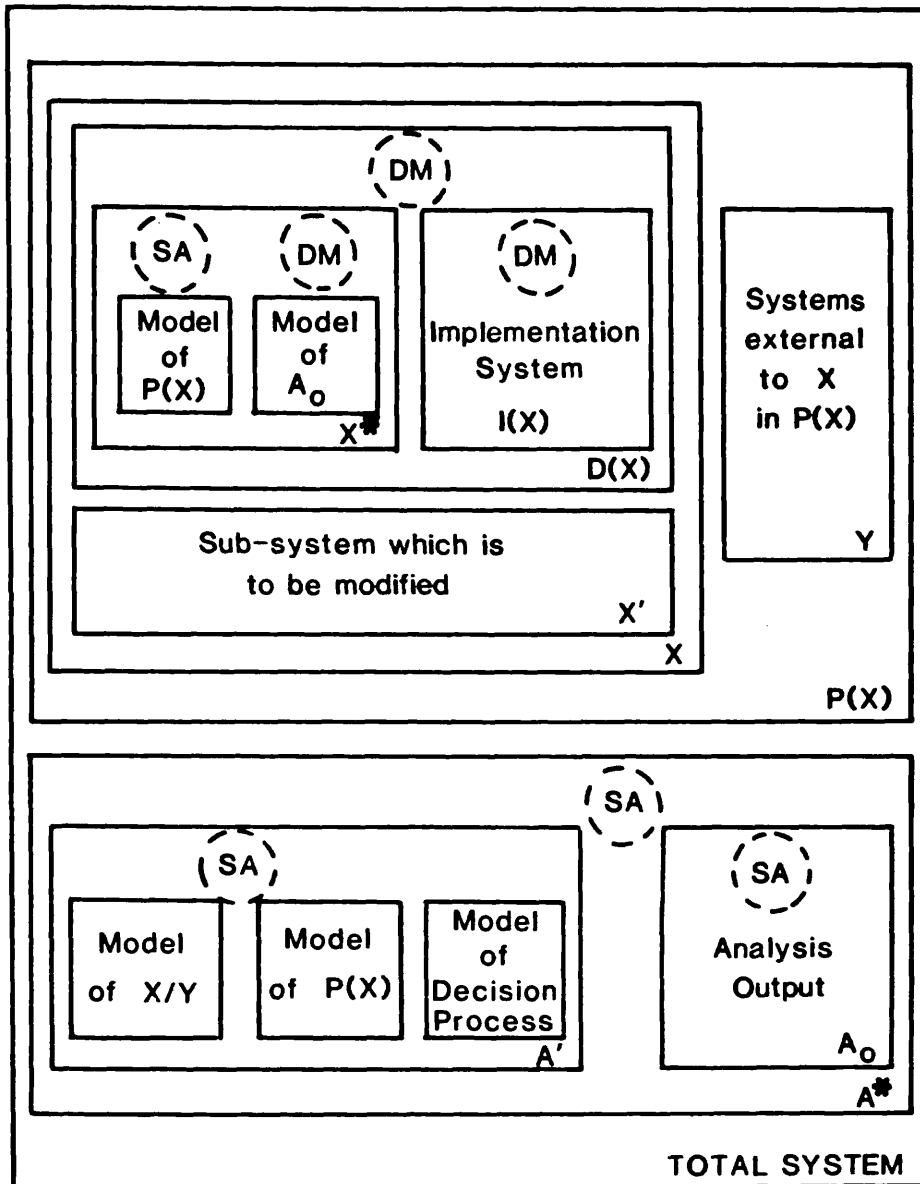


Figure C1. The OR Process: System Relationships

organisation and procedures are necessary, it must be a description eventually held in common by analyst and decision-maker. Briefly, what has been included is as follows.

- X is the system centrally involved in a particular problem.
- X* is the policy-making system for X.
- P(X) is the defined problem area which contains X and also
- Y , the external systems which are the most important identified systems which conflict with X*'s present intentions for X.
- DM has nominal control over X* (which identifies and chooses policies relating to X) and, in a second role over
- I(X), the system that implements choices to change X - in particular to change
- X' which is a specific subsystem of X.
- D(X) the overall decision system for X, contains X*, I(X) and DM. Note that DM, in charge of D(X), is assumed here also to play the role of DM in X* and in I(X) - but he can only play one role at any one moment in time.
- A* is the analysis system. It is (ideally) external to P(X) and it studies P(X) for DM of X*. It has two main subsystems,
- A' , the main analysis system, and
- A_o , the explicit analysis output which is modelled in X*.
- SA the systems analyst (or senior analyst) in charge of A* overall, plays other roles when in charge of A' or A_o separately. He plays an importantly different role when communicating with DM within X*.

The separate models in A' will be discussed later. Firstly, some of the more general inferences that can be drawn from the model of figure C1 will be discussed.

The Policy-Making System

Ideally, DM and SA will work in harmony in X*. Potentially, by the definition of the structure, they may be in conflict beyond the conflict level essential to their interaction, assumed here to be fundamentally co-operative. The explicit model of the problem area

P(X) is there to help them resolve any damaging conflict in the problem-formulation stage. Similarly, the explicit model of A_0 which they can relate to the model of P(X) will help them to remain co-operative at the model solution and policy decision stage.

The models therefore have an importance that extends beyond their value as outputs from A^* . It may also be noted that DM in X^* is nominally the resolver of conflicts that take place between purposeful subsystems under his control: but he cannot resolve conflicts between himself and other subsystems without acceptance of some independent "authority" or agreed procedure (he could get rid of SA, of course, although SA is, in this conception, partly independent).

DM of D(X) could nominally help to resolve conflicts, but here we are assuming him to be the same person playing a different role. This puts him in an unenviable situation if he is also DM of I(X). Since the purposes of policy and implementation may well conflict, considerable difficulties can arise for the two-hatted DM (difficulties not unknown to individuals whose social and professional duties and intentions conflict). There are even greater problems, since policy-making and implementation are separated in time, and analysis may become irrelevant to implementation. But those are difficulties which will not be discussed in this paper.

The Systems Analyst

As conceived here, the systems analyst, responsible for A^* , A' and A_0 , has similar multi-role difficulties. Again, if these are different people, SA in A^* could resolve disagreements between SA in A' who wants to report his analysis (which he perceives as entirely relevant to X^*) in full, and SA in A_0 whose job it is to see that analysis output is matched to policy-making needs. But one overriding difficulty occurs.

SA in A^* and SA in X^* are necessarily one and the same person. A^* is nominally outside P(X) but SA in A^* spends at least part of his life as an integral part of X^* (assuming that direct communication with DM is essential). A^* cannot therefore remain as detached as it should be if, in theory, we maintain the "disinterested" scientific

approach. The desired balance must be achieved through the models, communication and the freedom of SA to disassociate himself from analysis for $D(X)$, if he so wishes (a despairing act, since he is only partly independent!).

The Modelling Process

What is shown in A' is what is desired; it is not a description of what is usually modelled. The model of the X/Y interaction is normally limited to the X'/Y interaction at some future time. This model inquires whether X can handle interactions with the future Y if there is a new or modified X' . There are a number of questions that may not be examined in such a model, for example, how Y reacts to the changes made in X' over time. This is part of the wider question of the steadily changing situation of X and Y ; it poses further problems for $D(X)$, in particular problems for $I(X)$, as referred to above.

But the modelling of X/Y , however inadequate, may be overshadowed by the inadequate modelling of $P(X)$. Problem-formulation has as yet no clear methodology, and, indeed, is often so sketchily done as to amount to little more than a vague verbal description, although, for SA, much more is implicit in his modelling of X/Y . But how does that enhance the communication, and reduce the conflict, with DM? Experience shows that there is trouble, even at intervening levels of the hierarchy, if there is not an explicit model of $P(X)$. This, as time goes on, helps, in X^* , to get acceptance of the analysis (the model of A_0) as relevant to the problem as perceived by DM; it also helps DM to foresee possible policies, which again can be fed back by SA to control the development of the model of X/Y and the form of A_0 .

What is envisaged for the modelling of $P(X)$ is a structured diagram or diagrams of the type used here. It is apparent that even the limited structure provided in figure 1 is more than a trivial model of the problem of the analyst/decision maker interaction. But the most important issue of modelling is still to be discussed.

Models of the decision process are rarely provided: one reason may be that decision-makers do not like analysts treading on sacred

ground. Yet it is of great importance that SA should understand $D(X)$ thoroughly: how otherwise can he provide outputs that match $D(X)$ inputs for whatever decision process takes place?

One other way of demonstrating the importance of such a model is to go back to the requirement for a model of $P(X)$. $P(X)$ contains the X/Y interaction, but it also contains $D(X)$ as a subset of X . Modelling the problem includes modelling the decision-making system. If decision were a straightforward matter there would be no problem.

Much more could be said about the implications of the diagram, not only in relation to modelling but also (assuming more detailed structuring of aims, values, and other aspects of DM and SA) in relation to the importance of variables of a psychological nature. Further, if the diagram were to include those within Y , and those neither in X or Y , who might act in ways which constrain the decision-making system, a new dimension of $P(X)$ becomes explicit.

However, all I wish to emphasise here is that, if a systems-structuring can cast light on the nature of, and the difficulties in, the OR process itself, which is in part a psychological and sociological problem, it should also be usable for what I now consider the most important challenges. These are firstly, to develop a methodology for problem-formulation and for explicit description of the decision process: and, secondly, to find out how far this goes towards aiding the making of policy.

The capabilities of a systems approach, that are of overriding importance, are, firstly, the provision of the structure of the problem (mess) being studied, and, secondly, the provision of a coherent and simple "language" to aid analysis. This analysis may often be limited to relationships, to classification, and even to less formalised description. The essence is that all important elements, subsystems and systems be described and interrelated, even if this means that measurement, in the classical (absolute) sense, becomes an unlikely primary tool for analysis.

Systems should not necessarily be regarded as having a defined reality. It is how things are perceived that is important, for we may never know how things are. The purposeful systems must be seen

to contain concepts of history, culture and social organisation and these will play a considerable part in influencing behaviour. It is essential, in particular, that decision-making systems (that formulate policy and/or implement changes) are described as they are perceived to be, not as they are conventionally, hierarchically, defined (even the President of the US is powerless unless he can influence people, in the system which he nominally controls, to make the changes he desires).

The "language" which a systems approach demands can provide a means of treating conceptually similar systems (however different they may appear when described in natural language) in similar ways. It also offers a means of merging different disciplinary outlooks rather than choosing between them. There are sociological aspects of problems: there are also psychological aspects, economic aspects and so on. The problems include all these aspects and what is needed is something which helps to tackle the problem as a whole. I do not believe that the views* which Bryer expresses are necessarily incompatible with mine. If this conference helps to bring these and any other apparently conflicting views closer together, it will have served a valuable purpose.

Concluding Remarks

It is not possible in a short paper, intended as a basis for discussion, to develop arguments fully. Elsewhere (Bowen and Harris, 1978), I have outlined the direction of my personal research programme, and made clear my view that a wide range of expertises and techniques have to be integrated if OR is to have a major impact on important and complex social problems. Further, I would urge people to pay attention to Ackoff's views on how to approach these "messes" (Ackoff, 1974) and to appreciate those aspects of OR which are not and cannot be scientific - inspiration and insights cannot be formally extracted from the bewildering variety of the real world, but perhaps they can be helped to emerge.

* These are best referred to in Bryer, 1979.

I am encouraged by others who have made statements which I see as congruent with my own outlook. Recently, Rolfe Tomlinson sent me a short paper outlining his broad intentions for research with IIASA. On the management/systems analysis interface, he says

"...the systems analyst is unavoidably part of the overall system. Certainly, if his results are to be effective, there must be continual interaction between him and the system that he is trying to improve or affect. The study of this interaction is itself a systems problem, and constitutes an essential area for study if systems analysis is to be more effective."

On the question of whether OR is or can become a science, Dando et al (1977) refer to OR, as it is today, as a technology that will remain a hit-and-miss affair unless an underlying science can be developed. Such a science would have, as the phenomena of concern, the decision-making processes in organisations. The language of the science would be drawn from systems theories, and theory-testing would be associated with developments of decision methodology and controlled forms of gaming.

A systems approach is not a panacea. It will still be difficult to tackle difficult problems and provide a marked improvement in the means available to resolve them. But it has the right sort of characteristics to become the basis for a process of OR which is not biased. It may even make OR a coherent subject.

A Proposal for Research into a
Methodology for Problem-Formulation

K.C. Bowen

This document, dated 31 May, 1979, was submitted to the
Department of Mathematics, Royal Holloway College for
acceptance as a PhD study to commence November 1979.

A PROPOSAL FOR RESEARCH INTO A METHODOLOGY
FOR PROBLEM-FORMULATION

As tasks for decision-makers become more complex, clarity about what the problems are necessarily decreases. Those who offer help by providing aids for decision then need to be particularly careful in their specification, jointly with those who own the problem, of what it is they are attempting to do. In what Ackoff (1974) calls 'messes', there are generally many interlocking problems; and, among the people directly or indirectly involved in the decision-making process, there are many differing perceptions of how the existing systems work, and similarly, many views of the feasibility and 'goodness' of providing new or improved systems.

In a technical sense, there are, in such circumstances, many individuals and groups in conflict, real or perceived. There are those with nominal responsibility for decision; those others within the decision-making system, including analysts, who share some of that responsibility; and those who have no organisational responsibility but whose actions and reactions might constrain the options for decision or reduce the efficiency of implementation of decision.

The basis for the research proposed rests on the method of conflict modelling devised by Bowen and Smith (1976). This has not yet been developed very far, although its potential has been indicated through its use by Harris in examining the structure of games (Bowen, 1978b); by an application to a broad examination of the OR process itself (Bowen, 1977b); and by various descriptive uses in examining the nature of problems arising from conflict situations (e.g., Bowen, 1975b - no operational examples have appeared in the open literature). It is important to note that the method itself can and should be used to monitor its own application.

The idea is essentially simple. Systems and subsystems are defined as sets; some of these sets, representing concepts, may be theoretically fuzzy. Any set may be contained by and contain other sets, and there will be sets from which it is totally separated - overlapping sets are generally redefined. Producing the appropriate

set labels and the set relationships imposes a powerful discipline on the formulation of the total system structure, which in turn facilitates the search for implications not explicitly stated in the earlier process. In particular, attention is drawn to different possible or actual interpretations of the situation studied, as time passes or through the eyes of different people; also, the conflicts that may ensue, and the nature of these conflicts, are identified.

Research would have three stages (interactive rather than sequential).

1. Further formalisation and extrapolation of the diagrammatic notation. (The value of trying to put this into a strict mathematical, set-theoretic, form is uncertain; it would, in particular, make communication with non-mathematicians difficult).

2. Translation of conflict problems, documented or broadly described in the literature, into this notation.

(In particular, it seems important to examine the relevance of the notation to game-theoretic methods, e.g., Bennett's hypergame theory (Bennett and Dando, 1979) and Radford's analysis of options (Radford, 1977), and also to sociologically oriented methods such as those of Eden, 1978.)

3. Attempts to structure current problem studies and to evaluate the usefulness of the approach:

- a. in communicating with decision-makers,
- b. in formulating their problems, and
- c. in considering likely limitations on the implementing of various perceived options.

It is believed that, initially, this research should be the responsibility of a single individual. The nature of the research would require communication with and the convincing of others, and some useful support should arise from such interactions. Other support could come from second-degree students, since research of this nature invariably throws up a lot of interesting and important side issues which would provide a basis for project and thesis work.

Although some useful research findings would be expected throughout such a study, 3 years work is the order of effort required to reach a definitive understanding of the value and limitations in application of the proposed methodology.

Notes on the Analyst and the Decision-Maker
Interactions and Perceptions

K.C. Bowen

This is a version of research work carried out in 1974-75
at the Defence Operational Analysis Establishment, by
Miss Janet I. Harris, under my supervision. It was
never formally recorded or published.

NOTES ON THE ANALYST AND THE DECISION-MAKER
INTERACTIONS AND PERCEPTIONS

Introduction

These notes are abbreviated and amended versions of earlier attempts to make statements about the main features of the interaction between an analyst and his clients, who are faced with decisions on a perceived problem. Diagrams are presented representing the perceptions of 'problem' and pattern of 'solution' as seen by the various parties. A brief comment is made about the mismatch of perceptions that might lead to misunderstanding and conflict.

The main purpose is to put on record otherwise unavailable ideas which seem to be relevant to the central theme of problem-formulation, and which may offer some contribution as the work proceeds. I treat the ideas as my own because I have not entirely followed the direction of Janet Harris' inquiry which was carried out in collaboration with me in 1974-75. I take responsibility for any errors or misunderstandings that she may perceive, but, nevertheless, I acknowledge her original contribution.

The Decision-making and Advisory Situation

Figure E1 is a conceptual diagram of a problem under study (it is my, not necessarily the analyst's, conception). It shows a sub-system decision-maker, $D(\text{sub}X)$ under direction from $D(X)$, considering purposeful action to effect whatever it is, external to the system X , that creates a perceived discrepancy between existing and desired states.

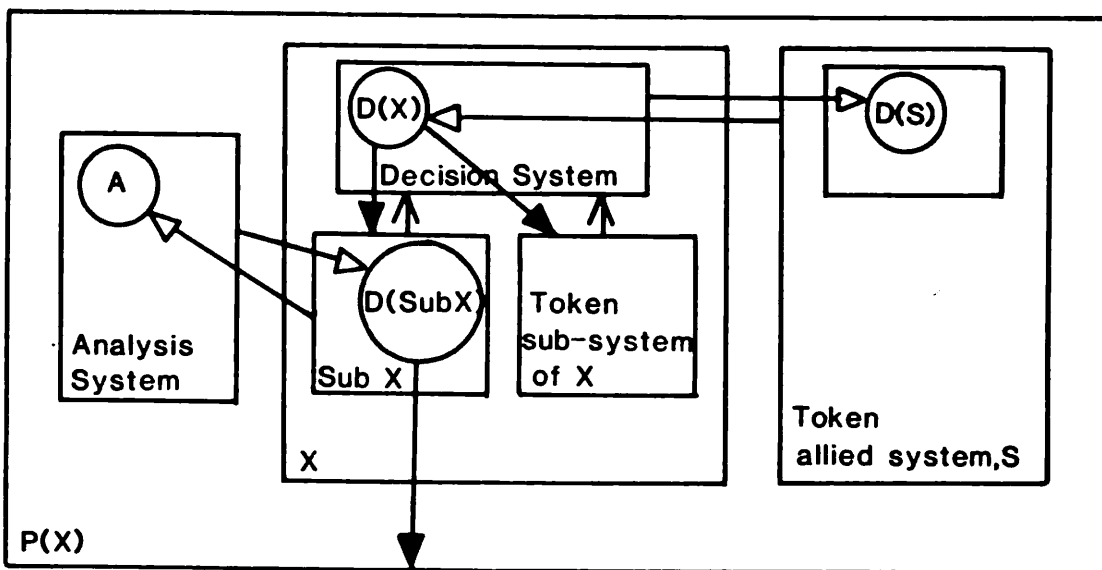


Figure E1. Conceptual Diagram of the Problem (meta-view)

The problem, $P(X)$, is shown as an environment of X , and this environment includes the analyst, A . Also shown are other potentially co-operating systems, similar to X and to sub X . Although it is not shown, it would be desirable (yet often not achievable in practice) for a direct link to exist between A and $D(X)$. Only arrows which indicate purpose, communication and interactions of primary importance to the progress of resolution of the problem are shown. The statement made is a very broad and general one.

Figure E2 is a diagram of the problem as the analyst is assumed to see it, at least initially. He concentrates on $D(X)$'s needs, although $D(\text{sub } X)$ is the person to whom he responds. He is aware also that another of $D(X)$'s subsystems is working on some aspects of the problem, but does not concern himself in any detail about the particular part of the environment on which it operates. However, he pays close attention to the sub-system of the environment with which $D(\text{sub } X)$ is concerned: this may be outside X but under some control by X , either by entitlement or through influence, persuasion or agreement. The analyst is also aware that, as understanding of the problem grows, a different sub-system of the environment may become more relevant.

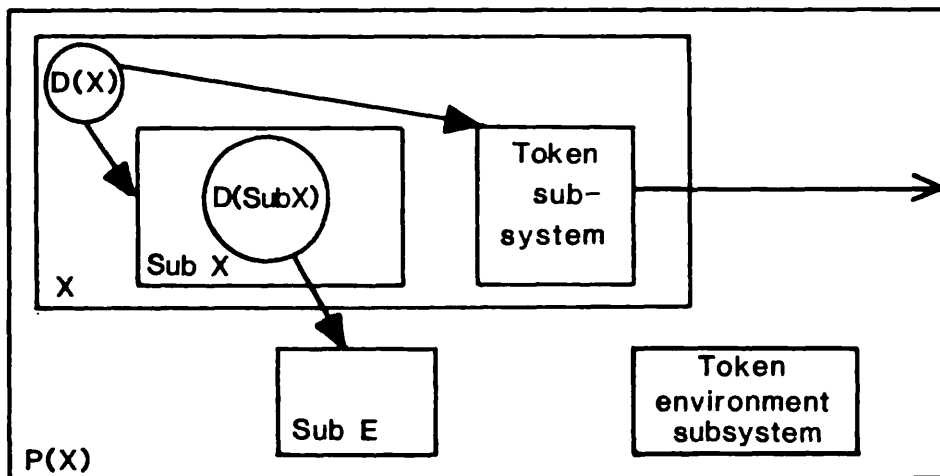


Figure E2. Conceptual Diagram of the Analyst's Perception of the Problem.

It may be that the analyst will, later, see the need to study what is going on in the alliance depicted in figure E1. Importantly, he may or may not come to realise that, as soon as his interaction with his client begins, he is automatically a part of the problem.

The next diagram, figure E3, is a comment on the analyst's advisory process. There may be immediate action, within the authority of D(subX), that he can suggest or that is being taken. Although this will affect later possibilities, it is not likely to be adequate, although it has the merit of getting something done quickly. The analyst sees it as wiser to spend time in looking for potential intermediate action, based on more detailed analysis which would include a closer look at what D(X) intends and how other sub-systems under control of D(X) may be behaving. At the same time, the analyst should be, ab initio, seeking to determine how far he can take the analysis in the long term. During this more ambitious phase, he should regard

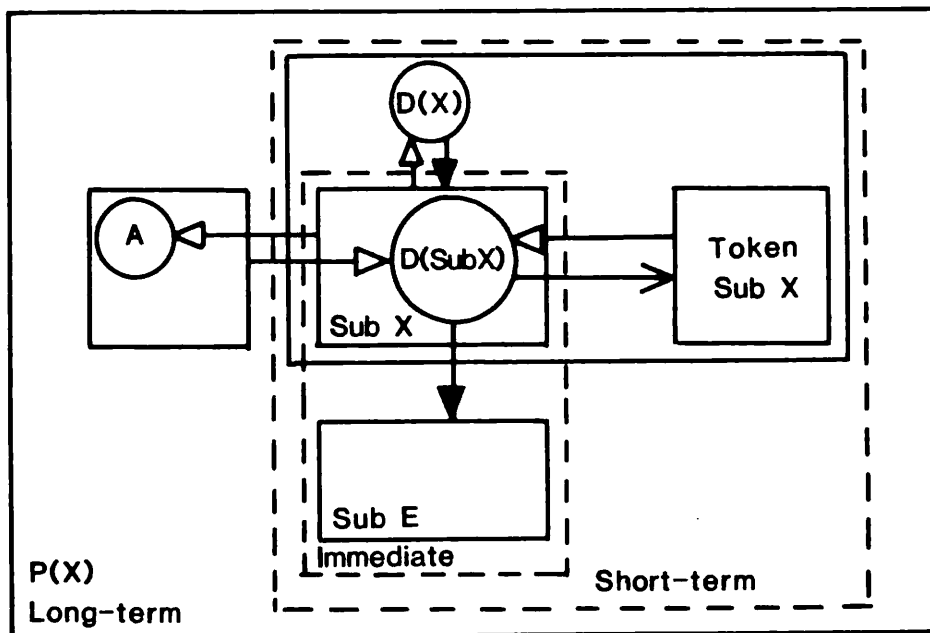


Figure E3. Conceptual Diagram of the Analyst's Advice (meta-view; the 'sets' shown by hatched lines* provide a time-dimension)

*While this conflicts with the use of hatched lines when systems have dual or alternative positions, it is unlikely that it will lead to any misunderstanding.

himself as part of the problem. He will consider how much of the total environment his analysis can encompass, and he will suggest interests and options which may not have been part of D(subX)'s conception of the problem, and which will need negotiation. Although this is not shown, such negotiation may have to be directly with D(X).

The hatched-line and outer boxes provide a time-dimension (moving outwards) of the analysis process. Figure E4 indicates broadly the relationship of the times involved. Only the immediate action is shown as actually occurring (with a time-lag). The rest is potential action under consideration but not liable to implementation for some undefined time.

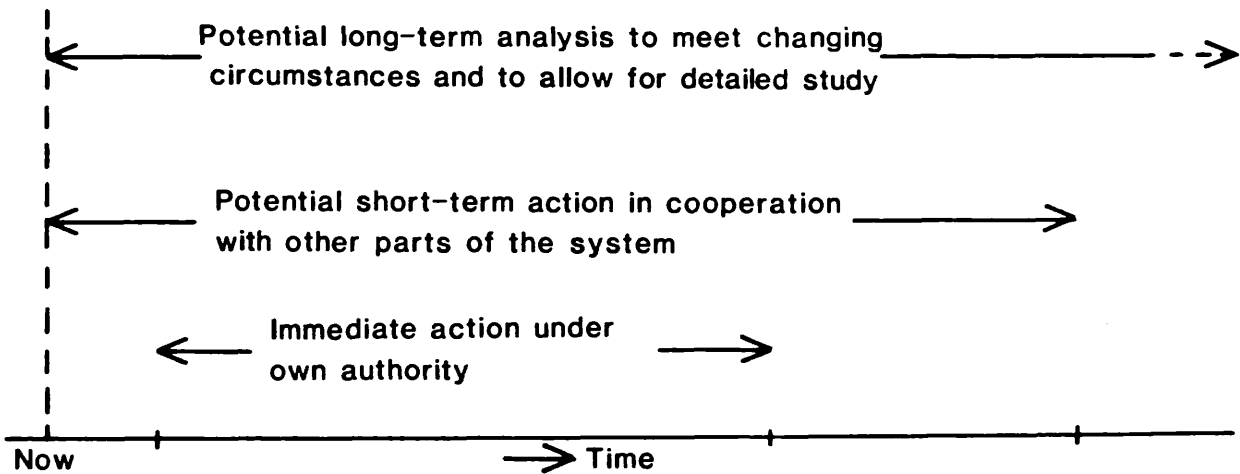


Figure E4. The Time-Sequence of Advice and Action

My conceptual structures, one of which (figure E2) is, by proxy, the perceptions of another, contain various degrees of detail. Such detail is always the choice of whoever owns the diagram. D.G. Smith has suggested four kinds of justification for inclusion and exclusion: expediency, authority, pragmatism and 'demonstrated consistency'. The last implies internal consistency and consistency with relevant parts of the real world that could be supported by argument about

the issue that the diagram is highlighting. The first three relate, respectively, to statements such as:

"It makes things easier"

"It is my diagram of my world"

"It seems reasonable to me for the present purpose".

The distinctions between these are obviously blurred.

The Decision-maker

Figure E5 shows how a problem may be perceived by a decision-maker who is autonomous, thus omitting any constraints 'from above'. It is a rather artificial situation, but it might well be the desired picture for a sub-system's decision-maker or even the perception he has of the authority delegated to him.

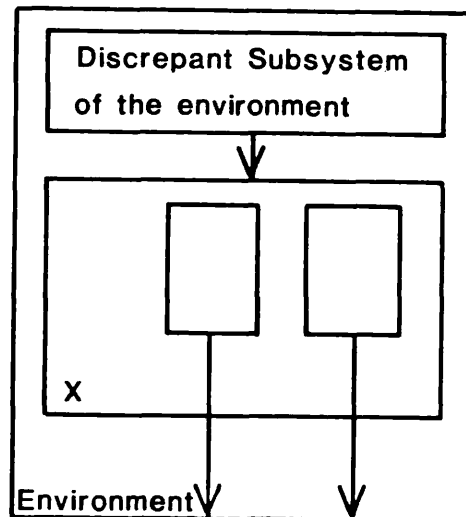


Figure E5. Problem-perception by an Autonomous Decision-maker

His problem arises from a perceived discrepant sub-system of the environment: he has sub-systems that operate directly or indirectly on the environment and which are his resources for change. The decision-maker himself comes into his picture as soon as he considers possible

'solutions' (figure E6).

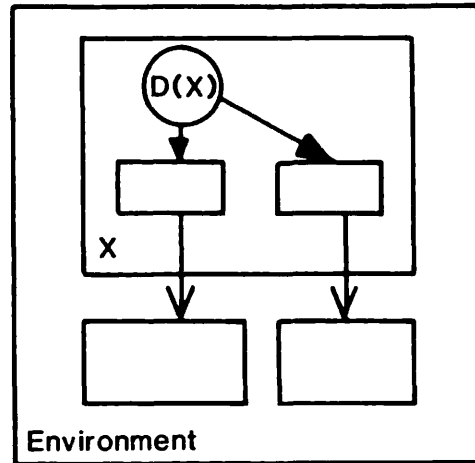


Figure E6. Pattern of 'Solution' for an Autonomous Decision-maker.

He will be able to act purposefully on sub-systems under his control so as to effect changes to chosen sub-systems of the environment. These parts of the environment may be under his direct control, i.e. part of X, or will be affected by what his sub-systems do: it is not always necessary to act directly on the discrepant sub-system, and not always possible unless it is part of X itself.

Figures E5 and E6 are not easy to define separately: problem and pattern-of-solution perceptions are normally so interwoven that the decision-maker's picture is better described by a combined diagram, figure E7. Although it is not shown, there may be cases in which X can affect the discrepant sub-system directly.

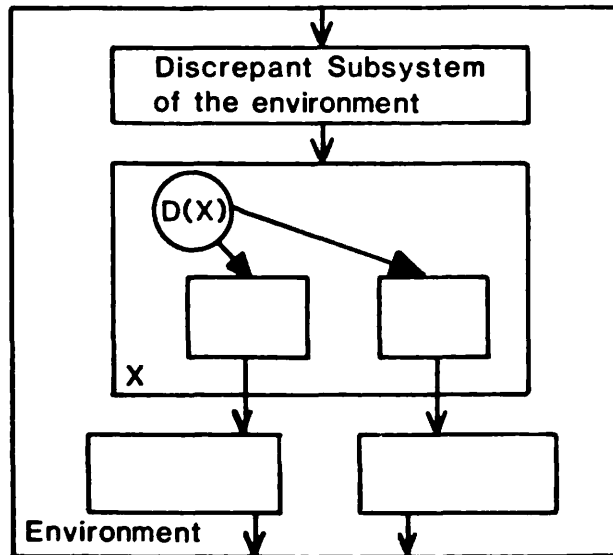


Figure E7. The Overall Picture of an Autonomous Decision-maker
(problem and pattern of solution combined)

However, the other diagrams have their interest. Figure E6, for example, which excludes the observed discrepant sub-system of the environment, may be the picture that the decision-maker communicates to an analyst: this is not a recommended action, but it does happen, which is in part why, in figures E1 to E3, the discrepancy observed by the decision-maker is not a prominent aspect of problem and analysis. It will also be noted in figure E5, that because patterns of solutions have not yet been considered, there is no constraint on what part of the environment may be chosen as the important area for change. There could also be more drastic effects by the time that figure E6 has been reached, since $D(X)$ may already sense crisis and be glad to discard his autonomy and appeal to a higher level of authority for help.

Figures E8 and E9 extend the ideas already discussed to two separately autonomous decision-makers acting in alliance: they parallel figures E5 and E6. Note that in figure E8, the alliance set is shown as it could have been in figure E1, although it plays no part as an entity in the discussion provided here.

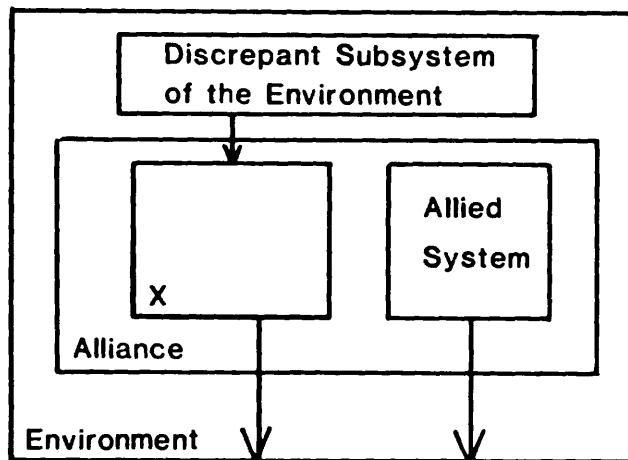


Figure E8. Alliance Version of Figure E5

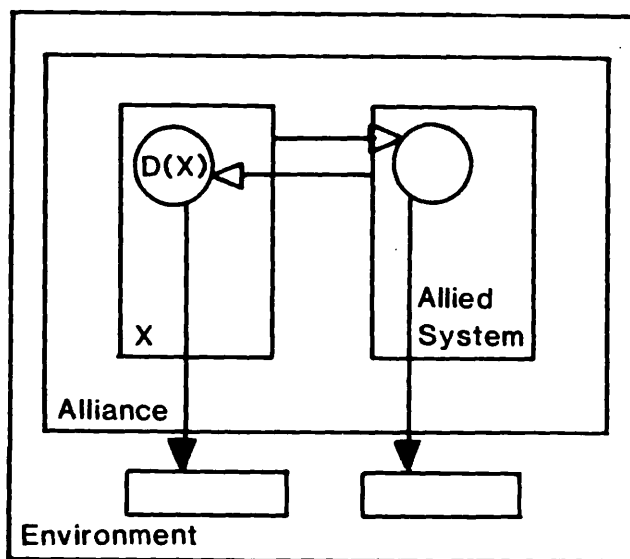


Figure E9. Alliance Version of Figure E6

The problem is as perceived by one of the alliance, namely X or, specifically, D(X). Clearly, if the two parts of the alliance have different perceptions of a 'common' problem, a prior problem arises in resolving this conflict of purpose. Figure E9 shows only communication for enhancing co-operation and in an alliance this is, in theory if not in practice, sufficient. Again the figures might well be combined, but I have not shown this.

The diagrams provided are parsimonious, yet a number of points for discussion and better understanding can be made both explicitly and economically. Additional detail, systems and sub-systems can be added as needed: with an actual problem, such detail would increase rapidly. It would be advisable, however, not to allow it to grow until basic perceptions have been communicated, say between analyst and decision-maker.

The Subsystem Decision-Maker's Problem

I now examine the broad structure of the problem as it may be perceived by the individual responsible for a subsystem of X; my intention is to provide a diagram which can be compared to figure E2, so that the sort of differences between D(subX)'s and the analyst's perceptions can be compared.

Figure E10 shows the overall picture of D(subX)'s perception* of problem and pattern of solution combined.

*He is shown as not at present including the analyst in his perception of the problem-solution process.

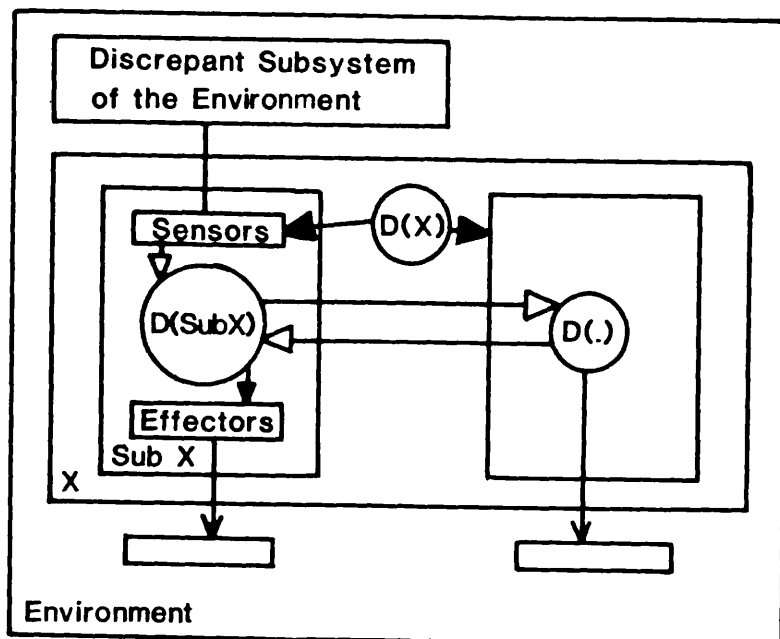


Figure E10. Overall Picture of a Sub-system Decision-Maker

There is an observed need for communication with other subsystem decision-makers under the control of $D(X)$, for whose purpose they too will be making interventions in the environment. The inclusion of sensors and effectors in this picture imply that, in general, there will be constraints imposed on $D(\text{sub}X)$ by $D(X)$ which will make some aspects of the operation of sub X independent of $D(\text{sub} X)$; the latter cannot be considered free to impose totally independent purposeful action on the environment (including sub X). In other words, once $D(X)$ has 'spoken', the machinery of organisation will go into action. Here, therefore, $D(\text{sub} X)$ is fully aware that he is not autonomous: his view of his fellow decision-maker is not more optimistic but simply more vague!

A Comparison of Perceptions

As drawn here, the perceptions of the analyst (figure E2) and of the sub-system decision-maker (figure E10) are very similar. This is not surprising since I am proxy for both. Nevertheless, there are differences which may be important (I add, and the reader must take my word for this, that these differences were observed after the diagrams were drawn and were not deliberately introduced).

- a. The analyst conceives of the environment as $D(X)$'s problem, $P(X)$, whereas $D(\text{sub } X)$ sees it as 'the environment'. The latter has something clear-cut to do, and, unless and until he finds himself in difficulty, he perceives no problem - at least no problem with which he needs to call for help. This is important to the analyst, if he feels that he should be intervening, but is not asked.
- b. The analyst has concentrated on what the system is likely to do and has not included explicitly why the system is thinking of doing it (the discrepant subsystem of the environment is not in figure E2). He may, for example, know that the system wishes to plan and develop a new transport facility: while this may identify the subsystem of the environment on which to operate, it may be far from clear why the former facility was inadequate. This may lead the analyst to 'optimise' on criteria which are irrelevant from $D(X)$'s point of view.
- c. The analyst is not clear, as $D(\text{sub } X)$ is, of the constraints under which the latter operates. The analyst's picture implies a much greater freedom of purposeful action by $D(\text{sub } X)$, in response to $D(X)$'s requirements, than will in practice be the case. (See note 1.)
- d. Moreover, the analyst does not focus on the need for co-operation between the subsystems of $D(X)$. As seen in figure E3, this becomes of importance to his dealing with $D(\text{sub } X)$ when advice in the intermediate and long-term is considered, and he may well take it into account at a later stage. However, he should be conscious of it before then, because (vide a. above) he may have to make a persuasive case for his involvement in the problem.

Necessarily, the above might be exaggerated because the perceptions although far from unreal, are artificially created. At worst, however, it illustrates something of the nature of what effect different perceptions might have on the interactions between analyst and decision-maker.

There are also differences between figures E9 and E10 that are potentially important. D(sub X) concentrates on what system X might do on its own and is relatively unconcerned with such external relationships that D(X) perceives as important. The analyst too (except in the meta-view of figure A1) is analysing entirely within the confines of X and its potential influence outside through sub X. It should be noted that often, in practice, he is constrained in this way by the perceptions that D(sub X), or D(X), may have of his, the analyst's, role - see appendix B.

In the earlier work, on which this appendix is based, an attempt was made to examine the process of communication between analyst and client, and how this might be viewed by them individually. However, figure E3, as interpreted here, is a meta-view and not the analyst's view, while a diagram which tried to give the decision-maker's view (not included here) was found not to go deeply enough, nor with sufficient conviction, to be useful for my present purpose.

Finally, it is worth noting that the representation of the OR process given in the diagram of appendix C was produced at about the same time as those discussed above, albeit for a different purpose. That diagram does not aim to examine perceptions and the problems that will arise from differences in these. It is a simple meta-statement of the process and the part that the analyst plays in a satisfactory analyst-client relationship, although it did in practice (through discussion based on it) provide some insights into difficult situations that might be encountered and that could perhaps be avoided. I regard it as representing a situation, or leading to an understanding of a situation, much closer to the ideal than that implied by figure E1.

Note 1

Professor McDowell has pointed out that comments on the different perceptions of constraints under which a sub-system decision-maker works do not follow logically from figures E2 and E10. This is a valid point: it is the interpretation in the text that leads to the conclusions stated and the intent when drawing the diagrams is not explicitly represented. All depends on how sensor and effector subsystems are defined. I see them as acting independently of the decision-maker: ideally they do his work and his bidding, yet they are not part of him and how they operate creates a constraint on what he can achieve - see, for example, Halperin, (1974). What might be needed, for the notation, is some rule about the inclusion or non-inclusion of sensors and effectors, or some way of indicating the perceptions, by a decision-maker, of organisational constraints.

Jannet Harris states, in relation to these very general diagrams, that, without verbal expansion, they can induce as much misunderstanding as any other communication. Normally, of course, such diagrams will be used for communication on a problem that is already, in part, shared knowledge.

Language - a Military Example

K.C. Bowen

This, like appendix E, records, for the first time, work carried out by Janet Harris, slightly altered for the purposes of this thesis.

LANGUAGE - A MILITARY EXAMPLE

Military conflict between two countries X and Y can be conceived in terms of their intentions to reduce the "value systems" of their opponents. "Value" is being used in a very broad sense here, as opposed to the more specialised use in, for example, Bowen, 1979. The expression connotes a combination of belief and resource systems. Here two particular military components of the value systems will be stressed, their firepowers (F_x, F_y) and their logistic (movement) capability (M_x, M_y). The latter have no inherent firepower in the concept at present being followed. The value systems contain many other components (capital assets, human resources, beliefs, ways of life and so on), but this example will not be concerned with them explicitly. So far, the statements made give figure F1.

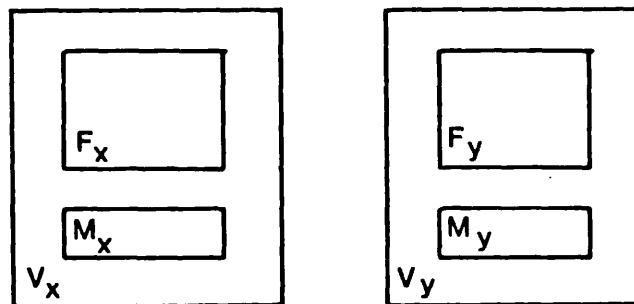


Figure F1. The Value Systems of Warring Opponents

X's purpose in having F_X will be taken to be its potential for the destruction of V_Y : it enables X to act counter to the value system of Y. This can be written

$$F_X = CV_Y, \quad C \text{ being an operator;}$$

and, similarly,

$$F_Y = CV_X.$$

Assuming symmetry between V_X and V_Y , it seems reasonable to put V_Y , with the preceding operator C, in place of the F_X box (figure F2).

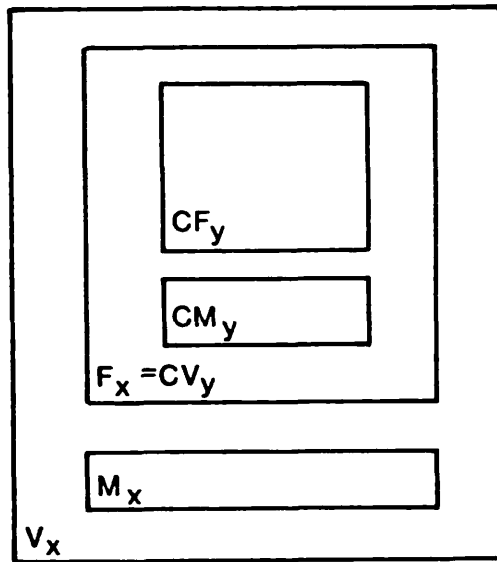


Figure F2. Use of the Operator C (counter)

Two systems. X and Y , have value systems (sets) V_X and V_Y . In general, if K is any set defined for $X(Y)$, $K_X(K_Y)$ will denote this set.

Definitions

1. F_X is the set of elements of V_X which have first order interaction with Y (i.e. F_X acts directly on Y).

2. M_X is the set of elements of V_X which have second order interaction with Y (i.e. M_X acts on Y only through F_X).

Now take the following as axiomatic.

Axiom 1. The structure of Y mirrors the structure of X .

Axiom 2. $F \cap M = \emptyset$.

From definitions 1 and 2,

Axiom 3. $V \supset F$ and

Axiom 4. $V \supset M$

are sufficient, with axioms 1 and 2, to produce figure B1.

In order to deal with operator C , a further definition is required.

Definition

3. For any subset K_Y of V_Y , CK_Y is that subset of V_X which is specifically directed to first order interaction with K_Y .

Using definition 1, it follows that $CK_Y \subset F_X$ and also that, if $K_Y \supset L_Y$ then $CK_Y \supset CL_Y$ (L is a further subset of V).

In particular, $CK_Y \subset F_X$ implies $CV_Y \subset CF_X$.

But, from definition 1, $F_X \subset CV_Y$.

Hence, $F_X = CV_Y$. Similarly, from axiom 1, $F_Y = CV_X$. We will treat these as axiomatic, viz.

Axiom 5. $F_X = CV_Y, F_Y = CV_X$.

From axioms 3 and 4 and definition 3, it also follows that, since F and M are subsets of V_Y , $CF_Y \subset F_X$ and $CM_Y \subset F_X$ and we treat this as axiomatic, viz.

Axiom 6. $CF_Y \subset F_X, CM_Y \subset F_X$.

Axioms 1 to 6 are still inadequate to produce figure B2. An additional axiom is needed, viz.

Axiom 7. $CF \cap CM = \emptyset$

As the production of diagrams towards figure B3 continues, reuse of definitions 1 and 3 are needed to deal with the sub-sub-sets and so on; new axioms arise, but further ones need introducing ab initio before figure B3 is reached.

Axiom 8. $CCF \cap CCM = \emptyset$

Axiom 9. $CCCF \cap CCCM = \emptyset$

Minimally we need definitions 1, 2 and 3 with axioms 1, 2, 7, 8, 9 and so on.

It will be observed that definitions 1 and 2 and axiom 1 are immediately inapplicable to figure F4. As soon as the roles of different physical entities in F and M are taken into account in the language developed, the simple axiomatic structure above becomes useless. It may be inferred that the language used for conceptual models, which represent the meaning of that language, may be quite inappropriate for discussing many of the complexities of physical systems; in the latter, allocation to role, spatial and temporal relationships, and many other factors are introduced. What language to use can be decided from the diagrammatic structures that seem to contain what it is desired to say! It may be found, as for figure F4, that finding suitable language, other than the diagram itself, may be far from easy.

Third-Party Consultant
A Method for the Study and Resolution of Conflict

K.C. Bowen

This, and the related text in chapter 3, was first prepared
in 1973 as part of a communication to A.S. de Reuck
of the University of Surrey in the context of his work
with J.W. Burton.

THIRD-PARTY CONSULTATION
A METHOD FOR THE STUDY AND RESOLUTION OF CONFLICT

The title of this appendix is that of a paper by Ronald J. Fisher (1972) which surveys the subject of conflict resolution and integrates ideas. It adopts the view that rival "theories" are based mainly on observations about different aspects or dimensions of the overall conflict problem. It suggests that all conflicts can be described in common generic terms. It regards conflict as an essential element of any relationship between systems, and it looks at resolution of conflict as requiring the control of the dysfunctional nature of conflict. Without processes of "third-party consultation", whether these be external to, or accepted within, the environment of the main interaction, he sees conflict to be more naturally escalatory than self-correcting. Fisher's outlook is seen to be similar to that of David Smith and myself: our studies (Bowen and Smith, 1976) were carried out at about the same time as Fisher's but the two inquiries were completely independent.

The tabular summary given by Fisher (his figure 1) is interpreted more briefly in table 1 overleaf. He refers to it as a model, although I regard it, in conjunction with his accompanying text, as only suggesting what such a model might be. My diagrams (figures 10 to 13, chapter 3) develop the essence of Fisher's finding into model form: its essential elements (representing the task of the third-party consultant, Z) are paralleled, in table 1, with the statements that Fisher extracts as generalities common to the majority of conflict resolution techniques that he analyses.

Refers to Figures 10 to 13 of Chapter 3	Refers to Figure 1 of Fisher's paper
<p>a. To change X, Y representations by:-</p> <ul style="list-style-type: none"> (i) making them aware of each other's representations; (ii) offering structures through which they can modify their concepts of X*, Y* aims and policies; (iii) helping them seek superordinal aims and policies (mutual, co-operative, non-conflicting, etc.); (iv) retaining neutrality as a member of Z, who would (figure 10) seek to modify X*Y* interaction, in ways similar to Z behaviour in the XYZ interaction. 	<p>Improving communications (improved relationship and attitudes - see also b(ii)).</p> <p>Professional expertise and knowledge of conflict (diagnostic and regulatory functions).</p> <p>Positive motivation. Movement towards conflict resolution.</p> <p>Low power. Moderate knowledge.</p>
<p>b. To retain his neutrality by:-</p> <ul style="list-style-type: none"> (i) developing X and Y representations of Z to match his perceived role; (ii) improving communication by controlling the neutrality of the XYZ environment (and by actions related to a. above). 	<p>Impartiality</p> <p>Control over situation.</p> <p>Improving communications (link back to a. (i) above).</p>

Table 1. The Roles of Third-Party Consultancy

As discussed in chapter 3, interactions are face-to-face communication or communication through the third-party. No other environmental feed-back occurs in the neutral environment which is so important: there is a need for the understanding and interactions of X and Y to belong to them entirely and not to be a function of an environment which is uncontrolled and difficult to understand.

It is noteworthy that the two roles of Z (a. and b. of table 1) are integrated through the overriding need to improve communication. This and other aspects of the resolution process that Fisher observes seem to be adequately covered by the diagrams of chapter 3. Finally, there is an implicit plea in Fisher's paper for a meta-language for the expression of Z's viewpoint and this too seems to be provided by the notation.

Attachment 2 to "A Methodology for Problem-Formulation", a thesis
submitted for the degree of Doctor of Philosophy by Kenneth C. Bowen,
Royal Holloway College, University of London, December 1983.

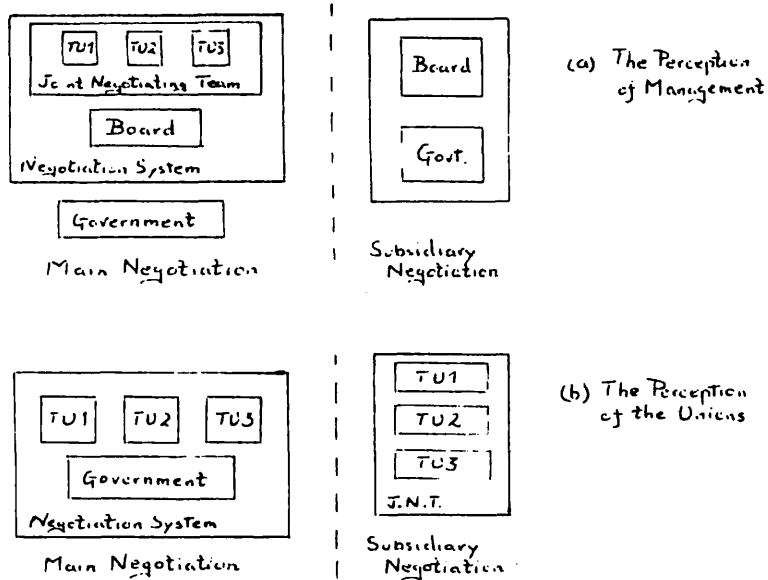


Figure 10. Two Perceptions of a Negotiating System

The difficulty stemmed from what was meant and understood by "we" and "you". If the board said "we", the unions heard "we, the government". If a trade unionist said "we", he referred to his union, but the board heard "we, the joint negotiating team". "You" had reverse implications, different for each side. This is a more complex version of the problem of getting a promotion candidate to distinguish between his contribution to team work and the joint contribution: he tends to use "we" indiscriminately, and, because of the way he perceived his task, finds difficulty in attributing any glory to "I".

Language and perceptions are so intertwined that it is difficult to see them as separate issues. Perhaps this is why experts often persevere with their technical language without observing that they are communicating little to those whom they are advising.

It is one of the purposes of the notation presented here to offer a simple, neutral language for discussion and description of problems. Importantly, the statements will be in explicit permanent form.

6. THE PROBLEM OF USING THE NOTATION

The notation has little future if I cannot make good use of it myself. I claim, although this has little weight as evidence, that I have been able through its use to see problems more clearly, and I have extracted from diagrams ideas which were not in my mind when the diagrams were drawn. In small ways, it has been useful to colleagues in discussing their problems. There are two obvious next steps.

Firstly, I should be able to draw my problem, to encapsulate the essence of conducting the process of problem-formulation with a client group. Figure 11 is a simple version of such a diagram.

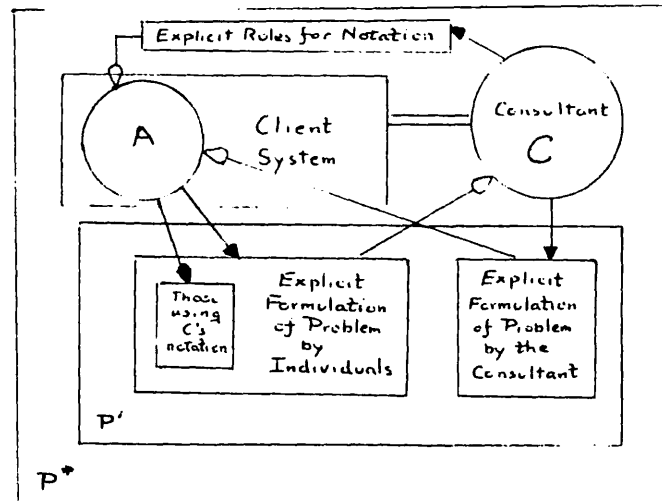


Figure 11. The Problem of Problem-Formulation

P^* is my problem. P' is the developing formulation of the problem, many intertwined problems of my client group. I am the consultant, C, and to each and every one of the group, of whom A is one, I provide explicit rules for the notation, e.g. this paper, and *my* initial perception of *their* problem. I act purposefully in providing these, but there will inevitably be distortion in the communication to A. A will respond, perhaps not at first in the language of the notation. The process is iterative: eventually a shared sense of ownership and purpose is expected, and any initial conflicts between A and C or within the client group (not shown here) should be reduced. The aim is that any residual conflict should be benevolent, part of a common process for understanding the full variety that constitutes the problem.

The second stage of testing is to apply the method in an environment in which:

- (a) the initial sense of conflict is small;
- (b) the language is broadly acceptable ab initio;
- (c) the clients will be cooperative for the experimental purpose; and
- (d) the clients will adopt a critical attitude to the process and to the notation.

The purpose of this initial experiment is to seek limitations or defects in the method proposed, and to see whether simple changes can overcome these or whether a more drastic reappraisal will be needed.

In my unpublished papers, mentioned at the end of section 1 of this paper, I discuss reasons for not extending the notation in an idiosyncratic way based on what emerges from the study of any particular problem. I base my outlook on my interpretation of Popper's views [6] on the process of developing and testing theory, although I have applied these to a methodology, to something less than a theory. In particular, I am concerned with *simplicity* and *falsifiability* as important related concepts. In brief, I cannot hope to falsify my theory that the notation as such is generally helpful, if it becomes specific in some aspects for each problem separately: the notation must remain general.

This does not imply that other notation, other languages, cannot be used. It merely means that these will not be relevant to the judgment of what my notation can achieve in its present or amended form.

7. THE FIRST ATTEMPT AT APPLICATION

I have just begun the process of becoming a consultant (unpaid) to an university group responsible for teaching OR and systems thinking at second-degree level. The task they face, as I see it at present, is the development and maintenance of the practical and academic acceptability and standards of their courses.

It is a wide-ranging problem area, rich in the variety of people and the potential conflicts involved. Its elements include the teachers; the students; the larger department of which these are part; the university and outside bodies, concerned with academic standards; potential employers, including those who provide facilities for practical work; and many others.

Those who are prepared to assist me in experimental consultancy, by being my clients, provide the environment summarised in the preceding section. They also have a vested interest which should increase the likelihood and relevance of a suitably critical attitude. If the method is sound, they would be able to use it as teaching material: this would help in the development of their courses in a manner quite distinct from its use in planning such development.

8. CONCLUDING REMARKS

Further research is planned to see whether this method of problem-formulation can provide a useful basis for the later employment of methods of analysis such as hypergames, Bennett et al. [7], and the analysis of options, Radford [8].

As far as use of the notation is concerned, six months will have been spent in attempts to apply it before this paper is presented. Unfortunately, I cannot predict the outcome. I believe however that any attempt to offer something in one of the most neglected areas of the total OR process is important, even if it does no more than encourage others to develop other and better methods.

It is worth bearing in mind that, sometimes, understanding of the nature of the problem, in the fullest sense, may be all that decision-makers require.

9. ACKNOWLEDGEMENTS

I wish to thank the Principal and the Head of the Department of Mathematics at Royal Holloway College, University of London, for the facilities provided for my continued research; the Leverhulme Trust for financial support; the Ministry of Defence, under whose aegis earlier research freedom was granted; and many colleagues over the many years the ideas reported here have, with their help, developed.

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**A CONFLICT APPROACH TO THE
MODELLING OF PROBLEMS OF AND IN ORGANISATIONS**

**Une méthode de formulation des problèmes
des organisations au moyen du concept de conflit**

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Abstract: A fundamental aspect of decision-making is the initial and continuing exploration of what problem is being addressed. An approach to the explicit formulation of problems is offered through a diagrammatic notation first developed for the study of conflict. It is a systems approach with attention to concepts such as language, roles, perceptions and prejudice. It aims to help decision-making groups to communicate and understand better their separate and joint purposes.

Résumé: Un aspect fondamental de la prise de décision est la définition et la continuelle remise en question de la problématique à considérer. Cet article propose une formulation explicite des problèmes, au moyen d'une notation par diagramme, développée il y a quelques années au cours d'une étude de conflit. Il s'agit d'une approche systématique où on utilise les notions de langages, rôles, perceptions et préjugés des acteurs du problème. Son but est d'aider à la prise de décision de groupes en formalisant la communication afin de faciliter la compréhension des buts individuels et collectifs.

1. INTRODUCTION

In the early 1970s, with a colleague, David G. Smith, I became interested in the nature of conflict. In particular, since I was then working for the Ministry of Defence, I was trying to understand better the process by which situations developed towards and into a state of war. Not only is it important in modelling warfare to know something about likely initial conditions, but it is important in peacetime to consider allocations of resources, to equipment, organisation, intelligence and so on, that could lead to wider options for steering conflict towards peaceful resolution.

During the study, two generalisations became apparent. Firstly, the conceptual modelling that was developed, and the diagrammatic notation that described the models, related to conflict of all kinds, between individuals and between groups. Secondly, the methodology followed seemed to have relevance to the analyst-client relationship in the OR process, especially to the early stage of discussing and making explicit the problem that was, jointly, to be resolved. Although various minor applications of the ideas were made in internal papers, only two published references are available. In 1972, Bowen and Smith [1] presented a paper to a social sciences seminar at Edinburgh University, and a later extension of the notation by Janet I. Harris was included by Bowen [2] in a book on research games.

The use of the notation for the formulation of problems is now the subject of a three-year research programme: this paper summarises the position at the end of the first year. The notation and rules for its use differ in several respects from what is described in the earlier papers. Although full documentation on all aspects of the research is available, it is in draft form only.

2. SYSTEMS, INTERACTION AND CONFLICT

In referring to *systems*, I follow the practice of Ackoff and Emery [3]. In particular, the elements that make up a system or a sub-system will be those and only those which are relevant to the inquiry, and similarly for the direct or indirect relations between them. The environment of a system will consist of all relevant elements that can affect the system's state: however, in contrast with Ackoff and Emery's definition, the environment will be defined as including the system itself. This allows labels, as in figure 1, to apply to everything in the *boxes* (systems) so named.

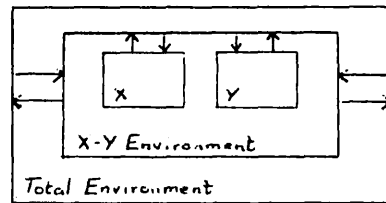


Figure 1. Interaction of Systems

Here, two systems, X and Y, *interact* in a common environment. They affect their environment and it, in turn, affects them, as shown by the directed lines (*arrows*). It will generally be assumed that *direct* interaction takes place through this process. Similarly, the wider environment, here called the total environment, influences the more immediate environment of the interaction.

It is not necessary to include all arrows, if, by convention, interaction takes place as shown between contained and containing systems (sets, boxes). In any set of boxes-within-boxes, the interaction takes place via the next system boundary. However, two cases in which arrows will be used, for emphasis, are:

- (a) to stress the importance of a particular interaction, as is done in figure 1 for the purposes of this paper; and
- (b) to stress an interaction, across system boundaries or otherwise, when this is seen in some sense as direct.

The choice of emphasis is left to whoever draws the diagram, since it is his statement to be used in a process of communication. Figure 2 gives an example of (b), the interaction of X and Y being primarily through X's influence on a subsystem (subset) of Y.

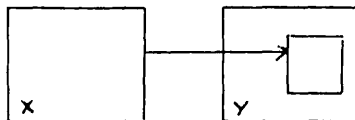


Figure 2. Direct Interaction

Potentially, conflict can exist between disjoint sets or systems within an enclosing system, e.g. within the immediate environment of X and Y in figure 1. This may be emphasised by a double line joining X and Y as in figure 3.

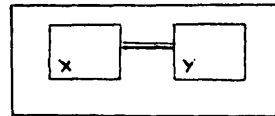


Figure 3. Conflict

It is important that the word *conflict* should not be misunderstood. It implies [1] that there are some differences (in aim, policy, understanding, etc.) between two systems that interfere with one or the other, or both, in their attaining future system states preferred by them. Resolution of conflict can take many forms, for example a change in own attitude and actions, similar change by an opposing system, or change in environment. Conflict may be benevolent in the sense that, without differences to stimulate a broader understanding of the issues faced, there would be no progress. The double-line notation is intended to be used when such differences appear to operate malevolently, contrary to hoped for cooperation or amelioration of hostile or conflicting attitudes. It is also usable to indicate potential conflict of an undesirable kind.

It will often be necessary, whether a system be an organisation or an individual, to describe some of its subsystems, particularly those that represent the data-store (memory, representation) and the decision-making capability. Such subsystems are clearly relevant to the formulation and resolution of problems: but they can also create, as well as resolve, both problems and conflict. Problems and conflict go hand in hand. There are some concepts which appear to be particularly relevant: *prejudice, roles, perception and language.*

3. DECISION-MAKING

The original paper [1] dealt with the sub-systems that receive data and those that put decisions into effect. Here I shall assume that, in many cases, these sub-systems, which are present in all purposeful systems, can be subsumed into the interaction of the representation and decision-making sub-systems with the system itself (figure 4).

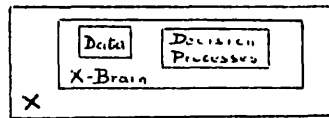


Figure 4. The Brain of the System

The two sub-systems shown in this figure are jointly referred to as the *brain* of the system. It is here that important processes go on when a decision by X is to be made to resolve the undesired influence of Y. Figure 5 will only be discussed here in relation to one important concept. Other aspects are treated elsewhere [1].

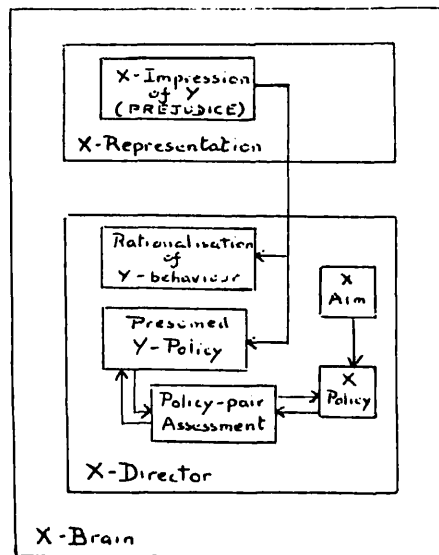


Figure 5. The Decision-Process

X is trying to choose a policy to match his aim. It must also take into account the policy of Y, which is not a cooperating one. X may not be able to guess Y's aim, and he can only get an appreciation of Y's policy through a rationalisation of Y's behaviour. This rationalisation will be based on his prior picture or judgment of Y: in short it is based on *prejudice*. (As an aside, I am aware that my use of this word, and the word conflict, may induce conflict

between analyst and clients, and will have to be used with care. For present expository purposes, I hope to escape censure.)

When X's beliefs about Y are false, it is likely that X's chosen policy will not produce the results he expected; a planner who believes that people will necessarily follow his criteria of what is good (for them!) is in for some rude shocks. So, X has to try to interpret Y's behaviour taking into account Y's culture and history. He need not agree with Y, but he does need to appreciate how Y might (in his own rational context) react to X's actions.

These aspects are important to most problems, within the decision-making group and outside. It may be that detailed procedures, such as those developed by Eden et al. [4], are needed to examine the beliefs, values and constructs that make up the relevant world-pictures of those involved in a problem. However attention can be drawn to such factors by including them in diagrams such as that of figure 5. The sub-systems which are concepts in the mind of an individual may be akin to fuzzy subsets, but the notation still seems appropriate and the choice of what and what not to include is for whoever *owns* the diagram to decide. Ownership here is an acceptance of a concept or a statement as one's own: the thing owned may have been borrowed, as has this concept of ownership.

4. ROLES

People are complex systems and equally complex in their *roles* as sub-systems. Because of their unique importance, a symbol to differentiate them from other systems is desirable. A *circled* is the chosen symbol. A group of people will be shown as a box containing circles, since a group requires things other than people: it is a purposeful system, but does not itself act like a person.

In a system, there is often someone nominally or actually in control. The circle is then placed in the upper left hand corner of the box. Figure 6 shows a hierarchy in simple terms.

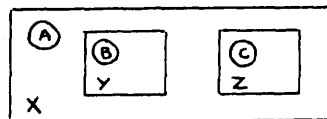


Figure 6. Control in a Hierarchy

B and C in charge of systems Y and Z are subordinate to A who is in charge of X of which Y and Z are sub-systems. Assuming that it works properly, conflict between Y and Z does not need to be indicated since A's role is to resolve

conflict through his control of B and C.

In figure 7, however, A is shown as having a dual role, being superordinate to B, but also directly in control of subsystem Z in which role he is at the same hierarchical level as B.

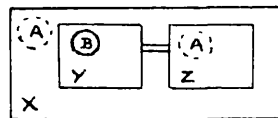


Figure 7. Role Confusion in a Hierarchy

The notation shows A in two places as hatched-line circles. At any one moment in time, A is thinking and acting in one of his two roles, but, having only one brain, he cannot fully dissociate himself from either. He is in no state for resolving conflict between the subsystems: potential conflict is shown accordingly.

Similarly, a person as an entity in, say, a business organisation may be influenced in his behaviour by his roles in other systems: in political, social, religious, parental and other roles, he may act in ways apparently illogical to those who see him as a subsystem of the business system. Accordingly, problems in a firm may have to be examined outside the natural boundary, the business environment. At the simplest level, any good manager knows that what is happening in an individual's private life is far from irrelevant to the office or workshop.

5. LANGUAGE AND PERCEPTIONS

Because individuals may perceive organisations, and the problems that organisations face, very differently, it will be necessary to produce more than one diagram for some purposes. It is in making such differences explicit that a first step in conflict resolution is taken. Reality, at any moment, seems to be a composite of all relevant *perceptions*. Conflict can arise from misunderstanding of *language* which is used to describe something according to one set of perceptions (world-picture) but which is interpreted through a different set.

A simple example is given in figure 8. *Policy* at one level of a hierarchy becomes *aim* at the next level. It is translated into policy at this lower level and again handed down. People in such a hierarchy talking about policy are not necessarily talking about the same thing, although it may often be similar enough for them not to notice and different enough to cause confusion. Also, in the process of communication down the hierarchy there will be distortion of what was

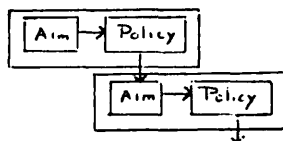


Figure 8. Aims and Policies

intended. One reason for this, discussed by Laing [5], occurs due to the use of oral communication: other reasons include the constraints that people perceive as limiting their actions, and obvious things like simple misappreciation.

Because of the importance of what happens contrary to what was intended, special arrows, dealing with purposeful action, communication and, in both cases, distortion are introduced (figure 9).

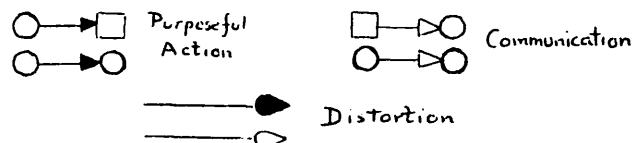


Figure 9. Purpose, Communication and Distortion

The rules are that purposeful action begins from a circle and communication ends at a circle. Boxes can provide communication but they are not communicated with, nor do they have purpose except through the people they contain. In this paper, I shall use these arrows only in the figure in the next section which describes my problem of putting the notation to effect with a client.

But before discussing that I want to add a little more about language and perception, firstly through a rationalisation of communication and conflict in a trade-union and management negotiation.

There were three unions concerned and together they formed a joint negotiating team. Subject to certain responsibilities to government, the management board was free to negotiate. Reading transcripts of some of the interchanges, I was struck by the apparent irrelevance of responses and the awareness of the participants that there was some hidden barrier to understanding. Figure 10 gives my guess of the perceptions of the two sides: it was sufficient to reinterpret and make sense of many of the confusing responses, and its correctness or otherwise is not important here.

An Experiment in Problem Formulation

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In a recent paper (in *Operational Research '81*, North-Holland, 1981), the author put forward a methodology for problem-formulation. In order to test it, a group of teachers concerned with the introduction of a new, integrated operational research and systems analysis M.Sc. course agreed to accept the author as a consultant. The aim was to clarify and define their problem of developing and maintaining their new course. This paper describes the nature and course of the experiment. It comments on the difficulties that were encountered, and on the perceived benefits to the client-group and to the researcher.

Key words: methodology, research, experiment

INTRODUCTION

ONE OF THE most important tasks for any operational researcher is to ensure that the problem that he studies for his clients is one that they perceive. If it is not, then either they will not use his results, or, worse, they will misuse them. Further, it is important that the problem be seen and analysed in its total context, however restricted the eventual boundaries may have to be for pragmatic reasons: without such an approach, a proper choice of analysis methods is very difficult and an adequate adaption to new demands and to a changing world is impossible.

The need for satisfactory methodology for this purpose drove the author to develop ideas from earlier work on conflict resolution, and a basis for problem formulation in diagrammatic form was proposed in a paper published recently.¹ The purpose of this explicit, largely non-verbal technique was to act both as a discipline for the analyst and as a medium for communication with his clients. It is essentially a systems approach.

It is not pretended that there is nothing else available. Over the period that this work has been in progress, other developments have taken place. Nevertheless, for different situations, different clients and different analysts, the same approach may not be satisfactory. The aim has been to find something more structured than the methodology of Checkland² and less detailed in its treatment than that of Eden *et al.*³ It is suggested that the former leaves too much to the idiosyncratic nature of the analyst, while the latter demands a type of client and analyst participation which, from personal experience, is not seen to be easy to achieve in bureaucratic organisations such as Ministries. However, there is nothing that is intended to be at variance with these two approaches, nor with other methodologies that have been studied, such as the use of systems dynamics by Coyle and Wolstenholme.⁴

This paper looks at what happens when the proposed methodology is put into practice.

THE CHOICE OF EXPERIMENTAL CLIENTS

Normally, experiment is undertaken to test a theory. Following Popper,⁵ one criterion for satisfactory experimentation would be that the theory initially postulated had the highest degree of universality and precision that seemed sufficient: in other words, one starts with the hope of being able to make simple statements and only introduces conditions and qualifications when this is inevitable. The notation proposed¹ has a simplicity which accords with this principle, and one purpose of the experiment was to test the sufficiency of the notation for describing problems.

A first draft of this paper was presented at the *Fifth European Congress on Operational Research*, Lausanne, Switzerland, July 1982.

Just before the 'communications problem' took people's attention, I had suggested extending the study into areas relevant to these, particularly the tasks of the Course Organiser and the resources, of time and people, required to handle these and other difficulties. How effort is to be made available is necessarily part of the policy issue.

I believe that, had this not been an experimental consultation, we might have got through these additional inquiries and, as expressed forcibly by one of my clients, have started on the "real problem"—"our inability to get ourselves into action over all things that concerns us".

CONCLUDING REMARKS

By itself this experiment is not enough: it is also, inevitably, incomplete. There are now in progress at Royal Holloway College two formal studies for outside organisations that will use the methodology. Only when satisfactory results stem from such operational tasks can any 'proof' of the usefulness of the methodology be claimed, although I shall hope that the University of Aston group will wish me to take the work done there to a further stage.

Even at the present stage, however, I am satisfied that, during the experiment, the methodology enabled me, in much more detail than I could otherwise have done, to interpret the clients' pictures of their problem. In turn, this helped them to formulate ideas and concerns which might otherwise have had little, or less satisfactory, debate. I would also stress that communicable diagrams, rich in information, have been created using very simple and explicit rules.

ACKNOWLEDGEMENTS

I wish to thank The Leverhulme Trust for their support for this research. In also thanking John Watt and his colleagues at the University of Aston, I express the hope that the help they gave to me has had a compensating return.

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A second criterion is that the theory must be potentially falsifiable. However, in dealing with a methodology, any statement in the form of a general theory is difficult. What is to be established is that people in general will be aided by the methodology and will wish to use it or have it used on their problems: not *all* people, but *some* people, and this 'some' must be an appreciable number. Any failure with a client or client-group must point to directions for reappraisal of the methodology: there may be a need for changes in notation or uses of notation, in the way in which the methodology is applied, or in the class of clients for whom the methodology is seen to be suited. Thus, the methodology must include the consultancy procedure for its application. It was with this in mind that the previous paper included a diagram in the notation to express the problem of applying the methodology: this diagram is repeated as Figure 1 in the next section.

To carry out a *first* experiment, it was necessary to find a real problem in process of study by those who had perceived it as a problem, but it had preferably to be one for which the relationship between analyst (consultant) and clients was already reasonably established and such that true consultancy and experiment could go hand-in-hand. It was essential that the clients be critical; and, if possible, that they should have a vested interest in there being such a methodology and in its having a general (rather than a specific, own-problem oriented) application.

After considering various possible clients of a general kind, who were aware of their difficulties in the past of having concentrated on the wrong problem, and more specific clients such as operational researchers, who were aware of their lack of a suitable problem-formulation methodology, it became apparent that teachers of operational research formed the most suitable group for seeking 'experimental clients'. Preferably, the client group would be one which was seeking to increase the generality and methodology content of their teaching of O.R.

An obvious choice was the University of Aston Management Centre's Operational Research and Systems Analysis (ORSA) group. They were, at the time that the experiment started, nine months away from the introduction of a new, integrated, M.Sc. teaching course and were well aware of the very considerable difficulties that faced them in this innovation. My personal relation with them (and it is essential that I now use the first person) was well-established and I knew what they intended, in general terms, through my position as External Examiner of the Systems Analysis M.Sc. course. At that time, this was a separate course from the Operational Research M.Sc. Towards the end of 1980, I proposed that they accepted me as a consultant on their problem, defined provisionally by me as

"developing and maintaining an integrated M.Sc. ORSA course in the Management Centre of the University of Aston".

They accepted this and, in December 1980, I commenced the experiment to apply my methodology to assist a client group of ten people, conscious that I had to beware of my own preconceptions due to my other role in the Department.

THE FIRST STAGE

In January 1981, I sent to each member of the client group the following material.

- (a) The rules governing the notation used.¹
- (b) A suggestion that each individual might wish to discuss with me personal problems within the overall course development programme and how these might arise.
- (c) A set of six diagrams, describing, on the basis of written documents and earlier discussions of a general nature,
 - (i) the management system;
 - (ii) the proposed structure of the ORSA M.Sc. course;
 - (iii) communication and purpose, with primary potential conflicts (relating to systems external to the group);

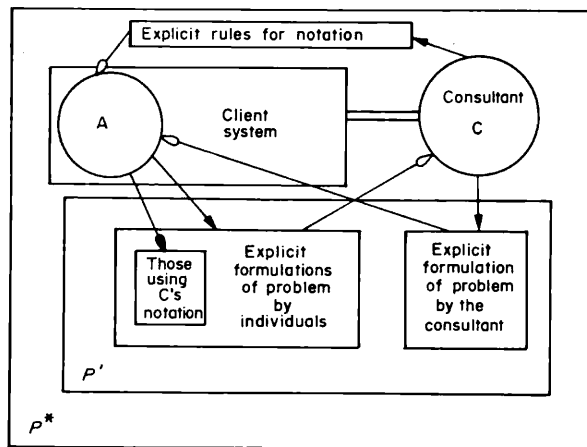


FIG. 1. *The problem of problem formulation. A is any individual client. P* is my problem. P' is the developing picture of their problem.*

- (iv) resource allocation;
 - (v) personal aims, policies and values;
 - (vi) the course programme monitoring and coordination system.
- This was all I was able to abstract from what had so far been given to me.
- (d) A request for differences of opinion on, or lack of understanding of, my treatment of the as yet incompletely defined problem.

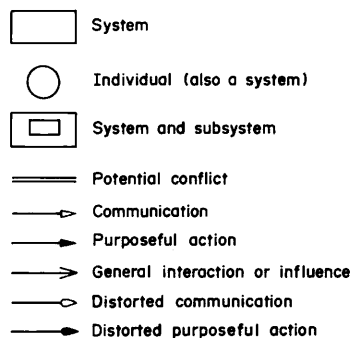
The process of interaction was described in the paper forwarded (a). Figure 1 repeats the appropriate diagram and gives implicitly some notion of the diagrammatic language. The main elements of that notation are shown in Figure 2.

It was intended that each person should respond to me in his or her own time. Dealing with busy people, already under pressure from current teaching and future planning, this was a mistake! In due course, I arranged a series of interviews at the University, spending an hour or more with each individual.

In a short paper, I cannot provide full details of the diagrams, nor of the way in which they changed as the consultations developed (these are still in progress). I have tried to provide enough to indicate how the methodology helped the exploration of the problem and communication of individually perceived issues.

The management system

The most important discussions stemmed from the perception of the roles of the Acting Head of the Group and his nominated Course Organiser. My original impression of the hierarchy was as in Figure 3, which is part of a much more detailed picture of the management system. Discussion led to a new picture (Figure 4), introducing the Course



Arrows are used to emphasise interactions.

FIG. 2. *Notation (other rules are made specific in Bowen¹).*

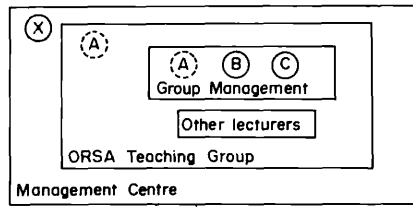


FIG. 3. My initial perception of the hierarchy. A = Acting Head of Department. B,C = other Senior Lecturers. X = Head of Management Centre.

Organiser as superordinate to his Head of Department for the purpose of developing the new course and reporting to the Director, Post-Graduate Studies. It also eliminated the concept of a 'group management', since the client group saw themselves as operating in a looser framework in which all major decisions were negotiated through a joint discussion process. The leading roles of the three more senior people, including the Acting Head of Department, operated by example and by persuasion.

Monitoring and coordination

Consequential changes occurred in three other diagrams—see c(iii), c(v) and c(vi) above. However, in the last of these, the system for the monitoring and coordination of the M.Sc. course programme, other major changes occurred, introducing the Admissions Tutor and the role of the Course Organiser in his later role of administering the new course under the general supervision of the Acting Head of Departments (the natural hierarchy now operated). Figure 5 shows the process as it finally appeared. It should be noted that this is not capable of integration with the diagram of Figure 4, since the roles of two people have changed (I believe that the discussions clarified their picture of their dual relationship).

Reporting back

A great deal of information on personal difficulties was obtained. The lack of a clear process for the later understanding of and control of what was going on was also identified. A detailed report (generalised to preserve certain confidentialities) was made to the Acting Head of Department with several modified diagrams. Following an interview with him, and his agreement to pass the information on to individuals, further discussions were held to decide how best to proceed.

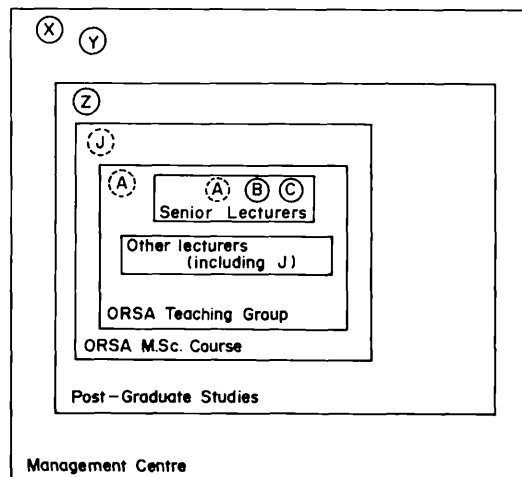


FIG. 4. Amended picture of the hierarchy. A = Acting Head of Department. B,C = other Senior Lecturers. J = Course Organiser. X = Head of Management Centre. Y = Dean of Studies. Z = Director of Post-Graduate Studies.

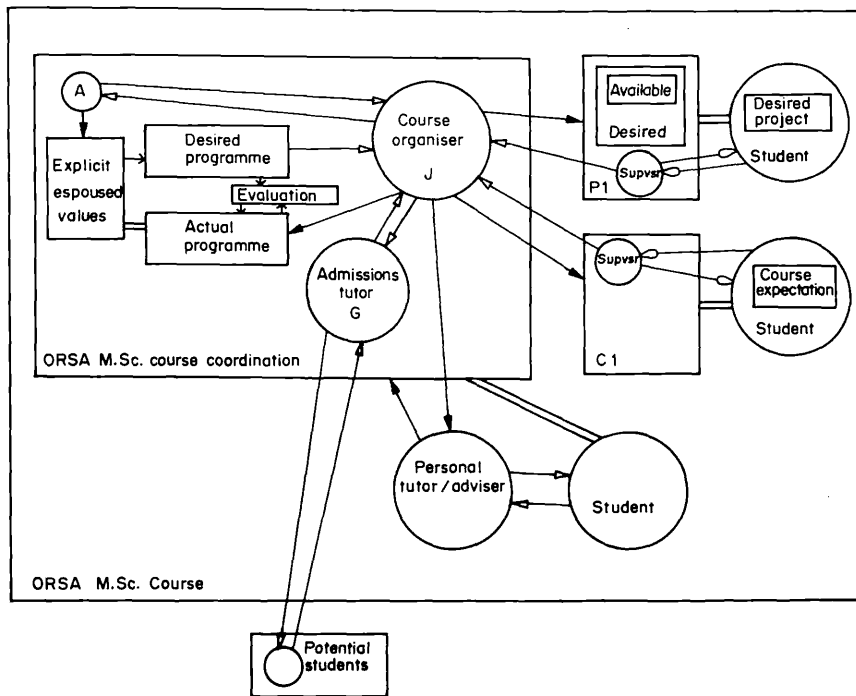


FIG. 5. Monitoring and coordination of M.Sc. course programme. P1, . . . , C1 . . . , C1 . . . , are projects and courses.

One evident shortcoming was that (Figure 5) the monitoring and coordination process depended on there being “explicit espoused values” (their phrase) and on there being adequate data fed back to indicate the satisfaction of both students and staff with what happened once the new course started. It was also evident that the initial picture of the proposed structure of the course—see c(ii) above—would have to be developed in considerably more detail.

The Course Organiser provided his version of what the course was intended to put into the minds of students: he called it the Learning Objectives. There were 25 of these; for example:

“At the end of the course students will:

1. understand and value the view that perceiving the world as a variety of nested and overlapping systems provides a useful way of generalizing the process of problem solving, decision making and the provision of information for managers;
- ⋮
6. be able to use statistical concepts to describe and estimate uncertainty in the behaviour of systems;
- ⋮
16. be able to identify, develop and modify a variety of models describing the relationships of system behaviour with action plans, strategies and objectives;
- ⋮
25. be able to use computer hardware to run systems programs and to develop their own programs.”

These objectives were generally idealised (in the Ackoff sense), but were nevertheless useful as broad guides to what was being aimed at. I was told that a questionnaire would be put to students, at various stages during the course, to get their reactions to whether these learning objectives were realised. I was asked to take the now more developed syllabus and provide a detailed diagram of the course structure linked with the learning objectives.

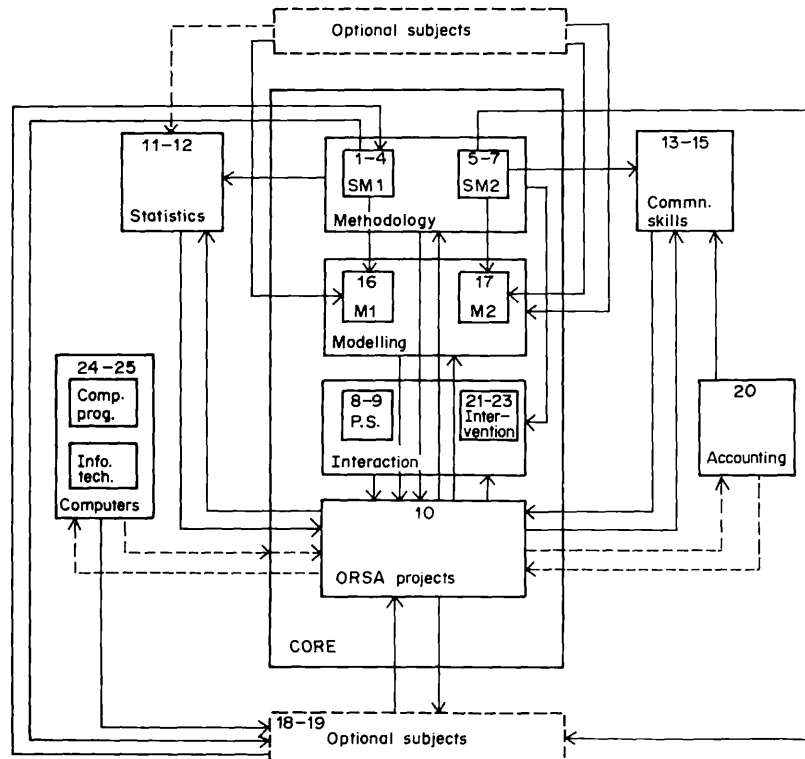


FIG. 6. Part of the initial conceptual diagram of the proposed M.Sc. course related to learning objectives. Numbers refer to learning objectives. Hatched lines with arrows are potential influences.

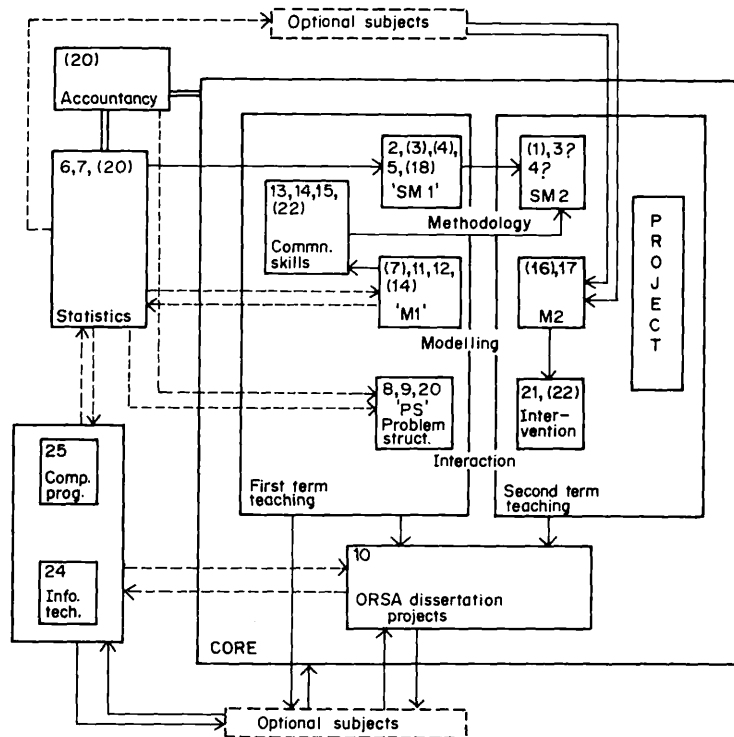


FIG. 7. Revised diagram of the developing M.Sc. course. (20) implies that there is some teaching relevant to learning objective 20, etc. Accountancy may be ill-matched to CORE and to Statistics as implied by 'conflict' double lines.

THE SECOND STAGE

The process of defining and discussing the nature of the course, how it was meeting the objectives stated, and whether these objectives were properly stated, took place during the first year that the new course was taught. It is, of course, a continuing process. As an indication of results, my initial diagram of the M.Sc. Course and Learning Objectives (Figure 6) showed the nature of the course as then documented. A knowledge of the syllabus and the Learning Objectives is, of course, needed to interpret it fully. It was provided to all members of the teaching staff, and interviews were conducted to obtain reactions to it. These were instructive and showed some inconsistencies. The final diagram offered is shown in Figure 7, and some interesting points can be made.

Firstly, certain subjects specified separately in the syllabus have not been taught separately, but as part of an integrated package. The concept has been one of a gradual learning process where methodology, modelling and the process of interaction with clients becomes increasingly clear through case studies (term 1), minor projects (term 2) and the major dissertation projects (after term 3). Consequently, there was a need to understand and monitor the time sequence of the teaching process: the diagram uses the systems defining the main term-by-term teaching to indicate this time sequence. This change between syllabus and teaching practice, although consciously intended, had not been entirely satisfactory and had caused some confusion, both to students and to some of the teaching staff. In particular, communication skills taught within the integrated package seemed to have been duplicating the separate module and perhaps conflicting with it.

Secondly, the links between separate parts of the syllabus and the Learning Objectives were far from one-to-one, and some of the objectives were not, or only sparingly, covered. It is quite clear that much study of these links is needed so that teaching can become appropriately integrated. The teaching had not been carried out with any explicit attention to the Learning Objectives, and the Acting Head of Department, for example, appreciated that he could in future greatly improve his own presentation of Information Technology, using links with other teaching.

Thirdly, the Learning Objectives will have to be rewritten and agreed (by and large) by all concerned. Some of them are woolly, and some are differently interpreted by different individuals. The fact that individuals perceive that there will be certain contributions from others to Learning Objectives central to their own teaching does not of course mean that these contributions will be made.

THE THIRD STAGE

This was planned to deal with syllabus and Learning Objectives, potential course changes for the second year and the so far neglected area of resources of time and people. Other important areas, which had only been superficially covered, were those of communication, values and beliefs.

In the event, all of these things were examined in a special context owing to the incidence of important differences of opinion about the direction in which the course was developing. There was also concern about the way in which other university pressures and duties had seriously affected the intended open communications on which the efficiency of the informal management procedures depended.

The details of the interactions involved are necessarily confidential to the clients. However, some general statements can be made. Firstly, it was possible to identify a number of the difficulties within the framework of the diagrams already produced. Secondly, it was possible also to obtain a useful picture of the primary communication channels used by individuals in the context of the main problem, that of developing and maintaining the course.

Thirdly and most importantly, I had assumed, in structuring many of the earlier diagrams, that because my clients so described their operations, free and undistorted communication was taking place within the group. I had not considered pressures which

might affect these communications, although it should have been obvious to me that if the basis of their management system was disturbed in any major way, conflicts would inevitably arise and these would be difficult to manage and resolve.

It is probably a sound general principle that communications necessary to a style of management should be described as part of any problem, since maintaining such communications is essential to the handling of any resolution of that problem. It is particularly necessary to stress communications, possibly new, that will be needed to manage change.

FINDINGS FROM THE EXPERIMENT

It is not easy to draw firm conclusions from an experiment of this sort. Any intervention by a consultant who is interested in and willing to involve himself in another's problem, with the consent of the problem owner, is almost bound to be helpful, whether his methodology is explicit or not. This perhaps explains continued support for O.R., even when little regard seems to be paid to the outcome of analysis! However, there are lessons that I have learnt and conclusions that I believe to be fair statements.

Use of the notation

Although the diagrams were generally easy for clients to interpret and were invaluable as a means of communication during discussions, they did not use the notation to express their own ideas. This is perhaps, on reflection, not surprising: it is important to everyone to be able to use their own language, and it is best that they should do this provided that it does not encourage major misinterpretations.

Nevertheless, it was an important discipline for myself to ensure that everything I received was incorporated in the structures, and an important means by which I tested whether my understanding was correct. What could not be incorporated was reported back in writing: this generally involved aspects of the problem not yet sufficiently explored for inclusion in the diagrams. At no time did I find it impossible or potentially difficult to include essential features in the diagrams within the constraints of the rules of notation.

The communication study raised an interesting technical issue, as well as the more fundamental one discussed in the preceding section. At first, it seemed that I needed to indicate, for the communication arrows, some measurement of the degree of communication that occurred. However, it transpired that, for the sort of fuzzy measurement I could make, the available notation sufficed:

- ▷: good communication;
- : incomplete communication, with inevitable distortion of information about the problem;
- no link: no communication or virtually none;
- (—→: could have been used to imply interaction with no particular stress on communication, but this seemed to introduce unnecessary special meaning to this interaction arrow); and
- ==: unconstructive communication in a conflict situation.

Every aspect of the notation came into play. Only one proved potentially contentious; it was drawn to my attention by a student (during an M.Sc. course which I was teaching elsewhere). It concerned the use of the double line to imply potential conflict, as used in Figure 5, between "explicit espoused values" and "actual programme". Since these two 'systems' are not themselves purposeful, this is perhaps not strictly logical. However, as a shorthand for a conflict between A, assumed responsible for the values, and J, assumed responsible for the course in being, it is meaningful. Indeed, in practice, J has produced the explicit statement of the values as well! However, it is ultimately A's responsibility to have J produce something which meets the values A is prepared to accept: in practice, again, the whole teaching team will adopt a consensus view.

The time taken to produce and draw the more complicated diagrams by hand is an

unsatisfactory feature. It may be possible to set up a graphics display to play about with layouts, and to use the rules to check the validity of diagrams and make changes as required.

Finally, the inability to represent well the time varying state of a system is a matter for further study. The ways this has been attempted so far are limited: a series of diagrams at different points in time; the definition of systems which occur successively in time, as in Figure 7; using environment boundaries to indicate the time sequence in which additional sub-systems, shown within those boundaries, become important; and, for people passing through a system such as a hospital, to include those people in a number of sub-systems with arrows linking them to the next sub-system that they go to. The choice, or invention of new procedures, seems likely to be problem-dependent.

Problems of time for consultancy

Since the clients were always busy with their everyday tasks, and the consultant was 120 miles away (and also had other work to fit in), there was an inevitable slowness in the rate of interaction. Because new knowledge about the problem came slowly and because the clients had too little time for planning the future, this was less of a disadvantage than it might have been. However, it would have enhanced the service to the clients had there been more interaction: not only could richer pictures have been produced, but some of the difficulties of the first year of the new course might have been avoided. For the purpose of the experiment, the slow time-scale for interaction was not a serious drawback, other than having to wait to get results.

In practice, I have always seen the process as operating for an in-house consultancy, with the consultant able to intervene regularly as the problem changes. For most problems, I believe that such closeness of contact is very necessary: the analyst must ideally be part of the decision-making team. Nothing experienced in this experiment leads me to doubt this.

Communication with clients

Apart from the issues just raised, no problems arose. All the clients gave their views clearly and uninhibitedly. Doubts and difficulties were freely stated: only occasionally did they put any confidentiality on what they said to me, and this usually only after I had suggested that they might so wish.

Although the group operates well in the sense that, normally, they hold regular discussions as a group and on an individual basis, there is no doubt that it is very difficult for them to find time enough to really know what each other is doing and thinking. Even in the relatively short time I spent with each of them, I found myself identifying issues that needed debate and attention, through acting as a communication channel for them. In the words of the Acting Head of Department, I “provided a stimulus to their thinking”, although this is no more than any methodology which pays attention to problem-formulation should do.

In general, I reported back only what was given to me. Additionally, in trying to produce the pictures of their problem, I found that I was short of data and had to probe for it: they had most of the data, but the formulation process made it available as relevant information. Importantly, it enabled this information to be shared and held in common.

The penultimate draft of this paper was sent to my clients to ensure that what I had said breached no confidences and was a fair picture of what had taken place. This has led to some useful clarifications, but more importantly it has raised a number of perceptions of ‘the problem’ as it is now.

One of these would involve expanding the full version of Figure 4 in order to explore policy problems inherent in the course’s future. Another would require a closer examination of the Course Organiser’s tasks and the facilities he has to implement what seems desirable. Yet others stem from an appreciation that what has been described was, in some sense, already ‘known’. None of these perceptions was made explicit to me at any earlier stage, although they were undoubtedly beginning to emerge more strongly.

The Learning Objectives

Attachment 4

to

A Methodology for Problem-Formulation

A thesis submitted for the degree of Doctor of Philosophy

by

Kenneth C. Bowen

Royal Holloway College, University of London

December, 1983

THE LEARNING OBJECTIVES

The attached document (retyped with minor editorial corrections) was produced by the Course Organiser. It is a first draft, not produced specifically for my needs, and not agreed formally within the teaching group. Nevertheless, it was accepted by my clients as representing a useful indication of what the course was aiming to do.

Its use drew attention to some of its shortcomings.

- a) Many of the objectives were far-reaching (e.g. in 3, one might ask whether it was intended to teach people how to describe the stated undertakings and activities at all levels).
- b) There were too many 'jargon' phrases which could (and were) interpreted in a variety of ways, For example, in 2c it is intended to imply that the effects of information on behaviour and vice versa have to be taken into account in system design, although other interpretations are possible; in 9, 11 and 12, words like "accountable", "faith" and "fidelity" are not the best that could be used in the context intended.
- c) There was vagueness in many of the statements, partly due to their being overgeneralised. The ways in which they were understood by the different teachers was clear evidence of the consequent ambiguity.

Despite all this, the document proved satisfactory for my purposes; indeed, without something like it, it would have been difficult for me to bring some aspects of their problem into the open.

It is extraordinarily difficult to make suitably explicit the aims of a task which the individuals concerned see as based on personal expertise and experience. My encounter with this particular aspect of problem-formulation leads me to suggest that any group of teachers would find value in trying to identify the purposes of their courses, and to link the elements of their written and/or taught syllabus with these purposes, in the way I have done in diagrams 3 (first and second revise).

In the case of an OR (or similar) teaching group, not only would it be a proper professional thing to do, but it would provide a useful teaching tool in covering systems thinking, and would help the students to understand and use the course better. For other teaching groups, it would primarily be the teachers' better understanding that would enable them to help the students to see the course in proper perspective.

LEARNING OBJECTIVES FOR MSc ORSA COURSE

At the end of the course students will:

1. understand and value the view that perceiving the world as a variety of nested and overlapping systems provides a useful way of generalizing the process of problem solving, decision making and the provision of informations for managers;
2. recognise and agree that ORSA is concerned with
 - a) the design or modification of linked physical and social systems aimed at meeting specified system behaviour objectives,
 - b) the design or modification of information handling systems which provide the means of regulating the behaviour of a physical/social system, and
 - c) the identification and design of behaviour/information and information/behaviour relationships which enable a) and b) to be effectively linked;
3. be able to describe governmental, industrial, commercial, social and domestic undertakings and activities in terms of the systems involved;
4. be able to describe the properties and relationships of systems and relate these to the behaviour of individuals, governments and organisations of all kinds and to use the knowledge to link the topics covered in the course into a coherent whole;
5. be able to describe the role of information in governing the behaviour of systems;
6. be able to use statistical concepts to describe and estimate uncertainty in the behaviour of systems;
7. be able to design experiments and test hypotheses concerning the behaviour of chosen systems;
8. be able to identify, observe, analyse and question sources of information relevant to the task in hand;
 - a) formulate an appropriate description of the system concerned,

the environmental (supra-) systems, the principal sub-systems and the relationships between them

- b) identify the objectives of the problem owners or clients and interpret them in terms of the systems description
 - c) identify and describe in terms of the systems description the potential range of actions, modifications or system composition that may be considered;
9. be able to interpret objectives as accountable entities;
 10. be able to plan and execute a project, the design of which is appropriate to the structure of the problem and the time and resources available, and the results of which extend the problem structuring phase through the modelling and analysis stages to the production of final plans, proposals and/or recommendations;
 11. be able to determine how much faith to put into a set of observations or data;
 12. be able to improve the fidelity of current or planned data gathering;
 13. be able to interpret, discuss, diagnose, propose and assess ORSA projects using the principal language and concepts that govern the regulation of organisations (particularly accounting);
 14. view communication as the mechanism governing
 - a) the acquisition of information
 - b) the testing and evaluation of progress during an ORSA project
 - c) the gaining of clients' satisfaction through understanding and acceptance of the project results:
 15. be able to describe the importance of communication in ORSA projects and have the skills needed to:
 - a) acquire information by informal discussion,
 - b) negotiate the establishment of a project and collection and/or provision of data,
 - c) to present progress reports, final conclusions and design specifications in oral and written form,

- d) to prepare for and make effective contribution to formal committee meetings,
 - e) to answer examination questions and write University project reports;
16. be able to identify, develop and modify a variety of models describing the relationships of system behaviour with action plans, strategies and objectives;
 17. be able to develop and/or implement model manipulation procedures (algorithms) to identify and recommend a course of action or system design that provides a good solution to the original problem;
 18. visualise the process of model development and use as that of providing information for the specialized social system (management) that is (in part) regulating, directing or controlling a more general and extensive social and physical system;
 19. be able to describe the nature and role of information in systems in general and organisations (management systems) in particular and to use this knowledge to:
 - a) identify and specify information needed to make a chosen decision or range of decisions within a particular context,
 - b) design ways of collecting, storing and presenting the required information;
 20. be able to make use of records and projections available from accounting departments and statistical digests;
 21. be able to recognise, describe and anticipate the difficulties involved in making changes within social systems (organisations) and be able to identify the source of these difficulties and suggest ways of minimising them;
 22. understand the importance of interpreting "theoretical solutions" derived from abstract models of the system concerned into less abstract, practical terms which can be understood and communicated to the people involved and be able to make such interpretations;
-

23. recognise the importance of monitoring the implementation of a project, policy or remedial action and be able to plan and execute an effective monitoring programme;
24. know what computers are, what they can do and how they can be made to do it;
25. be able to use computer hardware to run systems programs and to develop their own programs.

Diagrams for Chapter 4

Attachment 1 to
A Methodology for Problem-Formulation

A thesis submitted for the degree of Doctor of Philosophy

by

Kenneth C. Bowen

Royal Holloway College, University of London

December, 1983

DIAGRAM 2 (second revise)

Conceptual Diagram of the Developing MSc Course
related to the Learning Objectives

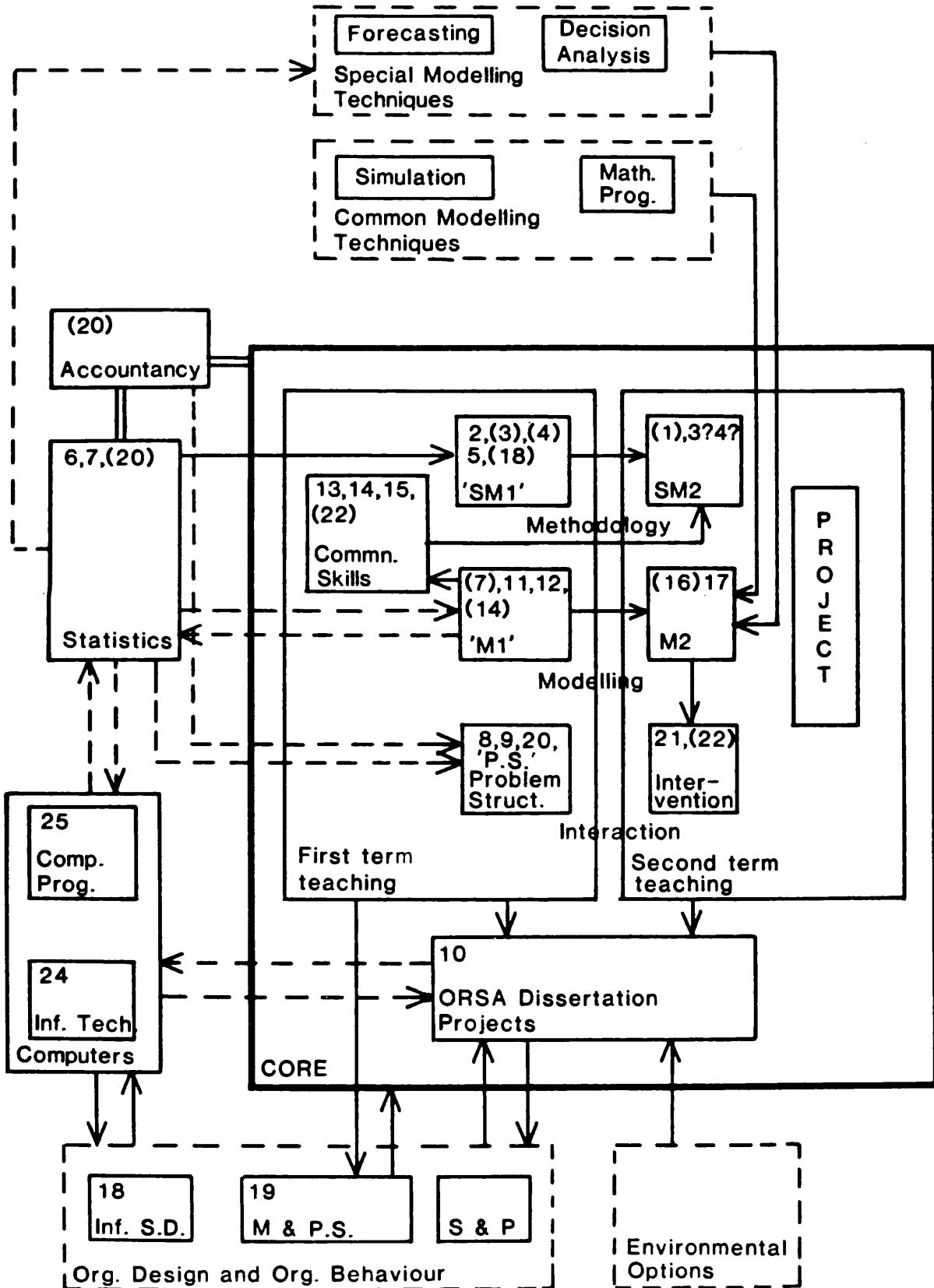
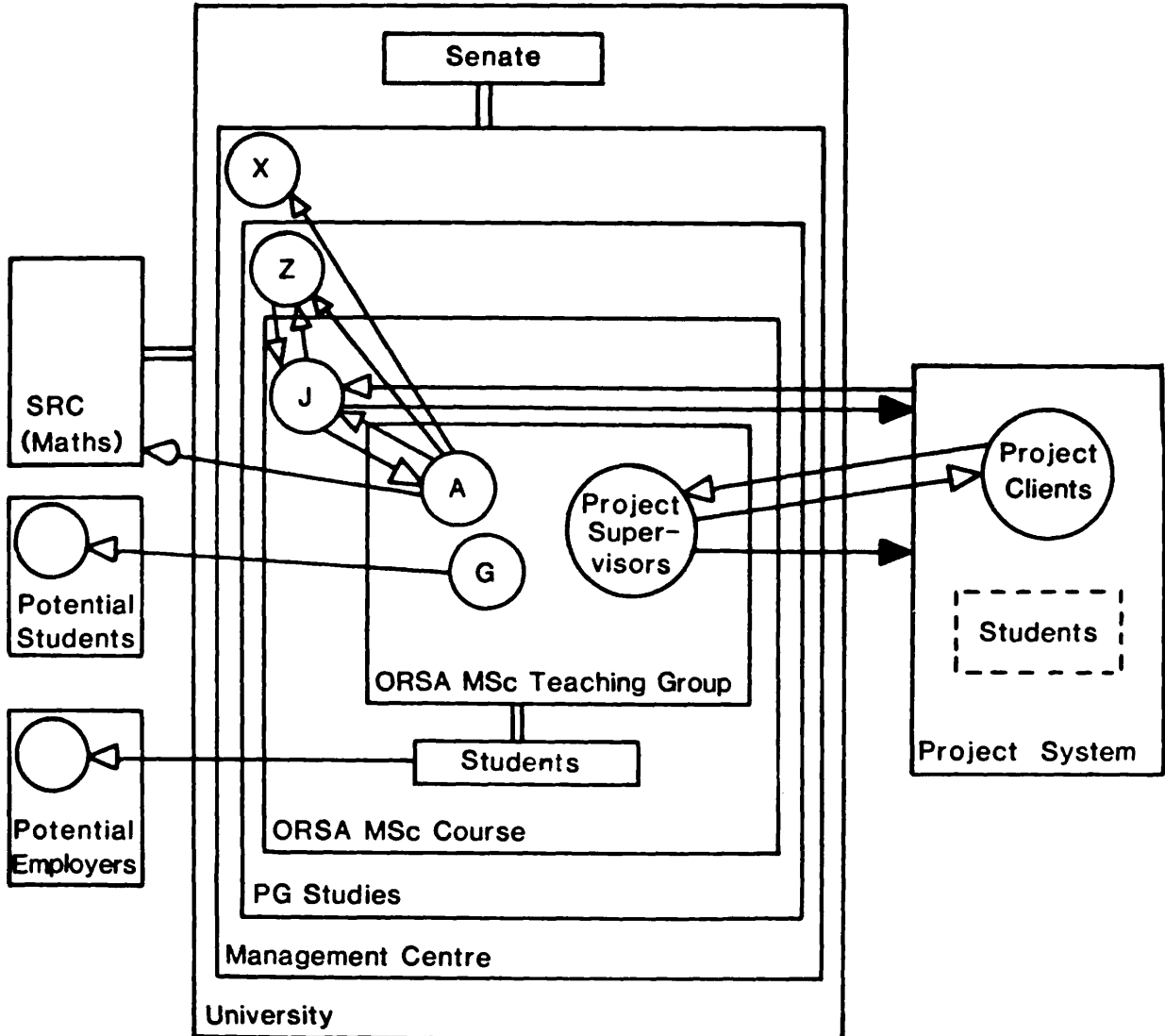
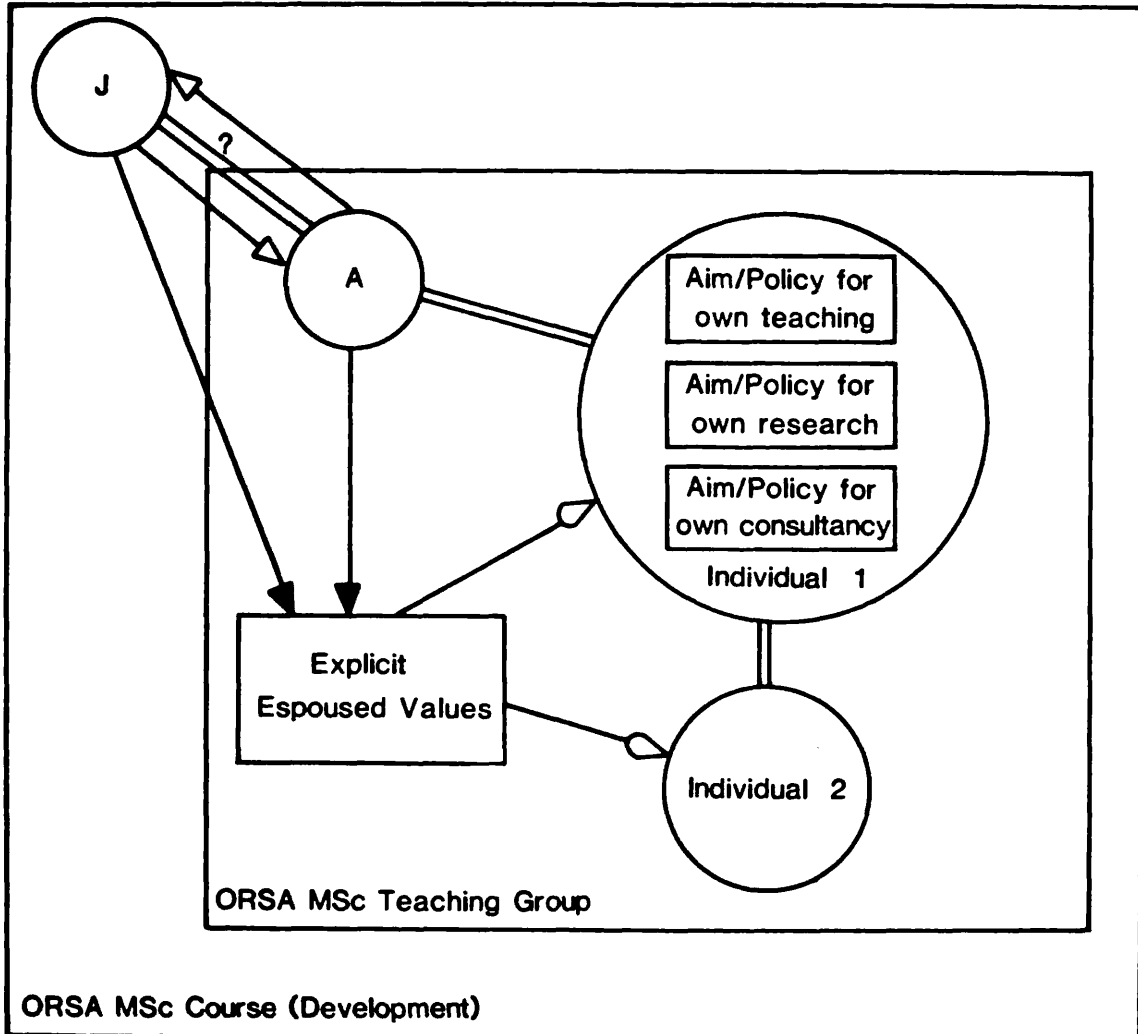


DIAGRAM 3 (first revise)
 Communication and Purpose
 with Primary Potential Conflicts



- Notes:
1. Not all communication and purpose links are stressed, e.g. J's communications with the individual teachers other than A.
 2. Interactions internal to the ORSA M.Sc. Teaching Group are extended in diagrams 5 and 6.
 3. This diagram is concerned with the development of the course. Its monitoring and control is considered in diagram 6, where J becomes subordinate to A.

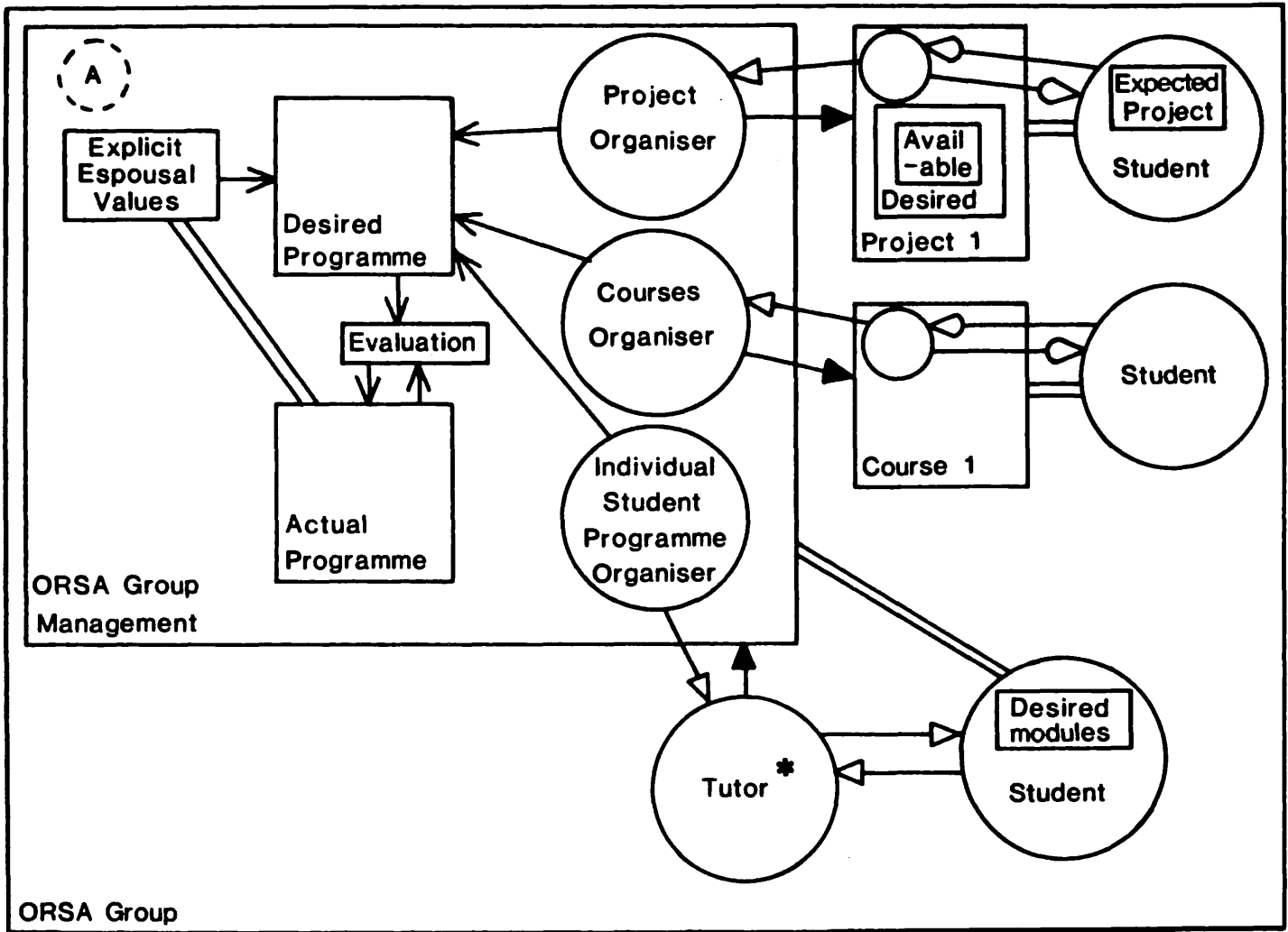
DIAGRAM 5 (first revise)
 Personal Aims, Policies and Values
 (Teaching Staff)



- Notes:
1. Like diagram 2, this is concerned primarily with course development, although, apart from J's position, it relates also to the monitoring and co-ordination function (diagram 6).
 2. Individual 1 is repeated for 2, ...
 3. It would be useful to have explicit aims, etc. for each individual where these are openly discrepant with the ideal (the explicit espoused values).

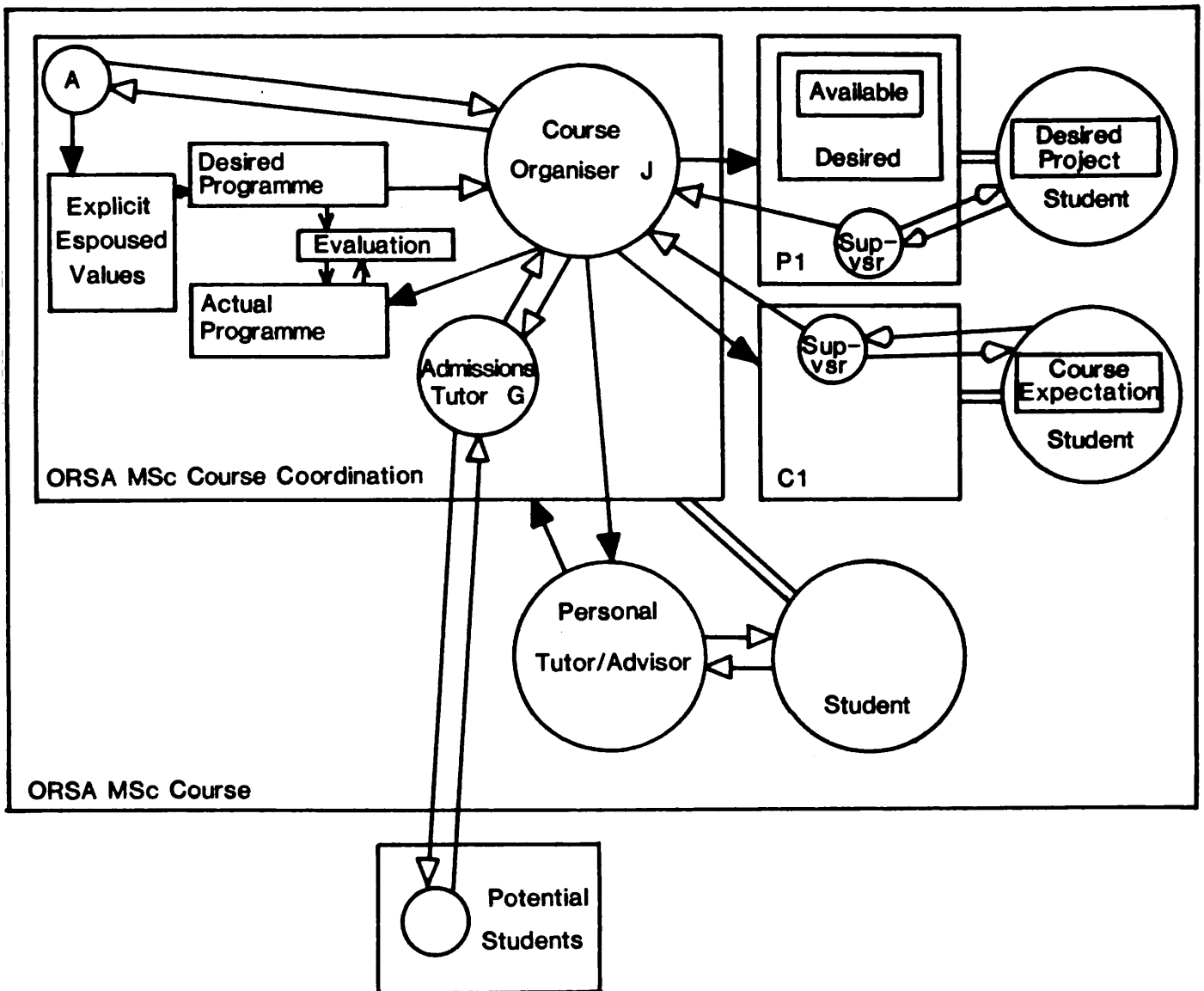
DIAGRAM 6

Monitoring of Programme



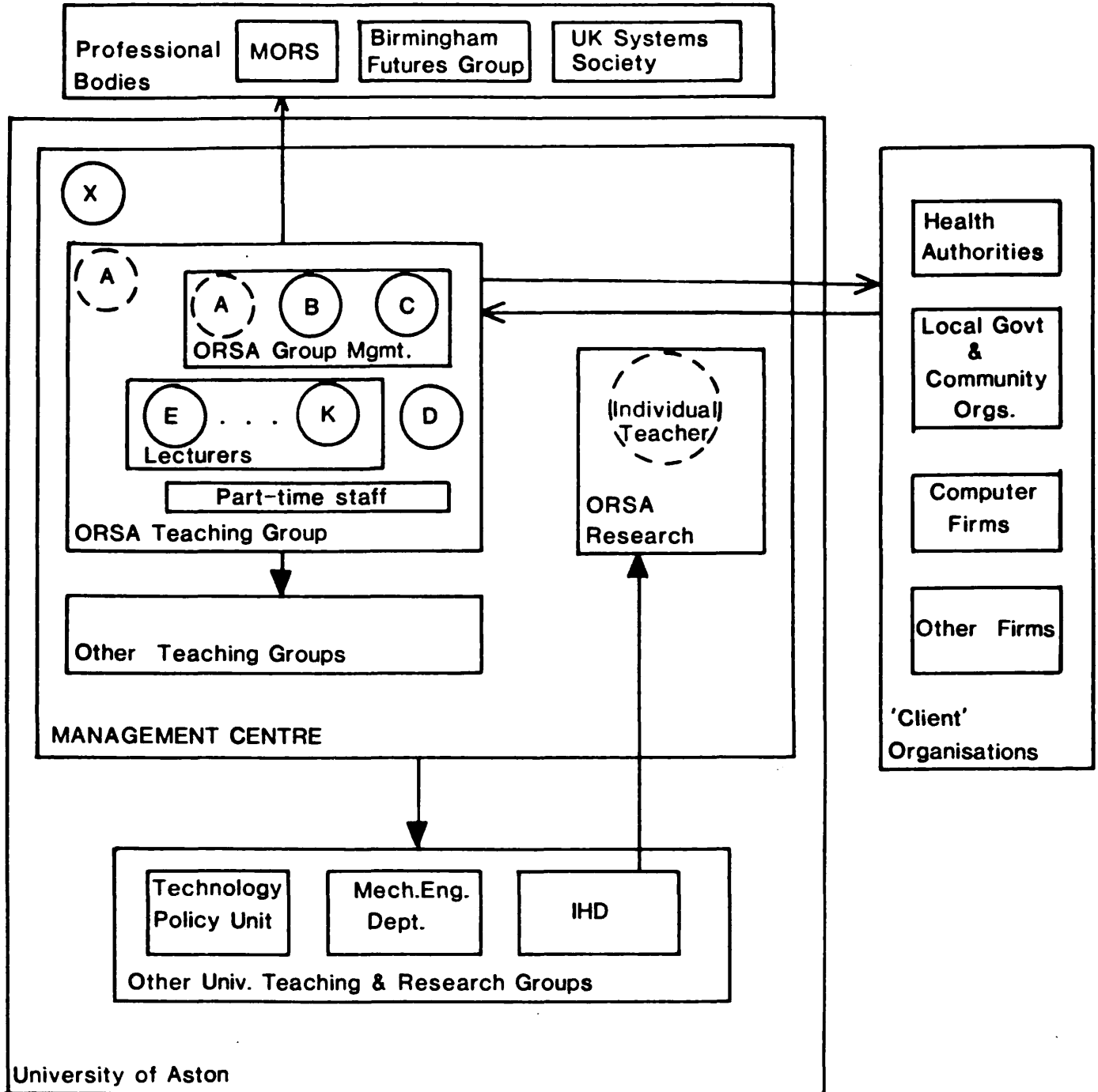
- Notes:
1. The problem of roles becomes increasingly important. I have not specified individual teachers in this diagram, but it should be so extended.
 2. By "tutor", I imply a general adviser to any individual student.
 3. Students are shown as examples. Satisfactions/dissatisfactions may be voiced by the student body as a whole (see diagram 3).
 4. The desired programme is limited by available teachers and what they can, and wish to, teach - also by what students expect, request, object to, etc.
 5. Diagram 2 must change as the process depicted above proceeds.
 6. Diagrams 4 and 5 need to be extended if a full monitoring programme is to be possible.

DIAGRAM 6 (first revise)
Monitoring and Co-ordination of MSc



- Notes:
1. 'Students' are typical examples. Conflict is shown with how the course is run following communication with personal tutor/adviser.
 2. P1, ..., C1, ... are projects and courses.
 3. Conflict between teaching staff and students as a body is represented in diagram 3 (first revise).
 4. The actual programme is governed by what teachers are available and what they can, and wish to, teach - also by what students expect, request, object to, etc.
 5. There is a strong link with diagrams 2 and 4 (when fully developed) and with diagram 5 (first revise). Development of these diagrams is part of the monitoring and co-ordination process.

DIAGRAM 1
The Management System



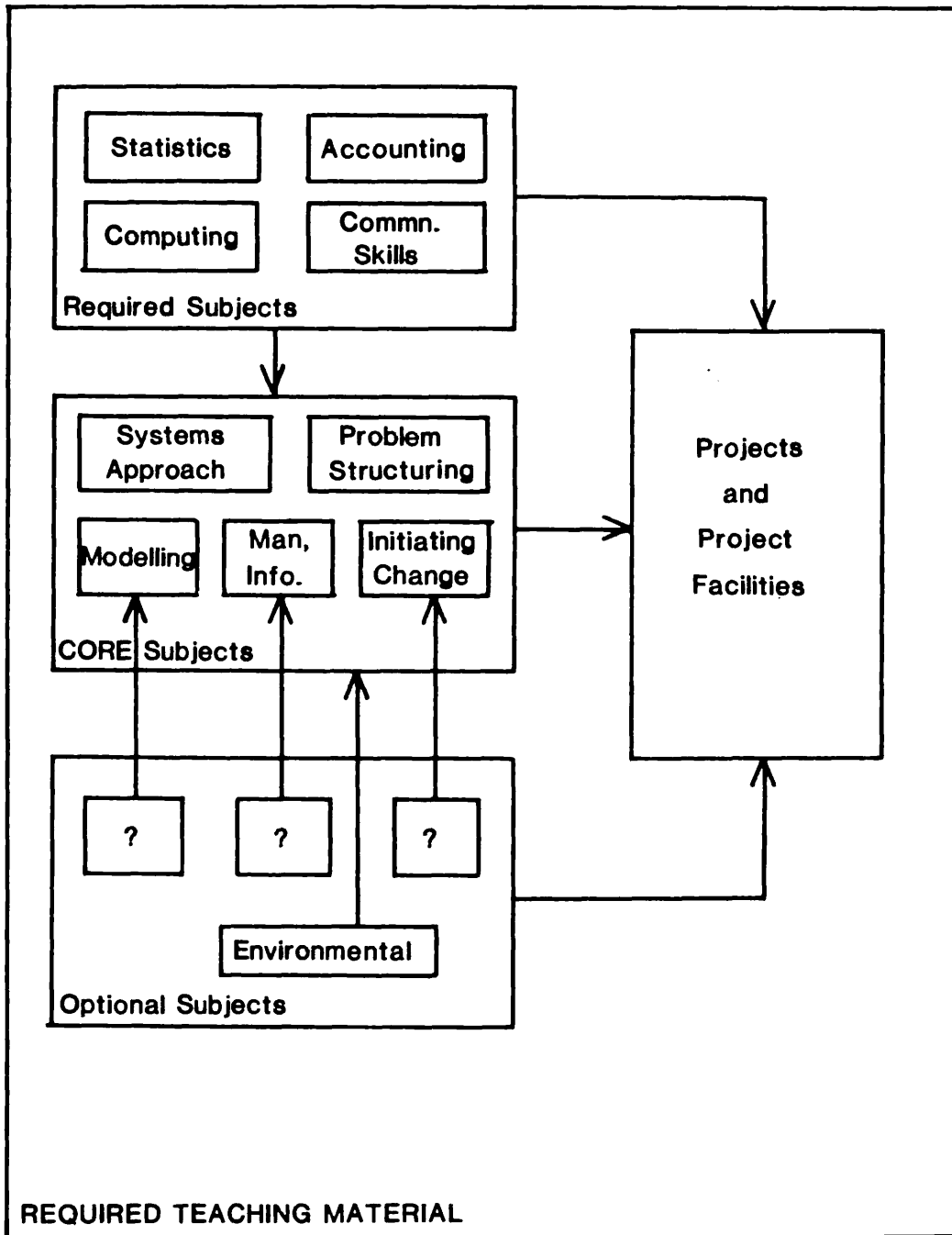
Legend

- A = Acting Head of Department
- B, C = Senior Lecturers
- D = Visiting Research Fellow
- E to K = Lecturers
- X = Head of Management Centre
- IHD = Interdisciplinary Higher Degrees
- MORS = Midland Operational Research Society

Notes

Students and Senate included in Diagram 3.
Conflicts (potential) are apparent from notational definition, but not stressed here.

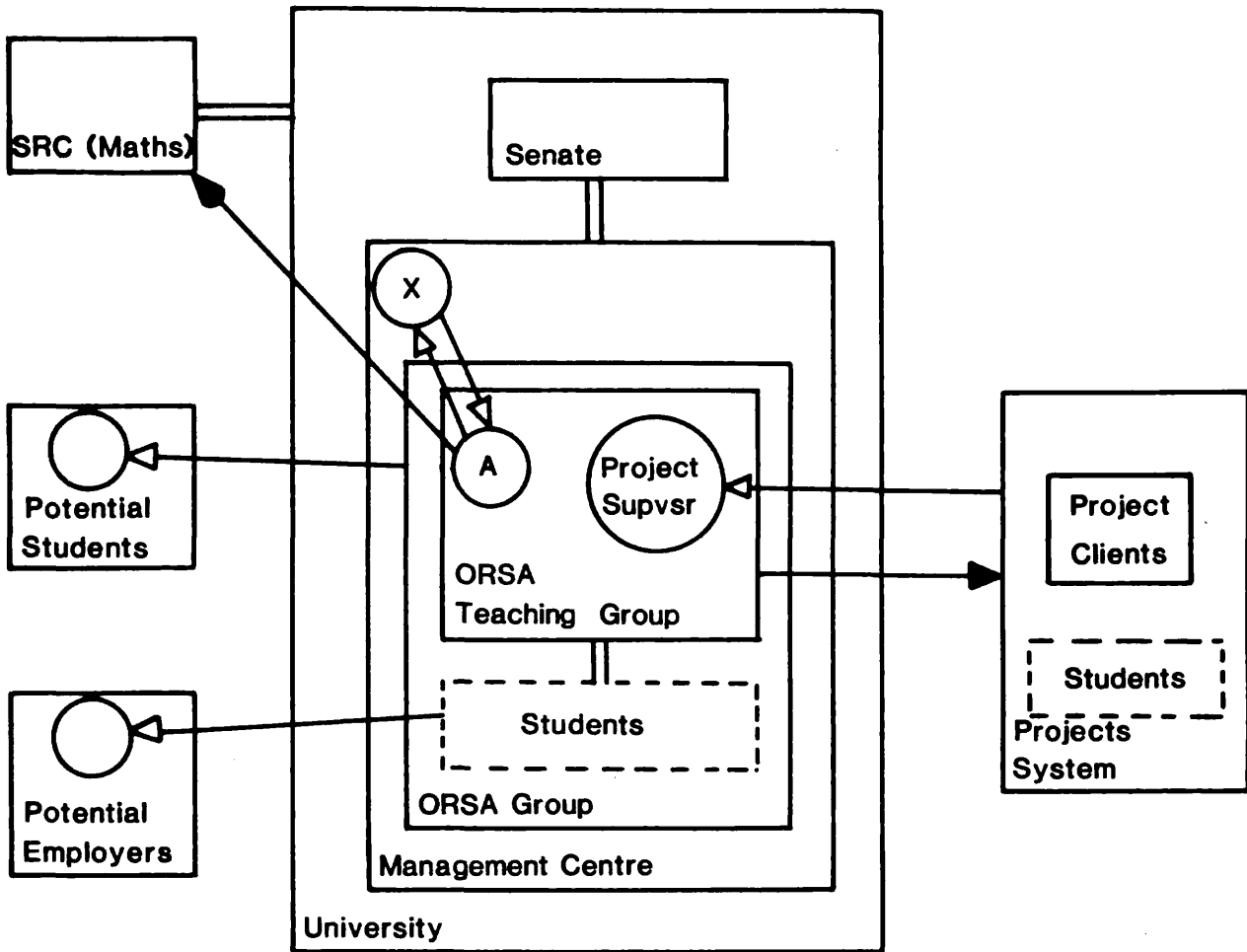
DIAGRAM 2
 Conceptual Diagram of the Proposed
 ORSA MSc Course



Note: As seen in later diagrams, this is subject to change due to conflicts and constraints.

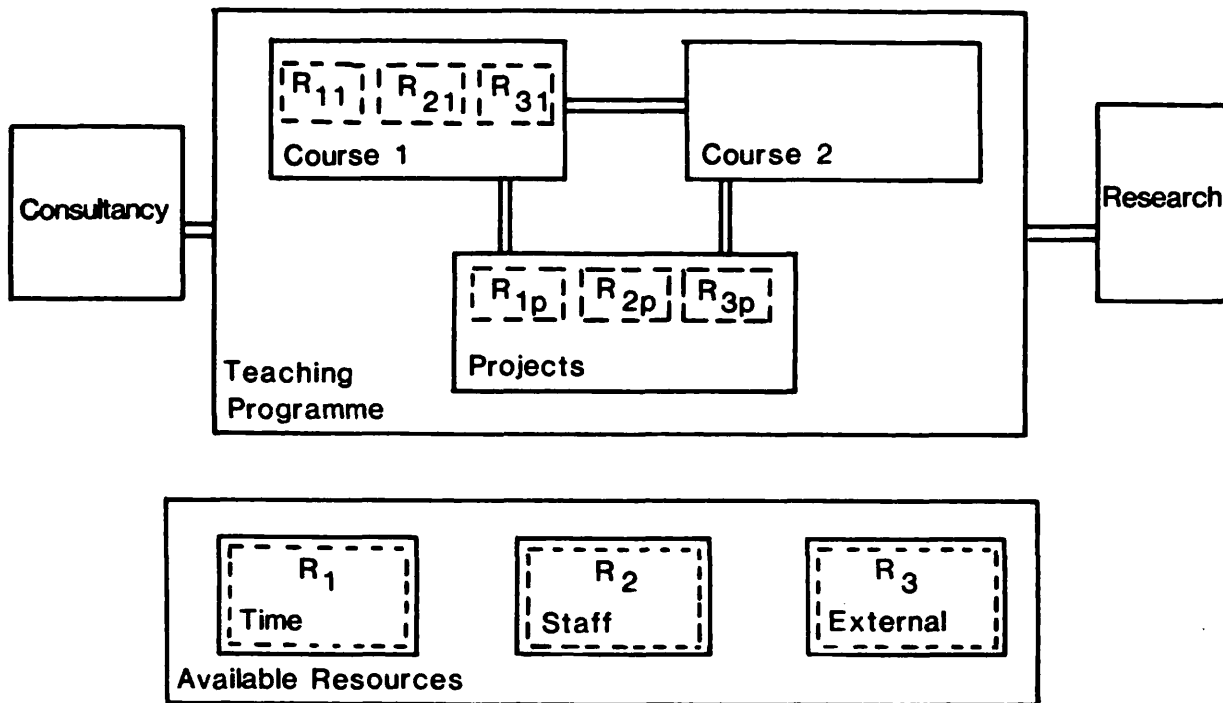
DIAGRAM 3

Communication and Purpose,
with Primary Potential Conflicts



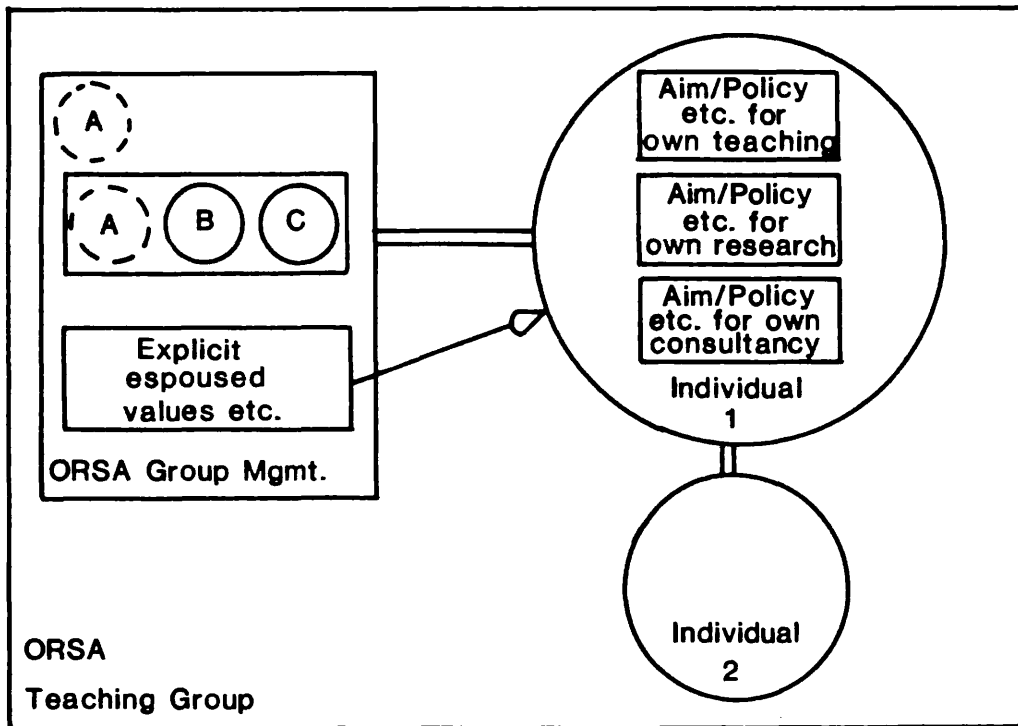
- Notes:
1. Not all communication and purpose links are stressed.
 2. Conflicts internal to the ORSA Group are extended in a later diagram.
 3. SRC = Science Research Council (later Science and Engineering Research Council).

DIAGRAM 4
Resource Allocation and Conflicts



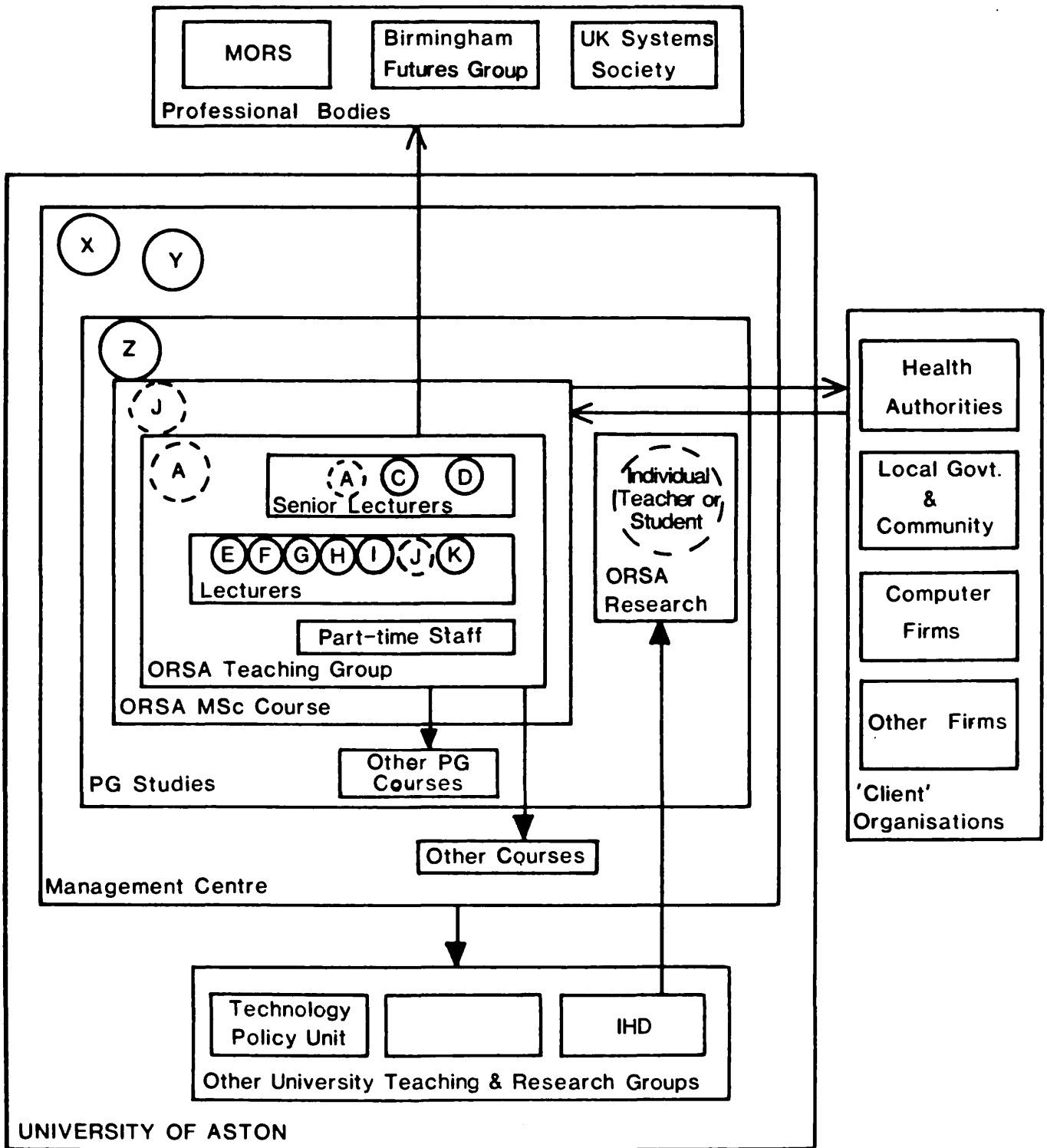
- Notes:
1. R_{11} , ..., R_{1p} , ... are desired allocations of available R_1 (time) for the teaching programme; etc.
 2. Some of the conflicts are seen, from other aspects in the next diagram.
 3. I am not yet satisfied with the notation, logic and potential usefulness (when developed) of this diagram.

DIAGRAM 5
 Personal Aims, Policies and Values
 (Teaching Staff)



- Notes:
1. Individuals may be members of ORSA Group Management, in which case hatched lines would be used.
 2. Individual 1 is repeated for 2, ...
 3. It would be useful (eventually) to have explicit aims, policies, etc. for each individual.

DIAGRAM 1 (first revise)
The Management System

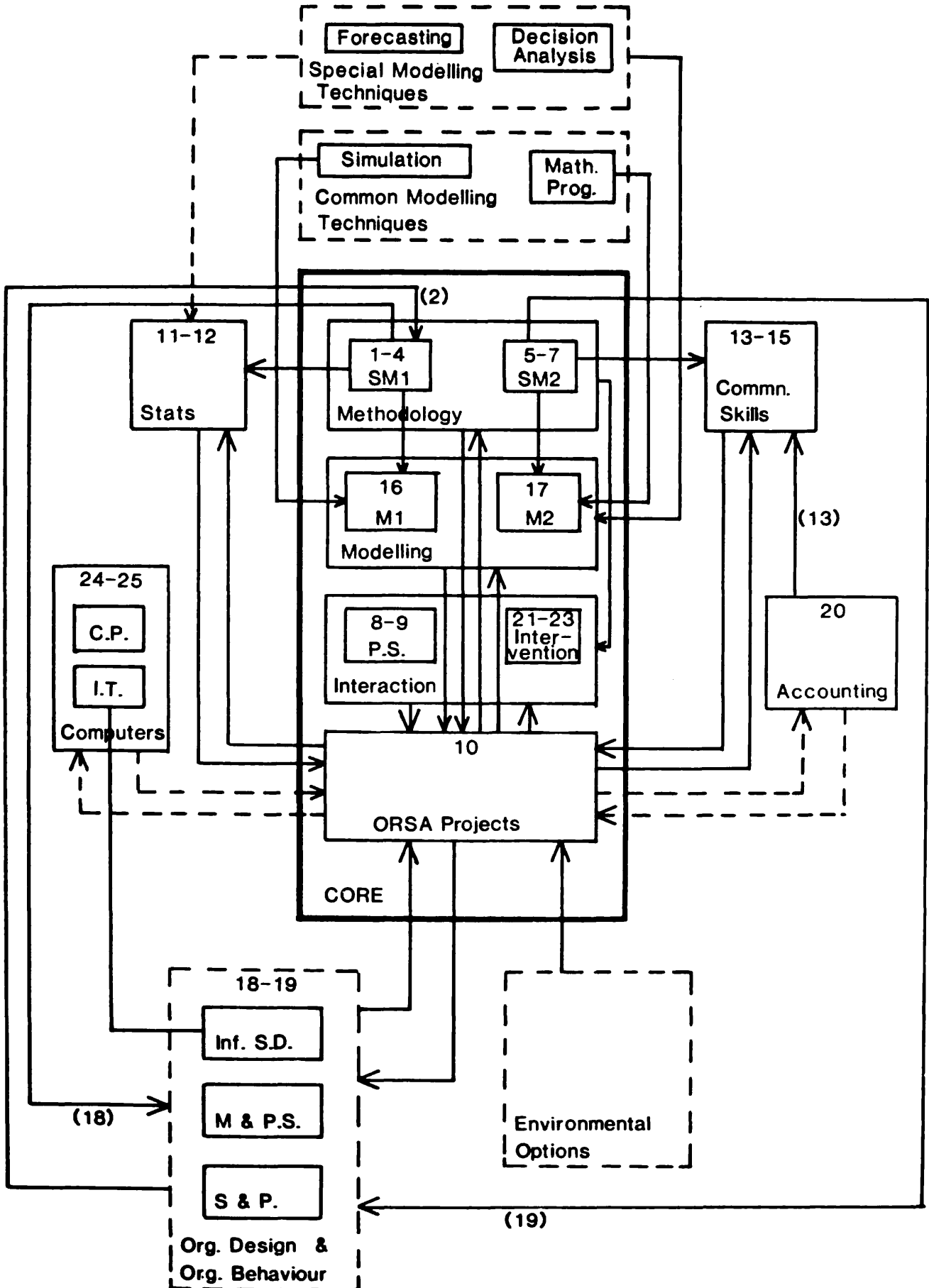


Legend: As for diagram 1, except
 B not included (on leave)
 Y = Dean
 Z = Director of Post-Graduate (PG) Studies
 J = Main Course Organiser
 G = Admissions Tutor
 E = Course Organiser for part-time students

Notes:

1. J (and G and E, not shown) has a direct responsibility to Z.
2. Mech. Eng. Dept. no longer seen as of any special importance.

DIAGRAM 2 (first revise)
 Conceptual Diagram of the Proposed MSc Course
 related to Learning Objectives



Notes on Diagram 2 (first revise)

1. Hatched boxes represent ORSA and Environmental optional modules. Unhatched boxes outside the CORE are additional common subjects.
2. Arrowed lines imply that the influence of the box from which the line originates will assist in the teaching of the box at which it terminates, particularly in relation to the learning objective number shown in brackets. Hatched lines show potential influences (option may not be taken or project may not be relevant).
3. Learning Objectives are listed (1 to 25) in Attachment 4.
4. Only what I perceived (prior to discussion with the teaching staff) as the more important and more likely interactions are included.

Abbreviations

CP = Computer Programming
IT = Information Technology
PS = Problem Structuring
M = Modelling
SM = Systems Methodology
Inf SD = Information Systems Design
M & PS = Management and Planning Systems
S & P = Systems and People

Notes on Diagram 2 (second revise)

1. () implies that something is taught relevant to the Learning Objective indicated by the bracketed number.
2. LOs 1 and 22 are probably not met.
3. The LOs do not seem to relate to SM2 as taught.
4. Accountancy teaching is ill-matched to that of the CORE and of Statistics - conflict lines show this.
5. The potential value of Information Technology teaching for other LOs was discussed, but no definite statements can yet be made.
6. This diagram represents an amalgamation of teaching staff's opinions, based on discussions of diagram 2 (first revise).