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Techniques and Tools Providing Strategic Decision Support: A Framework, Review, and Guidelines

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This research surveys and describes the potential applications of 58 tools for structuring and analyzing decision problems. It examines the mode of operation and support capabilities of the more promising tools in detail and concludes with an overall evaluation and guidelines for future tool development. This research is an extension to and update of: (1) Method and Tolls for Structuring and Analyzing Decision Problems (Technical Report 87-1), and (2) Building a Decision Structuring Library (Technical Report 88-1).

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Oldfield, A. I., and & Humphreys, P. C. (Technical Report 88-3): Differences between judgment of stakeholders in social decision making.

OVERVIEW

This final report on Contract Number DAJA45-85-C-0037, "Handling Decision Problems: A structuring language and interactive modules" might better have been titled, in retrospect, "Handling Decision Problems: Tools and processes." Research during the three years of the project took us in unexpected directions, with the result that three clear themes emerged from the work. These are reported in the three sections of this final report.

Each section begins with a paper written for this report. The papers provide a summary of work undertaken during the three years, a discussion of implications, and suggestions for important work yet to be done.

Part I reports the results of an extensive survey of software tools that can help users to structure and analyse complex decision problems. Questionnaires received from respondents have been edited and assembled into a catalogue, and a scheme for exploring this data base has been developed. More important, careful analysis of this catalogue has revealed that not all stages in structuring and analysing decision problems are well-served by the tools that have been developed.

Perhaps the most significant contribution in Part I is a new scheme for the management of complex issues. This is radically different from the old linear process often recommended for problem-solving: recognise problems, identify options, evaluate them, choose, implement, follow through. The new approach provides a general procedural schema for handling decision problems, and comes as close to the "structuring language and interactive modules" as we could manage in light of our research findings. Although the schema is nothing like that which we envisioned at the start of the project, it seems to provide new insights into the nature of creative problem solving.

Part II covers research on decision conferencing. It describes decision conferencing, gives a brief history, provides a case study, and compares this approach to the computer-centred decision support system (GDSS) developed at the University of Arizona. Twelve issues are identified as distinguishing the two approaches; the contrasts given here constitute the first written report of the differences between these forms of GDSS.

Four studies of decision conferences are also reported in Part II. Several new findings have emerged from this work. For example, top executives were found to put relatively more weight on "soft" than "hard" objectives in evaluating strategic options, while the reverse was true of lower-level managers. Also, groups under threat created models with few options and considered fewer criteria than groups faced with opportunities. It was also found that strategic and tactical issues are considered at all levels in organisations.

Because these findings were based on just 47 decision conferences from a nonrepresentative collection of organisations, the conclusions can be treated as no more than working hypotheses. However, nine working hypotheses are established in Part II, and suggestions for validating them are given.

Part III consists of two studies that involved extensive interviews with 40 people who lived near a hazardous waste incinerator. The purpose of the first study was to determine how the interviewer's framing of a problem affects the respondent's exploration of the issues. An unexpected and significant finding occurred in this study, a finding that has serious implications for the conduct of research on judgment and decision making.

The interviewer used one of four different frames for each interview: a vague prompt ("tell me your views on hazardous waste"), a scenario prompt ("would you talk about these aspects [four were given along with three methods of disposal] of hazardous waste"), a framework prompt (interviewee asked to consider [unspecified] options and criteria), and a fully structured problem prompt (interviewee given options, criteria, and evaluations of options on the criteria). The key finding is that the prompts dramatically affected the numbers of issues and the degree to which the issues were explored.

The vague prompt and the fully structured problem prompt yielded little exploration of only a few issues. The scenario prompt stimulated exploration in breadth; the framework prompt, exploration in depth.

Two implications are evident. First, most decision research, especially that on heuristics and biases, provides a fully structured problem. The research here suggests that this prompt elicits very little exploration of a problem, that cognitive capability shuts down under such conditions. How valid, then, are conclusions drawn from research that uses such prompts? Second, there is no possibility for an interviewer to be an independent, impartial investigator, for it is impossible to conduct research without framing the problem or issues presented to the subject or participant. Research on judgment and decision making cannot avoid this "experimenter effect," so will have to take it into account in research designs.

The second study examined differences among the judgments of four groups: industry, government, lay people, and pressure groups. Propositions and claims by the groups were compared using slice diagrams and found to be quite different in ways that would be predicted of these four groups.

The methodology used in this study shows how differences in perspectives can be elicited and displayed. Reflections on the study have led to suggestions, given in Part III, of how differences in perspectives might be resolved: through scenario exploration, extending the terms of reference, or extending the background of safety.

In summary, Part I covers the theme "how can structuring and exploration of decision problems be aided?" The theme of Part II is "what are some of the characteristic influences on problem structuring and exploration?" Part III is concerned with the theme "how are differences in perspectives evident in the structuring and exploration of social decision problems?"

SUMMARY

This report represents an extension to, and update of, Technical Report 87-1: *Methods and tools for structuring and analysing decision problems: A review and catalogue*, and Technical Report 88-1: *Building a decision problem structuring library: a review of some possibilities.*

It surveys and describes the potential applications of 58 tools for structuring and analysing decision problems. It examines the mode of operation and support capabilities of the more promising tools in detail and concludes with an overall evaluation and guidelines for future tool development. All this is done within the context of a *general procedural schema* (described in chapter 2) for handling strategic decision problems effectively, from start to finish, in situations that start out unstructured: that is, in newly occurring, nonrepeated situations in which the structure of the problem is, of necessity, initially unclear (e.g., making plans for developing new areas of activity, developing new intervention strategies, selecting between competing research projects, etc.)

We have confined our review to techniques and tools that should find practical application and acceptance in supporting strategic decision making in initially unstructured situations, providing they are embedded appropriately within the general procedural schema. In chapter 3 we identify four major classes of such techniques and tools (described as R1 through R4), each distinguished by the site within the procedural schema (i.e., point within the problem handling process) at which it can deliver effective support. Hence, the procedural schema helps the analyst or decision maker not only to move through the whole organizational decision making process, but also to know how to select a particular method, and where to use it along the way.

In our evaluation of the tools described in the four support classes, we found that those we selected for detailed examination all possess excellent local functionality; that is, they are all good at what they profess to do when used to provide practical, but restricted, support on their own. However, the global functionality of a decision problem structuring library, built simply through collecting the tools we have identified and mounting them so they could be accessed as required on a microcomputer, or from a terminal, would still leave much to be desired.

This is because the set of support goals identified for classes R1 through R4, taken as a whole, is much more difficult to achieve simply through aggregating tools bottom-up into a comprehensive tool set to comprise the library. Even when choosing the members of this set very carefully, as we did in the research that led to this report, one always ends up with interfacing and functional coverage problems. It is not easy to transfer information between tools because object and parameter conceptualisations are not consistent across tools (it is not just a matter of incompatible data formats). Also, the provided support functions overlap between the tools (which offers redundancy, which in itself is not necessarily a bad thing) and, more seriously, leave

gaps in functionality between the tools that are not easy to solve through constructing "bolt-on" software, or through decision analyst intervention in practical applications.

Hence, we conclude (in chapter 4) with some guidelines for future development of systems that could provide comprehensive decision support. These guidelines are derived by considering first of all the levels of knowledge representation that are required in handling *all* aspects of decision making, and then considering how the process of problem handling can be divided at *all* these levels between the decision maker and any computer-based system that might aim to provide truly comprehensive decision support.

CONTENTS

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TECHNIQUES AND TOOLS PROVIDING STRATEGIC DECISION SUPPORT: A FRAMEWORK, REVIEW, AND GUIDELINES

1. INTRODUCTION

This report surveys and describes the potential applications of 58 tools for structuring and analysing decision problems. It examines the mode of operation and support capabilities of the more promising tools in detail and concludes with an overall evaluation and guidelines for future tool development. All this is done within the context of a *general procedural schema* which describes how to handle the structuring of strategic decision problems effectively, from start to finish, in situations which start out unstructured: that is, in newly occurring, nonrepeated situations where the structure of the problem is, of necessity, initially unclear (e.g., making plans for developing new areas of activity, developing new intervention strategies, selecting between competing research projects, etc.).

Many organizations (state, military and commercial) have experienced difficulties in attempting to solve initially ill-structured strategic decision problems through the use of traditional 'in-house' decision making processes and methods, due to:

(a) the *complexity* of the problems, i.e., too many conditions, constraints, and consequences must be simultaneously considered (e.g., lack of resources, market competition, competing interest groups, etc.);

(b) the *uncertainty* related to the objectives and preferences of those concerned; and external conditions, etc.; and

(c) the *lack of available information* connected with the complexity of the problems, the uncertainty, and the problem-solving methods themselves.

Quite a number of decision support techniques and tools (software packages) attempt to provide assistance for the solution of such decision problems, but many of them are not really used very much by the actual decision makers, for a number of reasons:

(i) some of them are too artificial, using models and language that are too abstract, and are difficult for top-level decision makers to understand;

(ii) some of the models and methods do not consider the decision makers' own preferences and judgements; and

(iii) a number of them are not interactive or cooperative, so that the decision maker and those concerned do not interact during the decision-making process, either with each other or with the decision support system chosen; or,

(iv) on the contrary, some of the methods employed demand the active participation of the parties involved in ways they find inconvenient, through, for example, requesting information in a format that is not readily available before allowing the process to continue.

An especially important difficulty with respect to the use of such methods in *practice* is knowing how to select a particular method, when to use it, on what material, and how to embed the use of the method within the general problem handling and decision process. A failure in practice of a decision support technique or tool may usually be traced back to one of the above issues having been addressed inappropriately (McCosh et al, 1987).

We have confined our review to techniques and tools which should find practical application and acceptance in supporting strategic decision making in initially unstructured situations, providing they are embedded appropriately within the general procedural schema which is described in Chapter 2.

In Chapter 3 we identify four major classes of techniques and tools (described as R1 through R4), each distinguished by the site within the procedural schema (i.e., point within the problem handling process) at which they can deliver effective support. Hence the procedural schema helps the analyst or decision maker not only in moving through the whole organizational decision making process, but also in knowing how to select a particular method, and where to use it along the way.

1.1 Background: Requisite decision modelling

The general procedural schema we describe in Chapter 2 is of use when either of two approaches are adopted for handling initially unstructured problems in organizational contexts. The first approach involves developing methodologies with a conscious awareness of decision-making methods within organizations, so that trained decision makers may experiment with DSSs for structuring ill-defined problems independently of other individual or group decision-making procedures. The second approach involves employing decision analysts from outside the organization concerned to help structure the decision problem and supply the necessary procedures and methods.

In our opinion, both these approaches should involve requisite decision modelling. Phillips (1982) describes the criteria required to develop a requisite decision model as follows: "It is necessary to involve all those who are in some way responsible for aspects of the decision in the development of the requisite model. The process of building the model is iterative and consultative, and when no new intuitions emerge about the problem, the model is considered to be requisite".

A requisite decision model is thus much more than some abstract formalisation of material which are believed by the analyst - or model builder to constitute 'the problem' (Paprika and Kiss, 1985). In understanding the nature of such models it is important to view the representation of the knowledge required in the process of strategic decision making, and the capabilities of systems which may aid in this process, at a number of different levels of abstraction. We describe how this can be done in Chapter 4, where we present a five level framework for representing both decision problems and capabilities of decision support systems and tools.

Computer-based decision aiding tools with capabilities at the first three levels are comparatively well developed. These comprise *level 1* systems aiming at providing "best assessments" (e.g., most management information systems, systems for eliciting and calibrating probability assessments), *level 2* systems exploring hypotheses rather than reporting "facts" (e.g., most expert systems) and *level 3* systems capable of capturing and editing the structure of an aspect of a problem. In the initial stages of this project, we discovered a complete absence in practical applications of DSSs possessing the ability to work with the decision maker's own problem structuring language in determining the bounds of a problem through scenario generation. The problem here is not simply a failure of automated decision support systems on a higher level. In a recent, detailed analysis of this problem, we concluded:

> "It is not actually advisable to attempt to formalize level 5 scenario generation techniques and level 4 problem structuring languages into automated decision support systems. At level 5, decision makers' scenarios need to be explored rather than fitted into formal structures. At level 4 it is better to develop techniques for the psychological validation of the decision maker's own problem structuring language than to try to invent a universal problem structuring language that will have to be taught from scratch to high level decision makers." (Humphreys and Berkeley, 1985, p.30)

These findings pointed the present project towards the following two-fold research strategy:

(1) To assemble and standardize specifications on the elements of a library of problem structuring methods, each method being programmed as a complete interactive software module implementing a level 3 problem structuring frame and supporting level 2 (sensitivity analysis) and level 1 (data acquisition) procedures. (The appropriate specification of the contents of any library of this type held by a particular decision aiding/decision analysis group or institution will depend upon the types of decision problems to be handled with its support).

(2) Research is essential which will provide the basis for the development, validation and implementation in practice of DSSs providing effective support at higher levels (i.e. level 4 and above) where it is necessary to support the natural problem structuring languages used by decision makers and by skilled decision analysts working interactively with them.

A *Catalogue of methods and tools for structuring and analysing decision problems* was the first result of implementing this two-fold research strategy present project. It was originally published as Technical Report 87-1 (Volume 2) from this project (Humphreys and Wisudha, 1987). Our subsequent work on the project involved a detailed examination of the four classes of systems and tools for decision support which need to be provided within the general procedural schema in order to provide a comprehensive library of microcomputer-based tools to aid the handling of such problems at strategic and lower levels. (Involvement of problem owners at a strategic level is invariably necessary where the decision problem is initially unstructured, and therefore may have new policy implications within the organisation).

As a result, we re-visit here (in Chapter 3) the general procedural schema originally introduced in Technical Report 87-1, this time identifying on the basis of our subsequent research

(i) the needs for support at four key points in the schema, and

(ii) the capabilities of a set of micro- computer based systems and tools selected from those published in our catalogue of methods and tools for structuring and analysing decision problems (reproduced in Appendix A) as being the front runners in being able to supply the required support.

For each of these four classes of support provision, comparison of (i) and (ii) allows us to see the extent to which the support needs are met by the subset of selected tools in the class. We also examine, where appropriate, how support needs at each particular point may be better met (a) by a system synthesising the functionalities of several of the identified tools, or (b) by a system whose functionality is derived from our research and consultancy experience, but for which no implemented tools yet exist.

1.2 Compilation of the catalogue of methods and tools for structuring and analysing decision problems.

The methods and tools for structuring and analysing decision problems described in the catalogue (reproduced in Appendix A) were gathered from questionnaires sent to over 1000 researchers and practitioners (academic, industrial, military, commercial) working in the areas of decision support and decision aiding. A copy of this questionnaire is reproduced in Appendix B of this report. Ninety replies were received describing various tools. These were screened for relevance for inclusion in the catalogue; in particular, a tool had to meet the criteria described above for successful practical application within one of the four tool categories (R1 to R4) supporting the general procedural schema for problem handling and decision making described in Section 3, below. (58 of the 90 tools survived this screening process.)

Ideally, methods included in the catalogue (and software implementing them) should meet the requirement that they have capabilities at each of the following levels of knowledge representation in supporting the problem handling process:[1]

Level 3: restructuring capability within a particular problem frame (e.g., establishing new criteria within a multicriteria frame).

Level 2: assessing judgement on a variable within a fixed structure (e.g., "what if" models).

[1] These levels of knowledge representation are discussed in detail in Chapter 4.

Level 1: judgement within fixed structure (e.g., with information retrieval service).

No tool was included if it did not have capabilities at both levels 2 and 1. However, certain tools of particular interest, but which employed a pre-structured, domain specific frame, at level 3 were included. In Section 3, the latter are identified as "domain- specific expert systems" within tool class R3.

A description of each tool is presented in Appendix A. These descriptions were compiled through:

(i) reviewing each reply (and seeking further information where appropriate) in order to screen and categorize the tool described there,

(ii) editing the questionnaire describing the tools which passed the screening process and translating them into uniform tool-description format, and,

(iii) assembling the tool descriptions, thus providing the basis for a hierarchical, cross referenced overview of all the tools in the catalogue.

Since the tool descriptions are based upon only partially-validated self-report from method developers and users in response to a questionnaire developed in a form consistent with the concerns of this Section, we can not be sure (or take responsibility for) the accuracy and completeness of the descriptions in the catalogue. Instead, our aim in publishing the catalogue was to increase awareness of potential methods and to establish liaisons between method developers and method users. Indeed, we have by now received much feedback indicating that the catalogue has acted as a catalyst for many successful links between developers of methods and systems reported in the catalogue and new users.

The catalogue has been widely circulated in the two years since its first publication by us and has already formed the basis for an even more comprehensive Danish catalogue, now published as a book (Kohl et al., 1989).

1.3 Overview of classes of support provided by techniques and tools

A fundamental principal of effective decision aiding is that support and assistance should be focused at the point in the problem structuring and decision making processes where the problem owner/decision maker is experiencing difficulty in proceeding (Humphreys and McFadden, 1980; Jungermann, 1980).

In Chapter 2, we describe these processes in terms of seven major stages (A1 to A7, in Figure 1), and, in Chapter 3, indicate four major classes of techniques and tools (R1 to R4), each with a qualitatively different decision support function, and each pointing to the stage within the overall decision making process where decision aiding and decision support systems within that class may be able to render effective assistance.

The four classes of support are:

R1: Techniques and tools facilitating problem owners' expression of issues of concern in generating initial descriptions (or 'scripts') for issues of concern to them within the context of the problem at hand.

R2: Systems which assist the decision maker or an analyst to generate and develop a coherent conceptual model of the problem from an appropriate set of modelling elements or 'rich primitives' (Checkland, 1981). In the process of thinking about how to handle the problem, the decision maker gains assistance from the system through the use of these elements in the examination of issues and linkages to be explored.

R3: Expert consultant systems which facilitate and guide the exploration of a conceptual model relevant to the problem. (The model may have been created previously by the decision maker before he or she consults the system, or it may be a more generic model containing information relevant to a class of problems of which the current one is an instance).

R4: Systems which support preference structuring. These systems are of use when the options under consideration have already been well defined and when preferences have to be made between them. Here, we are concerned with systems which interact with the user in developing a preference structure and making the necessary trade-offs in order to choose or order the choice options.

2. A GENERAL PROCEDURAL SCHEMA FOR PROBLEM FORMULATION AND DECISION MAKING

In this chapter we describe the stages within a general procedural schema for the development, investigation and evaluation of proposals for organizational change. This schema, whose outevelopment, investigation and evaluation of proposals for organizational change. This schema, whose outline is given in Figure 1 as an *approximate net* model[2], has been developed from one first proposed within the framework of Checkland's (1981) soft systems methodology (Humphreys,1986)

Variants of this procedural schema has been applied successfully in analysing applications of many variants of systems and decision making methodologies within organisations in transition (see Hawgood and Humphreys, 1987; Humphreys, Larichev, Vari and Vecsenyi, 1989 for examples). The variant shown in Figure 1 is one which which was developed for use on an international collaborative project on *Strategic analysis of organisations in transition* (Berkeley et al, 1989a).

In Chapter 3 we describe how progress through the schema shown in Figure 1 may be facilitated in practical applications by decision support techniques and tools located in four categories, each providing a qualitatively different kind of support to the problem owner (decision maker) at a different point in the schema.

Starting from the initial entry at activity A1, progress through the procedural schema is rather like playing a board game. The procedural schema is the board, the players are the stakeholders in the problem definition process.[3]

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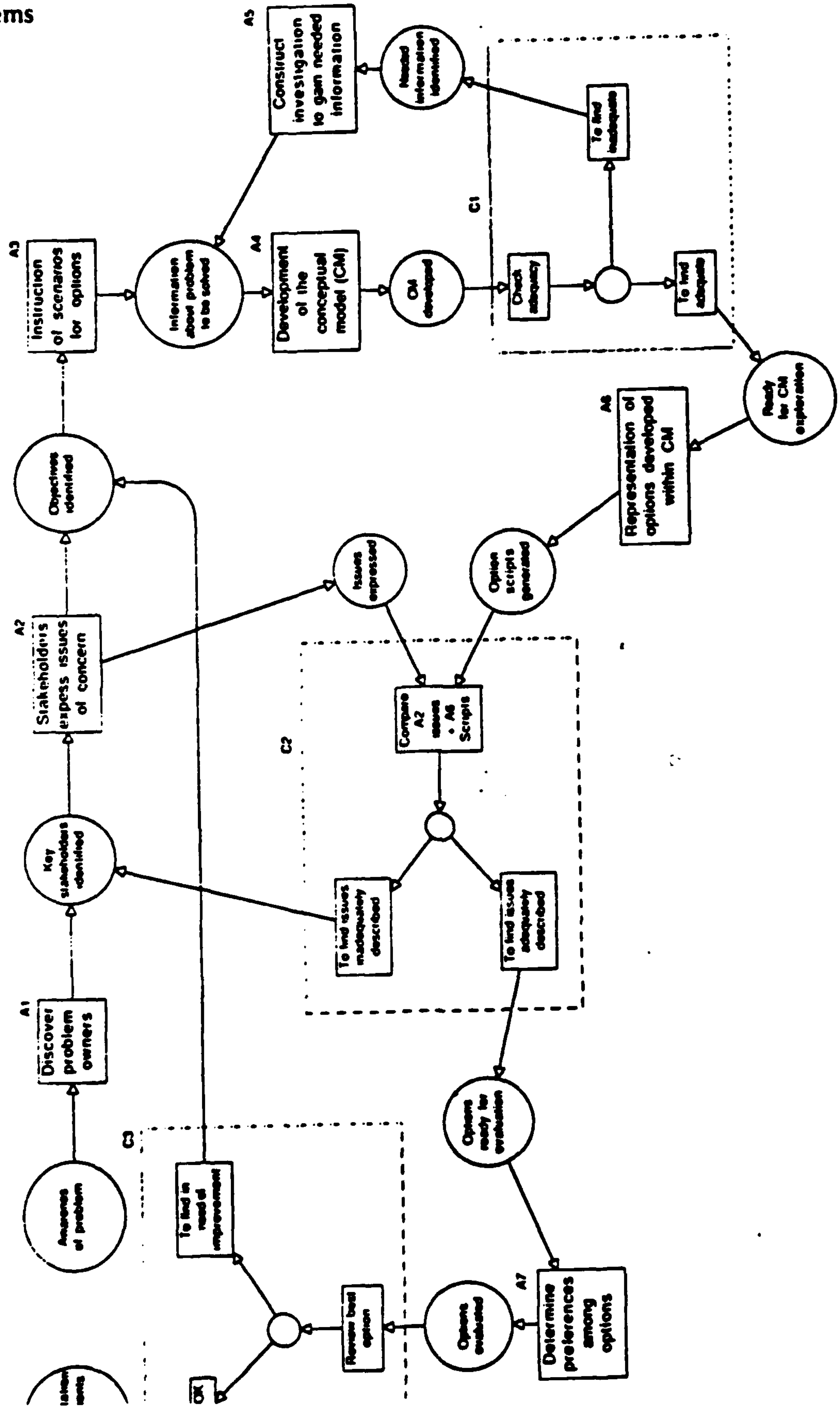
[2] In approximate net modelling, passive objects are represented as "places" by circles inscribed with text denoting their content, and active objects are represented as links, represented as arrows carrying rectangles inscribed with text denoting their function. Approximate net modelling is a very powerful and general technique capable of capturing all structural aspects of a modelled system. It has the advantage of a very simple visual semantics (just places and links), so the inscriptions carry most of the meaning. The user's understanding of the model is rarely locked up or hijacked by apparently meaningful visual structures which in fact are simply an artifact of the model representation method. Moreover, it is possible to refine any part of the model (to show more detail) at will, using the same representation language.

[3] Vari and Vecsenyi (1984) identify the principal stakeholder roles here as: *decision makers* who have the executive power to define the use of outputs of the decision making process, *proposers* who have the power to make recommendations to the decision makers, *experts* whose function is to supply inputs to the currently modelled problem structure, and *those concerned with the implementation* who will play an active role in the realisation of an accepted solution. Vari and Vecsenyi define two further stakeholder roles in situations where supporting techniques or tools are is used: those of the *client* who initiates the use of this support, and of the *consultants or analysts* who advise on methods of problem representation and definition procedures.

Figure 1: Example of a general procedural schema for handling strategic decision problems



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In general, progress through the schema is constrained to move sequentially through the activities indicated in Figure 1, but with considerable variation, according to the nature of the specific decision situation and of the decision maker. Progress depends on (i) the way the process is developed within each activity, (ii) the conditions which initiate the move from one activity to the next, and (iii) how the decision is made whether or not to re-traverse a part of the cycle in the overall process of problem definition (comparisons C1, C2, and C3).

In the case where all stakeholders share a common goal for the decision, the board (i.e., the procedural schema) need be traversed with just one playing piece. This is because a consensus should be achievable between the various stakeholders on what to represent within each activity. However, when stakeholders may be in conflict or have diverse motivations or are pursuing separate goals, the sequence of activities from A2 onwards has to be traversed separately in developing and refining the concerns of each stakeholder in the decision.

There is no finish point in this board game as real world problems are not solved in an absolute sense. Taking action on implementation of a chosen option marks the end of a cycle or *round* in the decision making process (Kunreuther, 1983) but this does not mean that new decision problems, requiring different knowledge representations, will not arise subsequently. Hence, in any organisational application, the playing piece simply pauses after the point in the procedural schema where action is taken until awareness of a new problem requiring definition crystallises.

Sections 2.1 through 2.7, below describe the seven principal activities (A1 through A7) in the schema. In Section 2.8 we describe how the procedural schema can also be used to identify some common pitfalls in practice when defining decision problems.

2.1. Activity A1: *Initiation*

The initiation of the procedural schema starts in any particular application with, in Activity A1, merely the awareness of a problem: as the situation is unstructured, only the manifestations rather than the structure of the problem are known (something is not as expected, something has to be done, etc.). We assume that the problem has not arrived 'neatly packaged' (Keen and Scott-Morton, 1978), and acknowledge that the appropriate actions to be taken has to be generated rather than automatically and uncontroversially contained within the initial problem statement.

Hence, decision making operations at this stage involve motivations to do with how to handle the problem. Supporting these operations implies supporting particular people or groups of people within the organization: the 'problem owners' in Checkland's terminology (Checkland, 1981). Where and how do we get the information required to provide this support, how is it to be represented, and to whom?

A wide range of calculi have been proposed for knowledge representation (see Coelho and Mittermeir, 1987; Johnson and Keravnou, 1985; Humphreys, 1989, for reviews). However, most of these stem from the assumption that the information required will consist mainly of declarative sentences which describe the organizations in a useful way provided they are correct or valid in some sense in the current context. Knowledge represented in this way will not be what is needed here. In fact, it will do more harm than good: preventing people (problem owners, analysts) from thinking in terms of dynamic processes and handling the considerable procedural uncertainty that must exist at this point about the 'solution' to the problem which is not already known: that is, uncertainty about what information to seek, and from whom, how to invent alternatives, assess consequences, and so on (Hogarth et al., 1980).

Hence, the procedural schema provides for the representation and handling of procedural knowledge about how to move from the initial awareness of an (unstructured) problem (activity A1 in Figure 1) to the choice of the appropriate action. Handling of procedural knowledge is described through six more activities (A2 to A7) between A1 and action, in an iterative format with qualitatively different procedures being involved at each stage. This is not to say that there is no place for declarative knowledge within the schema. Declarative knowledge may be assembled, structured and used within each of the activities A2 to A7, but in a qualitatively different way at each stage. More importantly, as the procedural operations within the various activities are goal directed, explicit guidelines are always available, and developed at each stage, concerning what information to elicit, from whom, and how it can be used in guiding the investigation. This permits considerable economy in modelling declarative knowledge as it is not necessary to collect an exhaustive set of declarative sentences about characteristics of the organization.

2.2. Activity A2: Expression of desire for improvement in the situation

At activity A2, the small world within which the problem is believed to be located starts to be explored as the problem is expressed. This does not mean: explore the *whole world* of the decision environment, or even of the specific organization in which the strategic decision making is situated. The small world is that which is sufficient to bound the exploration of the issues which are going to be expressed in articulating the organization's desire to make improvements in the current situation (Conrath, 1988).

We can think of what we are doing when we get the problem situation expressed as exploring in this small world, in the same way that the early 19th century explorers explored the world, they could not map everything at once or determine the boundaries of the terrain a priori. In this analogy it is unwise to expect to be able to get an 'aerial photograph' of the organization. Instead, the mapping of the small world is best stated by those people who first realized they owned (rather than just experienced) the problem (i.e., the problem owners as described by Checkland, 1981 and Vari and Vecsenyi, 1983).

However, the effective boundary of the small world of the problem owner is likely to be determined at whatever part (or whole) of the organization he or she is responsible for. It may turn out that those people who first became aware of the problem and had the desire to do something about it cannot handle the problem effectively except by referring it (or a proposal on what to do about it) to a higher level within the organization. But then the problem definition cycle will start again with the higher level problem owners.

This is one reason why the procedural schema shown in Figure 1 is iterative. It does not assume that a solution is obtained on the first cycle (or indeed on any other cycle). Instead, it allows for a methodology to guide the process through the notion of *conditional coherence:* putting things together conditional on the current way of looking at the problem, and to attempt to define *validation checks* in the procedural schema to see if this process has somehow 'lost its way' (in which case it is necessary to redo or revise certain steps to get round the cycle).

It is important to keep the scope of the investigation constrained as much as possible, if the costs involved in time, money and organizational disruption are to be kept within reasonable bounds. A key finding from earlier work is that the small world explored here as issues are expressed, shaped and constrained by the goals of the problem owners. When the exploration is predicated on some reasonably clear goal it becomes less diffused and therefore easier to analyse (see, for example, Humphreys and Berkeley, 1985, for further discussion of the concept of a small world, originally formulated by Savage, 1954).

2.3. Activity A3: Construction of scenarios for options

The move from activity A2 to A3 in Figure 1 should involve either a formal or informal *goal analysis* to identify problem owners' ideas about possible options for doing something about the deficiencies they have identified in describing issues. In fact, the goal analysis serves to give an initial structuring of the problem owners' desires, through decomposing their global goals into specific objectives, which in turn need to be operationalized. This involves constructing scenarios for options which appear a priori to have the possibility of meeting some - or all - of the objectives.

Given that a problem owner's objectives represent a decomposition of the global goal to improve the situation in some way, issues which are expressed usually point to the location within the system where improvement should be made. Expression of an issue does not necessarily identify option scenarios but, from the issues expressed in a goal analysis, we could get an idea of the points where we can start enquiring about scenarios and encourage problem owners to formulate possible ones (Jungermann, 1984). In this sense, a *goal analysis* can provide the motivational force for the development of initial option scenarios.

However, these initial scenarios may not be very good; they may need to be shaped up and tested against the reality of the organization. It is desirable, therefore, for an analyst to start with the scenarios that the problem owners themselves are considering as the policies ultimately implemented are going to be the problem owners' responsibility, not the analyst's.

In effect, this avoids the pitfall of divorcing the problem from the problem owner, described as a fatal flaw by Paprika and Kiss (1985).[4]

This approach conceptualizes scenarios for problem handling as 'mental constructions', rather than considers problems as 'associated to unsatisfactory objective realities, uncovered by the analysis of facts' (Landry, Pascot and Briolat, 1985; Humphreys, 1989). With this approach comes the recognition that any option scenarios developed through induction in activity A2 needs to be simulated within a model of the organization because almost certainly the person who initially formulated the scenarios will focus on those things that the implementation of the particular option will improve, but will not be able to check adequately on the repercussions of this implementation on other aspects of the organization. Thus a major requirement for the procedural schema is that it should facilitate checking and modelling these repercussions. For this reason, the procedural schema shows the goal analysis in activity A3 feeding into activity A4 where the conceptual model for the investigation is generated. This move marks the end of inductive pre- analysis and the beginning of logical analysis: that is, starting to think of how to generate the appropriate structure to simulate those options which are currently identified, through developing and 'reality testing' the scenarios associated with their representation.

2.4. *Activity A4:* Development of the conceptual model

The first step in activity A4 is to assemble the statements of objectives and the scenarios designed to operationalize them which was generated in activity A3. These collectively represent what Checkland called the 'rich picture' for the investigation. Subsequent steps are designed to convert this picture into a conceptual model through discovering whether the elements of the rich picture can be assembled into a coherent structure. This involves a primarily logical analysis while at the same time checking whether the 'descriptive signs' (Carnap, 1939) identified within the structure being built map appropriately onto the actual, identifiable states and conditions within the organization. In practice, this involves *reality testing* of the conceptual model by, for example, checking functions identified in the model with the organizational personnel actually carrying them out (by interview, or observation, or, less accurately, by relying on the opinion of persons with managerial or expert knowledge of how a particular function is, or could be, actually performed).

[4] It also makes the role of the analyst easier as he does not have to 'sell' options that are developed within the model of the problem to the problem owners in order to get the model accepted. He or she only has to develop and simulate the effects of those options currently formulated by the problem owners.

2.5 Activity A5: Gain information about the world of option implementation

The reality testing circuit shown in Figure 1 thus comprises two activities: conceptual model development (A4) and information gathering (A5). Traversing this circuit enables one to test out the extent to which a problem owner's desire to gain control over the implementation of any particular option under consideration is likely to be realised in practice. Moving to Activity A5 means incurring the cost (in time, effort and perhaps money) of information gathering, and, thus, branching to this step within a problem definition methodology is usually based on the decision that the value of this information (Raiffa, 1968) is greater than the cost of obtaining it. This value will depend on how the current status of the conceptual model is perceived by stakeholders, according to the methodology. In cases where the conceptual model is considered to be free of contradictions, and of intolerable areas of fuzziness, and no one is uneasy about its fit with reality, then the model is likely to be judged adequate in its current form, and further reality testing will be suspended in favour of moving to activity A6.

2.6. Activity A6: Representation of options developed within the conceptual model

Once the conceptual model has been judged adequate within activity A5 in the procedural schema, it is desirable for the original problem owners and other stakeholders to be able to compare the various options developed within the conceptual model with their originally expressed objectives and issues of concern. This should involve guided exploration of the conceptual model, with initial conditions set by each problem owner's or stakeholder's initial expression of issues they originally wanted included in the 'root definition' of the problem. Ideally the results of this guided exploration should be represented in linear script form (Abelson, 1976) in language similar to that originally used by the problem owner which may be compared directly with the scripts initially elicited in activity A2.

This comparison (C2 in Figure 1) may indicate that between activities A2 and A6 certain issues which were expressed 'got lost' through focussing on other issues when operationalizing problem owners' objectives within the conceptual model. If these issues still need to be expressed, then option generation is not complete and further work is required in activities A3 and A4.

2.7. Activity A7: Determine preferences among options.

In activity A7, the remaining task is to determine the appropriate preference structure within which the options described in activity A6 are to be assessed, so that their benefits and dis-benefits on the criteria, or attributes which comprise the structure can be traded off against each other in deciding on the 'best option overall' (cf. Edwards and Newman, 1982; Larichev, 1982).

It is desirable to conduct a sensitivity analysis on the extent to which the choice of an option depends on the importance assigned to the various criteria within the preference structure. If a particular option is found to dominate the others on all the major criteria, its choice as a basis for action is likely to be reasonably non- controversial (Svenson, 1979; Montgomery, 1983). Taking the action to implement this alternative completes the current problem definition cycle.

The sensitivity analysis may, on the other hand, indicate that the alternative identified as 'best' in the preference ordering of currently defined options 'could be improved' (i.e., it is suboptimal on some criteria), or even that an alternative ordered second or third might be preferred if *it* could be improved on one or more criteria. It is just as important to verify this conjecture as it was to verify the options initially explored in activity A3 within the cycle. Hence, in this case, comparison C3 in Figure 3 indicates that the problem definition methodology should effect a move to activity A3, develop the scenarios operationalising the objectives for the revised option, and, then, proceed as before through activities A5 and A5 (revising and verifying the conceptual model). The script consequently developed for this new option in activity A6 may then be evaluated against the pre-existing scripts for other options in activity A7 to ascertain whether or not the goal of formulating an 'even better' option was in fact achieved.

2.8 Identification of pitfalls in problem definition and formulating options

The procedural schema also clarifies some common pitfalls in practice in problem definition and formulating options. For example, a common pitfall, discussed by von Winterfeldt (1983) and Vari and Vecsenyi (1983), is for an analyst to take a client's problem at its face value within activity A2, or to consider only that part of the problem actually expressed as issues of concern at this stage. The analyst will often desire to move the analysis as quickly as possible to activity A7, where he or she is likely to possess special expertise in helping the client to develop a 'requisite' preference structure for evaluating alternative options and deciding upon action (Phillips, 1984). The problem owners may concur with this desire, as it accords with their own desire to take action as soon as possible to alleviate the problem.

However, while there is a pathway from activity A2 to activity A7 (through C2), shown in Figure 1, traversing this path can be understood as a violation of the rules of the game as the pathway from A2 to C2 can only be traversed in the appropriate direction, since the starting conditions from C2 have to be the scripts developed in activity A6, not in activity A2.

Although the general rule holds that one disturbs the sequencing of activities A1 to A7 shown in Figure 1 at one's peril, this does not mean that an equivalent amount of effort has always to be expended on each activity in every investigation. The rule here is that, within each cycle, most effort should be expected and most support provided at the activity where it is most needed.

3. FOUR CLASSES OF SUPPORT TECHNIQUES AND TOOLS

The general procedural schema shown in Figure 1 is applicable to a very wide range of situations involving organizational change in the service of the desire for improvement. It is cognitively rather than behaviourally based; that is, it is designed to support thinking about how problem owners might design and implement alternative options under the general goal of seeking ways to overcome, or alleviate problems of which they are aware. It is not prescriptive; instead, it provides a guide to ways of supporting problem owners' discretionary activities in scenario generation, deciding on whether (or to what extent) deep verification is required concerning the feasibility and realism of plans of option implementation, and, finally exploring and making trade-offs between alternative descriptions of options explored within the conceptual model in deciding on the course of action that will actually be taken.

Support is provided for problem owners, planners and analysts facing procedural uncertainty through interpreting the procedural schema as a game, comprising seven activities (A1 to A7), which may be traversed in any sequence permitted according to the layout given (i.e., according to the syntax of dynamic simulation of a state-transition net). That is, discretion can be expressed about when to move from one activity to the next, and, at points C1, C2, and C3, about which activity to move to next.

A fundamental principle of effective support for problem owners is that assistance should be focussed at the point within the system problem or project definition cycle where the problem owner is currently having difficulty in proceeding (Jungermann, 1980, Humphreys, 1989). These difficulties can be located and articulated at the appropriate activity within the general procedural schema which can be extended, as illustrated in Figure 2, to indicate four major classes of support techniques and tools (R1 to R4), each with a qualitatively different support function, and each pointing to the activity within the cycle where techniques and tools within that class may be able to render effective support. These are:

Support class R1: techniques and tools facilitating problem owners' expression of issues of concern.

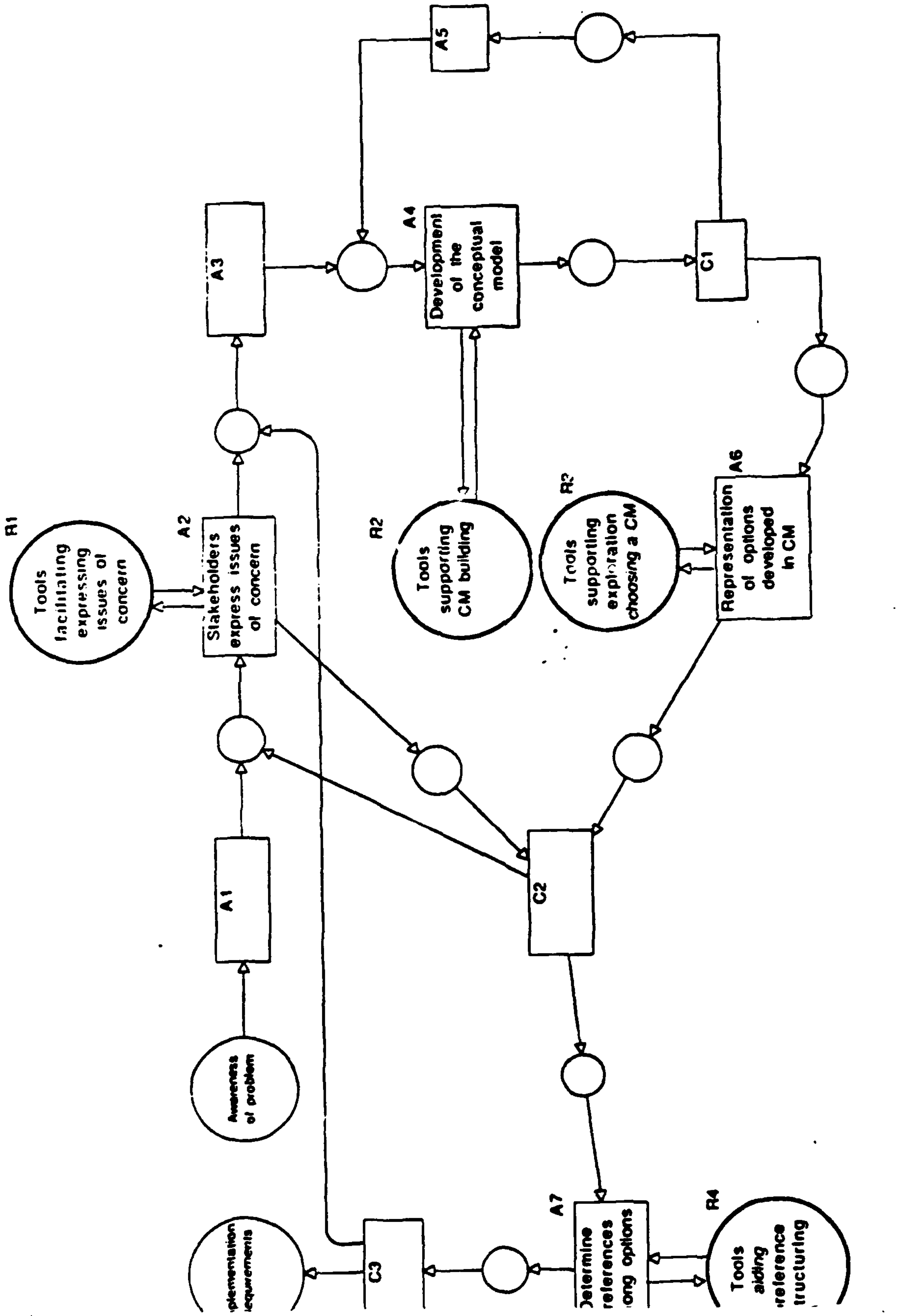
Support class R2: techniques and tools aiding the generation of conceptual models.

Support class R3: techniques and tools aiding exploration through a conceptual model.

Support class R4: techniques and tools aiding preference structuring.

The nature of the support which can usefully be provided within each of these four classes is described in Sections 3.1 through 3.4, below. In each Section we indicate which of the methods and tools included in the catalogue in Appendix A can usefully provide support within the relevant class, and discuss in more detail the characteristics of promising tools.

Figure 2: four classes of support techniques and tools located at the points within the procedural schema where they facilitate progress.



3.1 Support Class R1: Techniques and tools facilitating problem owners' expression of issues of concern

The goal for tools in this category is to support problem expressing and scenario development processes at activities A2 and A3 in the general procedural schema. User requirements here are for techniques and tools which can facilitate problem owners' use of their own problem- expressing language in generating initial descriptions or 'scripts', for issues of concern to them within the context of the problem at hand. (In activity A1, there is merely the awareness of a problem: as the situation is unstructured, only the manifestations rather than the structure of the problem are known, and so no formal support techniques are possible for this activity)

In Activity A2, the small world (Savage, 1954; Toda, 1976) or decision space within which the problem is believed to be located starts to be explored as the problem is expressed. The way the decision space is explored is shaped and constrained by the goals of the problem owners. When the exploration is predicated on some reasonably clear goal it becomes less diffuse and therefore easier to analyse.

Various tools have been proposed for providing a decomposition of well-understood complex goals, but we have not included any of these in our selection for class R1, as we have found that they do not facilitate a problem owner's exploration of what one's own goals, and those of other stakeholders, might be, rather they decompose the results of such exploration, and are therefore more appropriately situated within class R3.

Instead, we need here representation techniques which indicate the domains that problem owners wish to explore in their initial handling of the, as yet unstructured, decision problem. Some attempts have been made to provide support for this through cognitive mapping procedures (e.g., Eden, Jones and Sims, 1980; Sevon, 1984). However, in evaluating these mapping procedures we found that, while they were quite good at eliciting material to be explored, they faltered at the point of expressing the exploration within the form of a map.

At this stage in the decision making process it is premature to employ a fixed structure (as in the geographical representation of a map) to show the linkage between issues of interest to problem owners at particular points within a two-dimensional space. This premature imposition of structure by the mathematical techniques employed in cognitive map construction tended to lead to rejection of the whole map by problem owners. Also, the results often interfered with the process of conceptual model building in stage 4 of the procedural schema, which is the first stage where structured models may reasonably be developed and displayed.

Rejection of goal-decomposition and cognitive mapping tools as candidates for class R1 in the problem structuring library left us with a complete absence of suitable tools to select from among those currently available and recorded in our catalogue. Hence, instead of describing the capabilities of existing tools here, we suggest how two techniques, not previously incorporated into tools, may provide effective support for activities A2 and A3, respectively.

The first, described in Section 3.1.1, supports the exploration of the small worlds in which the problem owners wish to locate the decision problem, and aids the process of exploring the set of domains constituting that small world which is shared across the various problem owners party to the decision making process. The second, described in Section 3.1.2, deals with the presentation of the issues that various problem owners may wish to express within such shared domains through the inferences they advance.

3.1.1. Exploring problem owners' small worlds, and extending the background of safety.

We can think of problem owners' exploration of their small worlds to find material relevant to their decision problem as being carried out within the "small world" which defines the bounds of the material which the person is prepared to retrieve and attempt to structure in handling the judgement problem (c.f. Toda, 1976; Humphreys and Berkeley, 1983; 1985).

In Technical Report 88-3 on this project (Oldfield and Humphreys, 1988) we describe how problem owners with different interests due to their different organizational and social roles explored the small world they personally considered relevant to the decision problem in very different ways, according to their interests and, by extension, their roles. Also, Wagenaar and Keren (1988) describe a series of experiments where the role the subject was asked to play in performing a decision making influenced the way different kinds of information were used by subjects in making their decision. In short, people in different roles explore different small worlds for the purpose of seeking material relevant to the decision problem they share.

However, small worlds complete with contents do not exist as complete entities pigeonholed away in a person's mind ready to be retrieved intact. From the outside we infer the contents of the small world the person is using by looking at what he or she explores, and guessing its bounds or possible "holes" within it by what he or she leaves out. We are left with uncertainty of the bounds of this structure in the same way cartographers of the physical world in the middle ages experienced uncertainty about where to draw bounds when they had access only to explorers' reports and guesswork to fill in the gaps.

Risks associated with exploring other problem owners' small worlds

From the standpoint of this analogy, though, the person forming the judgement is not the cartographer, but the explorer. He or she can only establish the bounds by backwards and forwards processing (Jungermann, 1983; 1984), exploring alternative futures in a territory for which there are no maps and there may be considerable uncertainty not only about where the boundary is but also what unforeseen successes or anxiety provoking situations lie there, or along the route.

Humphreys (1982) has discussed how problem owners may find that exploration in domains given prominence by other problem owners, with interests and experience different from their own, may be much more threatening than exploring negative consequences within domains with which they themselves are familiar. This is due to the possibility of having to explore other people's scenarios which, for the explorer, are unbounded; that is, it is possible to imagine within them consequences which are not bounded by worst case scenarios. Such anticipation can arouse considerable anxiety about the possibilities of what might be encountered if the problem owner were to undertake this exploration in his own mind.

Why this is so has been discussed by Sandler and Sandler (1978) in terms of a "background of safety" built up through play; that is, structured and guided exploration of ways of setting bounds or having bounds provided by one's parents or others for one's "worst case" phantasies. The possibility that exploration might take one beyond the boundary of the background of safety is to return to the exploration analogy reminiscent of Columbus' crew's fears during the voyage of the Santa Maria that he was going to sail them over the edge of the world. It was only this fear, not those about awful situations they might encounter within the uncharted world they were exploring, which was paramount in the men's demand that their ship should turn around towards home.

Thus, it is often the case that the experience of risk and anxiety about going beyond the background of safety can lead to refusal to consider other stakeholders' views, not because of negative features, but just simply because it feels unsafe even to consider them.

Extending the background of safety

In Technical Report 87-3 on this project (Humphreys et al., 1987) we describe a context (the problem of hazardous waste disposal) where there is ample evidence that problem owners with different organizational roles are likely to experience considerable difficulties in exploring each other's small worlds in the way that would be necessary in any social decision making on the problem.

In such cases, what should be done in order to bring problem owners with different interests together so that they may use a common decision making framework? We consider below three alternative strategies. The first two have to do with the way terms of reference are set for the issues which may be considered in a public way in the decision making process; the third relates not to terms of reference, but to the background of safety.

Extending the terms of reference for what can be considered in a social decision making situation to admit material drawn from a enlarged "small world" encompassing the small worlds that each participant would like to explore may well be an unrealistic solution to the problem of handling differences between problem owners with different interests in the decision. Implementing this proposal would involve each participant being charged with a wider exploration, thus increasing the chance of encountering consequences which for them, if not for others, involve unbounded worst case scenarios. This could undermine the background of safety which participants need if they are to negotiate the knowledge structure within which all the various participants' judgements about options and consequences may be represented.

Moving to the other extreme is often recommended: that is, restricting rather than extending what can be talked about within the frame of reference, in the hope that scenarios in other areas will not be explored (thus not unduly scaring some participants, c.f., Mazur, 1984). Such a strategy is actually likely to be counter-productive as it would simply throw such exploration into the realm of taboo issues wherein phenomena excluded from social debate, rather than being neutralised, are experienced as having special agency and potency (Douglas and Wildavsky, 1982).

We would suggest that an alternative and more promising solution would be to consider ways of extending the background of safety, helping problem owners develop and bound scenarios in areas where, at present, they "don't know how to think about what might be involved". For more than two thousand years, this has been one of the aims of drama, though embraced in varying degrees by different playwrights, impresarios and censors. It has a long history of providing support to help audiences face the "unthinkable" from greek tragedies handling issues to do with death, bereavement and sacrifice, onwards.

These types of techniques have been also used for some years by social scientists working with small groups facing personal anxieties and interpersonal conflicts in problem bounding. For example, Moreno (1946) describes the use of role-playing within the context of psychodrama (exploring scenarios from the starting point of other problem owners' roles) to reveal things to problem owners that would otherwise be unavailable for exploration by them. Psychodramatic techniques (compared by Sampson, 1971 with Stanislavski's theory of acting) are employed to provide a structured context which effectively extends the background of safety for the problem owner's exploration of the small world accessed through adopting the viewpoint associated with another's role in the problem expressing process.

Some techniques of this type are also employed within the strategic choice approach to organizational decision making (Hickling, 1974, Friend and Hickling, 1989) in order to help decision making groups deal with uncertainty about the bounds of the small world within which the problem should be structured. However, the strategic choice approach focuses more on coordinating the boundaries of the small worlds shared by the problem owners comprising the group, rather than exploring the potential conflicts concerning what may safely be encompassed within these boundaries.

Implementation of psychodramatic techniques with the goal of extending the background of safety is a highly interactive process between problem owners and analysts. We do not suggest that such techniques themselves could be successfully programmed as computer-based functions of tools in class R1. However we have found that computer based display (within a slice-diagram) of the different degrees of exploration across domains carried out by the various stakeholders party to the decision can be very useful for providing the structured context that sets the agenda for the exploration through small worlds that the psychodramatic techniques facilitate.[5]

3.1.2 Analysis of inferences advanced by problem owners in constructing scenarios.

Once a small world, shared across problem owners, can be agreed upon for handling the problem (perhaps with the support of techniques of the type described in section 3.1.1), we can continue to Activity A3 in the general procedural schema. The move from Activity A2 to Activity A3 in Figure 1 usually involves either a formal or informal goal analysis: identifying problem owners' ideas about possible options for doing something about the deficiencies they have identified in describing issues. The aim here is to decompose their global goals into specific objectives, which in turn need to be operationalised (Jungermann, 1984). This involves constructing scenarios for options that appear a priori to have the possibility of meeting some or all of the objectives. The support tool we propose to aid this process is one which, through the construction of inference diagrams, enables the display and comparison of the issues and linkages that problem owners claim they want to have expressed in these scenarios. This tool would implement procedures first described by Vari, Vecsenyi, and Paprika (1986), and that have been used successfully in our own work on this project.

Vari, Vecsenyi, and Paprika (1986) identify two basic object categories to be structured in diagrams indicating the inferences problem owners incorporate into their scenarios. These are (i) states/goals that characterise the set of objects or events to be considered and (ii) actions/events that bring about changes in these states, according to the problem owner's reasoning. States may be subdivided into goal states (G) desired by the problem owner; exogenous states (ExS), which cannot be influenced by the problem owner, but affect the decision and its consequences; and endogenous states (EnS), which result from (sub) decisions taken within the scenario. Actions/events may be subdivided into actions taken, or controlled by, the problem owner (A), exogenous events (ExE), which cannot be influenced by the problem owner (though they may affect the decision and its consequences) and endogenous events (EnE), which result from decisions taken within the scenario.

Several types of relations may be defined, linking states and events, e.g., an action results in (R) a change of state of some persons or objects; a state may modify (M) the condition of an action's accomplishment; a certain state of an object or person may initiate a change in state of another object or person; an action may lead to other actions, or an action may be conditioned (C) by the previous existence of a state or

[5] For examples of slice diagrams, see Technical Report 88-3 (Oldfield and Humphreys, 1988), Figures 1-8. As part of a subsequent project at LSE, the techniques for constructing these displays will be used in the context of strategic analysis of organisations in transition. They are now being developed into a tool for Displaying Differences across Domains (DDD) as a means of supplying support for activity A2.

implementation of an action (inversion of the L relation).

These primitives (states/goals, actions/events, relations) may be used to construct inference diagrams which can be used to display clearly the structure of the goals and means-end relationships (goal-action- event-state schemata) implicit in the scenarios advanced by the various problem owners party to the decision. Within an inference diagram, hierarchical means-end relationships can be refined between goals using the I (or C) relation, proposed actions can be transformed into sequences of action using the C relation, and so on.

Inference chains may be of two types. In the first, used for representing forward scenarios, actions and exogenous events and states result in endogenous events and states. In the second, used for representing backward scenarios, goals and exogenous events and states result in actions. Forward, backward and mixed scenarios can all be represented in the same inference diagram, in cases where this is appropriate. The inference diagram representation also makes possible the direct and detailed comparison of scenarios advanced by different problem owners, even when some are forward scenarios and others are backward scenarios for the problem.

We have found that, in general, inference diagrams can provide useful support within class R1, helping (a) to reveal the way in which problem owners express their awareness of the uncertainties which they would like to be investigated further, and, (b) to demonstrate major differences in the approach to conceptual model building (in activity A4) which will be acceptable to particular stakeholders, and to display the divergences between them.

Thus, on a subsequent project, we plan to develop a support tool that would focus on providing interactive facilities for Exploration of Claims and Inferences (ECI). It would permit forward (options to goals), backward (goals to options) and mixed scenarios to be represented in the same inference diagram, in cases where this is appropriate. The inference diagram representation also makes possible the direct and detailed comparison, with the aid of the ECI tool, of scenarios advanced by different problem owners, even when some are forward scenarios and some are backward scenarios for the problem.

3.2 Support Class R2: Techniques and tools supporting conceptual model building

Techniques and tools in this class aim to support the user in locating scenarios under consideration in some sort of model where the context of these scenarios can be investigated in a coherent way. The way in which this context is represented depends on the set of 'primitives' or modelling elements employed by the system.

In the research which led to the compilation of the catalogue of existing support tools (in Appendix A), we found that we could divide up current tools which claimed to offer some sort of conceptual model building capability into four subsets, according to the nature of the primitives they employ for this purpose.

The first subset of tools in this class comprise tools which use rules from the predicate calculus as these primitives. Here, individual rules are expressed in logical terms, and the system aids the user in his or her attempts to build these rules into a coherent network which can subsequently be expressed in drawing inferences. Two of the tools described in the catalogue lie in this subset. These are:

Knowledge Craft
Personal Consultant

The second subset comprises tools which employ decision analytic techniques to model pathways toward scenarios, i.e., from immediate acts to future consequences. Six of the tools surveyed in this report construct act-event nets, i.e., decision trees. These are:

Arborist (domain independent)
OPCOM (domain independent)
Stratatree (domain independent)
Supertree (domain independent)
Automatic Diagnosis (focussing on medical problems)
Decision Tree Analysis of Litigation

Two more tools in this subset use the same decision theoretic primitives, however these are expressed in tabular rather than net form. These are:

Prologa
DSS-UP

The third subset comprises tools which model pathways in backward (rather than forward) scenarios. That is, they work backwards from goals to immediate acts. The three tools in this subset are:

CEIS
PG%
Facilitator

The fourth subset in this category comprises tools which aim to support negotiations, by exploring different stakeholders views within a single conceptual frame of reference, such that particular scenarios can be captured in terms of equity and optimality across stakeholders views. The tools in this subset are:

Equity (pareto optimal interpretation of stakeholders' positions)

Combined Arbitration (game theoretic interpretation of stakeholders' positions)

Phillips (1986) has pointed out that most model building tools generate their products on the basis of information about the past. The future is seen merely in terms of trend extrapolation from the past. In our experience of aiding decision makers facing strategic decision problems, we have found that problem owners largely discount such trend extrapolation to the future on the basis of the past. The decision problems they face tend to be ill-structured precisely because the problem owners find themselves in a situation where the past is not a good guide to the options they would like to consider for the future. Decision making marks a break from the past and may well focus on a choice between options for *organisational change*, each of which will transcend past experience (in fact, the results of past trends are often the symptoms identifying the current problem).

Hence, in the detailed discussion which follows concerning tools which can provide effective support for conceptual model building we consider only modeling techniques which serve to structure, develop, contextualise, explore and test future scenarios. To this end, we have selected two tools from those listed above. The first, OPCOM (described in Section 3.2.1), is for modeling forward scenarios, that is, those which start from immediate acts open to the problem owner, and working forward in time to their consequences. The other, EQUITY (described in Section 3.2.2), starts from future goals and models backward scenarios through constructing the option which might best achieve those goals.

Both these tools are based upon the fundamental assumptions of decision theory, though developed in different ways. In Section 3.2.3, we examine the types of uncertainty which can, and cannot, be handled in conceptual model building through the use of decision- theory based techniques and. In Section 3.2.4, we discuss the development of a more general conceptual model building system which can overcome some of the limitations of the decision theory based techniques.

3.2.1. OPCOM: A decision-tree based tool modeling forward scenarios.

Decision theory provides a decomposition of immediate acts through intervening acts and events (assessed in terms of the probabilities of their occurrence) along pathways leading to consequences at the decision horizon. The decision horizon is the point in the future where a scenario is no longer projected forward, and so consequences have to be evaluated as described at that point. Each option under consideration is described within a decision tree representation of forward scenarios in terms of the paths from an immediate act to the possible consequences that could follow from its choice.

There are a number of decision support tools which use this representation of forward scenarios. Of the six described in the catalogue in Appendix A, we selected OPCOM for discussion here. OPCOM was the most flexible of the six in terms of the interactive re-structuring facilities offered to the user, an important feature when modeling initially ill-structured problems where model structure is often developed on a trial basis, then tested (often through traversing the "reality testing circuit" comprising Activities A4 and A5 and Comparison C1 in Figure 1), and then restructured to take into account problems discovered in the test, re-tested, and so on.

OPCOM is designed for use by decision analysts and problem owners who are fairly familiar with decision analytic procedures. It allows the user to examine alternative choice options and pathways to consequences. Each level on the decision tree may represent a series of different time periods or state of affairs, at which point new topics or items are introduced. The structure of the model is, however, always determined in interaction with the user.

Possessing editing and sensitivity analyses facilities, OPCOM provides the user with flexible methods of experimenting with the data, giving rapid feedback on "what if" questions. Using these facilities, discrepancies between members of a decision making team may be resolved by analysing areas of conflict. OPCOM allows the user to enter data in any order and has sufficient control to detect an incomplete database. At any one stage, the user can get a summary to [Find out which parts of the data base are missing.

3.2.2. EQUITY: A tool modeling scenarios backwards from goals

Jungermann (1984) has pointed out that, in conceptual model building, problem owners often prefer to work backwards from goals to options that might achieve those goals, rather than forward from options to goals. The tools described here start from the definition of a global goal, and than help the decision maker in characterising the options that might meet this goal. Making this characterization requires a goal decomposition from the global goal to criteria on which options may be scaled, such that the option which scores best on the criteria should have the greatest chance of meeting the global goal. Such tools tend to be domain specific because the structure of the goal decomposition differs according to the nature of the global goal (for instance, a budget allocation global goal results in a different structure than does a regulatory goal; c.f. von Winterfeld, 1980).

Here, by way of example, we discuss EQUITY, a tool which starts from the global goal of efficient allocation of resources across options. (We have chosen resource allocation as the example as we think that this is by far the most common goal which participants in decision conferences at a strategic level wish to start from in applications which call for modeling backward scenarios.) EQUITY can also provide direct support for negotiations between problem owners who are stakeholders in the decision, by exploring their different views on the importance of the criteria in the goal decomposition within a single conceptual model, such that particular scenarios can be captured in terms of equity and optimality across stakeholders' views.

The first step when using EQUITY is to define the competing projects or purchase items and identify several levels of expenditure for each, ranging from the least costly to most costly. Next, the cost of each level and the benefit for each level is assessed (either may be assessed on multiple dimensions) and the relative benefits of the alternatives budget categories determined.

Once the model has been structured and the values entered, EQUITY identifies the set of efficient allocations from all of the possible allocations, that is the set of allocations which have the maximum cost for a given level of benefit. For any proposed allocation which is not in the efficient set, EQUITY can either select an efficient allocation which has the same benefit at a lower cost, or a greater benefit at the same cost. In addition, EQUITY provides a graphical display of the efficient set, showing how well any proposed allocation currently under consideration performs relative to the efficient set and how it needs to be improved to achieve the maximum benefit at a given cost.

EQUITY is highly interactive. It allows the user to structure the model and assess the necessary values, then calculates and displays the results. Sensitivity analyses are simple to perform, and the conceptual model structure (or its contents) can be changed quickly and easily, permitting the course of the analysis to follow any new directions the problem owner group wishes to take.

3.2.3. Capabilities and limitations of the decision theoretic approach to conceptual model building

Berkeley and Humphreys (1982) describe how decision theory based techniques can in general handle the following four types of uncertainty in conceptual model building:

(i) Uncertainty about the probabilities of outcomes of subsequent events, conditional on what has preceded them in the act-event sequence between immediate acts and consequences.

(ii) Uncertainty about the probabilities of subsequent events, conditional on the occurrence of other events extraneous to the sequences in (i).

(iii) Uncertainty about how to incorporate prior information in determining the probability of a subsequent event.

(iv) Uncertainty about how to conceptualise the worth of consequences.

They also describe three other types of uncertainty which need to be resolved within the conceptual model building process which are not handled within decision theory. These are as follows:

(v) Procedural uncertainty, which Hogarth et al. (1980) describe as "uncertainty concerning means to handle or process the decision", e.g., specifying relevant uncertainties, what information to seek, and where, how to invent alternatives and assess consequences, etc.

(vi) Uncertainty about how the decision maker will feel, and wish to act, having arrived at a subsequent act (choice point) in the scenario after intervening events have unfolded "for real".

(vii) Uncertainty about the extent to which the decision maker possesses agency for inducing changes in the probabilities of subsequent events, conditional on actions yet to be taken, through being able to alter relations between states of the world.

Handling uncertainty of type (v) in the process of conceptual model building requires the addition of expert system capabilities, namely a process guide for the user, helping him to use the basic functions of the model building tool at the appropriate time and in the appropriate way. This process guide needs to be linked to knowledge about the current structure of the conceptual model in relation to the generic characteristics of such models (Berkeley, Fernstrom and Humphreys, 1987).

Handling uncertainty of type (vi) requires the use of conceptual model building techniques which have more powerful simulation capabilities than that which is possible within the act-event structure of decision trees (Bauer and Wegener, 1975). Acts need to be modelled in terms of operations which may consume resources and produce results so that, in simulating through the model, the problem owner gains a better understanding of the experience of acting in a particular way in a particular context. This can help him determine how to adjust his preference structure in assessing subsequent choices in terms of how he might feel then, rather than how he feels now.

3.2.4. Overcoming the limitations: A Generic Organisational Frame of Reference.

Although none of the tools in class R3 which are included in the catalogue in Appendix A have the capability to handle uncertainty of types (v) and (vi), it is possible, in theory, to extend their capabilities in this respect by adding additional intelligent functions on top of their basic model-building and display functions.

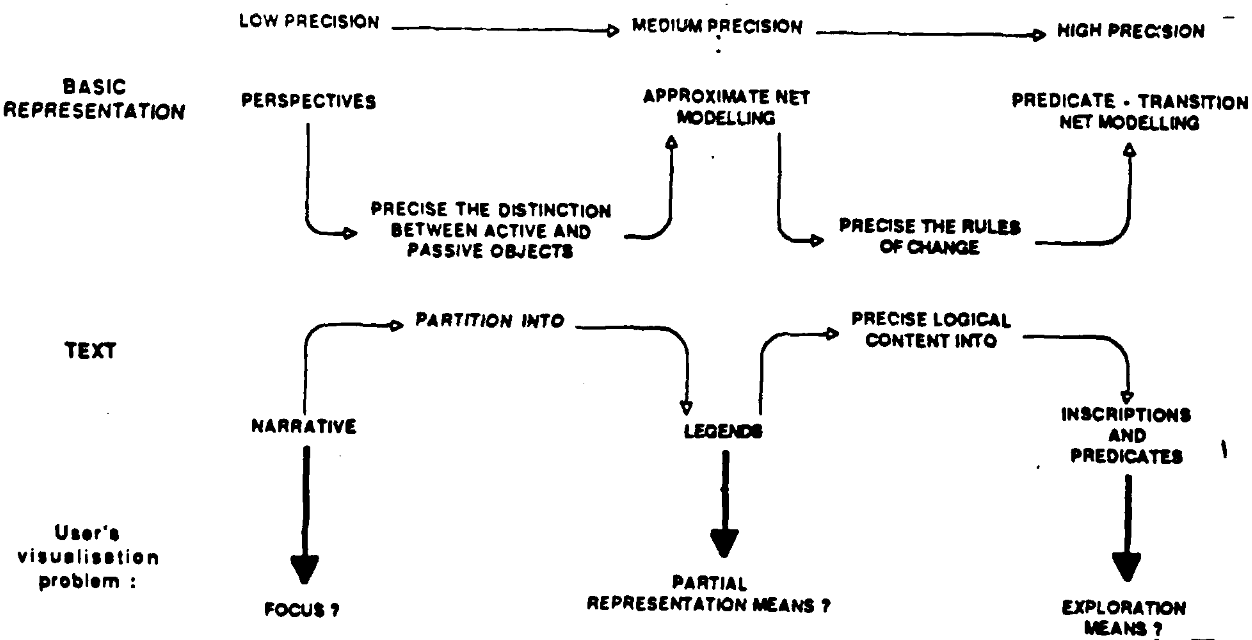
Resolution of type (vii) uncertainty, however, presents more of a problem. Berkeley and Humphreys (1982) describe how decision theory assumes that the decision maker has complete agency over his own acts, but none whatsoever over states of the world which do not constitute his own acts, even when these states occur as a result of the acts of other people over which he may have some agency (as when they work in the same organisation, or respond to his authority). Vari and Vecsenyi (1983) describe how problem owners in social decision making situations find, with partial justification, that this assumption is unreasonable. In a wide range of organisational decision making applications, we have consistently found that the problem of stakeholders' agency to effect change (and to anticipate its side effects) is one of the major issues of concern in problem owners' conceptual model building.

Handling this concern requires a more powerful and more generative conceptual model building calculus than that available in any of the tools surveyed in our catalogue. However, on a separate project (part of the European Strategic Programme on Research on Information Technology) we have recently developed, in collaboration with net modeling experts from GMD (Gesellschaft fur Mathematik und Datenverarbeitung, Sankt Augustin, FRG) a Generic Organisational Frame of Reference (GOFOR) which offers a generative conceptual model building calculus in a form accessible and useful to organisational problem owners, researchers and analysts. Its general aim is to guide the investigation and model building process within practical, systems-based analysis of organisational situations, problems and change option implementation. It offers a unified knowledge representation schema, based within Petri-net theory, but with the ability to present a desired view on this schema in a language (visual and text) with which the problem-owner is familiar. The development method for GOFOR started from the recognition that systems methodology in general is not intended to be a static entity whose procedures are fixed for all applications present and future; different organisational investigations will have different aims, different scopes, and different modeling requirements. Thus, GOFOR was not intended to be a static entity, but to be able to grow and become better refined as our knowledge of functional analysis of organisations, and of practical modeling techniques, increases through its use (in the proposed project and elsewhere).

GOFOR provides a consistent set of both formal and pre-formal representation means for organisational modeling and does not recognise any rigid distinction between hard and soft modeling. Rather, its formal modeling capabilities represent an optional facility towards increased exactness of models which have been developed with pre-formal capabilities.

GOFOR describes seven perspectives which are of particular importance in organisational modeling: a function perspective, three specification/implementation perspectives and three management perspectives. However, the relative importance of these perspectives rests on a social norm: they are those predominantly employed by problem owners within organisations in transition. Thus these perspectives are not treated as absolute but rather are used to guide the initial organisation of material to be modelled[6].

Figure 3: Variable precision modeling within GOFOR.



6 If a case is made for other perspectives to be considered for this purpose, these can be in-

Each perspective serves to organise intuitive knowledge about the organisation but there is no guarantee that what is initially represented within a perspective will be coherent, even at the level of local structure. Development, testing and maintenance of coherence requires increasing the level of precision of the relevant knowledge to that which can be achieved through *approximate modeling*.

To move from perspectives to approximate modeling what must be precised is the distinction between passive objects and active objects within the represented knowledge.[7] GOFOR indicates how the inscriptions (denotative descriptions) of both active and passive objects may be expressed in the natural language of the particular problem owners. Moreover, these inscriptions can be developed through partitioning intuitive narrative descriptions what can be "seen" within a perspective, as outlined in Figure 3.[8] A successful achievement of the above allows exploration of the model through asking what-if questions, and examining how the model simulates the dynamic implications of such questions. Now the conceptual modeling tool can provide support through exploration, allowing alternative scenarios to be tested, side-effects to be investigated, and contingency planning to be validated.

At present, GOFOR exists as a paper-based set of guidelines, techniques and examples which, while useful for informing and guiding conceptual model building, falls short of providing full *interactive* support during the process of conceptual model building and exploration. However, in a separate project which is proposed as part of the British Research Councils, *Human-Computer-Interaction Initiative,* we plan to develop and validate through user trials in real applications a computer-based fully interactive version of an enhanced GOFOR (IGOFOR) in order to provide really comprehensive support for analysts and problem owners in organisations in transition. In short, IGOFOR will *implement* what GOFOR *proposes.*

3.3. Support Class R3: Techniques and tools aiding exploration through a conceptual model

Systems and tools in this category start from a pre-existing conceptual model or 'structured knowledge-base' and aim to support the user by providing facilities for

[7] Sometimes, for example, in exploring possible side effects of implementing a particular option, it is desirable to increase the precision of modeling within relevant parts of the conceptual model so that the dynamic as well as the static aspects of the object system can be investigated.

[8] In approximate net modeling, passive objects are represented as "places" by circles inscribed with text denoting their content, and active objects are represented as links, represented as arrows carrying rectangles inscribed with text denoting their function. Approximate net modeling is a very powerful and general technique capable of capturing all structural aspects of a modelled system. It has the advantage of very simple visual semantics (just places and links), so the inscriptions carry most of the meaning, the user's understanding of the model is rarely locked up or hijacked by apparently meaningful visual structures which in fact are simply an artifact of the model representation method.

displaying aspects of this model and, ideally, for the decision maker and other stakeholders to explore through the model in developing scenarios for decision options.

The first subset of tools in this category comprises domain-specific expert systems which aim to support the user by providing the appropriate information he or she needs on handling a particular problem. This is conducted by exploring a generic knowledge-base parametized by a set of constraints, conditions and/or information which characterizes the problem at hand. From the tools surveyed in the catalogue in Appendix A, we can identify expert systems in the following domains:

a) Supporting organizational decision making

EIRES on information needs in information systems development

PLEXPLAN on organizational and information needs planning

ESSI on strategy selection

Demand/Supply Planning Support System on inventory and production planning

b) Supporting societal decision making

ACIDRAIN on acid rain damage

IDEAL-PET on transportation policies and environmental planning

IRIMS on chemical hazardous substances

NORMA on rule drafting and dispute resolution

The second subset of tools primarily aim to support the user by helping him or her to get a better idea of the organizational and/or business consequences (of his or her own and/or of others which may be under consideration).

Systems and tools in this category are divided into domain-independent and domain-specific tools. Those which are reasonably user-friendly also tend to be domain-specific. This subset of tools and their domain areas are:

MICROLAY for factory layout planning

SAFETI for risk analysis (in chemical engineering)

BPS for establishing budget priorities

CYBERFILTER for monitoring organizational activities

JAVELIN for financial modelling and business analysis

Jobber Business Simulation for small business planning and

Information Planner for examining information strategy plans

LOGSIM for resource allocation (calendar driven)

ORDO for job shop scheduling

PRIORITIES for establishing work priorities management

STRATMESH for strategy evaluation and competitive market planning

SYSTEM W for multi-dimensional financial modelling

The third subset of tools in this category provides purely analytic simulation methods for use within conceptual models where relevant information is described within algebraic structures. The tools are:

DESIMP uses discrete event simulation

QSB uses linear programming algorithms

VIG uses linear programming algorithms

Strategic Intervention Planning uses stochastic dynamic programming

LSM uses linear scoring models

In Chapter 2 we described how, once the conceptual model has been judged adequate in comparison C2 in the procedural schema, it is desirable for the original problem owners (and other stakeholders) to be able to compare the various options developed within the conceptual model with their originally expressed objectives and issues of concern. This involves guided exploration of the conceptual model in language similar to that originally used by the problem owner, which may be compared directly with the issues raised initially in stage S2.

Support can be provided for the process of developing these scripts for comparison through guided exploration of the conceptual model built in Activity A4. Most of the systems and tools we catalogued in class R2 have some limited capabilities in this respect as well, even if only through a graphic or structured display of the model. The problem is that these displays are passive, whereas the necessary scripts are best generated through a dynamic, guided exploration through the conceptual model, describing what is encountered along the path from the starting conditions for the comparison with the relevant scenario originally developed in Activity A2.

Most systems based on decision theoretic modeling display the model in a static form as a tree structure or hierarchy. Our experience, however, is that, even with simple trees, decision makers do not find the display to be a convincing account of the model unless and until they can explore through it. In decision theoretic interactive software, sensitivity analysis is usually employed for this purpose: the user changes a value (e.g., an event probability) at some node in the tree, and the system re-computes values at all the nodes affected by this change, so that the user can see the side effects of the change he made. The problem is that the user has to make for himself the exploration of the model that will generate the script describing the issue linkage underlying the changes evident in the sensitivity analysis.

A further, different type of problem arises as soon as there is any degree of complexity in the conceptual model, whereupon a full display of all its characteristics and parameter values becomes too much for the problem owner to apprehend (Larichev, 1984). One solution which has been adopted with some success in such cases is for the tool, rather than presenting the model, or some part of it, in its entirety, to present instead selected views within which certain aspects of the whole model are displayed in the foreground, and other aspects are displayed only partially in the background, if at all. As each view is on the same model, by moving from view to view the tool user gradually gains a comprehensive, structured impression of the full range of characteristics of the model.

Most of the tools in this class surveyed in Appendix A offer only two to four different views (e.g., decision tree, decomposition of worth on criteria, expected utilities of options). Here, though, we review below two tools catalogued in class R3 (JAVELIN and SAFETI) which are much more powerful in this respect. The problem, however, for integrating these tools within a problem structuring library is that they assume a particular type of well defined structure for the conceptual model a priori. One (JAVELIN) is constrained by spreadsheet structural conventions, the other (SAFETI) provides views on a number of models with different types of structure, but all the models (in the domain of hazardous substance risk analysis) were pre-structured by expert analysts, and are not available for interactive structural modification by the user. Nevertheless, we chose to describe these two tools here on account of their power in visualising and exploring aspects of conceptual models through the use of techniques which could profitably be incorporated into other interactive conceptual model building and display tools.

3.3.1. JAVELIN: A tool employing multiple views to display and explore aspects of a conceptual model.

JAVELIN is restricted to conceptual models built in spreadsheet format, but it generalises this format to include variables, formulae, data, graphs and notes, and links the result as a unified conceptual model of the business situation the user wishes to analyse. As the user builds the model and afterwards, when he wishes to communicate the results of the analysis, JAVELIN can display aspects of the information in the model in any of ten different perspectives, or views. Each view provides a different way to look at and manipulate the same underlying information, and is suited to a particular aspect of business analysis and reporting. However, beyond showing the user information and assumptions underlying the conceptual model in the appropriate view, JAVELIN does not aid the process of script generation through guided exploration within the view.

JAVELIN has ten views: diagram view, formulae view, table view, chart view, quick graph view, worksheet view, notes view, error view, macro view and graph view. Note that all these views are defined formally (according to type of data structure employed) rather than substantively (e.g., according to implementation and management perspectives, as in the case of GOFOR, reviewed in Section 2.2.3). This in itself limits the usefulness of the views in the comparison with scripts or issues raised at stage S2, where differences in problem owners' viewpoints are likely to be defined substantively, rather than formally. However, the idea of providing a number of partial representations, understood as alternative views, on a single, complex conceptual model is an important first step in developing tools which can explore within views in developing scripts.

3.3.2. SAFETI: A tool providing guided exploration through a domain-specific conceptual model.

The only tool with real capability for guiding exploration through a conceptual model reported in the survey underlying the catalogue in Appendix A was SAFETI. This is a comprehensive risk analysis package, but is limited to conceptual models of physical and chemical aspects of process plants. Nevertheless, this domain restriction allows SAFETI to form reports within substantively defined views on a unitary process plant model. Its aim is to facilitate the quick generation, display, evaluation and comparison of policy alternatives and individual scenarios.

SAFETI starts by generating a conceptual model of a plant. Then, plant failure cases are generated within the model, SAFETI's consequence analysis programs can be used to explore the conceptual model, starting from the initial conditions defining a failure case. Each consequence analysis program works by forward chaining within a particular, substantively defined, view. Current view include flammable gas (exploration yield radiation radii for early ignition), dense cloud (dispersion profiles) and toxic effects (risk contours). The results in each view are available for direct graphical display and also as overlays on a physical map (e.g., showing the plant location and details of the surrounding territory). The map displays allow arbitrary zooming by the user to provide the required level of detail and resolution for a given problem.

3.3.3 Capabilities and limitations of current tools for exploring conceptual models.

In the present context, it is important to be able to generate options within scenarios and to explore the conceptual model developing these scenarios, starting from issues of concern raised by problem owners. JAVELIN and SAFETI both have important features with aid this process but neither have sufficiently wide-ranging visualiser-model interfacing capabilities to be able, for example, to display and explore a comprehensive set of substantively defined views on the full range of conceptual models which could be built through the use of the techniques contained within GOFOR (described in Section 3.2.3).

In order to achieve such capabilities in future tools, we should keep the very useful concept of view visualisers in developing display and exploration techniques, but be able to attach visualisers to substantively as well as formally defined views.

Moreover, these substantive views should be able to be selected according to the concerns and experience of the current problem owners. Forward chaining, as employed in SAFETI is a proven technique for script generation (Schank and Abelson, 1977), but backward chaining may also be necessary (see, for example, Embrey and Humphreys, 1985, for a description of a system which generates scripts for scenarios through both forward and backward chaining through conceptual models developed by problem owners).

In the project building IGOFOR, described in Section 3.2.4, we plan to follow this approach in developing script generating methods in the provision of class R3 support, though with more careful emphasis than is usual in expert system work in making sure that the representation language (both verbal and visual) generated by the tool is compatible with the natural language used by the problem owners in any particular situation in expressing their issues of concern.

A major difference between IGOFOR and *all* the tools and techniques reviewed so far in this Section is that IGOFOR provides for the development of a fully theorised conceptual model, providing views on the currently developed conceptual model at the appropriate degree of precision, and in the appropriate language for the user. Hence a separate search tool for forward and backward chaining in exploring a conceptual model is redundant when the model has been built with the aid of IGOFOR. However, the user-oriented script production and visualisation needs remain and so we propose to meet them by adding to IGOFOR facilities for interactive *model representation and exploration (MoRE)* with user-sensitive visualisation and script generation. Hence, IGOFOR will be able to provide both class R2 and class R3 support, as appropriate.

Figure 3, (in Section 3.2.4) indicates the user's visualisation problem at each degree of conceptual model precision. When addressing low precision areas of the conceptual model, the MoRE facilities will rely on narrative scripts, focusing on the relevant issues. When addressing medium precision areas of the Object Organisation Model, narrative scripts will be generated from the relevant inscriptions, together with static visualisations, organising information about objects and relations of interest.

When addressing high precision areas of the Object Organisation Model, facilities for interactive exploration of the dynamic properties of the model, including concurrent side-effects ("seeing what happens if and as..."), will also be provided.

3.4 Support Class R4: Techniques and tools aiding preference structuring

Systems and tools in this category aim to support the user by helping him or her to explore the worth of options or consequences. Here we consider only those tools which aid the user in developing a preference structure (deciding which criteria or rules should be included, given his or her other current goals, and what their relative importance is). Once the preference structure has been developed, it can be used to evaluate options, assess tradeoffs, and examine the sensitivity of preference orderings for alternative options to differing views on the relative importance of criteria.

We identified three subsets of option evaluation tools amongst the tools surveyed in Appendix A. These are: (a) tools based in multi-attribute theory; (b) tools based on heuristic rules concerning tradeoffs to be made between scaled attributes; and (c) rule-based tools employing semi-ordering methods.

a) Tools based on multi-attribute theory

Tools in this subset are efficient at making tradeoffs, but insist that data concerning attributes of options be numerically scaled on criteria. Moreover, the criteria should meet MAUT value-wise independence assumptions, and be scale monotonically with increasing preference. Each of the tools, which are described in the catalogue within this category, provides for least partial checking of these assumptions. The tools are:

EXPECT

HIVIEW

HOPIE (uses value-theory, rather than MAUT to make tradeoffs)

MIDAS and **GROUP-MIDAS**

MAUD

POLICY-PC (this tools uses a mixture of assumptions from MAUT and social judgement theory)

Power's decision aid

PREFCALC

SELSTRA

EXPECT, HIVIEW and SELSTRA provide a hierarchical decomposition of overall worth (i.e., utility) within the preference structure (expressed as a tree) whereas the other tools provide a direct decomposition of overall worth into part-worths on attributes.

In addition, five of the decision analytic systems and tools which we describe as providing support in category R2 also have MAUT-based capabilities for developing a preference structure in order to evaluate the consequences modelled in the act-event-consequence structures built when providing support in category R2. This linking of decision theoretic methods under R2 with MAUT under R4 is facilitated by the fact that contemporary decision theoretic and MAUT axiom systems are compatible (Keeney and Raiffa, 1976; Edwards and Newman, 1982). These tools are:

Arborist

DSS-UP

OPCOM

Stratatree

Supertree

However, the capabilities of these systems in providing support for preference structuring is rather more limited than those of the tools listed previously.

b) Tools based on heuristic rules concerning tradeoffs to be made between scaled attributes

Tools in this category assume that preference structures should be represented by vectors of part-worths of alternatives on scaled attributes. However, here the scaling criteria, and composition rules from part-worths to wholistic preferences for attributes are not classed from the axioms of multi-attribute utility, and value- wise independence assumptions are usually not tested. Instead, capabilities of tools within this subset provide support for preference structuring maybe described in terms of psychological criteria: they support ways people 'naturally' wish to explore and represent intuitive preferences. This is the case with:

Expert Choice (provides hierarchical goal decomposition, based on Saaty's (1980) "Analytical hierarchy process")

FLEXIGRID (uses psychological structure principles from Repertory Grid theory)

HEURISCO (offers a variety of heuristic structuring and evaluation rules)

Alternatively, formal axiom system which are not fully compatible with MAUT may be employed. This is the case with:

Value Analysis (Churchman-Achoff axioms)

VIMDA (Multi-Criteria Decision Making axioms)

c) Rule based tools employing semi-order methods

Systems and tools in this subset are less efficient at making tradeoffs than those based in MAUT (they usually only identify semi- orders among alternatives), but they can accept verbal information about levels of attributes which characterise options, and use more flexible rules than does the linear-additive MAUT model. Tools in this subset which are described in the catalogue are:

ZAPROS

DECMAK

After evaluating the tools in these three subsets, we decided to consider in detail here only those which employed multiattribute or semi-order methods as a basis for choice. We found that none of the heuristic- method based tools offered sufficient advantages in terms of superior "naturalness of use" to outweigh the inherent weakness of the structuring principle employed, where there was no formal basis for testing the coherence of the model structure as it was developed.

From the MAUT-based tools, we selected the three (HIVIEW, MAUD, SELSTRA) which had the best interactive interfaces with the user during structuring/restructuring operations, but which differed in the way they performed the preference decomposition, and in the role of the intended user in the problem handling process (decision analyst, or the problem owner himself). These are described in Section 3.4.1.

The two semi-order based techniques described in Section 3.4.2 (ZAPROS and DECMAK had less good user interfaces than any of selected MAUT- based tools, but are included here on account of their much greater flexibility in creating preference structures which are not predicated on tradeoffs between uniform criteria). In Section 3.4.3., we discuss some possibilities for synthesising the advantages of the MAUT and semi-order based approaches into a single preference structuring tool called ASTRIDA.

3.4.1. Three tools based on multiattribute utility theory.

Tools in this subset are efficient at making tradeoffs, but insist that data concerning attributes of options be numerically scaled on criteria. Moreover, the criteria should meet MAUT value-wise independence assumptions, and be scaled monotonically with increasing preference. Each of the three tools described below provides for least partial checking of these assumptions.

HIVIEW

HIVIEW is a tool which assists the user in evaluating several alternative choice options in the face of many evaluation criteria. It enables the user to arrange a large number of criteria in a hierarchical fashion. For example, in evaluating competing business strategies, the three criteria strategic expense, strategic capital, and annual operating costs could be aggregated into a single higher level criterion called cost. Cost could be aggregated, in turn, with profitability and market share into a single criterion representing the total value of the options.

Creating a hierarchy of evaluation criteria is advantageous because it enables the user to disaggregate highly complex and generic criteria into their measurable components. Expert judgement and existing data are likely to be more effectively incorporated in guiding evaluations of these more concrete criteria. In addition, the clustering of criteria within hierarchies simplifies across-criteria comparisons.

The user systematically judges the relative value of each alternative on each criterion, and then judges the relative contribution of each criterion to the whole. Working through this systematic procedure permits the user to make a small number of relatively simple judgements to determine the relative value of the alternatives. The necessity for the user to make unaided the highly complex, and often unreliable, overall judgements of preference between alternatives is thus avoided.

HIVIEW performs the necessary structuring, elicitation, calculation display and editing as the analysis progresses. Sensitivity analyses and hypothetical changes to the inputs are handled simply and rapidly. The speed and convenience of these operations permit the user to develop a comprehensive model rapidly, refining the assessments and adding detail as the need arises and time permits.

SELSTRA

SELSTRA is a tool designed for direct use by a problem owner who is presumed to have no particular expertise in decision making methods or the use of computer-based decision support. It comprises an interactive system facilitating the structuring and representation of the utility aspects of a set of choice options in a hierarchical format. SELSTRA aids the elicitation of numerical assessments of these options on attributes specified by the client throughout the hierarchy. It then combines this information, providing an overall preference ordering of the choice options. No knowledge of decision theory is assumed, and the system can be used easily by anyone facing a choice that involves several objectives.

SELSTRA uses a "core" hierarchical structure as the starting point of the session, pre-built by a decision analyst, acting as a specialist intermediary who sets the system up for the user. This pre-structured "core" hierarchy acts as a framework directing the problem-owner user to think about various aspects of the options (e.g., it might comprise key social, financial and individual criteria which may be involved in evaluation job options).

MAUD

MAUD is a very flexible, microcomputer-based interactive system for use by people requiring help in deciding on their preferences between alternatives.[9] MAUD relies on MultiAttribute Utility Theory, and, as such, works with interval-scaled (numerical) estimates of alternatives on preference scales. MAUD can be used in a wide variety of personal decision making situations as it converses with the user, using his or her own description of the alternatives he or she is facing. MAUD helps the user identify and explore the criteria that really matter in choosing between alternatives, and has powerful interactive editing facilities, so that alternatives, criteria and preferences can be redefined as the decision maker's view of the problem changes.

MAUD starts by asking the user to name the choice alternatives under consideration. It then proceeds to help him or her elicit aspects relevant in choosing between these alternatives by asking him or her to specify differences and similarities between triads of alternatives. The words elicited in this way are used to represent the poles of an attribute dimension (which may be changed if the user is not satisfied with it) and

[9] For more details of MAUD, see (i) Humphreys, P.C. and Wisudha, A., 1979. MAUD4. Technical report 79-2/2. London: Decision Analysis Unit. London School of Economics and Political Science; (ii) Humphreys, P.C. and McFadden, W., 1980. Experiences with MAUD: Aiding decision structuring versus bootstrapping the decision maker. *Acta Psychologica, 45*, 51-69;

the user is asked to rate all alternatives on a scale between these poles and specify the ideal (most preferred) point on the scale for each attribute dimension elicited. If the user has successfully generated two attribute dimensions which are significant to him or her for choosing between the alternatives, MAUD allows the user to specify poles of dimensions directly (rather than through considering similarities and differences between triads of alternatives).

MAUD monitors the I-scaled estimates on the attribute dimensions entered by the user, checking each set as soon as it is elicited with the sets of I-scaled estimates on all other attribute dimensions currently in the preference structure so that it can ensure that conditional utility independence is maintained between these sets of estimates. In the case of a violation of utility independence, restructuring is accomplished in interaction with MAUD through the deletion of the offending attribute dimensions and their replacement with a dimension more appropriately expressing their shared meaning.

When the user thinks that he or she has specified a sufficient number of attribute dimensions representing all the important aspects of his or her problem and MAUD is satisfied with the coherence of the structure and its contents, MAUD then investigates value-wise importance weights and relative scaling factors for all attribute dimensions in the preference structure. These quantities have to be determined for MAUD to be able to apply a MAUT-prescribed additive composition rule.

MAUD has been found very useful in helping decision makers structure their decision problems in a way that a better understanding of the problem is reached by the end of the session even if the proposed best alternative (according to the criteria provided by the user) does not fully satisfy the decision maker. MAUD's main limitations are (i) that it is necessary to scale numerically all alternatives on all attributes, and (ii) then, an interval-scaled compensation method must be used in determining tradeoffs between attributes. When more than small numbers of attributes and alternatives are involved, this can involve a lot of hard work and difficult assessments for the decision-maker. In such cases, a more sophisticated system might be able to achieve part of the solution by employing dominance relations and semi-ordering techniques, with much less cognitive effort required from the decision maker. Note also that MAUD obtains estimates of alternatives on attributes by asking the decision maker to move a cursor on a continuous scale where only the poles are described in verbal terms. Often the decision maker would prefer to indicate the level on an attribute at which an alternative is estimated in verbal terms, rather than by positioning a cursor on a scale.

3.4.2. Two tools based on semi-ordering principles.

Tools based on semi-ordering principles are less efficient at making tradeoffs than those based in MAUT (they usually only identify semi- orders among alternatives), but they can accept verbal information about levels of attributes which characterise options, and use more flexible rules than does the linear-additive MAUT model. The two tools of this type that we selected (ZAPROS and DECMAK) are described below.

ZAPROS

ZAPROS makes use of a strategic-level decision maker's verbal preferences to fix his or her policy for assessment of complex alternatives (e.g., project proposals) before the alternatives are actually assessed. This is particularly useful in cases where diverse managers within the organisation are subsequently responsible for describing the alternatives to be assessed (e.g. in the context of different projects), but sets of alternatives must subsequently be assessed in a stable way so that comparisons may be made between them, and so that organisational policies may be consistently implemented in the management of individual projects.

In the problem structuring phase, ZAPROS works together with the strategic level decision maker in eliciting his or her preference structure, using his or her own language. The criteria the decision maker wishes to use are elicited in terms of verbal statements making up ordinal scales of grades of quality (verbally expressed) on each of several criteria (for example, statements about a criterion expressing the availability of research backup, within project which might vary from "a major part of the research is already completed, the rest poses no problem" to "the project depends on the solution of a number of different problems: there are no ideas concerning their solution").

Typically, about seven criteria are elicited with about five grades of quality on each criterion, but the actual numbers are at the discretion of the decision maker. Order relations within this preference structure are established by ZAPROS through presenting comparisons to the decision maker between hypothetical projects described in terms of his own descriptions of various grades of quality on the different criteria.

ZAPROS checks inconsistencies and uses the dominance relations it detects in the ordered preference structure to optimise the sequence of the comparisons if presents to the decision maker as the problems structuring session progresses. This makes the session much shorter and more interesting to the decision maker than would be the case when using conventional paired-comparison methodology.

Once the preference structure has been elicited and interactively confirmed between ZAPROS and the decision maker, it is ready for use. Alternatives are subsequently assessed as required in terms of their judged verbal quality grades on the decision maker's criteria. Unlike most multi-criteria assessment methods, ZAPROS does not make tradeoffs directly between the assessed alternatives. Instead, it uses semi-order techniques, exploring the decision maker's previously expressed preferences for each pattern of grades of quality characterising an alternative (e.g., the proposal currently being assessed), relative to that of each other alternative currently under consideration. The result is a partial ordering of alternatives, showing how some alternatives or groups of alternatives can definitely be preferred to (i.e., dominate) others, but also identifying sub-groups of alternatives within which a definite choice of preferred alternatives can only be made after further comparative investigation of their relative merits. This information, when fed back to the manager, or higher level decision maker, allows him to make a final choice after selectively reviewing only those alternatives between which the choice is controversial in terms of the organisation's policy.

DECMAK

DECMAK is a tool that, like MAUD, is intended to provide direct interactive assistance to a decision maker facing a multiattribute decision problem. Unlike MAUD, it is not based on multiattribute utility theory (MAUT). The decision maker is encouraged to learn and explore his or her "decision space" by defining relevant attributes, and the words that describe levels on that attribute, thus representing knowledge on attributes in a similar way to that employed in ZAPROS.

However, instead of using mathematics based upon formal axioms to establish tradeoffs between attributes (the central process within MAUT) or to establish dominance relations between alternatives (as in ZAPROS), the tool elicits the user's own "decision knowledge." This knowledge is expressed as rules in the user's own language (e.g., "if the price is high and the quality is low, then the option is not acceptable"). Exploration of the decision space is facilitated by a programme that checks the consistency of the option generation process and a programme that generates reports, the latter offering a choice between a full inference trace or a short executive summary.

DECMAK can be used in two modes. The first follows conventional expert systems practice, whereby the knowledge (decision rule) elicitation process is used to define an agreed knowledge base for subsequent use within a particular domain by practical decision makers. Here, as in ZAPROS, the knowledge base represents a policy that must be applied in the decision making process. (As an example, DECMAK has been employed in this mode at various management levels in the selection of trading partners. However, only the highest level managers were authorised to modify the knowledge base).

Alternatively, when DECMAK is used in the second mode, the decision maker himself can develop the structure of the problem, expressed as a set of *decision rules*. In this case, the decision maker constructs the knowledge base from scratch in interaction with DECMAK, according to the way he or she perceives the characteristics of the decision problem currently being handled. This process continues (with checking and reporting support from DECMAK) until the decision maker "feels committed to a decision."

DECMAK is less powerful in the mathematical sense than the other technical tools described here: it merely finds "solutions" to decision problems. However, DECMAK deserves special consideration on account of its total commitment to the natural language and reasoning modes of the decision maker, and for its emphasis on aiding decision making through exploration rather than prescription. In this regard, many implementations of methods that are more powerful in formal terms may have much to learn from DECMAK in terms of how to aid and be accepted by practical decision makers facing initially unstructured problems.

3.4.3 Optimal combination of multiattribute and semiordering principles in tool design.

Most of the tools we surveyed for the catalogue in Technical Report 87-1 which provided class R4 support adopted a multicriteria approach in developing a preference structure. Amongst these tools were those which had the best interactive user interfaces. Yet we are also faced with the problem that multicriteria-based decision support aids have generally not found favour in professional use by senior decision makers in organizations. The reasons which, in our experience, such users typically give for rejecting the support offered by a tool of this type are the following:

- A multi-criteria frame does not match the way the decision maker wants to think about the problem.
- The tool tries to lock the decision maker into using particular predefined criteria which are not those that he or she wishes to control the choice.
- The tool insists on numerical, scaled estimates where the decision maker wants to use verbal assessments which can be compared but not individually scaled.
- The tool insists that the decision maker performs artificial tradeoffs between criteria, while the decision maker wants to compare alternative in terms of their profiles over a number of relevant criteria.
- The tool is prescriptive rather than advisory; it states what should be the 'best' alternative, given the decision maker's assessments, rather than giving the decision maker useful information about the key advantages and disadvantages of particular alternatives versus other ones. Moreover, when such information is provided, it is often expressed in language which the decision maker considers artificial, rather in the language he or she would naturally use in comparing alternatives and reaching a decision.

Our evaluation of the tools included in class R4 in the catalogue in Technical Report 87-1 indicated that many of the current tools still failed to provide comprehensive support for several of the above reasons. Even the tools selected for discussion in Section 3.4.1 were not entirely immune. While not falling into the trap of being over-prescriptive, and having excellent capabilities for picking up the users' own language and criteria that they would actually like to use, they were still locked into a multi-criteria frame, with the attendant problems of insistence on numerical estimates and tradeoffs between criteria.

The tools we selected for discussion in Section 3.4.2. were much less restrictive on scaling (using verbal, not numerical, scaling levels). They could develop and explore complex preference structures. However, they were very weak at making tradeoffs between competing options which were preferred in different ways. Rather than be prescriptive, they went to the other extreme, and just displayed the basis for the confusion in choice between these competing alternatives in the absence of explicit tradeoffs.

We consider that there remains a need to develop a preference structuring and option evaluation tool which would synthesize the best aspects of the tools we described in Sections 3.4.1 and 3.4.2. In our opinion, in order to provide comprehensive class R4 support, this should combine rule based techniques for developing preferences, eliminating dominated options, etc., together with MAUT based methods which are brought into play only when it is really necessary when making tradeoffs between competing options which are preferred in different ways elucidated by the rule based techniques.

Thus, on a separate project, we have now commenced developing a class R4 support tool called ASTRIDA (Berkeley et al., 1989b) which provides a comprehensive problem definition and problem structuring environment in support of strategic decision making.

ASTRIDA's basic mode of operation is based on the premise that the decision maker possesses, in principle, the knowledge both about the problem he is facing and about the way he would like to handle it. The system is used for the purpose of

(a) organising and developing the decision maker's thoughts about the problem and the best alternatives to choose between, and,

(b) suggesting to the user how the "best" alternative may be developed in practice (rather than merely be selected).

The system comprises two fundamental interlocking functions: (1) problem structuring, and, (2) developing the choice of the best alternative. Thoroughly developed interactive dialogue facilitates problem structuring on the basis of the decision maker's preferences, elaborating on criteria and preliminary options. An innovative aspect of the system is that the whole interaction with the user is predicated on the use of his own natural language (i.e., in describing his problem, creating and developing alternatives and criteria and estimating alternatives on these criteria).

A special procedure for the choice of the best alternative is developed which is based on pair-wise comparisons of multicriteria alternatives. Throughout the process of comparison, the decision maker is presented with the possibility of developing the description of alternatives (e.g., via decomposing and/or aggregating criteria, introducing additional information, etc.) and also of generating new alternatives on the basis of an analysis of the problems experienced while considering the current alternatives.

ASTRIDA is designed to be capable of supporting individual, group and organisational decision making at a strategic level where the best courses of action (alternatives) are usually not among those initially considered but are best synthesised while the complexity of the real basis for preference between them is being developed. Furthermore, at this level the alternatives themselves are likely to be characterised verbally, rather than in a numerically scaled way, on criteria that may be hard to compare.

In facilitating the necessary comparisons in this respect, ASTRIDA builds on and provides an enhancement of the capabilities of MAUD (described in Section 3.4.1) and ZAPROS (described in Section 3.4.2). Hence ASTRIDA draws a great deal from the extensive field studies of both these systems carried out in various countries on various projects during the past eight years in providing a decision support environment which allows the implementation of psychologically valid methods of information elicitation and problem structuring.

4. EVALUATION OF CAPABILITIES OF CURRENT TECHNIQUES AND TOOLS, AND GUIDELINES FOR FUTURE SYSTEM DEVELOPMENT.

In summary of our evaluation of the tools described in the four support classes in Chapter 3, we found that these selected tools all possess excellent local functionality: that is, they are all good at what they profess to do when used to provide practical, but restricted, support on their own. However, the global functionality of a decision problem structuring library, built simply through collecting the tools we have identified and mounting them so they could be accessed as required on a microcomputer, or from a terminal, would still leave much to be desired.

This is because the set of support goals identified for classes R1 through R4, taken as a whole, is much more difficult to achieve simply through aggregating tools bottom-up into a comprehensive tool set to comprise the library. Even when choosing the members of this set very carefully, as we did in the research which led to this report one always ends up with interfacing and functional coverage problems.

It is not easy to transfer information between tools because object and parameter conceptualisations are not consistent across tools (it is not just a matter of incompatible data formats). Also, the provided support functions overlap between the tools (which offers redundancy, which in itself is not necessarily a bad thing) and, more seriously, leave gaps in functionality between the tools which are not easy to solve through constructing "bolt-on" software, or through decision analyst intervention in practical applications.

Hence, we conclude in this chapter with some guidelines for future development of systems which could provide comprehensive decision support. These guidelines are derived by considering first of all the levels of knowledge representation which are required in handling *all* aspects of decision making, and then considering how the process of problem handling may be divided at *all* these levels between the decision maker and any computer-based system which might aim to provide truly comprehensive decision support.

4.1 Levels of knowledge representation involved in handling decision problems

Given an initially unstructured problem, a decision maker faces the task of having to resolve uncertainty about how to go about developing a prescription for action. The desire to take some action is generated from an awareness of a lack - or a gap - between and actual state of affairs and a preferred state (Lacan, 1977). In practice, the decision maker starts out with complete discretion in how he or she translates desires into action; until constraints are placed on the way the problem is structured, all imaginable courses of action are possible, and could form part of the knowledge representation of the problem. However, the decision maker, in order to act, must first strengthen the constraints to such an extent that only one course of action is prescribed: the one which is actually embarked upon. Thus, the effect of progressively strengthening constraints, and thus structuring the decision problem in a *particular* way, is to progressively restrain the decision maker's discretion to structure the problem in alternative ways.

Five different levels of constraint-setting may be identified, each requiring a qualitatively different type of knowledge representation concerning how to structure the constraints at that level. The nature of this five level scheme has been discussed in detail elsewhere (Humphreys and Berkeley, 1983, 1985; Humphreys, 1984), and so only its key characteristics will be reviewed here.

The three major formal principles on which the scheme, taken as a whole, is based are as follows:

1. What is qualitatively different at each level are the *cognitive operations carried out by the decision maker in developing the problem representation* , rather that the formal or substantive content of the representation thus developed (this postulate is also fundamental within Piaget's, 1978, conception of intelligence).

2. The results of the operations carried out on a particular level constrain the ways operations are carried out at all lower levels.

3. Any decision problem is represented 'in the world' at all levels. Therefore, we cannot treat levels like a taxonomy, classifying decision problems as 'level 1 problems', 'level 2 problems', etc. We have to examine how each problem is handled at each level in turn. It follows from property (2) that this examination should be carried out from the top level working downwards.

The five levels of knowledge representation which are outlined below are fundamentally a cultural phenomenon, and a human rather than a mathematical or logical necessity. In theory, it would be possible to translate the desire to solve a decision problem into an action designed to solve it in a single step, but most organizational decision making situations would then demand the generation of a single level knowledge representation which was too complex for decision makers to apprehend in developing or justifying the course of action decided upon. (Larichev, 1984; Larichev and Moskovich, 1985). This, in turn, could have serious practical consequences. Attempts to over-complex representations in determining action may lead to 'bounded rationality' (Simon, 1972) where the decision maker is able to police coherence of his or her operations within *only* part of the total structure. Alternatively, the decision maker may be put into the position of having to use structure-simplifying heuristics (Svenson, 1979) which may yield suboptimal results, due to their inability to utilize fully the full range of diagnostic information available within the representation.

However, to assume that research on people's limited ability to process complex representations of declarative information simply points to 'a blemished portrait of human capabilities' (Kahneman, Slovic and Tversky, 1982) is to ignore the opportunities for knowledge 'chunking' (Miller, 1956) offered through a multi-level framework such as described here (Anderson and Bower, 1974; Fahlman, 1979). At a lower level one can develop structures (and check the coherence) for handling parts of the problem within a number of different frames, each simple enough to be apprehended without recourse to simplifying strategies. Each of these structured frames can then form a semantic primitive in its entirety (i.e., a single node or reference point) within the structure developed for handling the problem in a wider sense at the next higher level. In this manner, knowledge is used to reduce information load.

The knowledge with which we are concerned here is about the operations which can be used at each particular level to direct the structure development process in the service of the desire to find a course of action which may solve or at least alleviate the problem rather than about 'facts' to be represented or rules describing relations between those facts. It is important to remember that the procedural knowledge required in knowing how to develop structure at each level is quite separate from the declarative knowledge represented within the structure which is so developed (i.e., the "model of the problem"). The structure of the declarative knowledge will be specific to the decision problem which it uniquely characterizes while the procedural knowledge about how to go about developing the model is generic.

Level 5

At level 5, aspects of the decision problem are expressed rather than structured through exploration carried out within the small world which defines for the decision maker the bounds of the material which he or she is prepared to retrieve in the development of the structure of the decision problem. The direction of exploration within this small world is motivated by the decision maker's desire to search for the existence of possible consequences which express aspects of the situation which he or she currently experiences as lacking, while seeking to avoid those which may yield only anxiety or regret (Sjoberg, 1980; Toda, 1980).

The results of what is encountered in this search form the material basis for the content manipulated in problem structuring at lower levels. These results can be described in the decision maker's own language in the same way one uses language to describe associations in a dream (Lacan, 1977). But the cognitive operations at level 5 are in themselves beyond the language or the person carrying them out (Jameson, 1972), and so, studying or aiding decision makers' activities at level 5 requires the use of internal exploratory techniques rather than external formalizing techniques. A major problem for the design of systems able to provide support at this level is that, as in dream interpretation, what needs to be addressed at this level is what is left out of the decision maker's language - the gaps and 'resistances' to exploration (Mannoni, 1972).

Level 4

Small world boundary setting at level 5 effectively sets the constraints within which a decision maker operates at level 4. These operations involve the use of a problem structuring language in selecting and linking the variants of judgemental structures or frames that will need to be used in handling the problem. The simplest problem structuring language is that which simply allows one to select a single predefined frame within which problem structuring can be carried out.

Berkeley and Humphreys (1982, see also Humphreys and Berkeley, 1985) describe how decision theory in its current state of development provides a technology for displaying structure within four different types of frames, each employing a restricted calculus for developing structure to represent the type of uncertainty which may have to be faced in handling a particular decision problem. However, these four frames are distinguished within decision theory in analytic terms but there is no formal requirement within the multi-level knowledge representation scheme that this has to be the case.

Von Winterfeldt (1980) suggests that, in handling real problems, decision analysts prefer to distinguish frames according to their substantive, rather than analytical, features (e.g., 'resource allocation frame', 'standard setting frame'), although they are usually quite clear about the analytic features of the restricted calculus they intend to use to represent structure within a frame. Similarly, Beach, Christensen-Szalanski and Barnes (1984) describe how intuitive decision makers (students) faced with a set of ten decision making tasks commonly used in psychological experiments always chose to classify them into frames based on substantive features (e.g., 'problems about people', 'maths problems', and so on).

It is important to remember that there is no definition of 'right' or 'wrong' frame for handling a particular problem within the multi-level scheme. Operating at level 4, a decision maker is able to exercise discretion on the selection and utilization of frames through the use of problem structuring language. Idiosyncratic choice of frames can yield successful results provided that structure can be developed in an appropriate way to handle the aspect of the problem delegated for consideration within each frame selected. It is no use deciding that part of the problem should be handled within a 'resource allocation' frame if one is unable to develop the structure of a resource allocation model.

Problem structuring language for more complex problems usually involves more than just matching a problem to a single frame. It serves as a generative problem structuring calculus linking together a number of different structural variants in forming a 'requisite model' (Rowbottom 1977; Phillips, 1984) for forming the judgements involved in handling the problem comprehensively. The decision maker's own language is a natural candidate for this task, but some fundamental problems often arise when it is used to attempt to construct a knowledge representation for problem solving.

The fundamental structural units within natural language employed in this way are propositions (Anderson, 1976). If propositions are viewed simply as syntactically organized sets of words (i.e., phrases) then we are left with the problem of how to 'fix the meaning' of these words in a denotational sense. Structural representation based on selection and linking words with clear denotational referents in terms of acts and events in the world of implementation of the problem solution involve the development of highly complex patterns of linkages with all the attendant difficulties of attempting to police coherence and incomprehensibility of the result (Staats and Staats, 1963).

The alternative strategy of keeping the structural linkage simple by using language to construct what are in effect 'cognitive maps' (e.g., Axelrod, 1976; Eden, Jones and Sims, 1980) often requires the use of words or phrases with complex signification (e.g., 'Foreign trade outlook', 'active labour market policy' - see Sevon,

1984) as semantic primitives. Direct 'fixing' of denotational meaning is very difficult in these cases which is why cognitive maps have rarely been found to provide an *effective guide to action.*

An alternative is to treat the semantic primitives used in level 4 knowledge representation as frames, each of whose denotational meaning can be developed and explored separately through operations developing structure within the frame. In this way, operations at level 4 serve to set the agenda for problem structuring in a way that can *transform* desire into action, but the problem structuring process is completed piecemeal (within each frame selected) at level 3. Within a frame, only part of the problem is processed, allowing the use of a restricted calculus, which can be optimized for handling the type of content to which the frame is addressed.

Level 3

Operations represented at level 3 are concerned exclusively with developing structure within a particular frame identified as a node within whatever knowledge representation was developed (or selected on the basis of 'received wisdom') at level 4. For example, suppose for the sake of argument, we decide to select frames from within the taxonomy provided by decision theoretic technology. If the frame selected has the function at level 4 of providing an evaluation of (multiattributed) consequences, then, within this frame, development of structure implies eliciting and defining the set of attributes to be included in a multi-attribute utility structure (Edwards and Newman, 1982; Humphreys and McFadden, 1980).

If, on the other hand, the frame selected at level 4 has the function of providing an assessment of the likelihood of an event, which is dependent on other events, then, within this frame, development of structure implies eliciting and defining the set of conditioning events and relations between them within an influence diagram (Howard and Matheson, 1980; Phillips, Humphreys and Embrey, 1983).

Level 2

The result of the operations carried out at level 3 is a knowledge representation whose structure is now conditionally fixed: all the syntax is in place, and the remaining two lower levels involve the operations which Carnap (1939) described as "interpreting a calculus" through "assigning conditions of use to its logical signs and referents to its descriptive signs". At level 2, there is no longer any discretion over, say, which attributes are to be considered in a multi-attribute utility structure, but sensitivity analysis may be used to explore 'what-if' questions about the impact of changing values at nodes or reference points within the structure developed at level 3. An example would be changing the probability of an event in an act-event sequence to see what effects are propagated throughout the decision tree structure in which that sequence is embedded.

Hence, at level 2, the content manipulated within the structure is not 'facts' (where the decision maker is not expected to exercise discretion over their true value) but hypotheses (opinions, views, etc.). At this level, it is explicitly recognized, for example, that probabilities can vary according to views on future states of the world and that utilities vary in reflecting the range of specific participants' interest and preferences in group decision making.

The advantage of exploring the dynamic properties of a knowledge representation at level 2 is that the resulting sensitivity analysis may indicate areas within the structure where change of values makes very little impact on a node of crucial interest (e.g., that defining a choice between immediate courses of action). In cases where the choice may be difficult or controversial, discovery of such insensitivity can be very useful, as it indicates that it does not matter how the decision maker's discretion is exercised, and thus one can dispense with difficulties or expenses that would be encountered in attempting to arrive at a theoretically optimal assessment.

Level 1

Operations at level 1 are exclusively concerned with assigning referents to the descriptive signs (Carnap, 1939). The only degree of discretion left for the decision maker is to decide on how to make a 'best assessment' of the value to be assigned to each node in the knowledge representation whose structure has now been completely fixed through the operations carried out at the higher levels.

4.2 Division of labour between decision maker and support system

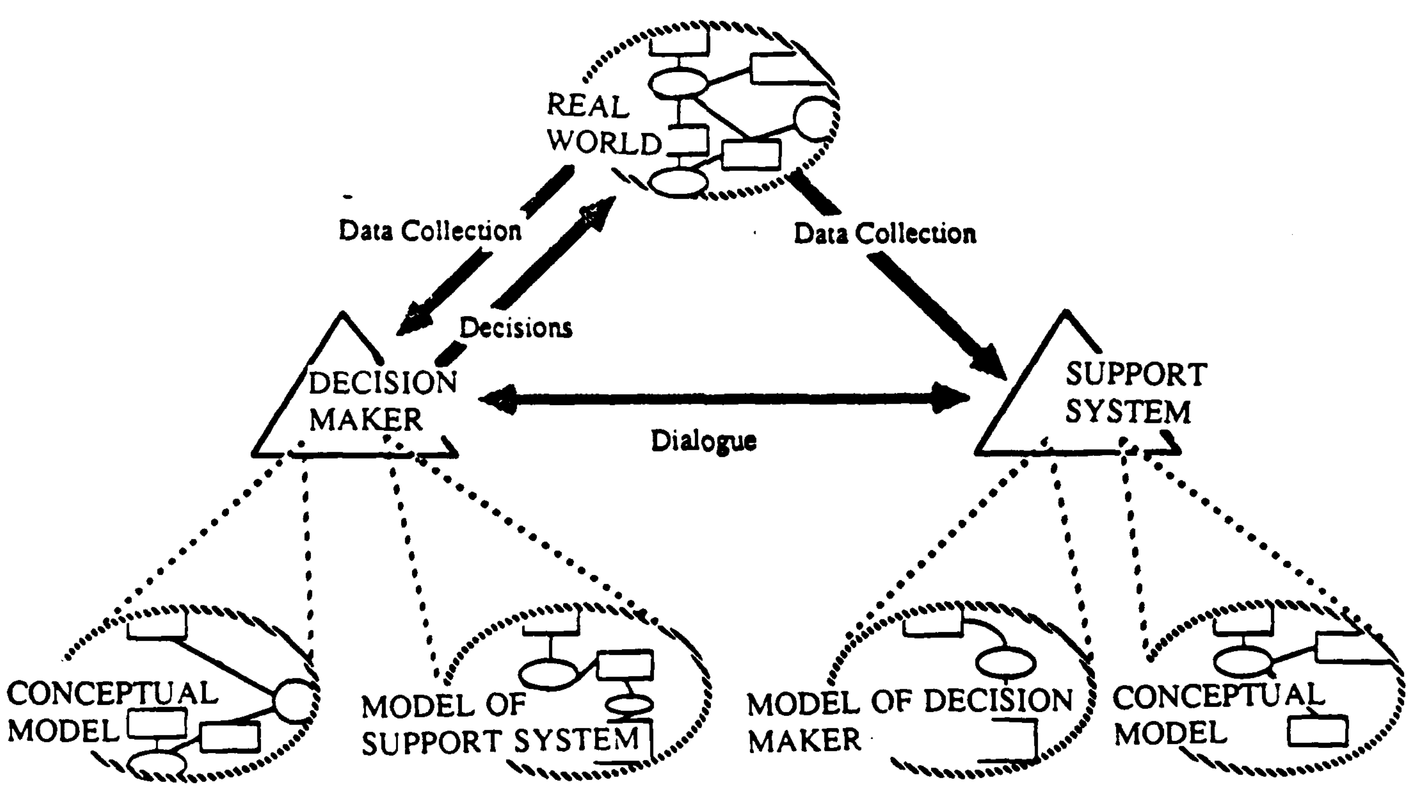
In Section 4.1 we implicitly assumed that the responsibility for developing a decision problem representation was assigned to a single, human entity, the decision maker. In this section, we consider the additional issues which need to be taken into account and the way in which the exercise of these responsibilities may be enhanced, when they are assigned to a hybrid entity: a decision maker working with the support of an integrated decision support system.

We consider the way in which the work of decision problem formulation and representation can be shared between the decision maker and a comprehensive decision support system. We assume that both the decision maker and the support system can store relevant information in their own memories, but only the decision maker acts directly in the real world in implementing his decisions. We further assume that the support system operates in a fully interactive mode with the decision maker, so there is a direct dialogue between them when they are jointly performing problem structuring activities. Also, since the support system will only be able to store certain types of information about certain aspects of the problem, it is very important that the decision maker knows what these are so that the responsibilities for what has to be remembered about the problem representation can be divided efficiently between the decision maker and the support system.

In this respect, an ***intelligent*** support system can help through providing information about the scope of what it "knows" and about how it may be able to work with the decision maker in organising this information. It may also be able to prompt the decision maker at appropriate points in the dialogue to think about what he probably "knows" concerning some aspect of problem handling which is beyond the scope of the support system itself (Berkeley et al., 1987).

Figure 4 (adapted from Berkeley et al., 1987) illustrates the general situation where a decision support system works with a decision maker. This complex situation involves the decision maker's models of both the problem and the support system, together with the support system's models of its user (the decision maker) and its working domain (the represented problem) It is important for successful division of work between decision maker support system that their models of the problem being handled, while not identical, be consistent and include the same notions in order to allow a meaningful dialogue. Moreover, in this dialogue, the support system should be responsive to the decision maker's needs for support in different situations - it must make the correct interpretation of what the decision maker wants to obtain (through its user model) *and* provide suitable feedback to the decision maker, assuring him or her that his or her *own* model of the support system is correct.

Figure 4: Division of labour between decision maker and decision support system.



4.3. Balancing the dialogue between decision maker and support system at five levels

To get the full picture of the assistance offered by a decision support system, the dialogue and in particular the content of the initiative in the dialogue must also be taken into account. At one extreme, the decision maker has the complete initiative, in which case the support system in principle serves as a repository of data providing structured access to decision problem related information upon explicit request from the decision maker. In a mixed dialogue, the support system also offers procedural assistance: requests from the decision maker trigger more complex operations in which the support system temporarily takes over the initiative. A completely balanced system involves a division of the initiative between decision maker and decision support system, the support system being responsive to requests from the decision maker and at the same time offering spontaneous guidance to him or her.

As was shown in Section 4.1, the decision maker's modes of thinking in handling the decision problem will need to vary between being quite concrete and closed (e.g., making best assessments at level 1) to very abstract and open (e.g., negotiating the boundaries of the decision problem for which he or she has agency at level 5).

It is inappropriate for a decision support system to operate in a concrete and closed way in a dialogue with a decision maker working at a level requiring abstract and open thinking, and vice versa. Hence, we describe below an appropriate matching of support system capabilities and the decision maker's typical problem handling activities at each of the five levels described in Section 4.1., arranged in order from the most concrete (level 1) to the most abstract (level 5).

At level 1, in *making best assessments*, it is important that the decision maker understands the capabilities (and limitations) of the support system in providing or checking assessments through its data tracking functions. These will involve support system capabilities for acquiring and storing the relevant data. The system should be able to report the appropriate set of data in response to a manager's command, formatted in a way that the manager can understand. In supporting the making of best assessments, the system needs to provide information about what *is*, rather than about what *could be*, as the focus is on the relation between a fixed problem representation and the immediate reality of the presenting problem.

At level 2, exploring what "could be" involves ***simulation***, i.e., the ability to explore "what if" situations within the conceptual model, whose structure is treated as fixed. Fixed structure is necessary for the support system to be able to perform a *sensitivity analysis*, indicating the other points in the conceptual model where changes occur or problems arise (and to what extent they do so) as a result of a specific course of action considered by the decision maker. Successive changes of values by the decision maker, with the support of feedback and guidance from the associated sensitivity analyses, can provide for effective exploration of possibilities under consideration.

Knowing which courses of action to consider as decision alternatives depends upon the ***diagnosis*** of the problem to be investigated within the simulation. The responsibility for such diagnosis remains with the decision maker rather than the support system, as it is the decision maker's responsibility to formulate the courses of action which constitute the decision alternatives.

At level 3, effective *coordination* of all the elements within the problem representation is a major goal of the project manager in building and maintaining the conceptual model Within a balanced dialogue, in response to the decision maker's commands, the support system should be able to build the structure of this representation Through *policing the coherence of the structure* as it is built, the system can advise on gaps, and inconsistencies, and warn when a proposed reorganisation of one part of the structure may require much subsequent re-structuring to restore overall coherence.

At level 4, when *reorganising* the problem representation, alternative ways of structuring (framing) the problem may usefully be compared. The support system can help here by *advising on implications* of particular ways of framing the problem. This facilitates the comparative evaluation of alternative ways of framing the problem. and also indicates where the decision maker might best direct his efforts in developing the most appropriate way of representing the problem.

Where reorganisation has potential repercussions beyond the boundaries of the decision situation where the decision maker has agency over the activities represented in the conceptual model, then problem formulation and conceptual model development is likely to involve the decision maker **negotiating** with other stakeholders in the decision problem's real world environment. Effective support from the system for these negotiating activities is likely to be *active* in mode rather than responsive: that is, advising on *possibilities*. However, such advice should be offered as provisional in the support system's dialogue with the decision maker, as the support system, like the decision maker, is likely only to have partially structured information about the wider environment in which the presenting decision problem is really located.

In summary, effective divisions of labour between the decision maker and a system which can provide truly comprehensive decision support requires that, in practice,

(i) the decision maker and the support system trace the same project over the full range of their interactions,

(ii) the responsibilities for developing, storing and retrieving information within the conceptual model are properly divided between the decision maker and the decision support system, and,

(iii) in developing and using a problem representation for decision making purposes, the dialogue is appropriately balanced between the decision maker and the support system. In turn, this implies that the decision maker's model of the support system and the support system's model of the decision maker be linked appropriately for activities carried out at each of the [illegible] levels of decision problem handling, from the most concrete (e.g., assessing, tracking) to the most abstract (e.g., negotiating, advising on possibilities).

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APPENDIX A: A catalogue of methods and tools for structuring and analysing decision problems

The following descriptions of the 58 tools discussed in Chapter 3 of this report are organised alphabetically by tool name, and are given in a standard format. The types of information available for each tool are sequentially numbered (1 to 24). Cross-referencing between tools can thus be done by comparing information of the same sequential number. Missing numbers denote that no information was entered for that Section. A copy of the questionnaire used in the survey can be seen in Appendix B.

Each description provides information about the manufacturer or author of the tool, its availability, its capabilities, the types of decision making it is designed to support and the types of intended users of the tool. Information is also provided about any back-up available to facilitate learning to use the tool, about the types of computer systems on which the tool may be run and about any reference publications or case studies concerning the particular tool which are available.

List of Tools:

Questionnaire no:

1 ACIDRAIN (version 2.0)
2 ARBORIST
3 Automatic Diagnosis
4 BUDGET PRIORITY SYSTEM (BPS)
5 CEIS (Chief Executive's Info. System)
6 Combined Arbitration
7 CYBERFILTER
8 DECMAK
9 DESIMP (Discrete Event Sim. w/ Pascal)
10 DSS-UP
11 Decision tree analysis of litigation
12 Demand/Supply Planning Support System
13 EIRES
14 EQUITY
15 ESSI (Exp. Sys. for Strat. Sel in ISD)
16 EXPECT
17 Expert Choice
18 FACILITATOR
19 FLEXIGRID
20 Group MIDAS (provisional name)
21 HEURISCO
22 HIVIEW
23 HOPIE
24 IDEAL/PET
25 Information Planner
26 IRIMS (Ispra Risk Management Support)
27 JAVELIN
28 Jobber Business Simulation
29 Knowledge Craft (TM)
30 LOGSIM
31 LSM
32 MAUD
33 MICROLAY
34 MIDAS
35 NORMA (prototype)
36 OPCOM
37 ORDO
38 P/G% (Part/Whole Percentaging)
39 PERSONAL CONSULTANT
49 PLEXPLAN
41 POLICY PC
42 POWER's Decision Aid
43 PREFCALC
44 PRIORITIES
45 PROLOGA (Procedural Logic Analyzer)
46 QSB (Quantitative Systems for Business)
47 SAFETI Package
48 SELSTRA
49 Stratatree
50 STRATMESH
51 SUPERTREE
52 Strategic Intervention Planning
53 SYSTEM W
54 VIG
55 VIMDA
56 Value Analysis
57 WORK PRIORITY SYSTEM (PDS)
58 ZAPROS

1] Title of tool: **ACIDRAIN** (version 2.0)

2] Manufacturer or name of Author: Cambridge Decision Analysts

3] Address: Management Studies Group
University Engineering Dept.
Mill Lane
Cambridge

4] Contact person: Dr C.W. Hope

5] The tool is available from: Manufacturer, subject to approval of
Mr A. Sinfield, Department of the Environment.

6] The general application area of the tool is:
Analysis of acid rain damage reduction strategies.

7] The tool has the capability to help structure the decision problem by:
- providing pre-defined attributes

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- probabilities of uncertain events
- weights on attributes

9] The tool has the capability to combine assessments of different types, viz:
Probabilistic MAUT.

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
"RETRIEVE" pre-stored sets of probabilities/weights,
"ENTER" probabilities and weights from scratch.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie: MAUT.

14] The tool is designed to support:
- personal decision making
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

1] Title or Name of tool: ARBORIST

2] Manufacturer or name of Author: Texas Instrument

3] Address: Corporate Office
PO Box 225474
MS 8203
Dallas, TX 75265
USA

5] The tool is available from: Manufacturer, national distributor.

6] The general application area of the tool is:
Decision trees and risky choice. Version 2 has LOTUS 1-2-3 interface.

7] The tool has the capability to help structure the decision problem by:
- generating options
- generating and linking exogenous events or conditions
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- probabilities of uncertain events
- computational formulae for entering values

9] The tool has the capability to combine assessments of different types, viz:
Rollback analysis in decision tree.

10] The tool helps the user to:
- choose a single best option/alternative
- order options/alternatives on a preference criterion

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Sensitivity analysis for both probabilities and values.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Expected value calculations.

1] Title or Name of tool: **Automatic Diagnosis**

2] Manufacturer or name of Author: Jose M. Bernardo, et al.

3] Address: Dept. Bioestaoistica
Fac. Medicina
Ave Blasco Ibanez 17
46010 Valencia
Spain

5] The tool is available from: Author.

6] The general application area of the tool is:
Automatic probabilistic classification in medicine, biology, sociology, psychology, etc.

7] The tool has the capability to help structure the decision problem by:
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events
- providing a normative solution to a well-defined problem

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- probabilities of uncertain events

9] The tool has the capability to combine assessments of different types, viz:
Rollback analysis in a decision tree combining utilities and probabilities.

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Sensitivity analysis to variations in all departments.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Bayesian Decision Theory.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Automatic classification.

1] Title or Name of tool: **BUDGET PRIORITY SYSTEM (BPS)**

2] Manufacturer or name of Author: Work Sciences

3] Address: 26 Southwood Lawn Road
Highgate
London N6 5SF
England

4] Contact person: Tina Bamford, User Manager, Work Sciences.

5] The tool is available from: Author, manufacturer, national distributor, Brunel Management Decision Programme, BIOSS, Brunel University, Uxbridge, Middx.

6] The general application area of the tool is:
Plan, budget or evaluation analysis by individuals or group, esp: resource alloc resource evaluation, results evaluation, zero-budgetting,PPBS,demand estimating.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events
- eliciting valid priorities; checking ind. consistencies & team agreement, providing validated decision standards.

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- probabilities of uncertain events
- demand, post levels,costs,planning emphasis,supply levels, requirements, planned priorities, implicit priorities and implicit costs.

9] The tool has the capability to combine assessments of different types, viz:
Combines preferences on attributes & importance weights;rollback evaluation.

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion
- place options/alternatives into classes which are ordered

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Evaluation model and analysis built-in and program-generated; allows alternative scenarios, allows what-if analysis.

BPS

18] The tool is available as:
- method specification (ie. not implemented as software)
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines:
IBM-PC/AT/XT/compatibles;Sirius;Victor;Apricot.
- operating systems:
PC-DOS,MS-DOS.
- data base systems:
Tailoring services available.

20] The software is available in:
English, German.

21] The software is available as:
Source code: on disk

24] KEYWORDS:
Planning, budgeting and evaluation
Plan evaluation
Budget decisions

CEIS (Chief Executive's Info. System)

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- consultancy from an experienced analyst/user

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines: MICROAPL SPECTRUM: 1 Megabyte + Textronix displays.
- operating systems: Built in.
- languages: APL.

20] The software is available in:
English.

21] The software is available as:
Source code: as listings

23] The following reference publications are available:
- user manual (available separately)

24] KEYWORDS:
Chief executives' system.
CEIS.
Colour graphics.
Boardroom systems.
Menu-driven software.

Combined Arbitration

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/ theory employed by the tool

COMMENTS:
Generally applicable to 2 party dispute resolution over a quantifiable & divisible good or numeraire e.g.wage scale.

17] The following back-up materials are generally available to facilitate learning to use the tool:

- consultancy from an experienced analyst/user
- Authors will discuss implementation with users.

18] The tool is available as:
- method specification (ie. not implemented as software)

23] The following reference publications are available:
- technical manual (available separately)

Evaluation/validation studies are:
Forthcoming Management Science article in which issues of implementation are discussed.

24] KEYWORDS:
Arbitration.
Game Theory.
Conflict Resolution.
Equilibrium.
Fair Settlement.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- teaching material
  The tool is used as part of course in Information Management for M.BA students. A manual will be available in the future.

- consultancy from an experienced analyst/user
  The measurement system used by CYBERFILTER requires an experienced analyst.

18] The tool is available as:
- a programmed procedure with supporting software

19] The software is compatible with:
- IBM PC, 128K, 2 floppy disks, colour VDU, printer

- operating systems: DOS

- data base systems: LOTUS, SYMPHONY, in general DOS data files.

20] The software is available in: English, Spanish

21] The software is available as:
part consultany only. CYBERFILTER is not fully developed yet, there is not enough support for autonomous use.

22] Other information:
End user can be any manager in charge of an operation, e.g., general manager, plan manager, in production and service enterprises, public or private sectors.
As yet it has only been used as part of consultancy contracts.

23] Published case studies involving the application of the tool are:

R. Espeto - Cybernetic filtration of Management Information, Aston Management Centre WPS No. 126, 1979.

R. Espeto and D. Garcia "A tool for distributed planning". In Proceedings Orwellian symposium and International Conference on Systems Research, Baden-Baden, 1984.

24] KEYWORDS: Exception reporting
Performance monitoring
Planning system
Cybernetic filtration
Decision Support System

DECMAK

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Rule-based multiattribute dec. making, using fuzzy set and/or probability theory

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

The ability to describe and structure options by a set of criteria is required. Also, the ability to express preferences among values in form of logical rules.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- consultancy from an experienced analyst/user

Experienced analyst or user can show a case study to a newcomer, or completely disburden him from methodological point of view.

18] The tool is available as:
- a programmed procedure with supporting software

19] The software is compatible with:
- machines: IBM PC, VAX, PDP-11.
- operating systems: MS-DOS, VAX/VMS, RT-11 Share -eleven.
- languages: Pascal

20] The software is available in: English

21] The software is available as:
Compiled code: on tape and disk

1] Title or Name of tool: DESIMP (Discrete Event Sim. w/ Pascal)

2] Manufacturer or name of Author: Stokking, E.J.

3] Address: Fazantweg 3
9765 JL Paterswolde
The Netherlands.

5] The tool is available from: Author.

6] The general application area of the tool is:
(Stochastic) discrete event simulation.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- probabilities of uncertain events

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
It is a simulation tool, its main purpose to investigate the effects of possible changes in values.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
It's easy to change the process descriptions.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Discrete event simulation.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Resource allocation.

DESIMP (Discrete Event Sim. w/ Pascal)

21] The software is available as:
Source code: on disk
Modifiable code

22] Other information: Contact the author or distributor.

23] The following reference publications are available:
- user manual (available separately)

Evaluacion/validation studies are:
Demonstration disk IBM compatible pers.comp. Turbo-Pascal compiler reqd.

Published case studies involving the application of the tool are:
Birtwistle,G:Discrete Event Modelling on Simula (DEMOS),ISBN 0-333-23881-8.

24] KEYWORDS:
Simulation.
Discrete event simulation.

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/ theory employed by the tool

COMMENTS:
Needs to understd. his busns.in terms of strategies,objectives,problems,products
In order to use it on their own they need undrstd. of info.syst. eg.data classes

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes
- On line help.
- consultancy from an experienced analyst/user

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
  IBM PC/XT & AT, 3270AT, or any other IBM compatible, 512KB RAM, hard disk.
- operating systems:
  DOS 2.0 and above.
- languages:
  PROLOG.

20] The software is available in: English.

21] The software is available as:
Compiled code: on disk

22] Other information: Contact author, software is copyright.

24] KEYWORDS:
Information requirements.
Expert Systems.
Strategic Planning.
Decision Support.

EQUITY

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- decision analyst/consultant

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/ theory employed by the tool

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines: IBM PC or compatible, Perq with PNX.
- operating systems: UNIX, MS DOS, PC/DOS.

20] The software is available in: English.

21] The software is available as:
Compiled code: on disk

24] KEYWORDS:
Resource Allocation.
Cost/benefit.
Utility.
Decision Conferencing.
Decision Analysis.

ESSI (Exp. Sys. for Strat. Sel in ISD)

14] The tool is designed to support:
- personal decision making
- organizational decision making at departmental management level
- organizational decision making at general management level

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

COMMENTS:
The interface of ESSI has 2 levels; 1 for expern.usres, 2 for naive user, changing from 1 lvl. to another is easy & directed by the users need

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- consultancy from an experienced analyst/user

18] The tool is available as:
- method specification (ie. not implemented as software)

19] The software is compatible with:
- machines: VAX 11/750.
- operating systems: UNIX.
- languages: APES - expert system building tool.

20] The software is available in: English.

24] KEYWORDS:
Strategy selection.
ISD (Information System Development).
Contingency Theory.
Project Management.
Expert System.

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

Maximum number of simultaneous users = 9

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant

COMMENTS:
The program does not require any special expertise in computer techniques, only the understanding of multiattribute models for the assessment.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- consultancy from an experienced analyst/user

The program is basically provided by consultancy, but can be used without consultancy as well.

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines:
  IBM-PC and compatibles
- operating systems:
  DOS
- languages:
  BASICA

20] The software is available in: English, Hungarian.

21] The software is available as:
Source code: on disk

24] KEYWORDS:
Decision support systems
Multiattribute decision making
Hierarchical attributes
Expected utility

Expert Choice

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
Any Expert Choice model can be altered in a variety of ways as the problem changes or as external factors change. Elements can be added or deleted and judgements can be changed and recalculated.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie: Analytic Hierarchy Process.

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

Expert Choice is ideal for group decision making. Decision can be made three ways: by consensus, withthe members agreeing on the judgements, or by having each member make judgements on a particular section of the model, or by having each member do his own model and combining the results.

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

Expert Choice is ideal for group decision making. Decision can be made three ways: by consensus, withthe members agreeing on the judgements, or by having each member make judgements on a particular section of the model, or by having each member do his own model and combining the results.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes
- tutorial for system
- user modelling and didactic error collection within the tool itself
- consultancy from an experienced analyst/user
- telephone support

1] Title or Name of tool: FACILITATOR

2] Name of Author: Dr L. Floyd Lewis

3] Address: Decision Science Department
Western Washington University
Bellingham
WA 98225

5] The tool is available from:
Author

6] The general application area of the tool is:
Supporting group decision making. It incorporates 3 problem phases and uses a modified NGT & cross-impact analysis approach. It will support groups of 2-10 members in a network of microcomputers.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- identifying and ranking goals, obstacles and alternatives
- Performs cross-impact analysis of obstacles versus alternatives

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
Face-to-face discussion of each set of goals, obstacles, alternatives, with item editing following discussion. Cross-impact analalysis of alternatives versus obstacles with discussion of results and alternative reformulation.

13] The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
NGT and Cross impact analysis.

14] The tool is designed to support:
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

FACILITATOR

23] Published case studies involving the application of the tool are:
- Study currently in progress at WWU & Univ.of Louisville
- Previous research summarised in dissertation:
"FACILITATOR: A Microcomputer Decision Support System for Small Groups", 1983, Univ. of Louisville.

24] KEYWORDS:
Group Decision Support.
GDSS.
NGT.
Microcomputer DSS.

FLEXIGRID

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes
  Good examples within manual.

- user modelling and didactic error collection within the tool itself

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines: Wide range of CP/M, MS DOS, APPLE or TANDY M/cs.
- languages: GW Basic needed for MS DOS.

20] The software is available in: English.

21] The software is available as: Modifiable code on disk

22] Other information:
  Single user licence is usual.

23] The following reference publications are available:
- technical manual (available separately)
- user manual (available separately)

Published case studies involving the application of the tool are:
- Higginbottom, P. and Bannister, D. The GAB computer program for repetory grids. Univ. of Leeds, 1983.
- Pope, M. and Keen, T. Personal Construct Psychology & Education. Academic Press, 1981.
- Thomas,L. and Shaw,M. PEGASUS manual, Centre for Human Learning, Brunel, 1977.

24] KEYWORDS:
Rep. Grid. eliciting.
Rep. Grid. analysis.
Dyad Pegasus Grid.
PCA Focus, GAB.

Group MIDAS

15] The tool is designed to support the user in the role of:
- decision maker
- subject matter expert

Every user is a group member, 1 person is the 'expert' from inside or out the group

Maximum number of simultaneous users = 10

17] The following back-up materials are generally available to facilitate learning to use the tool:

- user modelling and didactic error collection within the tool itself

18] The tool is available as:
- a programmed procedure with supporting software

19] The software is compatible with:
- machines: IBM Compatible micros.
- operating systems: MS DOS.
- data base systems: DBASE III.
- languages: Clipper D Base III Compiler.

20] The software is available in: English and Dutch.

21] The software is available as: Compiled code on disk.

22] Other information:
Experimental applications with right of use of data is free.
All other applications - a fee will be negotiated.
Program will be commercially avail. within 5 months, from Courseware Europe BV, Nieuwstraat 59, 1441 CL Purmerand, The Netherlands.

23] The following reference publications are available:

Evaluation/validation studies are:
One case study to date, two are forthcoming.

Published case studies involving the application of the tool are:
Brooner, Van Dijk, Hoog: Can a Computer Aid Group Decision Making. Paper presented at the 3rd FUR Conference, Aix-en-Provence,1986.

24] KEYWORDS:
Group Decision Making.
Supporting Negotiation Process.
Identifying differences of opinions that do matter.
Identifies most likely candidate for concensus.
Partially MAUT based.

HEURISCO

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines: Various
- operating systems: Various
- data base systems: Various
- languages: FORTRAN 77.

20] The software is available in: German.

21] The software is available as: Compiled code on disk

22] Other information:
Please ask dealer for present state and options.

23] The following reference publications are available:
- technical manual (available separately)

Evaluation/validation studies are:
Please ask dealer.

Published case studies involving the application of the tool are:
There might be an English article soon, ask dealer.
Isermann-Garke, M., Jungermann, et al: Eine Simulation von Entscheidungen uber Multiattribute Optionen. Bericht zu8/85. Institut fur Psychologie, Technische Universitat, Berlin, 1985.

24] KEYWORDS:
Decision heuristics.
Decision simulations.

HIVIEW

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- macnines: IBM PC or compatible: 256K, graphics board, MS compatible mouse. Perq with PNX.
- operating systems: Unix, MS-DOS, PC/DOS.

20] The software is available in: English

21] The software is available as: Compiled code on disk

24] KEYWORDS:

Evaluation.
Multi-Attribute Utility.
Source Selection.
Choice.
Decomposition.

HOPIE

14] The tool is designed to support:
- personal decision making
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- decision analyst/consultant

Several decision maker assess jointly their utility function.

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

17] The following back-up materials are generally available to facilitate learning to use the tool:
- teaching material/programmes
- user modelling and didactic error collection within the tool itself
- consultancy from an experienced analyst/user

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
  Main Frame: IBM, CDC, etc. IBM PC 256KB, 2x360 KB disk.
- operating systems:
  MS DOS 2.
- languages:
  FORTRAN.

20] The software is available in:
English, German.

21] The software is available as:
Compiled code: on disk.

22] Other information:
No restrictions, single user:University DM 700.00, Industry DM 1400.00. Multiple user upon request. right now $320.00.

1] Title or Name of tool: IDEAL/PET

2] Manufacturer or name of Author: J. Whelan

3] Address: c/o School of Economic Studies
University of Leeds
Leeds LS2 9JT.

4] Contact person:
Dr A.D. Pearman

5] The tool is available from:
From author, via Dr A.D. Pearman.

6] The general application area of the tool is:
Evaluation of alternative transport policies, principally in the context of pedestrianisation of urban areas.

7] The tool has the capability to help structure the decision problem by:
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Sensitivity analysis on importance weights.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Transport/environmental planning.

14] The tool is designed to support:
- organizational decision making at general management level
- social decision making where there is consensus on goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- subject matter expert
- decision analyst/consultant

Only one class of users at a time.

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant

1] Title or Name of tool: Information Planner[R]

2] Manufacturer or name of Author: Knowledge Ware, Inc.

3] Address: 2006 Hogback Road
Ann Arbor, Michigan 48105
U.S.A.

5] The tool is available from: Manufacturer

6] The general application area of the tool is:
Decision support system to develop information strategy plans, assist in creation and analysis of a model of the business enterprise, and help define and prioritize a collection of information system development projects based on their contribution tothe objectives of the organisation.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

The program helps define potential solution boundaries based on diverse criteria, using a form of cluster analysis.

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- Affinities between members of a group

10] The tool helps the user to:
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion
- place options/alternatives into classes which are ordered

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz: problem statement is retained in a database and is fully searchable and may be freely and readily edited to restructure the problem statement.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie: Information Engineering.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie: Information Strategy Planning.

14] The tool is designed to support:
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved

1] Title or Name of tool: IRIMS (Ispra Risk Management Support)

2] Manufacturer or name of Author: Joint Research Centre Ispra

3] Address: Commission of the European
Communities
C.C.R. Ispra (Varese)
21020 ISPRA (Italy)

4] Contact person:
H. Otway, Technology Assessment Sector.

5] The tool is available from:
Author.

6] The general application area of the tool is:
Decision-oriented system for the management of chemical hazardous substances.

7] The tool has the capability to help structure the decision problem by:
- generating options
- generating evaluative criteria or attributes
- identifying relations between options
- identifying relations between consequences

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences

9] The tool has the capability to combine assessments of different types, viz:
Identification of non-dominated options w/ incommensurable criteria. Best sol.

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
The tool supports the selection of criteria(min/maximize/ignore)& the setting of constraints(max/min values of criteria to be considered).

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Decision support system with multi-criteria data evaluation & optimization.

14] The tool is designed to support:
- organizational decision making at general management level
- organizational decision making for strategic/business planning

15] The tool is designed to support the user in the role of:
- decision maker

1] Title or Name of tool: JAVELIN

2] Manufacturer or name of Author: JAVELIN Software Corp.

3] Address: Cambridge
Mass.
USA

5] The tool is available from:
Manufacturer.

6] The general application area of the tool is:
Business analysis and reporting.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- probabilities of uncertain events

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning

15] The tool is designed to support the user in the role of:
- decision maker

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual

1] Title or Name of tool: Jobber Business Simulation

2] Manufacturer or name of Author: Dennis P. Slevin

3] Address: Innodyne, Inc.
734 Orchard Hill Dr.
Pittsburgh
PA 15238

5] The tool is available from:
Author.

6] The general application area of the tool is:
This simulation program helps entrepreneurs and business managers assess the results of their operating decisions in a competitive small business environment

7] The tool has the capability to help structure the decision problem by:
- generating and linking exogenous events or conditions
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- results of operating decisions on financial statement & cash flow

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
The tool assists user in evaluating the effect of opreating variable changes on business financial performance.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:

14] The tool is designed to support:
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker

Each user/team manages 16 operating vars. in an ongoing small business.SEE SCHED

Maximum number of simultaneous users = 9

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

1] Title or Name of tool: Knowledge Craft (TM)

2] Manufacturer or name of Author: Carnegie Group, Inc.

3] Address: 650 Commerce Court
Station Square
Pittsburgh, PA 15219

4] Contact person:
Mike Chambers

5] The tool is available from:
Manufacturer.

6] The general application area of the tool is:
AI-based knowledge engineering.

7] The tool has the capability to help structure the decision problem by:
- providing a relational approach to structuring knowledge

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Knowledge rep. rule-based reasoning, deductive reasoning.

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes
- consultancy from an experienced analyst/user

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
Symbolics, VAX, TI Explorer.
- operating systems:
UMS.
- languages:
Common LISP.

1] Title or Name of tool: LOGSIM

2] Manufacturer or name of Author: United Nations

3] Address: Software and Support for
Population Data Processing
United Nations
Room DC2-1570
New York 10017, USA.

4] Contact person:
Mr Michael R. Lackner, Project Co-ordinator.

5] The tool is available from:
Manufacturer.

6] The general application area of the tool is:
Simulation modelling of simple systems featuring resource allocation over calendar days.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- probabilities of uncertain events

9] The tool has the capability to combine assessments of different types, viz:
The user constructs algorithmic model and defines variables except calendar.

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion
- place options/alternatives into classes which are ordered
- place options/alternatives into classes which are nominal

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Doesn't optimize/solve but merely generates time series of values according to logic of algorithm and calendar.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user.

15] The tool is designed to support the user in the role of:
- decision analyst/consultant

1] Title or Name of tool: **Linear Scoring Models (LSMs)**

2] Manufacturer or name of Author: various

4] Contact person: Dr P. Lovie
Dept of Mathematics
University of Keele
Keele
Staffordshire ST5 5BG

or Dr A.D. Lovie
Dept of Psychologiy
University of Liverpool
PO Box 147
Liverpool L69 3BX

5] The tool is available from: see above

6] The general application area of the tool is: widely applicable in situations where a limited number of predictor variables can be identified, weighted and combined in a simple fashion for prediction on a dichotomous outcome variable.

7] The tool has the capability to help structure the decision problem by:
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- probabilities of uncertain events
- predictor variable weights

9] The tool has the capability to combine assessments of different types, viz: as in MAUT

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz: sensitivity analysis on changes in predictor weights.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie: mainly regression (OLS and robust).

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

1] Title or Name of tool: MAUD

2] Manufacturer or name of Author: Humphreys & Wisudha

3] Address: Decision Analysis Unit
London School of Economics
Houghton Street
London WC2A 2AE
England

5] The tool is available from:
Authors or Decision Analysis Unit.

6] The general application area of the tool is:
Individual/group decision making where assistance is required in generating criteria, making tradeoffs between options, or resolving goal confusion.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences

9] The tool has the capability to combine assessments of different types, viz:
MAUT: combines preferences and importance weights.

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Sensitivity analysis on importance weights and preference values.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
Comprehensive opportunities for amending list of options, re-structuring attributes, etc. guided by the system.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Multiattribute Utility Theory.

MAUD

23] The following reference publications are available:
- technical manual (available separately)
- user manual (available separately)

Evaluation/validation studies are:

Humphreys & McFadden, Experiences with MAUD, Acta Psychologica, 43, 1980.

John, Von Winterfeld & Edwards, Quality and acceptability of MAU analysis. In Humphreys, Svenson & Vari (eds) Analysing & Aiding Decision Processes. Amsterdam: North Holland, 1983.

Rosa, et. al. Applications of Slim-MAUD. NUREG/CR4016: US Nuclear Regulatory Commission.

24] KEYWORDS:

Preference structuring.
Evaluation of options.
Interactive Decision aiding.
Goal classification.

MICROLAY

19] The software is compatible with:
- machines:
IBM PC/XT/AT 256K, SIRIUS/VICTOR I
- operating systems:
MS DOS, PC DOS.
- languages:
PASCAL.

20] The software is available in: German.

21] The software is available as:
Source code.
Modifiable code.

22] Other information:
On request.

23] The following reference publications are available:
- user manual (available separately)

Evaluation/validation studies are:
Wascher & Chamoni:MICROLAY-An Interesting Computer Prog. for Factory Layout Planning on Microcomputers. In European Journal of Oper. Research, 1986.

24] KEYWORDS:
Factory Layout Planning.
Microcomputers.
Interactivity.

MIDAS

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- user modelling and didactic error collection within the tool itself

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
  All IBM compatible, all mini's & main frames supporting std. PASCAL.
- operating systems:
  MS DOS/UNIX 4.2.
- languages:
  I STANDARD PASCAL (easily converted to other PASCAL dialects).

20] The software is available in:
English, Dutch.

21] The software is available as:
Compiled code.

22] Other information:
Use is free for non-commercial applications.
A fee will be negotiated for commercial applications.

23] The following reference publications are available:
- user manual (available separately)

Published case studies involving the application of the tool are:
Bakker, Topman, Hoog: Studiekeuze en computerbegeleidung. Paper presented at Dutch Psychology Conference, Ede, 1984.
Bronner, Hoog: Non-expert use of a Computerised Decision Aid: in Humphreys, Svenson & Vari (eds) Analysing & Aiding Decision Processes, NH. 1983
Bronner, Hoog: The Intertwining of Information search & Decision Aiding,

24] KEYWORDS:
Domcil Independent.
MAUT -Based.
Different Weighing Procedures.
Explanation Facilities.
Sensitivity Analysis.

NORMA (prototype)

18] The tool is available as:
- a programmed procedure with supporting software

19] The software is compatible with:
- machines:
IBM AT.

20] The software is available in:
English. Modification would be easy.

21] The software is available as:
Compiled code to U.K. Universities.
As part of consultancy only to others.

22] Other information:
Individual contracts.
Participation by those interested in the prototype will be encouraged.

23] The following reference publications are available:

A list of over 90 papers from the research project is available from the author they cover all the above aspects either for earlier prototypes(LEGOL SYSTEMS) or the current norma prototype.

24] KEYWORDS:
Semantic analysis.
Social norm structuring.
Time handling.
Information analysis.
Group decision support.

OPCOM

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- decision analyst/consultant

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes
  Videotape of a supporting case study which can be analysed with OPCOM.
- consultancy from an experienced analyst/user available from Decision Analysis Unit, LSE.

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
  IBM-PC/compatibles
- operating systems:
  PCDOS, MSDOS.

20] The software is available in:
English.

21] The software is available as:
Compiled code: on disk

22] Other information:
Single user end user licence: sterling 150 (teaching only)& 250 commercial.

23] The following reference publications are available:
- user manual (available separately)

Published case studies involving the application of the tool are:
L.D. Phillips Requisite decision modelling: A case study. Journal of the Operations Research Society, vol.33, 1982.

1] Title or Name of tool: ORDO

2] Name of Authors: Courbon, J.C. & Franzosi, F.

3] Address: CUI
University of Geneva
10, Rue du Lac
1211 Geneva 4
Switzerland.

5] The tool is available from: Author.

6] The general application area of the tool is:
Job-shop scheduling: Gantt interactive manipulation.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Priority rules /job displacement/ machine assignment etc.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
In the future, possibility of shop description and rearrangement.

13] The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Heuristic job shop scheduling rules.

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- in the future, communication between various linked shops.

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance

It is a tool for job shop foreman.

1] Title or Name of tool: P/GW (Part/Whole Percentaging)

2] Name of Author: Stuart S. Nagel

3] Address: Decision Aids, Inc.
1720 Park Haven Drive
Champaign
IL 61820
USA

5] The tool is available from: Author and manufacturer.

6] The general application area of the tool is:
The system processes a set of: goals to be achieved; options for achieving them; relations between goals and options - to choose best option or combination.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events
- examining what it would take to bring an Nth place option up to a higher place

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- probabilities of uncertain events
- weight or input by giving the threshold value of the input, above which there is one conclusion and below which there is another conclusion.

9] The tool has the capability to combine assessments of different types, viz:
Payoff matrices, decision trees, classical calculus optimization, MAU analysis.

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion
- place options/alternatives into classes which are ordered
- place options/alternatives into classes which are nominal

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Ability to do threshold analysis, convergence analysis, best-worst analysis, indifference curve analysis, as well as what-if analysis.

P/GW (Part/Whole Percentaging)

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes
- Summarising articles are available, so is a programming manual and forthcoming books, especially S. Nagel, Microcomputers and Evaulation Problems, Sage, 1986.
- user modelling and didactic error collection within the tool itself
- consultancy from an experienced analyst/user
- Help statements & Self checking devices esp.for how one goes from raw data to a bottom line conclusion.Workshops given by S.Nagel.

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines:
  Any IBM compatible computer.
- operating systems:
  Any DOS, PC, MicroSoft operating syst.
- data base systems:
  Any data base system, esp. one based on a matrix of alternatives & criteria.

20] The software is available in: English

21] The software is available as: Compiled code on disk

22] Other information:
Copies of the software & documentation obtainable from Nagel for $30 providing will report back.

23] The following reference publications are available:
- technical manual (available separately)
- user manual (available separately)

Evaluation/validation studies are:
Microcomputers & Evaluation Problems, Sage, 1986.
A Microcomp.Prog. for dealing with Eval. Probs. Eval.& Prog.Plang.1986
New Varieties of Sensitivity Analysis, 9 Eval.Review,209-214, 1985.

Please contact author for a bibliography list.

Published case studies involving the application of the tool are:
Optimally Allocating Money to Places & Activities, Humphreys & Vecsenyi(eds)'86.
Using Personal Comps. for DM in Law Practice. Greenwood Press,1986.
Microcomputers & Improving Soc.Sci.Prediction, 10 Eval.Review, 1986.
See attached bibliographies. on appl. pol. sci.,law,judicial proc.& pub.admin.

1] Title or Name of tool: **PERSONAL CONSULTANT**

2] Manufacturer: Texas Instruments

3] Address: European Marketing Division
Texas Instrument
1101 CB Amsterdam
Netherlands

4] Contact person: Mr M. Bulder.

5] The tool is available from: Manufacturer.

6] The general application area of the tool is:
Users: managers, consultants.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between goals
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- (un)certainty weights

9] The tool has the capability to combine assessments of different types, viz:
via rule-based specification.

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion
- place options/alternatives into classes which are ordered
- place options/alternatives into classes which are nominal

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Via (un)certainty weights.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
Editing the rule base by execution.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie: Logical Clauses, fuzzy set theory.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Logic.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes

Helps on multiple levels.

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines: IBM PC 340K RAM
- languages: Requires Ashton Tate's Framework.

20] The software is available in: English

21] The software is available as:
Source code: on disk

22] Other information:
Research version available to other researchers at cost.

23] The following reference publications are available:
- user manual (available separately)

24] KEYWORDS:
Outlining.
Word processing.
Decision structuring.
Integrated package.
Framework.

Decision tree analysis of litigation

17] The following back-up materials are generally available to facilitate learning to use the tool:
- teaching material/programmes

Teaching notes, software support is near completion.

18] The tool is available as:
- a programmed procedure with supporting software

19] The software is compatible with:
- machines: software is currently being revised for use on IBM PCs.

20] The software is available in: English.

23] The following reference publications are available:
- user manual (available separately)

24] KEYWORDS:
Decision tree analysis.
Decision analysis.
Litigation analysis.
Litigation risk analysis.
Alternative Dispute Resolution.

Demand/Supply Planning Support System

COMMENTS:
Tool is menu driven and will automatically produce the best alternative.
It's meant for people who know their job and can interpret the output.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- teaching material/programmes

Each user was subjected to 8 hours of 'hands on' training.

- consultancy from an experienced analyst/user

Both in terms of using the computer & the models. We give intensive support.

18] The tool is available as:
- a programmed procedure with supporting software

19] The software is compatible with:
- machines: IBM PC or compatible Burroughs B25 >512KB RAM.
- operating systems: MS DOS.
- data base systems: LOTUS 1-2-3.
- languages: LOTUS 1-2-3.

20] The software is available in: English.

21] The software is available as:
Internally developed & proprietary to Burroughs.

24] KEYWORDS:
Inventory management.
Goodsflow management.
MRP.
Production smoothing.
Interactive graphics.

PROLOGA

23] The following reference publications are available:

Published case studies involving the application of the tool are:
CODASYL,(1982),:a Modern Appraisal of Decision Tables. ACM, New York.
Maes, Vanthiegen & Verhelst,(1982):Practical Experiences with PRODEMO, Proc.IFIP WG 8.3/IIASA WC, Laxenburg.

24] KEYWORDS:
Decision Tables.
Procedural Decisions.
Logic Validation.
Knowledge Engineering.
Software Engineering.

QSB (Quantitative Systems for Business)

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/ theory employed by the tool

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines:
  IBM PC, comp[atible
- operating systems:
  DOS.

20] The software is available in:
English.

21] The software is available as:
Compiled code.

22] For further information, contact authors.

23] The following reference publications are available:
- user manual (available separately)

SAFETI Package

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes

Provided by technician.

- consultancy from an experienced analyst/user

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
Standard F77 (X3J390 ANSI, 770620)
- operating systems:
Any mixture which supports the above.

20] The software is available in:
English, Any language can be supplied.

21] The software is available as:
Source code.
Compiled code.

22] Other information:
Single user licence fee approx. £80.00, subject to required additional support.

23] The following reference publications are available:
- technical manual (available separately)

Evaluation/validation studies are:
A Dutch publication

Published case studies involving the application of the tool are:
Risk Analysis of the DSM site.
Risk Analysis of the Transport of Chlorine & Ammonia in the Rynmond Area.
Ammonia Risk Studies Pt.1.
All avail. Ministry of Housing,Physical Planning & Environment, Netherlands.

24] KEYWORDS:
Risk Analysis.
Process Plant.
Individual Risk.
Societal Group Risk.

SELSTRA

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines: IBM-PC, BBC-B
- operating systems: PC/DOS

20] The software is available in: English

23] The following reference publications are available:
- user manual (available separately)

24] KEYWORDS:
Individual decision making
Group decision making
Hierarchical structuring

STRATATREE

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant
- it can be used by a group using the consensus/method

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/ theory employed by the tool

COMMENTS:
STRATATREE has been developed for educational purposes, - to teach decision tree analysis. It can also be used by anyone who has an understanding (elementary) of the process.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes

recommended standard OR & business texts such as Quantitative Methods for Business by Anderson, Sweeney and Williams - West publishers.

- user modelling and didactic error collection within the tool itself

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines:
IBM PC & 100% compatibles with 256K RAM, 2 disk drives or a hard disk.

- operating systems:
IBM PC DOS 2.0 or greater

20] The software is available in: English

21] The software is available as: compiled code

1] Title or Name of tool: STRATMESH

2] Manufacturer or name of Author: Dickson, P.R.

3] Address: Academic Faculty of Marketing
The Ohio State University
1775 College Road
Columbus, Ohio 43210.

5] The tool is available from:
Author.

6] The general application area of the tool is:
Planning - competitive & marketing planning.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating options
- generating evaluative criteria or attributes
- generating and linking exogenous events or conditions
- identifying relations between options
- identifying relations between consequences
- identifying relations between events

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Simon's Satisfycing Theory of Managerial Decision Making.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Competitive Market Planning.

14] The tool is designed to support:
- personal decision making
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

STRATMESH

24] KEYWORDS:
Competitive planning.
Product market planning.
Marketing planning.
Strategy evaluation.
Marketing strategy evaluation.

SUPERTREE

19] The software is compatible with:
- machines:
  IBM PC
- operating systems:
  PC DOS
- languages:
  Interface to Lotus 1-2-3 (optional).

20] The software is available in:
English.

21] The software is available as:
Compiled code: on disk

23] The following reference publications are available:
- technical manual (available separately)
- user manual (available separately)

24] KEYWORDS:
Decision tree.

Strategic Intervention Planning

24] KEYWORDS:
Sequential Interventions.
Planning.
Sequence generation.
Sequence representation.
Optimal sequence search.

SYSTEM W

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines: IBM (4300), DEC VAX (microvax), ICL (2958)

- operating systems: VM/IMS, VMS, VME, MVS/TSO

20] The software is available in: English

21] The software is available as: compiled code

22] Other information:
15 year licence with annual software maintenance charge of 15% software charge.
Prices range from £12,000 to £200,000 depending on machine size, and modules purchased.

23] The following reference publications are available:
- user manual (available separately)

Evaluation/validation studies:
Evaluation is available - usually on 3 month basis, with a charge which can be written off the list of subsequent purchase.
Can be on-site or bureau evaluation.

Published case studies involving the application of the tool on application to Comshare.

24] KEYWORDS:
Management Information System
Decision Support System
Management Accounting
Corporate Budgetting
Financial Modelling

VIG

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/ theory employed by the tool

COMMENTS:
The expert is needed to construct the model, but the decision maker(naive user) can use the model for finding the most preferred criteria.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- teaching material/programmes

The system is almost self explanatory.

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
  IBM PC/1 256Kbytes, graphics card, colour graphics,(not necessarily).
- operating systems:
  DOS.

20] The software is available in:
English.

21] The software is available as:
Compiled code.

22] Other information:
$500 for Universities.
$3000 for Private companies.

23] The following reference publications are available:

Published case studies involving the application of the tool are:
Korhonen,Soisma(1985):A Multiple Criteria Model for Pricing Alcholic Bevs. Working Paper, Helsinki School of Economics.
Korhonen,Wallenius(1986)A Pareto Race. Working Paper,DIS 85/86-13,Arizona Univ.

24] KEYWORDS:
Multiple criteria.
Linear.
Interactive.
Visual.
Colour graphics.

VIMDA

17] The following back-up materials are generally available to facilitate learning to use the tool:

The system is almost self explanatory.

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
  IBM PC 256Kbytes, graphics card, colour graphics.
- operating systems:
  DOS.
- languages:
  BASIC.

20] The software is available in:
English.

21] The software is available as:
Source code.

22] Other information:
$500.00 for Universities.
$3000 for private companies.

24] KEYWORDS:
Multiple criteria.
Discrete.
Interactive.
Visual.
Colour graphics.

Value Analysis

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

17] The following back-up materials are generally available to facilitate learning to use the tool:

- user modelling and didactic error collection within the tool itself
- consultancy from an experienced analyst/user

Author available to provide support as called upon for a normal consultancy fee.

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
  IBM PC & compatibles, APPLE II series.
- languages:
  BASIC.

20] The software is available in:
English.

21] The software is available as:
Source code.

22] Other information:
Single user $100.00, Multi-user & OEM to be negotiated.

24] KEYWORDS:
Value Analysis.
Decision Support.
Criteria Rating.
Candidate Evaluation.
Preference/indifference curves.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
Through built-in program-generated evaluation analysis, also analysis of individual inconsistencies and group conflicts.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Non-linear programming, judgement analysis, priority scaling.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Resource allocation and evaluation; project decision making and evaluation.

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

Allows any user roles. Inter-relations are governed by combining ind. judgement
Maximum number of simultaneous users = 9

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

Designed for computer novice and expert users. Mainly used by line managers and their financial advisers.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes
  A pamphlet, a training workshop, a user's club, hot-line support.

- user modelling and didactic error collection within the tool itself
- consultancy from an experienced analyst/user
  (available from Work Sciences)

1] Title or Name of tool: ZAPROS

2] Manufacturer or name of Author: Prof. Oleg Larichev

3] Address: UNIISI
9 Pr 60 Let Octjabrya
Moscow 117312
USSR

5] The tool is available from:
Author.

6] The general application area of the tool is:
It uses decision maker's verbal preferences to fix his policy for assessment of complex alternatives (eg. R&D proposals) before the alternatives are assessed.

7] The tool has the capability to help structure the decision problem by:
- identifying subgoals
- generating evaluative criteria or attributes
- identifying relations between goals

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences

9] The tool has the capability to combine assessments of different types, viz:
It combines decision maker's preferences with evaluations of options on criteria

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives
- order options/alternatives on a preference criterion
- place options/alternatives into classes which are ordered

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Graphical representation of semiorders of options showing zones of possible sensitivities to trade-offs between criteria.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
The preference structure is developed interactively with the user. However, once developed, it remains fixed while evaluating options.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Semiorder and dominance relation (developed from the ELECTRE theory).

14] The tool is designed to support:
- personal decision making
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved

PERSONAL CONSULTANT

23] The following reference publications are available:
- technical manual (available separately)
- user manual (available separately)

A number of publications are bundled with the tool.

24] KEYWORDS:
Expert system.
Knowledge base.
Personal consultant.
Inference machine.
Goal directed reasoning.

PLEXPLAN

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

Used by organisational planners, decision analyst/facilitation
Maximum number of simultaneous users = 10

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- consultancy from an experienced analyst/user

Used in context of a strategic planning session in MIS Planning & Decision Lab. at University of Arizona, Dept. MIS.

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines:
IBM PC/compatible, Networked/PC NET.Current config.PC/AT,W/30meg hrd.disk server
- operating systems:
PC DOS.
- languages:
TURBO PASCAL.

20] The software is available in: English.

21] The software is available as part of organisational planning session, moderated by University of Arizona.

22] Other information: System is still experimental.

24] KEYWORDS:
Electronic Brainstorming.
Stakeholder & Assumption Analysis.
Plexplan.
Organisational Planning.
Information Systems Planning.

POLICY PC

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

POLICY PC has been used in decision conferences as a group decision support system.

Maximum number of simultaneous users = 8

16] The tool is suitable for direct use by:
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

COMMENTS:
Used in teaching: Psychology (theory of human judg., Management (principles of executive decicion making, Medical (diagnostic skills).

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes
- user modelling and didactic error collection within the tool itself
- consultancy from an experienced analyst/user
- User support is provided by telephone for a small user support fee.

18] The tool is available as:
- a programmed procedure with supporting software
- stand alone software

19] The software is compatible with:
- machines:
  IBM PC/compatible.
- operating systems:
  MS DOS

1] Title or Name of tool: POWER's Decision Aid

2] Manufacturer or name of Author: Daniel Power

3] Address: 9002 Gettysberg Lane
College Park
MD 20740
USA

5] The tool is available from:
Author.

6] The general application area of the tool is:
Personal and management multiattribute and qualitative decision problems.

7] The tool has the capability to help structure the decision problem by:
- generating options
- generating evaluative criteria or attributes

- pro-con comparison, also possible for two best alternatives

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences

9] The tool has the capability to combine assessments of different types, viz:
Using multiattribute utility analysis.

10] The tool helps the user to:
- choose a single best option/alternative
- order options/alternatives on a preference criterion

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
Changing weights - crude implementation.

12] The tool has limited capabilities for restructuring the problem representation as it is developed in interaction with the user.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
MAUT and Comparison Theory.

14] The tool is designed to support:
- personal decision making
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker

The system can be used by small groups.

1] Title or Name of tool: PREFCALC

2] Manufacturer: Euro-Decision Inc.
Author: Eric Jacquet-Lagreze

3] Address: BP 57
78530 Buc
France

5] The tool is available from: Author, manufacturer, national distributors.

6] The general application area of the tool is:
It assesses preferences of a decision maker using additive utility functions which aggregates multiple criteria in a single criterion.
Application areas: marketing, management, international business, education.
Types of problems: semi-structured decision situations, eg. buying a car, a PC, site selection, acquisition.
Types of users: consumers, corporate decision makers, students.

7] The tool has the capability to help structure the decision problem by:
- generating options
- generating evaluative criteria or attributes
- identifying relations between options
- identifying relations between consequences
- identifying preferences and generating importance ratings of the criteria relevant to the decision maker.

8] The tool aids the user to evaluate or assess:
- characteristics of options or consequences
- user preferences

9] The tool has the capability to combine assessments of different types, viz:
Supporting multiattribute utility analysis, combining preferences on attributes and importance weights.

10] The tool helps the user to:
- order options/alternatives on a preference criterion

11] The tool has the capability to investigate the effects of possible changes in values represented within the problem structure, viz:
The user can change the set of selected attributes, a-priori preferred alternatives, and the importance weights.

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
As above, also, the user can change the number of linear pieces in the graphical representation of the marginal utility curves.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Multiattribute utility theory.

PREFCALC

24] KEYWORDS:
Decision Support System
Multicriteria Decision Making
Multiattribute Utility Theory
Additive Utility Functions

PRIORITIES

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
Through analysis of inconsistencies and group conflicts.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Judgement analysis, choice theory, priority scaling, management by obj., MAUT.

The frame within which the tool operates is defined in terms of a substantive methodology for a particular problem domain, ie:
Problem solving, objectives-setting, criteria analysis.

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level
- organizational decision making for strategic/business planning
- social decision making where there is consensus on goal to be achieved
- social decision making where there may be conflict between stakeholders/interested parties on the goal to be achieved

15] The tool is designed to support the user in the role of:
- decision maker
- proposer
- subject matter expert
- decision analyst/consultant

Any user roles are allowed, inter-relation governed by combination of judgements
Maximum number of simultaneous users = 9

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool

COMMENTS:
The system is designed for computer novices and expert users. It imposes minimal structure on users. It is mainly used by line managers.

17] The following back-up materials are generally available to facilitate learning to use the tool:
- user manual
- teaching material/programmes

A pamphlet, training workshop, a user's club, hot-line support.
- user modelling and didactic error collection within the tool itself
- consultancy from an experienced analyst/user
(available from Work Sciences)

1] Title or Name of tool: **PROLOGA (Procedural Logic Analyzer)**

2] Manufacturer or name of Author: J. Vanthienen

3] Address: Katholieke Universiteit Leuven
Dept. of Applied Economics
Dekenstraat 2
3000 Leuven
Belgium

4] Contact person:
Prof. Dr. M. Verhelst

5] The tool is available from:
Author

6] The general application area of the tool is:
Interactive structuring of decision problems or procedures through decision tables, with emphasis on completeness, consistency and correctness.

7] The tool has the capability to help structure the decision problem by:
- generating options
- identifying relations between consequences
- identifying relations between events

- identifying and representing relations between conditions and consequences

8] The tool aids the user to evaluate or assess:

- completeness, consistency and correctness of decision representation

10] The tool helps the user to:
- choose a single best option/alternative
- choose a preferred set of options/alternatives

12] The tool has capabilities for restructuring the problem representation as it is developed in interaction with the user, viz:
Automatic restructuring to a condition oriented representation.
Automatic reordering of conditions, program code generation.

13] The frame within which the tool operates is defined in terms of a formal theory/system, ie:
Decision Table Theory.

14] The tool is designed to support:
- personal decision making
- organizational decision making at shop/office floor level
- organizational decision making at line management/supervisor level
- organizational decision making at departmental management level
- organizational decision making at general management level

ZAPROS

15] The tool is designed to support the user in the role of:
- decision maker
- subject matter expert

16] The tool is suitable for direct use by:
- a user who is naive with respect to the methodology/theory employed by the tool, working along without assistance
- a naive user, working in conjunction with an experienced analyst/consultant
- an analyst/consultant who is well acquainted with the methodology/ theory employed by the tool

COMMENTS:
The user should be a senior decision maker with full responsibility for determining the preference structure that assessors should use.

17] The following back-up materials are generally available to facilitate learning to use the tool:

- user modelling and didactic error collection within the tool itself

18] The tool is available as:
- stand alone software

19] The software is compatible with:
- machines:
  VAX/11: 256K.
- operating systems:
  VMS.
- languages:
  Fortran.

20] The software is available in: Russian

21] The software is available as:
Source code: as listings

22] Other information:
No instruction on method, software theoretically in public domain, but hard to obtain from USSR.

23] The following reference publications are available:
- user manual (available separately)

Evaluation/validation studies are:
O.Larichev, A method for evaluating R&D proposals in large research organizations. Working Paper WP-82-75. International Institute of Applied Systems Analysis, 2361 Luxenberg, Austria.

24] KEYWORDS:
Preference structuring.
Semiorder techniques.
Policy development.

Appendix B

Decision Support and Decision Aiding Tools Questionnaire

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1. Title or Name of tool:

2. Manufacturer or Author's name:

3. Address:

4. Contact person (if different from 2.):

5. The tool is available from:
   [Please mark the appropriate box or boxes]

   - O Author (direct)
   - O Manufacturer (direct)
   - O National distributors (append addresses)
   - O Local distributors
   - O Other (please specify) ....

6. Please state the general application area of the tool, or the types of problems and users for which it is generally recommended:

7. Does the tool have the capability to help structure the decision problem by:

-identifying subgoals?	O YES	O NO
-generating options?	O YES	O NO
-generating evaluative criteria or attributes?	O YES	O NO
-generating and linking exogenous events or conditions?	O YES	O NO
-identifying relations between goals?	O YES	O NO
between options?	O YES	O NO
between consequences?	O YES	O NO
between events?	O YES	O NO

   If the program helps structure the problem in another way, please describe this below:

8. Does the tool aid the user to evaluate or assess

- -characteristics of options or consequences? ○ YES ○ NO
- -probabilities of uncertain events? ○ YES ○ NO
- -other quantities (please specify below): ○ YES ○ NO

9. Does the tool have the capability to combine assessments of different types (e.g., rollback analysis in a decision tree combining utilities and probabilities; multiattribute utility analysis combining preferences on attributes and importance weights)?

○ YES (please specify below) ○ NO

10. Does the tool help the user to

- -choose a single best option/alternative? ○ YES ○ NO
- -choose a preferred set of options/alternatives? ○ YES ○ NO
- -order options/alternatives on a preference criterion? ○ YES ○ NO
- -place options/alternatives into classes
  - which are ordered? ○ YES ○ NO
  - which are nominal? ○ YES ○ NO

11. Does the tool have the capability to investigate the effects of possible changes in values represented within the problem structure (e.g, sensitivity analysis on event probabilities or attribute importance weights)?

○ YES (please outline below) ○ NO

12. Does the tool have capabilities for restructuring the problem representation as it is developed in interaction with the user?

○ YES ○ NO
(please state below how this is achieved)

13. Is the frame within which the tool operates

-defined in terms of a formal theory/system (e.g., Multiattribute utility theory, fuzzy set theory)?

○ YES (state which below) ○ NO

-defined in terms of a substantive methodology for a particular problem domain (e.g., resource allocation, strategic planning)?

○ YES (indicate the domain below) ○ NO

14. Is the tool designed to support

-personal decision making?	○ YES	○ NO
-organizational decision making		
at shop/office floor level?	○ YES	○ NO
at line management/supervisor level?	○ YES	○ NO
at departmental management level?	○ YES	○ NO
at general management level?	○ YES	○ NO
for strategic/business planning?	○ YES	○ NO
-social decision making		
where there is consensus on the goal to be achieved?	○ YES	○ NO
where there may be conflict between stakeholders/interested parties on the goal to be achieved?	○ YES	○ NO

15. Is the tool designed to support the user in the role of

decision maker?	○ YES	○ NO
proposer?	○ YES	○ NO
subject matter expert?	○ YES	○ NO
decision analyst/consultant?	○ YES	○ NO

If the tool is designed for simultaneous use by more than one user, please give details below of the various users' roles, and their interrelation:

[Maximum number of simultaneous users=]

16. Is the tool suitable for <u>direct</u> use by

- a user who is naive with respect to the methodology/theory employed by the tool, working alone without assistance? ○ YES ○ NO

- a naive user (as above), working in conjunction with an experienced analyst/consultant? ○ YES ○ NO

- an analyst/consultant who is well acquainted with the methodology/theory employed by the tool? ○ YES ○ NO

Please write below any comments you may have on the suitability of the tool for special classes of users:

17. What kind of back-up is generally available to facilitate learning to use the tool?

- user manual ○ YES ○ NO

- teaching material/programmes ○ YES ○ NO (give details below)

- user modelling and didactic error correction within the tool itself ○ YES ○ NO

- consultancy from an experienced analyst/user ○ YES ○ NO (give details below)

18. Is the tool available as

- method specification (not implemented as software)? ○ YES ○ NO

Go to question 23

- a programmed procedure with supporting software? ○ YES ○ NO

- stand alone software? ○ YES ○ NO

19. Please indicate what the software is compatible with in terms of

-machines:
(for each type of machine, please give the minimum configuration required to use the program in a practical application)

-operating systems:

-data base systems:

-languages (if relevant):

20. Please indicate if a version of the software is available for users whose natural language is:

○ English ○ French ○ German ○ Spanish ○ Russian

○ Other (please specify):

21. The software is available as:

Source code	○ YES (tape/disk)	○ YES (listing)	○ NO
Compiled code	○ YES (tape/disk)	○ YES (listing)	○ NO
Modifiable code	○ YES (tape/disk)	○ YES (listing)	○ NO

As part of consultancy only ○ YES (please give details below) ○ NO

22. Please outline below any conditions/restrictions on software licences, necessary status of end user, restrictions on types of application, and sample single/multiple user licence prices:

23. Please indicate any reference publications which may be available:

-technical manual available separately ○ YES ○ NO
-user manual available separately ○ YES ○ NO
-evaluation/validation studies
(please give source references below)

-Published case studies involving the application of the tool
(please give source references below)

24. Please give 5 keywords (or key phrases of not more than three words) useful for indexing the tool in the catalogue:

1:
2:
3:
4:
5:

THANK YOU VERY MUCH FOR YOU HELP THROUGH COMPLETING THIS QUESTIONNAIRE.

Please mail the questionnaire to:

Patrick Humphreys
Department of Social Psychology
London School of Economics
Houghton Street
London WC2A 2AE, U.K.

Please complete the label below, which will be used to send you your copy of the catalogue:

NAME

ADDRESS

Handling Decision Problems: A Structuring Language and Interactive Modules.

Final Report

PART II

Decision Conferences:
Description, analysis and implications for group decision support

Lawrence D Phillips

Decision Analysis Unit
London School of Economics and Political Science

Decision Analysis Unit Technical Report 89-2

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SUMMARY

This report begins with a brief history of decision conferencing, tracing the development in both the USA and the United Kingdom. It then considers recent developments in group decision support systems, and contrasts the computer-centred approach of the University of Arizona with the people-centred approach of decision conferencing.

The report next brings together and summarises work derived from decision conferences. Originally, it was intended to use decision conferences as a means for discovering the 'natural language' used by people in attempting to resolve real issues of concern facing their organisations. However, we soon learned that no such language exists, and that a major benefit of the modelling in a decision conference is that it provides both a language and a grammar that facilitate exploration in depth of the issues.

Research then shifted to using the decision conferences as a unique and valuable source of information about the nature and operation of facilitated groups. Four studies were conducted over the three years of this project.

In the first study (Wooler, 1987), a data-base of 45 decision conferences was constructed. A major finding was that managers revise their thinking about a problem differently depending on their level in the organisation. Senior managers are more likely to restructure their thinking about a problem than middle managers who, having established a structure, stay within it while exploring the issues. A second finding was the differential emphasis, depending on the manager's level in the organisation, that the manager places on information from outside the organisation as contrasted to internal information.

The second study (Chun, 1988) extended the data base to 47 decision conferences, added several new measures, and revised some of the former ones. An important finding was that top executives place more weight on 'soft' than 'hard' objectives, while the reverse is true lower in the organisation. These top executives are more 'future oriented', are less concerned with (but do not ignore) short-term financial goals, and are more likely to take account of risk than managers at lower levels.

The third study (Chun, 1988) looked in more detail at just 12 decision conferences. Two clear findings emerged: groups faced with little external threat construct more options and consider more choice criteria than do groups experiencing threat.

The last study (Oldfield and Wooler, 1988) explored the kinds of issues managers bring to decision conferences, the ways they handle the issues, and the effect of the decision conference on their resolutions. Again, stratum-specific differences were found, with lower-level managers generating more issues with less structure

than more senior managers. The decision conference proved to be successful in aiding problem identification and formulation. Interestingly, strategic, tactical and operational issues arose at all strata.

Collectively, these studies have led us to formulate nine working hypotheses that concern the functioning of facilitated work groups:

1. There are strata-specific differences in the way managers handle decision problems and resolve complex issues facing their organisations.

2. Senior executive restructure models of the issues more frequently than lower-level managers, who are more likely to explore issues within the structure they generated initially.

3. The relative importance of internal and external information depends on stratum: more concern for external information at strata 4 and 6, more concern for internal at stratum 5.

4. Larger groups conduct more sensitivity analyses than smaller groups.

5. Neither group size nor stratum has any influence on the complexity of the model.

6. The relative weight on 'hard' and 'soft' objectives shifts from more weight on hard objectives at lower strata to more weight on soft objectives at the highest strata (levels 6 and 7).

7. High-threat groups generate fewer options and consider fewer criteria for evaluating the options than do low-threat groups.

8. Stratum-specific differences in the importance of issues at the initial-discussion and final-action-list stages of decision conferences occur.

9. Strategic and tactical issues occur at all levels of the organisation.

We have called these 'working' hypotheses because they were derived from a limited data base dominated by one company in the computer industry. To establish generalisability of the hypotheses it will be necessary to test them on new data bases.

INTRODUCTION

In the late 1970s, Dr Cameron Peterson of Decisions and Designs, Inc., developed a way of using decision modelling to help a group of people explore issues of concern to their organisation. Special computer programs were designed so that on-the-spot models could be developed quickly from empty shells, then revised and changed easily as the group altered its views of the issues. A special room was constructed at DDI's McLean, Virginia offices, containing various audio-visual aids, including two back-projection screens for displaying computer output.

As the service evolved through trial-and-error, staff were trained to facilitate and support it, and eventually decision conferencing emerged as an efficient and useful way to help a group achieve a shared understanding of the issues concerning their organisation, and to gain a commitment to action.

The Decision Analysis Unit introduced a low-tech European version of decision conferencing in 1981. By 1984, International Computers Ltd., had become convinced of the value to their management of decision conferencing, and a five-year agreement was entered into with the London School of Economics to develop the service, transfer the technology to ICL, and provide support. New software was written in which menu items and icons are selected using a mouse, and which provides easy-to-interpret graphical displays of output. A high-tech room, the Pod, was installed at the LSE, providing a variety of computers and audio-visual features in a secure, comfortable environment. The group process approach of the Tavistock Institute of Human Relations was incorporated into training programs for decision conference facilitators, and ICL established its own Decision Conferencing Unit. At this writing, about 150 decision conferences have been conducted by ICL and LSE staff.

Development of decision conferencing has continued in North America as well. The service continues to be offered by Decisions and Designs and consultants in the Washington, DC, area. Dr John Rohrbaugh at SUNY in Albany has pioneered applications in the public sector. Several companies and universities are developing a decision conferencing capability. Dr Peterson has founded his own company, Decision Conferences, Inc., in Boulder, Colorado, whose only business is decision conferences. A major customer has been Westinghouse; Dr Peterson has conducted over 200 decision conferences for this company.

GROUP DECISION SUPPORT SYSTEMS

Quite independently of the development of decision conferences, a related movement concerned with facilitated work groups arose in the United States in the mid 1980s: group decision support systems (GDSS). This approach looks to computers for assistance in managing a meeting as contrasted to the modelling role for computers in decision conferences. While the goals of a decision conference are shared understanding and commitment to action, the goals of these more computer-centred GDSSs are to make meetings more productive and to improve communications. Nevertheless, there are several common features: specially-built environments, concern for process, use of trained facilitators, etc.

Because the GDSS movement came to the attention of the principal investigators of this project during the conduct of the project, it seemed appropriate, even necessary, to devote some effort to understanding how decision conferencing fits with the GDSS movement. The results of initial investigations conducted in the last year of the project, are given in Phillips (1988), which contrasts the two approaches as 'computer-centred' or 'people-centred'. (The paper is enclosed as part of this final report.) The report also describes decision conferencing and explains the theory of modelling on which the approach relies. A case study illustrates the main features of decision conferencing. (The reader who is unfamiliar with decision conferencing might find it useful at this point to read the paper.)

The computer-centered approach is now represented at several universities and companies in the USA, most notably at the University of Arizona which has two facilities: an earlier one seating about a dozen people around a U-shaped table, and a new room seating up to about four dozen people arranged in curved, raked rows facing the front in a small auditorium.

Personal discussions with Doug Vogel, one of the key proponents of the University of Arizona approach, and others, have led me to contrast the two approaches in terms of twelve issues as shown in Table 1 below.

It is clear that there are substantial differences here and many can be attributed to differences in assumptions about the nature of human work and in theories of the individual, the group and the organisation. Unfortunately, publications about these approaches reveal little about the theoretical differences. The University of Arizona approach in particular appears to be an ad hoc collection of tools assembled for their potential usefulness, and evaluated in a series of experimental studies.

TABLE 1: A comparison of two approaches to group decision support

	ISSUE	UNIVERSITY OF ARIZONA	DECISION CONFERENCING
1.	Goal	Automated support for collaborative work	Shared understanding and commitment to action
2.	Means	Computer-aided session management	Management of group process and requisite modelling of issues
3.	Environment	Computer-centred	People-centred
4.	Room	Computers, LAN, electronic white-board, OHPs	POD: various computers and audio-visual support
5.	Environment flexibility	Fixed locations	Transportable (doesn't require Pod)
6.	Role of computers	Operational support; systems integration	Modeling, some word processing
7.	Interaction with computers	Direct by participants	Via analyst
8.	Software	Variety of tools providing electronic paper and pencil	Decision analytic shells, e.g., INDIA, DAVID, ARBORIST, SUPERTREE, HIVIEW, EQUITY
9.	Role of facilitator	Meeting coordinator, some group dynamics	Manage process and structure: 'hand back in changed form
10.	Participants	Students to senior executives	Middle management to boards of directors
11.	Group size	4-48 people	4-24 people (in UK, 6-12)
12.	Cost of facility	large room: $2,000,000	Pod: $150,000 porta-Pod: <$10,000

I am not at all clear whether the two approaches will one day converge, or whether they will continue to develop and progress along separate tracks. Xerox and IBM may well have an important role in deciding the outcome if they can turn the GDSS movement to their commercial advantage; both are now developing the concept. It is unlikely that the military will assume the role of disinterested spectator, for both approaches to GDSS report substantial improvements in group efficiency of over 50% (e.g., twice as much work done in the same time; meeting times halved), and much anecdotal evidence is available of improved outcomes from decisions by the group.

As these claims proliferate, the need for solid research becomes more evident. What are the benefits of a GDSS? To what are the benefits attributable: the environment, the session management, the modelling? How much of a novelty effect is there? When should which approach be used? How can any GDSS be institutionalised? How crucial is the role of facilitator? How can facilitators be trained? What makes a good facilitator? and more.

With more and more organisations moving toward collaborative forms of working, the facilitated workgroup will become an increasingly common feature of organisational life. Better understanding of the various types of GDSS will facilitate the evolution of more effective forms of collaborative work.

When this project began, much effort was expended on an attempt to discover the 'natural language' used by participants in a decision conference as they struggled to explain and explore the issues of concern that were the subject of the meeting. It was our view that the early problem finding stage of a decision conference provided a unique opportunity to observe decision makers as they wrestled with complex, messy issues. At this point in a decision conference, the facilitator mainly listens; indeed, discussion is prompted by the facilitator asking only 'what are the issues concerning you that you would like to deal with over these two days?'

Analysis of notes taken by the facilitator and analyst of this early phase revealed no common language, and eventually it was realised that no such language exists. This may strike the reader as obvious, and it does to us ... in hindsight. But before we began, we assumed that senior managers must have evolved some set of common terms, phrases and expressions to enable them to deal with strategic and tactical issues in a mutually-understood way, just as accountants, engineers, computer programmers and others have developed specialised language, jargon, to enable complex ideas and concepts to be communicated quickly and efficiently with maximum understanding.

We soon found that there is no agreed, shared understanding of such terms as mission, vision, strategy, tactic, scenario, parameter, objective, option, outcome, consequence, criterion, and so forth. Yet, a clear understanding of these terms is needed for managers to share their views of why the organisation exists, to develop a common sense of purpose, to agree goals and the direction the organisation must take to achieve those goals, to establish what must be done to achieve the goals, and to agree how to do it. Too often, we found, managers espoused general goals, then moved to consider specific actions without considering intermediate objectives and strategies.

So we shifted the emphasis of our research to consider instead how participants in decision conferences handle the issues they are dealing with. We started with hypothesis derived from Jaques (1976) stratified systems theory: That the handling of issues would be different depending on the level in the organisation of the roles of the participants. A data base of 45 decision conferences was created by coding information obtained from notes taken during each decision conference, from the decision conference report written after the meeting, and from interviews with the facilitator. Variables concerned process, not the content or subject matter of the decision conference.

The first study (Wooler, 1987) confirmed the hypothesis. A key finding was that senior executives twice as frequently restructure a model once they have seen the initial results than do general managers. The latter confine revisions to changing evaluations of options on criteria or to changing weights on criteria, i.e., they stay within the initially established structure more than senior executives.

Wooler also found different themes emerging from discussions of the issues depending on level. One puzzling finding contradicted the usual view of the 'information triangle' in an organisation: that external information is increasingly required at higher levels, with more internal information at lower levels. Instead, Wooler found stratum 4 and 6 managers sharing an emphasis on external concerns, with stratum 5 managers more focussed on internal factors. This finding has obvious and important implications for the design of management information systems.

Other relationships that did not involve level of the participants' roles were found. As might be expected from groups with more perspective, larger groups created more complex models than smaller groups. Also, larger groups conducted more sensitivity analyses.

The next study (Chun, 1988) expanded the data base to 47 decision conferences and added some new variables. Several measures, particularly those related to model complexity, were refined. Again, stratum-specific differences were found. Perhaps the most significant finding, never before documented as far as we know, is that there is a shift in the relative weighting between 'hard' and 'soft' objectives as one moves to higher levels in the organisation. 'Hard' criteria include profit, revenue growth, cost reduction; 'soft' criteria represent future potential, risk, synergy, flexibility, innovativeness. Executives at stratum 6, placed relative weight of about 60% on soft criteria, with the other 40% on hard criteria (thus, they don't ignore hard criteria). For general managers, at stratum 4, the percentages were roughly reversed. Similarly, the higher stratum managers showed more concern for future potential than short-term financial goals, whereas the concerns of lower-stratum managers are reversed.

This finding gives rise to an interesting speculation. Perhaps senior executives 'steer' the organisation by focussing on soft objectives, while measuring the success of their policies and strategies by hard objectives. Attention to soft objectives in the long run creates hard results in the short run. If true, this would cast some doubt on economic theories of the firm.

Chun's research resolved a curious finding in the earlier work. Wooler had found an interaction effect on model complexity between stratum and the type of model developed. The newer research, with its improved measures of complexity, found no effect of stratum. Senior managers create models of equal complexity to middle managers. Nor was any effect of group size observed. Large groups and small groups develop equally-complex models. So much for the 'obvious' relationship between group size and complexity reported in the earlier study!

Chun confirmed that larger groups conduct more sensitivity analyses than small groups, and that the higher stratum groups more frequently restructure the models.

The next study by Chun (1988) examined a selection of decision conferences that used the same model type but which differed in the degree of threat expressed by the group in the discussion at the initial problem-formulation stage. High threat groups indicated that they were in some difficulty, experiencing loss of profits, declining market share, lack of competitiveness, etc. Low threat groups usually talked about having more opportunities than they could realise with their limited resources, were usually operating profitably and often growing.

Chun found that the degree of threat had a pronounced influence on the complexity of the model developed: high threat groups developed fewer options and considered fewer criteria in evaluating those options. A very clear message emerged for decision conference facilitators: threat groups may well be in convergent mode, and might be helped more by encouraging divergent thinking.

Finally, Oldfield and Wooler (1988) selected eight decision conferences to represent strata 3, 4 and 5, and examined the handling of common issues (organisational, economic, product/development, marketing, image, risk) that preliminary work had shown to be common to many decision conferences. The relative importance of these issues was found to be stratum-specific. Stratum 5 managers raised more tactical marketing issues than lower stratum managers, while stratum 3 managers mentioned more strategic organisational issues than higher-level managers. Image was of more concern to stratum 3 and 5 managers than to stratum 4 managers.

The action list developed at the end of a decision conference also showed differences associated with strata. Strategic organisational issues assume increasing importance at higher levels. Tactical and strategic economic issues are most pronounced at stratum 4, with strategic marketing issues most pronounced at this stratum.

Perhaps the most important finding of this research is that strategic and tactical issues emerge at all three levels in organisations. A more common view is that strategy is the province of more senior levels, tactics of less senior roles. This view is contradicted by the findings of this study.

CONCLUSIONS

It is important to recognise that the findings from these four studies were based on a limited data base of 47 decision conferences, and that the majority of these were from an electronics company and a food company. Other companies represented cover financial, manufacturing and consultancy organisations. They do not represent a random sampling of organisations, so it is possible that some of the findings may be specific to this data base.

To test the generalisability of the findings it will be necessary to establish new data bases. Three sources exist: one is a substantial collection of records held by Dr Cameron Peterson, but representing mainly decision conferences in one USA manufacturing company; another is the decision conferences conducted for various agencies in the state government of New York by Dr John Rohrbaugh and his associates at SUNY; a third is the growing data base in the UK.

To facilitate exploration of these new data bases, and to summarise the work in this section of the final report, the following working hypotheses have been established.

1. There are strata-specific differences in the way managers handle decision problems and resolve complex issues facing their organisations.

2. Senior executive restructure models of the issues more frequently than lower-level managers, who are more likely to explore issues <u>within</u> the structure they generated initially.

3. The relative importance of internal and external information depends on stratum: more concern for external information at strata 4 and 6, more concern for internal at stratum 5.

4. Larger groups conduct more sensitivity analyses than smaller groups.

5. Neither group size nor stratum has any influence on the complexity of the model.

6. The relative weight on 'hard' and 'soft' objectives shifts from more weight on hard objectives at lower strata to more weight on soft objectives at the highest strata (levels 6 and 7).

7. High-threat groups generate fewer options and consider fewer criteria for evaluating the options than do low-threat groups.

8. Stratum-specific differences in the importance of issues at the initial-discussion and final-action-list stages of decision conferences occur.

9. Strategic and tactical issues occur at all levels of the organisation.

Once the generalisability of these hypotheses is established, their implications and practical consequences can be developed. At this stage, a few tentative observations can be offered.

First, if managers handle complex issues differently depending on the level of their role, then problem-solving procedures need to be developed that take account of these differences. For example, less senior managers might be encouraged to question their initial assumptions, to reconsider their perspectives on the issues, and to restructure their thinking in qualitatively different ways.

The development of management information systems, executive information systems and decision support systems need to accommodate the differing emphasis on internal and external information required at different strata in the organisation. It should not be assumed that external information becomes more important as one goes up the executive hierarchy.

If top executives really do place more weight on 'soft' than 'hard' objectives than lower-level managers, then economic theories of the firm need to be reconsidered. It would appear that senior executives 'drive' the firm by creating an organisational climate, and developing strategies and policies that are focussed on soft objectives. Hard objectives may be the way these senior objectives 'keep the score'; they measure the consequences of being driven by soft objectives.

The facilitation of decision conferences would be affected if the finding is correct that high-threat groups create models of less complexity than low-threat groups. Groups under threat might be encouraged to explore issues in breadth. Here, a finding from the research reported in Part III of this final report is relevant. There it is shown that exploration in breadth is encouraged if participants are asked to explore scenarios. This can be done in decision conferences by using a variety of techniques (e.g., 'backward thinking') to encourage participants to think of alternative futures. With these in mind, rather than a single 'best guess' about the future, participants are more likely to generate a larger number of options.

Finally, the observation that strategic and tactical issues arise at all levels in the organisation confirms the view held by many planners that every unit, department, grouping, etc., in an organisation needs to develop its own mission consistent with, but more relevant than, the mission at the next higher level; must make objectives explicit; then needs to consider strategy as well as tactics. Organisational disfunction can arise from the failure to answer any of these questions:

MISSION	'Why are we here?'
OBJECTIVES	'What are our goals?'
STRATEGY	'What must be done to achieve the goals?'
TACTICS	'How should we do it?'

Too frequently in decision conferences, we see participants arguing about tactics when the real problem is lack of agreement at one of the higher levels.

In summary, this research began with a fruitless search for a common language that would enable people at managerial and executive levels to handle complex and messy issues of concern to their organisations. The research has generated nine working hypotheses that now should be tested in new settings, and the work has suggested the beginning of a language that could help to clarify the way in which people in organisations can turn purpose into action.

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People-centred Group Decision Support

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In: Knowledge Based Management Support Systems

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People-centred Group Decision Support

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1. INTRODUCTION

Over the past few years the management style of managers has changed in many organizations. Knowing that they were accountable for their own work and that of their subordinates, managers delegated tasks to ensure that things were done properly. By treating employees fairly, rewarding them well and providing good working conditions, managers felt that work would be accomplished efficiently and expeditiously. But in recent years this style has become less effective as employees demand work that gives a greater sense of responsibility and accomplishment.

Recognizing that responsibility can be delegated, whereas accountability cannot, the newer style manager delegates responsibilities, telling subordinates what must be done but not how to do it. Instead of apportioning tasks to subordinates, this new manager assigns responsibilities, then reviews performance periodically, rather than continually, against these defined responsibilities.

Older-style managers issue directives from the top and communication is mostly one way downward. Newer-style managers use their authority to respond quickly when urgent decisions are required, but they also engage in dialogues with their subordinates who they treat more like colleagues. In short, an older centralized style is giving way to a decentralized, collegial form of working. Under this new approach employees feel a sense of responsibility that creates commitment to their work, and they are better able to respond quickly and effectively to changes in the business environment. The sense of ownership becomes a powerful motivator.

However, with decentralization comes a new set of problems. The sense of ownership becomes so strong that fiefdoms are built which inhibit lateral communication and prevent true team functioning. Although each manager may optimize the use of his or her resources, the boss can see that this use is not collectively optimal. The temptation, then, is to impose a greater degree of central control. The conflict is between efficient use of limited resources, which is easier with centralization, and real ownership of the work, which is best achieved through decentralization.

If the ownership advantages of decentralization are to be maintained, then something must be done to ensure that limited *resources are used as effectively* as possible. This requirement establishes the need for better communication and a sense of common purpose among the management team. The question is, how can these be accomplished?

2. GROUP DECISION SUPPORT SYSTEMS

One approach is through the use of a group decision support system. This might be defined as the application of information technology to support the work of groups. Although that definition is uncontroversial, disagreement arises in the notion of work and in how that work is best supported.

2.1 The nature of work

Elliott Jaques [12] has defined human work as 'the exercise of discretion within prescribed limits'. The first part of the definition relates to the psychological component of work, 'the exercise of discretion', while the second part points to the organizational context which imposes limits on the scope of that discretion. The limits open out as one progresses up the organizational hierarchy, but at all levels discretion is exercised in deciding an appropriate balance between the pace and quality of work.

Decision theory [14], [17], tells us what is meant by 'the exercise of discretion'. If decisions are to be coherent, i.e. internally consistent, then it is necessary to take account of two features that characterize all choice situations: uncertainty and preference.

When facing a complex, ill-structured problem, we might be uncertain about many things: what is the problem, how should we proceed to solve it, what options should be considered, how likely are relevant future events and possible consequences? Data might help to answer these questions, and that is why information technology in the form of management information systems (MIS) and intelligent knowledge-based systems (IKBS) are built into some decision support systems.

Uncertainty is only half the equation. We must also consider our preferences: subjective values associated with consequences, time and risk preferences, and trade-offs between objectives. In the quest for an objective basis for decisions, many organizations attempt to objectify these factors, often by referring to some external standard, without realizing that choosing a standard is itself a judgement. However, valuing a £5m loss as more painful than a £5m profit is pleasurable, or deciding to use a 12% discount rate in a discounted cash flow calculation, or choosing a project that is sure to yield £1m over a project that has a 50–50 chance of £2m or nothing, or deciding to sacrifice short-term profit in order to establish market share, is a matter of preference and judgement. Even here, computers can help; such use constitutes *preference technology* [17].

In summary, 'exercising discretion' means that a person is considering uncertainty, forming preferences, making judgements and taking decisions. With this understanding of the nature of human work, I would like to offer an expanded definition of GDSS:

The use of information technology to help groups of people consider uncertainty, form preferences, make judgements and take decisions within prescribed limits.

2.2 Two approaches to GDSSs

Some designers of GDSSs assume that information and the exchange of information is the main work of a group. DeSanctis and Dickson [3] argue that 'the most fundamental activity of group decision making is interpersonal communication, and the primary purpose of a GDSS is to improve group communication activities'.

This view of a GDSS is evident in the workbench environment of GDSS rooms at Xerox [23] and the University of Arizona [1]. Participants sit around a U-shaped table at positions equipped with networked microcomputers that are recessed into the table. At the front of the room a large projection screen displays the output of any one computer or of aggregated information. Subgroups or individuals can move to small syndicate rooms, each equipped with microcomputers that are networked to the ones at the table, and a variety of software is available to help participants in their collective work.

This computer-based type of room is very different from the group-centred approach of those who believe that the exercise of discretion constitutes the work of groups. An example is the Pod shown in Fig. 1. Group members sit around a circular table in an octagonal room whose walls provide conventional and self-copying whiteboards, and two screens for displaying 35mm slides, overhead transparencies, drawings and printed material, video-tapes and the output from computers. Save for a single infra-red hand-controller, which enables the user to turn the displays on and off and to control the level of room and board lighting, no computers or other information technology devices are evident. The room is inviting even to individuals who are computer illiterate or who shun technology. The environment is conducive to problem solving, and makes it easy for the leader or facilitator to use technology, including computers, when appropriate.

Fig. 1 – The LSE Pod.

In summary, two styles of group decision support system are emerging. One provides a workbench environment and is computer-based, with the intention of facilitating group communication. The other provides a problem-solving environment that is group-centred and is primarily intended to help managers consider uncertainty, form preferences, make judgements and take decisions.

2.3 GDSS and decision analysis

While decision theory contributes to the definition I have offered of GDSS, it is decision analysis, the applied technology that was developed from decision theory [10], [13], [20], that has important roles to play in modelling issues that concern a group of people who are making use of a GDSS.

First, decision analysis provides a language that participants can share. Research at the Decision Analysis Unit [25] has shown that senior executives lack a common language for discussing strategic issues. Even within the same company, there is usually no shared understanding of terms like mission, vision, goal, objective, strategy, option, scenario and risk. Decision theory provides a language that makes it possible to fix the meaning of these terms in a way that contributes to communication and the subsequent development of a model.

Second, decision analysis provides a grammar for manipulating meaning in ways that are not easy with words alone. For example, it would not be an exaggeration to say that all problems, in both public and private sectors, involve multiple objectives. Finding solutions requires that trade-offs between objectives be considered. That is difficult to do with words, but is easily accomplished within the context of a multiattribute value model. Lacking such a model, members of a group often find it difficult to establish priorities, for that usually requires a comparison of apples with oranges, a major stumbling block for most groups. One of the most important contributions decision analysis can make is to help with this task.

Third, decision analysis provides structure to thinking. The form of the model developed to tackle the issues at hand shows how the issues interrelate. The model is the expression of the language, and it shows how the grammar should be used. The model form most often associated with decision analysis is a decision tree: it provides a way of representing choice situations in which there are a few options, uncertainty about the future, and where possible consequences differ in several ways, i.e. they are multiattributed. However, many managers find the decision tree representation too passive; it does not do justice to their ability to deal effectively with unexpected events as they arise. More frequently used are two model forms that seem to accommodate most of the concerns expressed by senior managers: evaluation and resource allocation.

Evaluation problems are characterized by a few options (strategies, projects, choices, systems, etc.) and many objectives or attributes. The goal is to find an overall ordering of the options, and this is achieved by scaling the options on the individual attributes, assigning relative weights to the attributes and then taking a weighted average of the individual scales. Multiattribute value modelling [28, ch. 8] is the approach favoured by decision analysts. (For cogent criticisms of alternative approaches – analytical hierarchy process, fuzzy set theory and cost-effectiveness analysis – see [7, ch. 10].)

Resource allocation problems present a large number of options (possible ways of dividing the pie) and only a few objectives. The goal is to find the best way of allocating a fixed resource (usually people, material or money). This is done by creating, for each budget category, a small multiattribute model in which options at different resource levels are evaluated against the objectives, then assessing weights across the categories and objectives, and combining all models into one efficient curve that shows the overall best allocation for any given level of resource.

Resource allocation models play a crucial role in resolving the conflict mentioned earlier between centralization to achieve efficient use of resources and decentralization to create ownership of the work. Known in decision theory as *the commons dilemma*, the problem can be solved through group participation in resource allocation modelling. This requires managers to discuss and agree trade-offs in light of identified strengths and weaknesses, opportunities and threats, in the areas over which they have responsibility. As a result, some managers may lose resource, but the resulting loss of benefits should be more than made up by gains in those areas of higher opportunity to which the freed resource is allocated.

Much of a senior manager's work is concerned with evaluating options and allocating resources in light of conflicting objectives and uncertainty about the future (which can be accommodated in a multiattribute value model as a risk attribute or by incorporating alternative scenarios). Later in this paper, a case study that used these two approaches will be presented. For other kinds of issues and problems, decision analysis provides alternative model forms.

For example, Barclay and Peterson [2] show how decision analysis can be used as an effective tool in bargaining and negotiation. Event trees, fault trees and influence diagrams [11] are good ways of modelling uncertainty about a target event by 'extending the conversation' to include related events, with assessed conditional probabilities representing the degrees of belief associated with the events. Bayesian models capture the influence of data on uncertainty, while hierarchical Bayesian models [22] have the added advantage of dealing both with the inferential uncertainty inherent in data, and the errors of measurement or unreliability of the data. Finally, in credence decomposition models [5] a target variable is expresed as a function of other variables, whose probability distributions are individually assessed and then combined using the functional relationship to determine the probability distribution for the target variable.

These various model forms are sufficiently rich to cover a wide variety of issues faced by organizations and individuals. Other approaches, for example, social judgement theory [8] or systems dynamics modelling [21] have also been used successfully in GDSSs [19].

Finally, it should be noted that knowledge of how people actually make choices as individuals [24] can contribute to the design of effective GDSSs. Most people have developed a rich collection of rules of thumb for dealing with complex, messy situations characterized by uncertainty and conflicting objectives. Psychologists have studied these rules of thumb, or heuristics, and discovered several commonly used ones that may often be helpful, but can also lead to poor decisions. GDSSs should be designed to minimize the tendency to use heuristics in unhelpful ways.

2.4 GDSS and group processes

A good GDSS must provide a balance between content, process and structure. Eden and Ackermann [6] postulate a multiplier effect between content and process: in an effective system, as content develops, it should alter the process by which the group works, but process also effects content. Both have to be managed effectively, and to do this requires knowledge of group processes.

It is helpful to know how the inevitable anxieties that arise when individuals work in groups can affect the group, how groups impose roles on individuals who may then find themselves acting on behalf of the group, how different assumptions may operate covertly to influence the group's behaviour, how deflections from the task at hand can be managed with effective facilitation. Research on group processes has identified conditions and situations that increase the ability of groups to solve problems effectively [4], [9], [15–16], and it is knowledge of small group functioning that is used by a facilitator to help a group achieve its goals. This research should also be of use to designers of GDSSs.

2.5 Conclusion

GDSSs that are designed to help groups of people to consider uncertainty, form preferences, make judgements and take decisions require inputs from three disciplines: information technology, decision theory and group processes. In addition, knowledge of how people actually make decisions, unaided, will focus design efforts on those aspects of GDSS that can improve decision making. Concentrating only on the technology, computers, software and networks, will not realize the full potential of GDSS.

3. DECISION CONFERENCING

One approach to GDSS (there are others: [6], [18]), invented in the late 1970s by Cameron Peterson at Decisions and Designs Inc., is decision conferencing, which in its current state draws on experience and research from information technology, decision analysis, group processes and behavioural studies of actual decision making. Decision conferencing is an intensive two-day session attended by a group of people who are concerned about some complex, messy issues facing their organization. The group is aided by at least two people from outside the organization, a facilitator and a decision analyst, who are experienced in working with groups. The facilitator helps the participants to structure their discussion, think creatively and imaginatively about the problem, identify the issues, model the problem and interpret the results. The analyst helps the facilitator and attends to the computer modelling.

The purposes of a decision conference are to generate a shared understanding of the issues and a commitment to action. This is achieved by creating a computer-based model which incorporates the differing perspectives of the participants in the group, then examining the implications of the model, changing it and trying out different assumptions. As actions are shown to be insensitive to differences of opinion, as new, more robust options are developed, and as higher-level perspectives emerge, participants develop a common understanding that facilitates agreement about what to do next.

Although every decision conference is different, most are characterized by several stages that can be distinguished. Before the conference begins, the facilitator meets with the client to establish the nature of the problem and whether a decision conference is appropriate. If so, objectives are set, key players are identified, preparation required of participants is determined, and the main points of a calling note are agreed.

At the start of the conference, after an initial introduction by the facilitator, the group is asked to discuss the issues and concerns that are to be the subject of the conference. An attempt is made to formulate the nature of the issues: does the group wish to reconsider strategy, or is a fundamental change of direction required? Perhaps budget items or projects need to be prioritized. Evaluating alternative plans, ventures, systems, bids of projects may be required, especially if objectives conflict. During this phase the facilitator has to decide whether exploration in depth or breadth will best help the work of the group.

Once the nature of the problem has been formulated, the facilitator chooses a generic structural form for representing the issues, and the group begins to provide the content that is used in constructing the model. This is usually a simple, though not simplistic, representation of the group's thinking about the issues. The model is drawn by the facilitator on the whiteboards in the room, and at the same time the analyst inputs the model to the computer. Both data and subjective judgements are added to the model, and the computer output is projected onto a screen so all participants can see the results.

These initial results are rarely accepted by the group. Modifications are suggested by participants, and different judgements are tested. Many sensitivity analyses are carried out; gradually, intuitions change and sharpen as the model goes through successive stages. Eventually this process of change stabilizes, the model has served its purpose, and the group turns to summarizing the key issues and conclusions. An action plan is created so that when participants return to work the next day, they can begin to implement the solution.

3.1 A case study

It is difficult to convey the experience of participating in a decision conference, but some feeling for it can be communicated in a case study. The managing director of an operating company, which manufactures and sells a leading women's shampoo, has been told by the head office that advertising expenditure on the product in his country is much larger than in any other company where the shampoo is sold. The MD believes that special circumstances in his country justify the large expenditure, which is mostly for television advertising, but he does not have time to try reducing the advertising in a part of the country to see what affect it would have on sales. He decides to call a decision conference attended by his marketing manager, distribution manager, production manager, several supporting staff, and representatives from their two advertising agencies.

During the opening discussion that established the issues, the facilitator asked the group what they would do with the extra resource if they did reduce television advertising. This proved to be a key question, for the group had been locked into thinking only about the size of the advertising expenditure, and were intending to use the decision conference as a vehicle for rationalizing the current expenditure. The question stimulated a discussion of alternative strategies. Eventually, these six options were agreed as possibilities:

- *Status quo*: Continue to spend the current amount on advertising.
- + *Consumers*: Increase the number of consumers by changing the product to a family shampoo so that men and children will be encouraged to use it.
- + *Promotion*: Increase promotion of the shampoo with wide distribution of free samples.
- + *Products*: Develop new hair products to complement the shampoo.
- *High quality*: Develop a special high quality, prestigous product.
- *Distribution*: Improve the current distribution network for the existing shampoo.

Discussion of the pros and cons of these options was used by the facilitator to construct the value tree shown in Fig. 2. The bottom-level attributes capture the main differences among the options, while the higher-level nodes express the main objectives of the company: to grow profitabily while maintaining a position of leadership in the shampoo market. In addition, the group was concerned to retain as much flexibility as possible so they could respond to incursions by the competition, and because one ingredient of the current shampoo was imported, they wished to minimize the effects of exchange rate fluctuations.

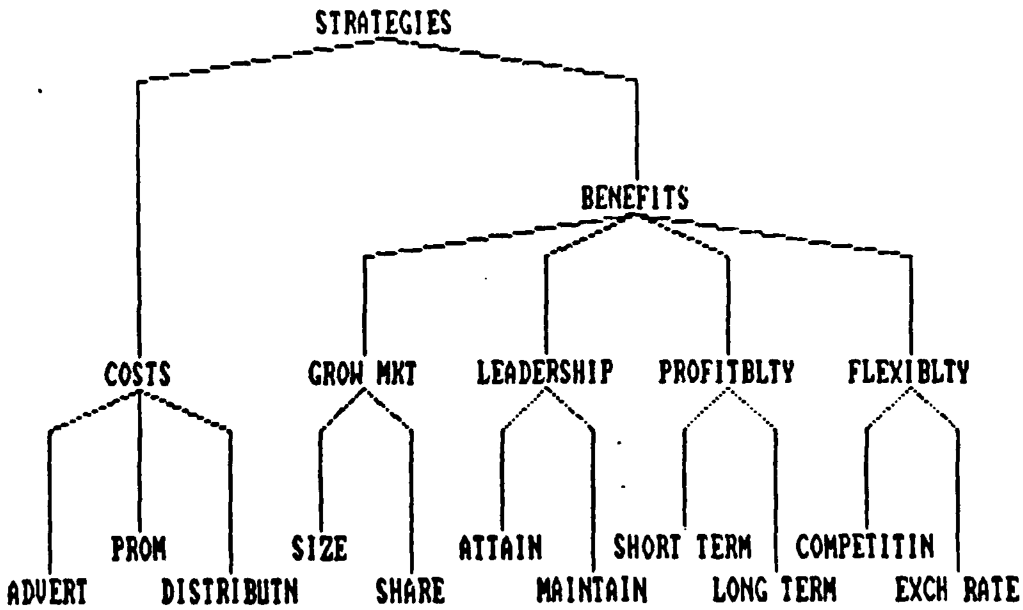


Fig. 2 – Value-tree for the shampoo problem.

Once the value-tree was agreed, participants turned next to scoring the options on each attribute. Preference scales were used, with 100 at the top representing the most preferred option, and 0 at the bottom indicating the least preferred one. For example, improving distribution was judged by the group to be best for short-term profitability because the investment would be paid back quickest, while adding more products was judged least preferable because they would take a long time to become established (see Fig. 3).

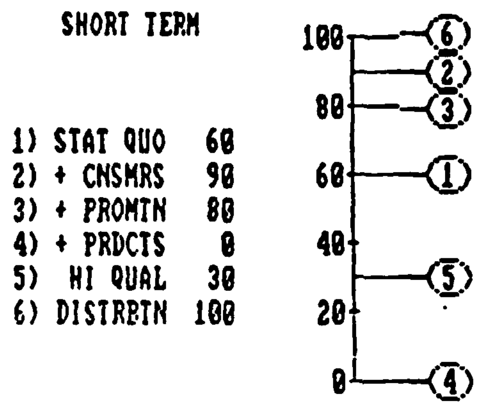


Fig. 3 – A preference scale for short-term profit.

All other options were scaled between these end points such that the differences in the numbers reflected the importance of the differences in short-term profit expected from the options. For example, the status quo was scaled at 60 because the 60-point difference from option 4, more products, was judged to be one-and-one-half times as important as the 40-point difference from option 6, increase distribution. Similarly, the importance of the difference in short-term profit between options 1 and 5 and between options 5 and 4 was judged to be the same. Various differences were compared to serve as consistency checks, and to ensure an equal-interval scale. Revisions were frequently made by the group to yield scales that reasonably accurately represented the group's views. When agreement could not be reached on a particular score, it was marked with a red asterisk and later changed in the sensitivity analysis phase.

After the options were scaled on all the attributes, assessments were made of the relative importance of the attributes. These weights represent the importance of the differences between the top and bottom of the scales. For example, Fig. 4 shows that the difference in short-term profitability between improving distribution and more products is 80% as important as the difference in long-term profitability between improving distribution and high quality product. It is the ratio of the weights that is interpretable, not their absolute values. Another way to think of the weights is that they express the trade-offs between the scales: moving from 0 to 100 on the short-term scale is equivalent to moving from 0 to 80 on the long-term scale. This fact is used in helping a group to assess the weights; a simple paired-comparison technique makes the assessment understandable, if not easy.

PROFITBLTY

BRANCH	WT	STAT QUO	+ CNSMRS	+ PROMTN	+ PRDCTS	HI QUAL	DISTRBTN	CUMWT
1) SHORT TERM	*(80)	60	90	80	0	30	100	6.25%
2) LONG TERM	*(100)	60	60	60	60	0	100	7.81%
TOTAL		60	73	68	33	13	100	14.06%

Fig. 4 – Scores and weights for the two profitability attributes.

Next, the weights are normalized by dividing each by their sum to give two numbers that add to 1.0, and a weighted average of the scales is computed. This is shown in Fig. 4 as the 'total' row. (The last column, 'cumwt', is the product of the normalized weights at each branch from the top of the tree down to the branch shown.) This weighted averaging process is repeated at each node in the tree. Thus, the weighted average of all eight benefit attributes provides a single benefit scale, and similarly a single cost scale is computed as the weighted average of the three cost scales.

Each option, then, is characterized by a pair of numbers, a weighted-average cost and a weighted-average benefit. Rather than assigning weights to these objectives to give a single scale, it is instructive to look at all options in a benefit versus cost space (Fig. 5).

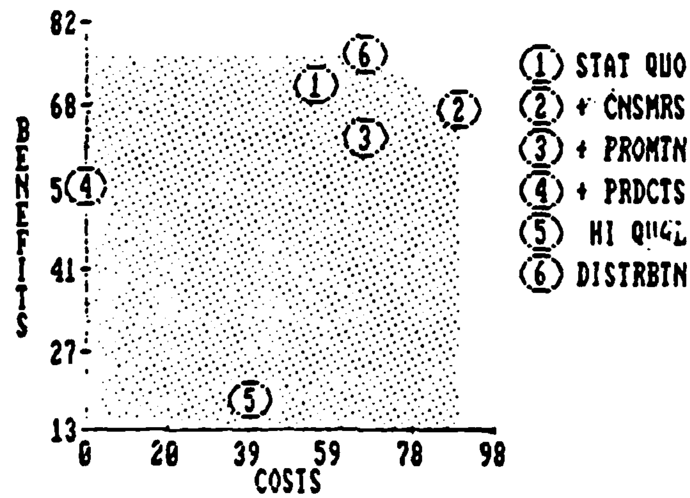


Fig. 5 – Benefits v. costs for the shampoo options.

Options 4 and 5 are clearly less good than the others; 5 is low in benefits and 4 is costly (since preference scales are shown, a high number on the cost scale means less costly). Fig. 5 also shows that more distribution is both cheaper and more beneficial than the status quo, so should be preferred. Options 2 and 3 are both less costly than the status quo, but also slightly less beneficial. Options 2 and 6 are on the outside boundary, indicating that only they would ever be chosen by the model, depending on the trade-offs between costs and benefits.

Several changes were then made to the model by the group. For example, debate about the appropriate weight on costs led to the sensitivity analysis shown in Fig. 6. The total weight on costs is varied over its full range from 0 to 100, and the score of each option at the given weight is calculated and displayed by the computer. At the current weight of 50% on costs (and, so 50% on benefits), option 2 is most preferred, overall, but if the weight on costs falls below 30%, then option 6 is preferred. Several participants felt that costs were relatively unimportant and that option 6 was very attractive. However, other changes to the model suggested that options 1, 3 and 6 were all tenable.

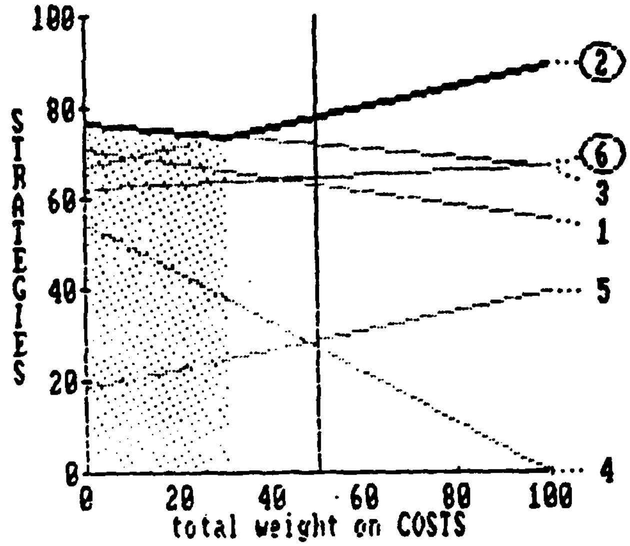


Fig. 6 – Sensitivity analysis on costs.

After considerable exploration of the model, the group shifted their view of the problem. They began to recognize that the distribution of available resource between advertising, promotion and distribution was the real problem. The modelling had transformed their thinking shifting them from defending the advertising expenditure, to thinking about resource allocation among their key activities.

The next morning was devoted to developing a new model that expressed the resource allocation issue. The distribution, promotion and advertising managers were each asked to explain their current strategies and to consider alternative strategies that would require significantly more, or less, resource. These strategies are shown in Fig. 7. The current distribution strategy was to distribute the product to 60% of the country, but with more resource it would be done quicker and better. With even more resource, the distribution manager would urge nationwide distribution. On the other hand, if he suffered a cut in the current level of resource, he would simply distribute to fewer areas. The promotion manager considered three strategies, the advertising manager, five. Altogether 4 X 3 X 5 = 60 combinations of strategies are possible (though some combinations don't make sense!).

Next, the total cost of each strategy was determined. For the status quo, data were available, but for other strategies judgements about costs were discussed and agreed by the group. The group then evaluated the strategies using preference scales on the three key objectives, growth, leadership and profit (see Fig. 8).

VARIABLE	LEVEL 1	2	3	4	5
1 DISTRIBUTN	Fewer areas	SQ: 60%	SQ,quicker & better	Nationwide	
2 PROMOTION	None	SQ:sample, price off	Heavy sampling		
3 ADVERTISNG	Cut back area & fre	Cut back freq only	SQ: 80% area	Increase frequency	+ nationwide

Fig. 7 – Strategies for the resource allocation model.

VARIABLE 1: DISTRIBUTN

	COST	BENEFIT GROW	LEAD	PRFT
1 Fewer areas	7.5	0	0	70
2 SQ: 60%	9.5	60	70	80
3 SQ,quicker & better	11.5	90	90	100
4 Nationwide	13.5	100	100	0
WITHIN CRITERION WTS		100	100	100
ACROSS CRITERIA WTS	100	100	10	10

VARIABLE 2: PROMOTION

	COST	BENEFIT GROW	LEAD	PRFT
1 None	.0	0	0	0
2 SQ:sample,price off	1.5	30	70	40
3 Heavy sampling	3.0	100	100	100
WITHIN CRITERION WTS		30	10	20
ACROSS CRITERIA WTS	100	100	10	10

VARIABLE 3: ADVERTISNG

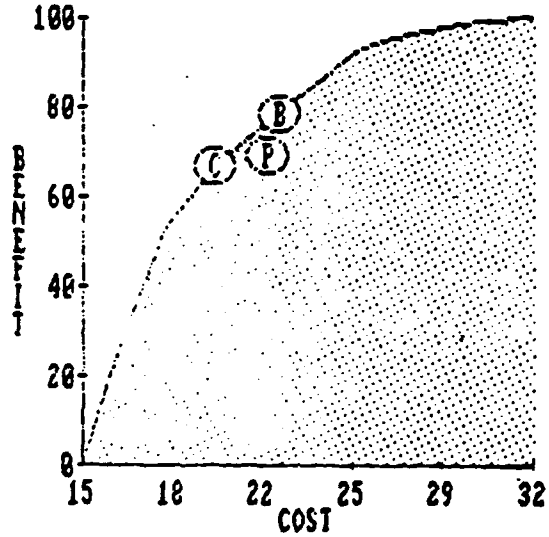
	COST	BENEFIT GROW	LEAD	PRFT
1 Cut back area & freq	7.25	0	0	50
2 Cut back freq only	8.50	50	65	70
3 SQ: 80% area	11.10	75	80	100
4 Increase frequency	12.50	85	90	60
5 + nationwide	16.00	100	100	0
WITHIN CRITERION WTS		100	75	100
ACROSS CRITERIA WTS	100	100	10	10

Fig. 8 – The complete resource allocation model.

Two sets of weights were assessed: one, the 'within criterion weights' expresses the trade-offs between the three areas, the other, the 'between criteria weights', the trade-offs among the three criteria. For example, the weights in Fig. 8 directly beneath each of the growth scales, 100–30–100, show that the differences between the top and bottom of the growth scales in distribution and advertising are equally important, while moving from 0 to 100 on the growth scale in promotion is 30% as important. The across criterion weights of 100–10–10 show that the importance of the differences in the strategies is greatest for growth (because the market is still growing), that leadership (which is already established for this product) and profit (currently high) are 10% as important.

The computer takes a doubly weighted average of the three benefit scales in each area with the result that each strategy is characterized by two numbers, a cost and a single benefit. Thus, the total cost and total benefit of all 60 combinations (here called packages) can be calculated. The computer displays the curve of the *most* beneficial option for each level of total cost (Fig. 9); all others lie somewhere in the shaded area.

	PROPOSED PACKAGE				
VARIABLE	COST	WTS	BEN	LEVEL	
1 DISTRIBUTN	9.5	432	285	SQ: 60%	(2 OF 4)
2 PROMOTION	1.5	138	44	SQ:sample,price off	(2 OF 3)
3 ADVERTISNG	11.1	430	361	SQ: 80% area	(3 OF 5)
	22.1		690		



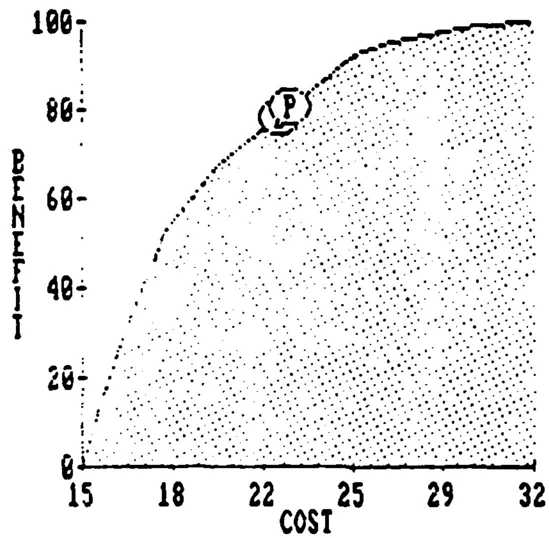
VARIABLE	LEVEL 1	2	3	4	5
1 DISTRIBUTN		P	CB		
2 PROMOTION	CB	P			
3 ADVERTISNG		C	PB		

Fig. 9 – Evaluation of the status quo, a better (B) package and a cheaper (C) one.

One particular package, the status quo in each area, is shown: it is point P (proposed). Also shown is a better point, B, and a cheaper point, C. These three points show that the current strategy can be improved. The changes are shown in the table below the curve: distribute more quickly and better (level 3), drop promotions (level 1) and keep the current level of spending on advertising (level 3). In other words, advertising isn't the problem; it is the allocation of current resource between distribution and promotion that can be improved.

The group agreed that the current promotion campaign was feeble; it should be dropped or done properly. They then asked to see a new proposed package: level 3 in distribution and promotion, but cut back in advertising to satisfy head office. This is shown as point P in Fig. 10. Note that it costs a little more than the current plan, 23.0 instead of 22.1, but it is almost on the curve. Even there, a trade-off between advertising and promotion is identified by the model, but the group decided that this new package was very attractive, partly for reasons not included in the model.

VARIABLE	PROPOSED PACKAGE COST	WTS	BEN	LEVEL	
1 DISTRIBUTN	11.5	432	428	SQ,quicker & better	(3 OF 4)
2 PROMOTION	3.0	138	138	Heavy sampling	(3 OF 3)
3 ADVERTISNG	8.5	430	238	Cut back freq only	(2 OF 5)
	23.0		805		



VARIABLE	LEVEL 1	2	3	4	5
1 DISTRIBUTN			CPB		
2 PROMOTION	CB		P·		
3 ADVERTISNG		P	CB		

Fig. 10 – Evaluation of a proposed package.

Three actions were agreed by the group:

- the two advertising agencies were told to cut their budgets by 10% and were asked to put forward proposals to accomplish the reduction,
- the promotion manager's budget was doubled and he was asked to submit a new promotion campaign within two weeks, and
- the distribution manager was asked to put forward a new plan for quicker and better distribution.

Within the month all strategies had been implemented.

Thus, starting with one problem that had been imposed externally, the group ended by considering a different set of issues which were more fundamental. It was the group, not the computer or the model, that recognized the real issues, but the GDSS was instrumental in helping the group to that recognition. Note, however, that here the GDSS is taken as the *entire* system composing participants, facilitator and analyst, computer, software and other equipment. The GDSS isn't just the IT, it is the whole socio-technical system.

The case also demonstrates an error in decision making that is so universal it deserves a name. It might be called the *single-option fallacy*: attempting to analyse a single option. Most people do this by weighing up pros and cons; if the pros outweigh the cons, you go ahead, if the other way around, you don't. The fallacy is in failing to do the same thing for the alternative. Suppose, for example, that the cons outweigh the pros for an option you are considering. You then reject the option. But perhaps the cons outweigh the pros even more for the alternative, which you implicitly accept by rejecting the option! You might be badly off by accepting the option, but you are even worse off by accepting the alternative.

As applied to the case, the group was prepared to consider the pros and cons of the advertising budget, believing that the pros outweighed the cons. But when participants' attention was shifted to alternative uses of the available resource, an insight about the real problem emerged, enabling the group to develop a deeper understanding of the issues and to agree to a new plan of action that included a cut in advertising expenditure. In short, weighing up pros and cons of a single option is mere rationalization; *comparing* pros and cons of alternative options is real analysis, and this is the activity that should be supported by GDSSs.

4. CONCLUSION

By now, the features that I consider important in a GDSS should be apparent. The system should be *problem-centred* so that it will help participants deal with the issues that concern them. Although some group work can be informed by data, which the system should make easily available, the basic nature of human work concerns the exercise of judgement, so the GDSS should be *processing-oriented*, helping the group by structuring thinking rather than contributing substantive content. The system should be able to deal with *group dynamics*, helping the group to stay task-oriented. Models developed during a session with a GDSS should be *transparent* so that results will be believed and trusted. The GDSS and the modelling approach should be *theoretically sound* so that changes and additions to the model can be accommodated without creating inconsistencies in the results, or having to re-do parts that are not affected.

The GDSS should be *flexible* with regard to the issues that concern the group, so that changes in perspective or in the problem itself can be accommodated. Those who are offering a GDSS should make only *modest promises* about its benefits, for as much depends on the participants as on the GDSS. Finally, the GDSS should be *adaptable* to group needs; a strictly rule-based approach to

GDSS, or a fixed sequence of activities that are linearly driven by the facilitator, will inevitably fail in many situations.

Properly designed and used, a GDSS can help a group to better, more acceptable solutions. The system will build commitment in a group and help participants to generate agreed action plans. It does this by lending structure to thinking, with all perspectives represented in the model. The modelling activity, in which the issues are taken apart into their components, takes the heat out of disagreements, and the whole process facilitates communication. Assumptions that participants are making are revealed in useful ways, and creative thinking is encouraged. In short, by helping to build a sense of common purpose among participants in a group, a good GDSS can help an organization to resolve the dilemma between ownership of work and efficient use of resources.

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Technical Report 87-2

Analyses of decision conferences: Interpretation of decision maker's activities in problem identification, problem expressing and problem structuring

Stuart Wooler

Handling Decision Problems: A Structuring Language and Interactive Modules: Final Report on First Year's Work.

PART II

Analyses of decision conferences: Interpretation of decision maker's activities in problem identification, problem expressing and problem structuring.

Stuart Wooler

Decision Analysis Unit
London School of Economics and Political Science

Decision Analysis Unit Technical Report 87-2

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SUMMARY

The work described in this report is aimed at developing a better understanding of how groups of managers debate critical choices, of what issues they take into account and what information they focus on, of how they include measures of risk and uncertainty; in short, of how they make decisions. The immediate focus of this effort is rather specific, however - that of developing an understanding of these management decision processes in order to improve our understanding of how to aid them. Of particular concern therefore are the implications which can be drawn from the research reported here for the development of new generations of computer-based aiding systems or new types of analyst intervention.

The empirical base for this research consists of records of managers' decision making activities carried out within decision conferences (backed up by retrospective interviews with a selection of managers involved). This provides a unique opportunity to investigate a wide variety of management decision makers from a number of different commercial sectors through analyses of actual decision making activities. Two approaches have been used in analysing decision conference material.

First, a database of decision conferences has been constructed. Currently totalling data on 45 decision conferences, it far exceeds the level of effort promised in the current stage of the project. Analyses of data coded in this database have revealed associations between a variety of features of the management group and the characteristics of their decision model construction and manipulation activities. For instance analyses so far indicate an association between the seniority of the management team and the extent to which they are willing and able to revise the basic parameters of their thinking about a problem. This may well prove to have implications for the design of decision support systems tailor-made to the needs of managers at different levels in organisations. These implications are explored in the report.

Second, an interpretation scheme has been developed and used to identify, within material generated in particular from the early problem definition discussion in decision conferences, key themes and focuses of concern being addressed by managers. Analyses have suggested that, for example, the concern of managers with external information (about competitors, markets and so on) is greater at some levels of organisations than others and, furthermore, that this differential concern is distributed in hitherto unpredicted ways. Once again implications of this and other findings are discussed.

The provisional nature of both findings and interpretations is however stressed. As we state in the report, in a field which is both as under-researched and as important as this one, it is prudent to proceed with caution toward firm conclusions.

CONTENTS

1. Introduction.

The aim of the research described in this report is to analyse a number of real-life decision conferences, with emphasis on the ways in which problems were formulated and structured. This research is desinged to provide the foundation for the identification of ways where effective support could be provided by analyst and/or computer based systems, which will be the focus of a subsequent report on this research. Our original plan was to focus on the analysis of transcripts between participants in each conferences, with the objective of developing a coding scheme for the problem structuring they employed. However, two principal modifications to this initial focus and objective have been made during the research period to date.

The first of these follows from our discovery that attempts to develop a strict coding procedure for analysing the discourse of decision conference participants were inappropriate (as reported in our Second Progress Report, 1986). We have consequently substituted for this a looser interpretation scheme, concerned to identify key themes and focuses addressed in decision conferences. These themes thus provide a basis for describing and distinguishing decision conferences and developing working hypotheses of how they may usefully be categorised.

There are of course numerous types of critical features which may form the bases for categorising decision conferences. In line with framework of ideas derived from Stratified Systems Theory, outlined in our project proposal, our emphasis thus far has been on attempting to relate differences in decision conferences, defined by the emphasis placed within them on the various themes identified, to the level or stratum of the management group involved. The results of this work are presented below.

Plans for the next phase of this work include broadening the focus to attempt to differentiate decision conferences not just by management stratum but also by other factors - including type of industry and management style.

The second divergence from the initial focus of our research arose from the realisation in the light of the data that our assumption of the existence of some form of unique symbolic language available to senior managers was mistaken. It seemed a priori reasonable to assume that a common language (in the form of some specialist set of concepts) for outlining strategy, rather than tactics or operations, would be apparent when senior executives discuss strategic problems with one another. In fact, current evidence suggests that far from this being the case, the language of managers becomes less specialist, less technical and simpler at the higher levels of organisations. Moreover, a common complaint of senior executives is that they lack precise means of communicating about strategic issues with one another.

2. Research method

In the light of these two modifications to the initial focus of our analyses of decision conference material, the approach employed consists in two types of research endeavour, results of which are reported separately below.

First, a database of decision conferences has been constructed. It currently comprises data on 45 decision conferences. This far exceeds the scale of data analysis scheduled for the current stage of the project.
By analyses of data coded in this database, associations between a variety of features of decision conferences - such as management group size and the characteristics of the decision model construction and manipulation activities of the group - have been investigated.

Second, an interpretation scheme has been developed and used to identify, within material generated from decision conferences, key themes and focuses of concern being addressed by managers. Analyses have then been carried out to see if these themes can be related meaningfully to various features of the management teams involved in the decision conferences, in particular to the organisational stratum or work level of the managers.

As described in the results reported below, these two lines of investigation have led to provisional hypotheses which will be further investigated in future work. Where appropriate we also discuss how these findings and their interpretations run counter to current beliefs and assumptions about aspects of management decision making.

It is important to stress however the provisional nature of both findings and interpretations. In a field which is both as under-researched and as important as this one, it is prudent to proceed with caution toward firm conclusions. It is in this spirit that, unlike the hazardous waste study reported above, we have held off giving backing to results of examining the decision conference database through statistical analysis. Many of the results would be shown to be statistically significant. Others would not. It seems to us that statistical criteria for the reliability of our findings are inappropriate at this early stage of development, and thus that statistical backing would be spurious. Useful working hypotheses and rich descriptions are the important desiderata. It is these we have concentrated on, rather than on generalisations.

3. Results of analyses of decision conference database

A copy of the decision conference database is included as Appendix 1. Note that in this copy decision conference names (column A) and names of the senior executive in each decision conference group (column C) have been deleted.

A large variety of relations between the various types of data on decision conferences collected in this database have been investigated. Below are presented those which currently appear most meaningful.

Similar databases have been developed and analysed both by Dr. John Rohrbaugh of the State University of New York at Albany, collating information derived from his experience of carrying out decision conferences in the public sector, and by Mr. Peter Hall of the Decision Conferencing Unit at ICL, recording information of decision conferences carried out by his team both inside and outside ICL. Both these databases have been made available to us for purposes of cross checking findings from examination of our database. Unless otherwise stated, findings from our database are corroborated by these other sources.

As shown in, Figure 1 there appears to be an effect of group size on the complexity of the model developed. In the case of both of the two generic modelling software packages usually employed in decision conferences (HIVAL and DESIGN[1]) there is a tendency for larger groups to create more complex models. Furthermore, as shown in Figure 2, there is a tendency for these larger groups to investigate the implications of these models more thoroughly through more comprehensive sensitivity analysis.

These results are perhaps unsurprising. Under the belief that larger groups are likely to embody more and more diverse perspectives, they may be expected to engage both in more comprehensive model building and in more comprehensive manipulation and investigation of models.

In these findings, however, there is as yet no discrimination of decision conferences by the strata of the managers involved. One simple but potentially rather important convergence is between management stratum and group size, as shown in Figure 3.

The trend shown here for higher level managers to convene smaller groups merits further attention. Explanations if this tendency are not obvious. It may be that there are percieved to be fewer stakeholders whose views need to be represented in higher level strategic problems. Alternatively, it may be that fewer people contribute to higher level problems because the numbers of people in the organisation perceived to have the necessary perspective on the strategic problems at hand are few.

Note however that this effect does not appear to occur in the American public sector. There is no difference in the size of groups of different strata convened for decision conferences under the auspices of the State University of New York at Albany.

Combining all the results presented in Figures 1, 2 and 3 would lead to the expectation that higher level managers would produce simpler models than those lower down the organisation. This was tested for each of the two major generic modelling tools used in decision conferences, HIVAL and DESIGN. The surprising result gained is shown in Figure 4.

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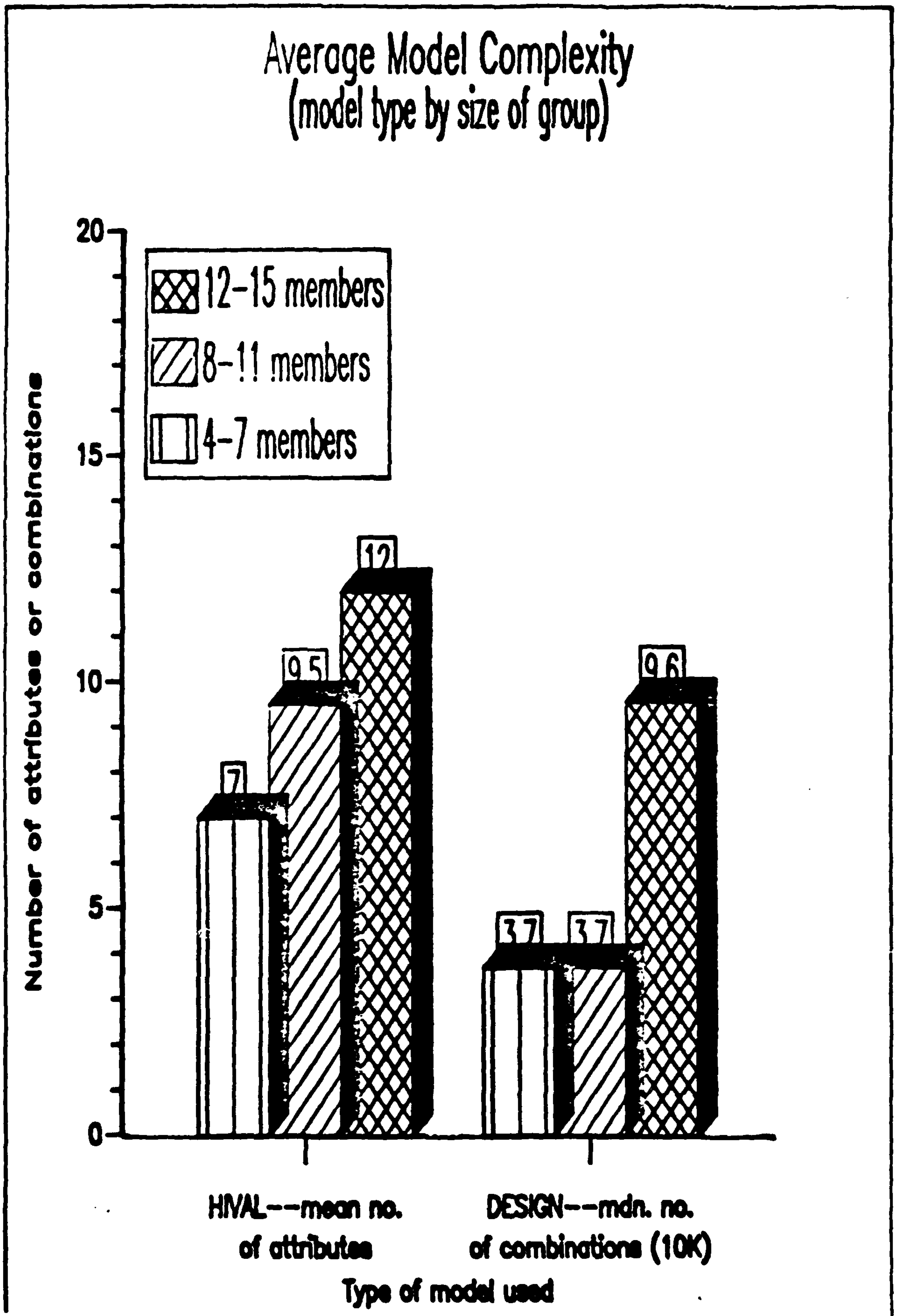
1. More advanced developments of these programs are now in use under the names HIVIEW and EQUITY respectively.

Figure 1



Average Model Complexity
(model type by size of group)
12-15 members
8-!1 members
4-7 members
20
15
10
5
0
Number of attributes or combinations
7
9.5
12
3.7
3.7
9.6
HIVAL--mean no. of attributes
DESIGN--mdn. no. of combinations (10K)
Type of model used

Figure 2

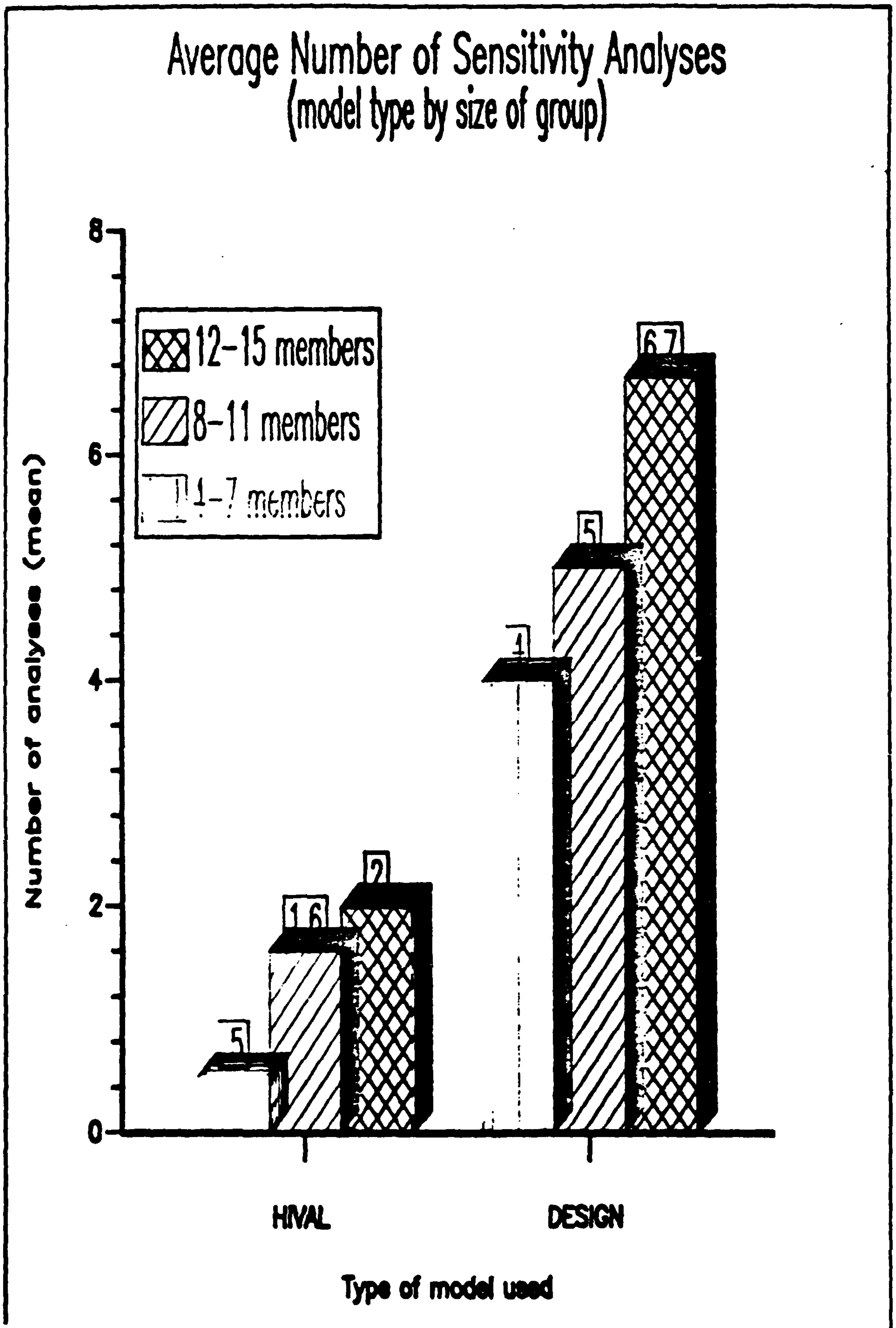

Average Number of Sensitivity Analyses
(model type by size of group)
12-15 members
8-11 members
1-7 members
8
6
4
2
0
.5
1.6
2
4
5
6.7
Number of analyses (mean)
HIVAL
DESIGN
Type of model used

Figure 3

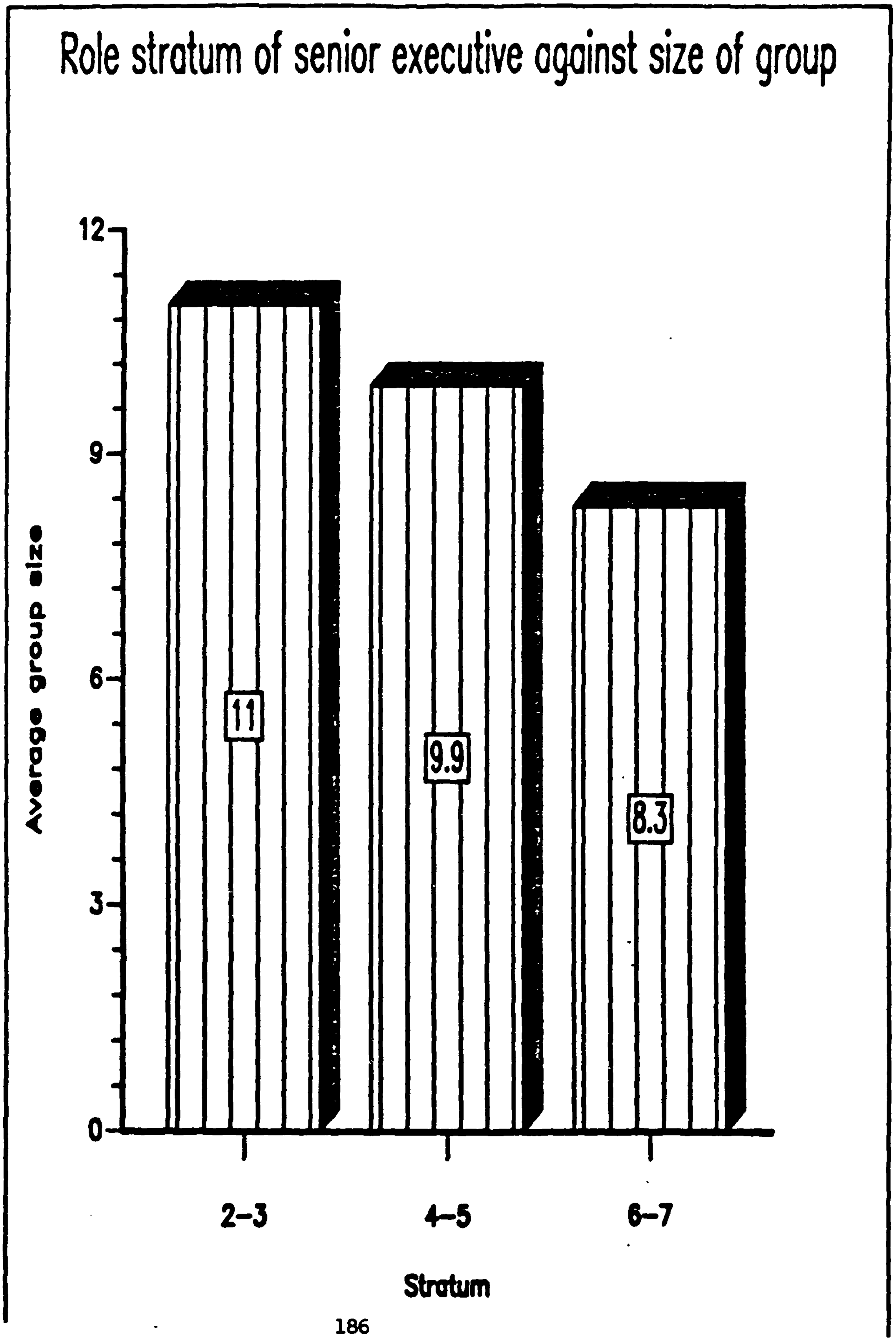
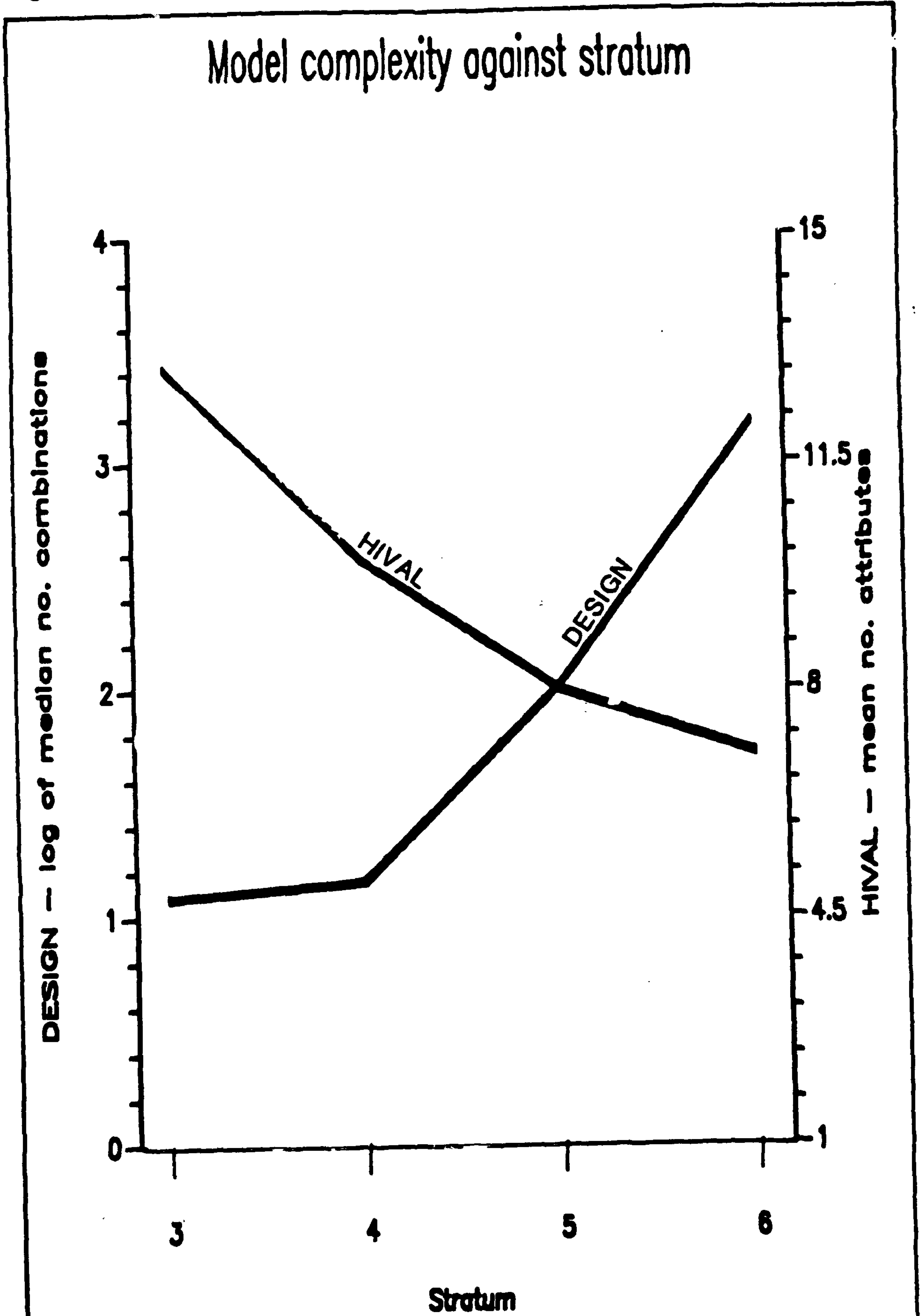

Role stratum of senior executive against size of group
12
9
6
3
0
11
9.9
8.3
Average group size
2–3
4–5
6–7
Stratum

Figure 4



Model complexity against stratum
DESIGN — log of median no. combinations
HIVAL — mean no. attributes
HIVAL
DESIGN
0
1
2
3
4
1
4.5
8
11.5
15
3
4
5
6
Stratum

As Figure 4 shows, the result for HIVAL models was as anticipated. Higher level executives produced simpler hierarchical evaluation models than their lower level counterparts.

However for DESIGN (resource allocation) models higher level executives tended to produce more complex models. It is again non-trivial to produce ready explanations for this reversal. We shall be looking to generate further confirming or disconfirming evidence for this finding from subsequent analyses.

For the moment explanations must remain only conjectural. It may be that the increased complexity of resource allocation models amongst higher level executives derives from the relatively larger number of budget categories over which they exert authority and accountability compared with less senior managers. This is open to empirical test. If this is the correct explanation it follows that the complexity within these resource allocation models should derive from the larger number of budget 'pots' defined, rather than from the number of spending strategies defined within each pot. This is one of the analyses planned for the next year of this project.

Whatever the correct explanation for this reversal the fact that in DESIGN models the stratum of the group is positively associated with the complexity of the model built is important because there is a clear tendency for increased use of the generic DESIGN structure at higher levels.

The above results and discussion concern managers' model building activities. Are there any discernible differences between managerial strata in the ways in which they manipulate these models once built?

This was investigated by distinguishing three types of manipulation of models which the management group may demand within the sensitivity analysis phase of decision conferences. These are firstly Changing Scores, where the group revises its judgements about evaluations of strategies on some dimensions of cost or benefit. The second type is Changing Weights, where the group wishes to test out the effect of revising its original assessment of the distribution of importance weight across the dimensions of the model. The third type is where the group wishes to make more fundamental changes to the model by not merely giving different values to its parameters but revising the parameters themselves. This we have called Restructuring the model and consists in such activities as adding/deleting/ redefining an attribute dimension or a strategy.

There are indeed marked differences in how managers at different levels in organisations question, modify and manipulate the problem models they construct. For convenience these differences are shown in Figure 5 by reference to just two strata: Stratum 4 representing the level of general management with responsibility for managing a business unit (or division) consisting of operating departments or sub-units, and Stratum 5 where responsibility is held for coordinating the efforts of a group of business units acting as an operating company (sometimes referred to as a Division in a multi-national or large corporation).

As Figure 5 shows, the principal difference between the stratum 5 and stratum 4 decision conferences is that the higher level managers in the former show a much greater tendency to engage in Restructuring modifications to their problem models than do those in the latter. There is a clear suggestion here that higher level managers are prepared to entertain more radically different conceptions of the problem at hand than that originally developed.

Restructuring in our sense here is a higher level cognitive activity than either Changing Weights or Changing Scores, involving modifications to the basic ideas through which the problem is grasped rather than simply 'What if?' revisions. To this extent then senior managers clearly exhibit a greater preparedness to undertake higher level revisions to their ideas, to rethink the basic conception or logic of the model than do their subordinates.

While for simplicity and ease of communication Figure 5 shows data only for managerial strata 4 and 5, comparison of strata 3 and 4 tells a similar story.

While it is premature to place too much weight on this finding, its potential significance is clear. If it holds up, and becomes more clearly focussed under further investigation, it opens the way to more detailed examinations of just what this restructuring capacity consists in. Under the assumption that it is desirable for this restructuring capacity to be more widely shared across the levels of organisations, this in turn may introduce the possibility at some future stage of designing methods for increasing the restructuring capacities of junior managers.

The results of analyses to date of the decision conference database material are summarised in Figure 6. The more significant of these have been discussed individually above.

One issue worthy of discussion is the apparent absence of any time span effect in these data. In the Jaquesian schema differential time span (defined as the length of time up to completion of a managerial task at which point a result of the manager's activities with respect to this task may be seen and his/her performance may be judged: Jaques 1976; Evans, 1977) is a defining characteristic of differential capacity. Since in every decision conference the team is required to agree time horizons over which the costs associated with the focal issue in the conference will be incurred and the benefits received, it might be anticipated that these time horizons may act as surrogate measures of time span of capacity.

If this were the case, an association between the stratum measures of senior executives in decision conferences in column D of the database in Appendix 1 and the agreed time horizons in column O should be expected. A glance at the data in these columns shows that there is no such association.

Does this constitute evidence against Stratified Systems Theory? This depends, firstly, on whether the issues and problems which form the focus of decision conferences are managerial 'tasks' in the Jaquesian

Types of sensitivity analyses for Strata 4 and 5
(restructure model, change weights, change scores)

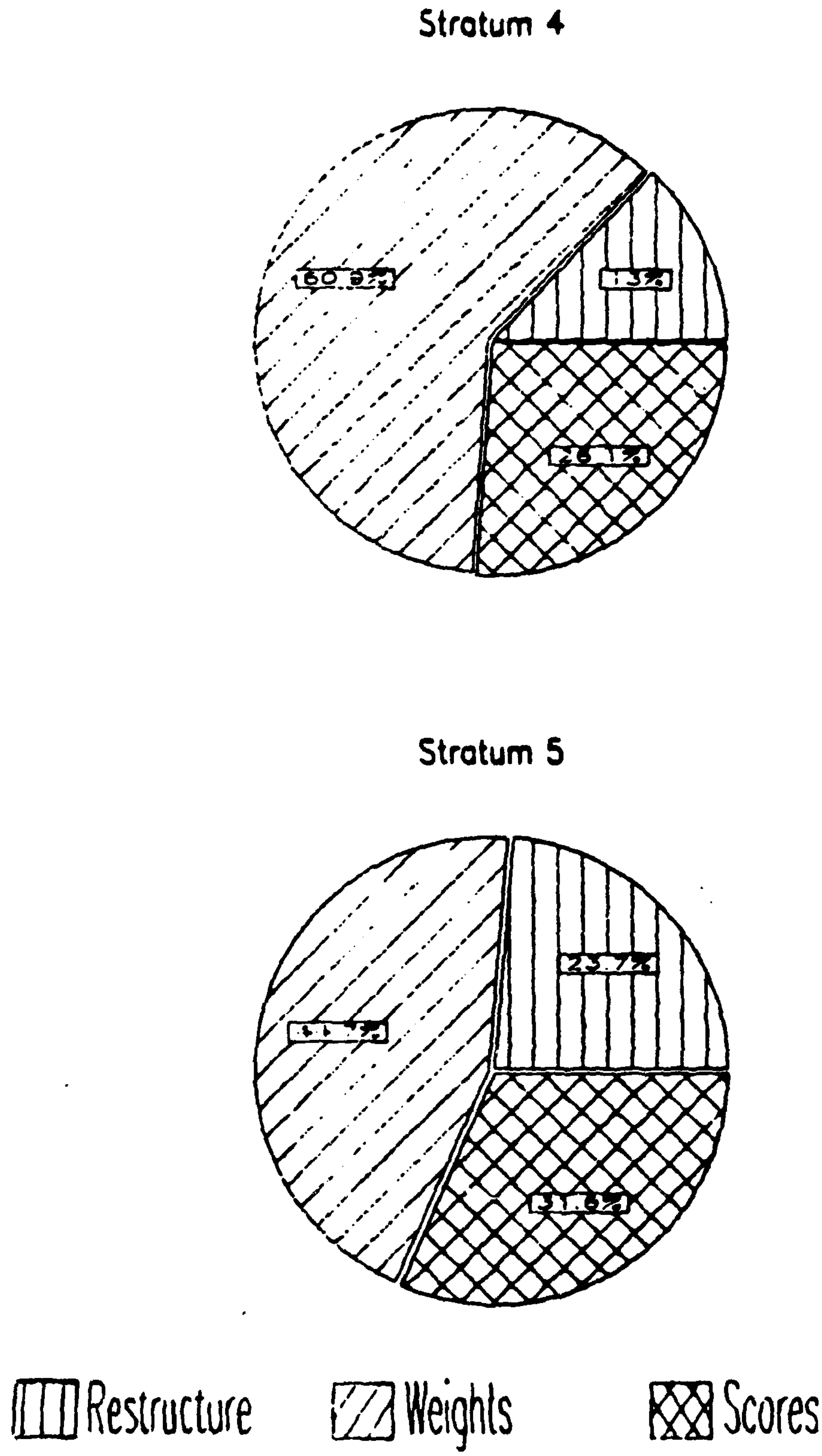


Figure 6

	Group size	Model complexity	Number of sensitivity analyses	Type of sensitivity analyses	Stratum of senior executives	Perceived success	Model type
Group size		1 ● Positive relationship	2 ● Positive relationship	3 No association	4 ● Negative relationship	5 No association	6 See cells 4 and 20
Model complexity			7 No association	8 No association	9 ● For HIVAL negative rel. For DESIGN positive rel.	10 No association	11 —
Number of sensitivity analyses				12 (Positive relationship)	13 Mild association?	14 ● Positive relationship	15 ● More sens. in DESIGN than HIVAL models
Type of sensitivity analyses					16 ● More restructuring and score revisions at higher strata	17 Mild association?	18 ● More score revisions in DESIGN
Stratum of senior executives						19 No association	20 ● Higher stratum → more DESIGN models
Perceived success							21 No association
Model type							

sense - that is, whether they are specific work units with specifiable target completion times, rather than more general managerial responsibilities. The issue is further clouded by recent suggestions of a 'time span compression' phenomenon (Cashman & Stroll, 1986), whereby the differential pace of change (in particular, technological change) across industries dictates the necessity and 'requisiteness' of shorter time horizons in some sectors compared to others.

A focus of the next phase of the current research, once a larger number of decision conferences has been added to the database, will be to differentiate them by industry sectors to investigate, on the one hand, whether any time span compression effect is discernible from one sector to another and, on the other, whether within sector any differential time horizons are associated with the stratum of the managerial group.

4. Results of investigation of decision conference themes

Several methodological advances over recent years in two critical areas have impacted the current study. The first is in the area of case study methods for studying unique situations emphasising the richness of the semantic material generated rather than relying on statistically based techniques. Methods of this kind are now becoming increasingly available.

The second is in text analysis methods (eg. Gallhofer et al., 1985), whereby means have been developed and applied for analysing a range of materials relevant to decision making situations. Interviews with decision makers, reports of decision making activities (for example, minutes taken during governmental meetings), and so on, have become analysable data which are of use for making inferences about the decision rules being applied and the substantive focuses and concerns of the decision makers. Also of relevance here are the process tracing studies of decision making by Svenson (1979), amongst others.

Ideas from these areas of methodological innovation have been adopted, adapted and extended in the current study for analysing a variety of decision conference-related materials - the notes taken during the conference by the several members of the decision analytic team, the report presented to the clients subsequent to the conference, and post-conference interviews carried out with participants.

Analyses of these materials have centred, first, on the features of the problem structuring debate amongst the group (which typically occupies the first half day of a two-day decision conference), and, second, on identifying themes preoccupying the groups. Each of these is reported in turn in the following subsections.

4.1 General features of managers' problem structuring debates

From current evidence two features characterise the problem structuring debate of higher level managers compared with their more junior colleagues. They are more focussed in that the issues raised in the debate will be less disparate, more directly relevant to the problem at hand, whereas in the debates of their subordinates a great deal of time and energy will be expended on expressing highly disparate concerns and dissatisfactions.

The problem definition eventually constructed and accepted by the group as a satisfactory basis for model development will also tend to incorporate and subordinate previously suggested problem definitions. With lower level managerial teams, on the other hand, the problem definition eventually arrived at will be unlikely to subordinate alternatives.

An example may help to clarify the concept of subordination, as it is being used here. In one particular decision conference with a senior management team concerned with launching a new product, an initial suggestion from one group member for how to define the problem they faced was that the decision concerned "the timing and phasing of the product launch". Considerable discussion followed this suggestion in which the group attempted to tease out what it was about this definition which was unsatisfactory. The re-definition eventually formulated which satisfied the group and enabled them to move onto modelling the problem was one concerning "the branding and positioning of the new product". In moving from the former to the latter definition the group had realised that the question of the timing of the product launch was just one aspect of the wider issue which spans not just when to launch, but also how to launch, package, advertise and retail the product.

At present of course this constitutes merely an initial formulation of a general feature by virtue of which stratum-specific differentiations may be made between management groups. This idea does not only need to be further tested but, even more importantly, further refined in the light of more data and analysis.

4.2 Specific predominant themes

The themes identified in the discussions within decision conference groups and the differential tendencies of groups at different levels to explore these themes are summarised in Figure 7, parts (i), (ii) and (iii).

The identification of these themes follows detailed inspection of all records emanating from a subset of 25 decision conferences (chosen to represent a fairly balanced sample of the various managerial levels and of industry sectors) by two judges separately. The judges' task was to identify similarities and differences between the preoccupations of the various groups, to group the conferences in terms of these various similarities and to generate labels or brief descriptions encapsulating the features by virtue of which the conferences were similar.

Before these findings become publishable, at least one more judge will be needed to undergo this exercise, and particular attention will need to be paid to measures of consistency between judges. At the present stage however, echoing our previous statements above, our primary concern is to develop fruitful first-stage ideas for further development in the next phase of our research, and not to rush into hasty publication.

Figure 7: Part 1

Themes

Stratum 3/4:

- Emphasis on programming of work for provision of goods and services
- Emphasis on environmental uncertainty
- Emphasis on interdependent collateral relationships with other units of company
- Tendency to perceive corporate head as unresponsive barrier to effective action
- Market oriented thinking

Figure 7: Part 2

Stratum 4/5:

- Emphasis on vertical relationships within company

- Emphasis on internal organisational concerns rather than direct market orientation

- Concern with trade offs in light of constraints from above

- Predominance of procedural uncertainty

Key words: trade off, control, balance, prioritize

Figure 7: Part 3

Stratum 5/6:

- Re-emergence of environmental uncertainty

- Concern with business definition for focussing whole company

- Emphasis on role of corporate head to give a lead, therefore shared meaning essential

- Emergence of psychological descriptors

- Concern with effectiveness of individual personnel

Key words: get a group judgement, focus, develop thinking

Included in Figure 7 are the summary labels/descriptions of the key concerns of decision conference groups as generated by our judges and agreed between them. These have been grouped into the three most commonly occurring management strata involved in decision conferences. Thus Figure 7 part (i) presents a summary of the themes prevalent in decision conferences in which the senior manager present is at organisational stratum 4 with his/her subordinates at stratum 3; part (ii) presents themes where the senior manager is at stratum 5 and other participants at stratum 4; in part (iii) the senior manager is at stratum 6 and others at stratum 5.

To clarify the meanings of these summary descriptions in Figure 7 examples of each of the themes are given below.

Examples of themes

Emphasis on programming of work: Stratum 3/4

"How to change production schedules in light of fact that business not growing at rate predicted."

Emphasis on environmental uncertainty: Stratum 3/4 and 5/6

"Inadequate perception of the market."
"Lack of knowledge of product development to project company into market lead."
"How will competitors react."

Emphasis on collateral relationships within the company: Stratum 3/4

"Coordination of business units with neighbouring markets."
"Developing effective relations with sales force."

Corporate head perceived as unresponsive: Stratum 3/4

"No central direction for our business."
"Corporate mission imposes a solutions approach without sufficient understanding of mass volume market."

Emphasis on vertical relationships within the company: Stratum 4/5

"Shortage of money allocated to Division for product development head count."
"Constraints on Divisions by Group."

Emphasis on internal organisational concerns: Stratum 4/5

"How can we shape the organisation to get done the things we're committed to and allow space for other opportunities."
"We need to control our own house."
"How can we turn a development Division into a business Division."

Concern with trade-offs in light of constraints from above: Stratum 4/5

"Goals are clearly stated, how do we get there?"
"Conflict between profit and growth."
"Since not enough money for everything, difficult to adequately support three businesses."

Predominance of procedural uncertainty: Stratum 4/5

i.e "How can we ...?" questions.

Concern with business definition for focussing whole company: Stratum 5/6

"What kind of business are we in?"
"Currently too much functional allegiance, detracts from what the business is about."
"Are we a broker or an insurance company?"

Emergence of psychological expressions: Stratum 5/6

"Need to change the company's mind set."
"Company value system."

Concern with effectiveness of individual personnel: Stratum 5/6

"He's a good man, we have to back him."

We are confident that, if the picture emerging so far through this analysis of themes holds up under further examination, it has some significant practical implications.

5. Implications

One example of such implications concerns the issue of information provision to managers within Decision Support Systems (DSS) and Group Decision Support Systems (GDSS).

The issue is important because it has become increasingly clear that for managers more information is not necessarily better. Rather information systems need to present focused information - only about the crucial issues, only as much as is necessary, at the right level of detail and in the appropriate form. As a result good design has become increasingly critical to the success of such systems. However, good design is hampered by the lack of knowledge of the specific information needs of managers.

A common (if not universal) view of the differing information needs of executives at various levels of organisations is that presented in Figure 8. The inversion of the information triangle suggests a simple picture of increasing need for external information (about environment etc.) as one ascends organisations and for internal information as one descends them.

The analysis of themes presented here suggests a more complex picture of stratum 4 and stratum 6 managers sharing an emphasis on external concerns, whereas managers at the intermediate stratum 5 focussing on internal factors and concerns. If this holds up under further analysis and if we are able to flesh it out through combination with other associated findings it may become possible to develop some prescriptions for critical features of stratum-specific information systems.

A variety of other potential implications emerge from this research. For instance, it is clear from Figures 1 and 2 that size of the group employing the GDSS will have an important impact on how it is employed. Consequently anticipated group size may prove to be an important design variable.

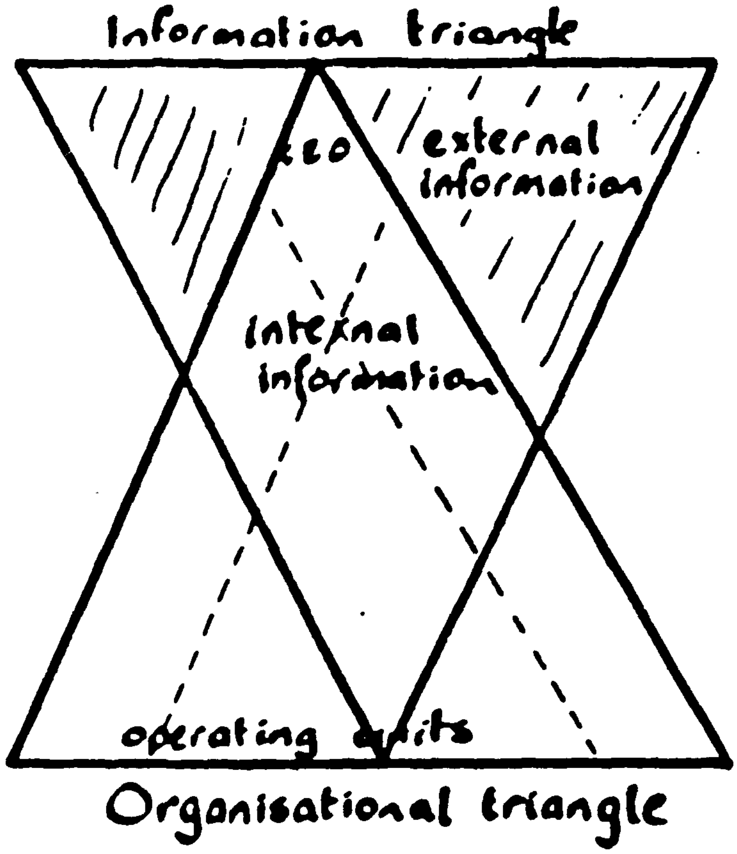
While group size effects are noted in the group problem solving literature, it is not at all clear <u>why</u> they occur. It may be that the nature of the interaction within the group is different for smaller groups (eg. up to 6/7 people). For instance it may be that smaller groups engage in less sensitivity analysis because for them the problem of developing a concensus is not so pressing as for larger groups.

Figure 2 also shows that typically more sensitivity analyses are carried out on DESIGN models than on HIVAL models. Why is this, and what implications for GDS developments does it have?

Certainly a typical DESIGN model will be more directly action oriented, tending toward evaluation of real, alternative courses of action, rather than, for instance, agreeing principles. This may suggest that models of aspects of a problem other than concrete actions and consequences will be less likely to generate intensive group work. From this point of view it appears that the type of modelling used in a GDSS may have substantial impact on group interaction. A fuller understanding of this impact would lead to some useful prescriptions for GDSS design.

Perhaps the most direct and immediate implication from this research is that deriving from the result reported in Figure 5. In a nutshell, any DSS must accomodate sensitivity analysis within structure; a GDSS operating at higher levels must accomodate and facilitate restructuring.

Figure 8: the information triangle



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APPENDIX: Decision Conference database.

Explanatory key for columns of database: those columns not included in this key are considered self-explanatory.

Column

G	H = HIVAL, D = DESIGN
H	Number of sensitivity analyses carried out upon HIVAL models
I	Number os sensitivity analyses carried out upon DESIGN models
J	Types of sensitivity analyses carried out: R = restructuring model S = changing scores (BS = benefit scores; CS = cost scores) W = changing weights in HIVAL model ACW = changing across criteria weights in DESIGN model WCW = changing within criteria weights in DESIGN model
K	Depth of decomposition of hierarchical structure in HIVAL models
L	Number of bottom level nodes in HIVAL hierarchy
M	Number of choice alternatives being evaluated on HIVAL hierarchy
N	Number of possible combinations (in thousands) of all levels of all variables in DESIGN model
O	Stated time horizon being used by group in assessment of benefits in model

	A Name	B Date	C Senior Exec.	D Stratum Senior Exec.	E No. in Groups	F No. Models	G Model Type	H No. Sess. HIVAL	I No. Sess. DESIGN	J Type Sess. R, S (R or C) W, ACM, MCM	K HIVAL: Tree Depth	L HIVAL: no. Atts.	M HIVAL: no. Options	N DESIGN: no. Combs. (K)	O Time Horizon	P Model Focus
1.																
2.																
3.																
4.																
5.		NOV 1/2 1983		6	6	1	D		5	CM,MCM,BS				3265173	3	Strategic invest review
6.		DEC 8/9 1983		4	7	1	D		6	MCM,BS,ACM				37	3	Market/Product
7.		JAN 16/17 1984		5	8	1	D		2	C&BS				23	3	Budgeting
8.		MAR 5 1984		6	15	1	D		4	R,BS					4	
9.		MAR 7/8 1984		5	11	1	D		3	C&BS,R,W,				260	3	How to grow
10.		MAR 27/28 1984		5	16	1	D		10	ACM,CM				105	3	Strategies for territories
11.		APR 17/18 1984		4	10	1	D		4	CS,MCM,BS,CM				30	3	Strategy for adaptation
12.		MAY 29/30 1984		6	13	1	D		15	R,ACM,MCM,BS,CS				45	3	Develop strength in market
13.		JUN 13 1984		5	12	1	D		14	MCM,ACM,BS				4	3	Market/Product
14.		JULY 10/11 1984		5	8	1	D		4	ACM				35832	3	RA to businesses
15.		OCT 29/30 1984		4	14	1	D		3	CS,CM,MCM				96	3	Product
16.		OCT 1/2 1984		5	9	2	H,D	6	4	W,S/ACM,BS	3	8	9	18	3	Objectives setting
17.		DEC 3/4 1984		4	11	2	H,D	0	7	R,ACM	4	15	6	2	2,3	Organisation
18.		JAN 17 1985		4	9	1	H	3		W	4	11	9		2	Market/Internal
19.		FEB 4/5 1985		5	12	1	D		0	S,ACM,MCM				38	6	RA to businesses
20.		FEB 11/12 1985		4	10	1	H	0		S,W	4	10	6		3	Reorganisation
21.		FEB 27 1985		4	7	1	D		4	ACM,MCM				3	5	RA business divs.
22.		MAR 4/5 1985		5	11	1	D		6	CS,ACM,MCM				212	4	RA to BCs
23.		MAR 8 1985		6	8	1	D		3	MCM,ACM				37	7	RA business divs.
24.		APR 1/2 1985		4	5	1	D		3	CS,BS,ACM					5	RA across products
25.		APR 22/23 1985		3	8	1	D		2	R,CS,ACM				.3	3	Team building
26.		MAY 2/3 1985		4	8	1	D		2	R,B&CS,2				103	3	Organisation
27.		MAY 20/21 1985		4	9	1	H	0			3	11	9		10	Product strategy
28.		MAY 23/24 1985		6	9	2	H,D	1	0	W	3	8	7	90700	4	Strategy
29.		JUN 3/4 1985		5	9	1	D		13	ACM,MCM,R,CS				30	7	Strategy
30.		JUN 25/26 1985		5	11	1	D		7	CS,ACM				140	3	RA following budget cuts
31.		JUL 2 1985		5	14	1	D		6	ACM,CS				120	3	RA following budget cuts
32.		JUL 2/3 1985		4	13	1	D		3	ACM				180	5	Prod. range positioning
33.		JUL 2/3 1985		4	5	1	D		3	ACM				504	3	Business plan
34.		JUL 8 1985		6	10	1	D		2	ACM,BS				2519	5	Strategy
35.		JUL 10/11 1985		5	12	2	H,D	2	6	W/R,ACM	4	12	8	288	3	Key markets, new ideas
36.		JUL 24/25 1985		3	9	2	H,D	3	0	W/	4	8	8	37	3	Strategy
37.		AUG 1/2 1985		5	8	1	D		10	R,CS,BS,ACM,MCM				7776	5	RA
38.		AUG 19/20 1985		4	11	1	D		12	ACM,MCM				4	6	RA
39.		SEPT 3 1985		6	7	1	D		2	ACM,MCM				.072	10	New product intro.
40.		OCT 8/9 1985		4	11	1	D		9	ACM,R				12	5	RA
41.		OCT 15/16 1985		5	9	1	H	0			3	4	7		3	Strategy planning
42.		OCT 26/27 1985		4	6	2	H,D	0	4	ACM	4	8	8	17	3	RA
43.		DEC 16/17 1985		5	10	2	H,D	2	5	W/ACM	2	9	6	9	4	Strategy planning
44.		JAN 6/7 1986		6	4	1	H	1		W	3	6	7		2	Assess computer needs
45.		JAN 14/15 1986		** NO MODEL DEVELOPED											7	
46.		JAN 16/17 1986		4	8	2	H,H	1,1		W	3,3	8,10	6,6		4	Strategy planning
47.		JAN 23/24 1986		4	11	2	H,D	3	3	W/ACM,BS,CS	4	12	7	14	2	Strategy planning
48.		FEB 4/5 1986		3	16	2	H,H	5,7		W,W	4,4	17,10	6,4		7	Market
49.		FEB 27/28 1986		6											3	
50.		AUG 4/5 1986		?	12	2	H,D	4	0	W	4	12	9	.06	4	Advertising spend

1. Key words
2.
3.
4.
5. invest for current bus & to extend in new areas
6.
7.
8.
9.
10. growth, profit, mkt share, increase orders
11. change agent, organisation, adapt
12. profit, mkt share, Div. organisation
13.
14.
15. how to, int. & ext. uncertainty
16. org'l instability, new mkts, how to
17. alloc res given tradeoff between Div and BC
18. mkt growth, product range, internal communication
19. sustained profit, RoI, rev
20. objectives, responsibilities, clarification, strat d
21. devt, spend levels, co.strat
22. tradeoff, strat direction, portfolio
23. priorities, corp devt, strat plan
24. exploit, resource constraint
25. focus, agreement
26. shopping list, focus, priority, control
27. agree strategy, communicate
28.
29. new mission, objectives, direct BCs
30. prioritize
31. agree a plan, prioritize
32. mkt growth, internal skills, uncertainty
33. evaluate, exploit, plan
34. define
35. plan, agree actions
36. agree, focus
37. rev, mkt share, growth
38. rev, profit, growth, targets
39. pace of new business, mkt position, change mindset
40. rev, profit, coordination, segmentation
41. objectives, how to implement, focus, direction
42. mkt share, growth, profitability
43. direction, bus plan, invest, competitive position
44.
45.
46. direction, image, org structure
47. direction, bus plan, mission, profitability
48. where are we now, where is mkt going
49.
50. grow mkt, price elasticity, lead mkt.

1. Miscellaneous
2.
3.
4.
5. 6 cost dims, 1 ben dim
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16. v difficult model devt
17.
18.
19.
20. model only served secondary function
21. DC for recommendation only
22.
23. working with model already structured
24. mixture of strat & tactics
25. v diff, boss kept disappearing, major group process intervention
26. senior manager not present
27. across co. problem, not all recomm actions implemented
28.
29. v difficult, participant said failure
30.
31.
32.
33.
34. follow on but with different people, JMW missed the morning
35.
36.
37.
38.
39. Ad agency and Brand Positioning Services represented
40.
41. a simple model was pushed through primarily to demo technique
42. RA model built on head counts not £
43.
44.
45.
46.
47.
48.
49.
50. Ad agency represented

Working Paper 88-1

Analysis of the stratum-specific information requirements and group interaction processes in "Decison Conferencing"

K J Chun

INTRODUCTION

The work described in this article has three main aims :

1. To provide a theoretical basis of "Decision Conferencing (DC)" as a requsite (see Phillips [39] ; [42]) Group Decision Support System(GDSS) for top executives in an organisation.

2. To find the different management information requirements according to the different management strata in an organisation. Therefore, the results of this research could be used to design effective and efficient stratum-specific computer-based decision aiding systems in an organisation.

3. To develop a better understanding of management decision processes in DCs in order to improve the specialists' understanding of how to aid them.

The first aim has been approached through theoretical investigation and has been dealt with in Part I. The second and third aims have been examined through empirical investigation and have been dealt with in Part II.

PART I

Various decisions can be thought of with respect to the structure that can be provided for making them. The structured, programmable decisions tend to be routine and frequently repeated ; the unstructured decisions tend to occur with less frequency and tend to be nonroutine. The unstructured decisions require decision makers to rely relatively heavily on their experiences, subjective judgments, and intuitions than do structured decisions.

The various definitions of DSS have one common characteristic. That is DSSs are designed for semi- and unstructured decisions. Thus, DSS must help the manager to make judgments, activate intuitive processes in decision making, and take decisions. But, many computing services and computer packages which have been sold under the name of DSS, have generally failed to support the manager to do so (see Alter[2] ; Humphreys & Wisudha[18]).

This fact suggests that we should develop "true" DSS for top executives in an organisation, who mostly engage in more discretionary activities, and in making more unstructured decisions than do those in lower strata.

One approach toward "true" DSS is Decision Conferencing (DC). It helps the manager to form sound judgments, clarify preferences and take decisions. One of the most exciting aspects of DC is its great potential for supporting intuitive processes in decision making.

PART II

The empirical basis for this research consists of records of managers' decision-making activities carried out in 47 DCs.

Analyses of records have revealed associations between on the one hand a variety of features of the group in DC and on the other, the characteristics of their information requirements, decision model construction, and manipulation activities. The implications are explored in Part II.

I have also tried to derive a formula to measure EQUITY and HIVIEW model complexity.

PART I

1. Why information system support for higher level managers in an organisation should be different from that for lower level managers

A system is generally composed of several sub-systems, one of which is the information system of the organisation. It has often been shown that the major role of sub-systems in an organisation is to cooperate together to achieve the mission of the organisation (synergism effect). Land and Kennedy-McGregor [29 ; 30] say that information system exists to generate, record, manipulate and communicate "signs"* necessary for the management activities which have to be carried out if the organisation is to accomplish its goals.

Anthony [3], who views an organisation through its hierarchy of decision making, classifies the management activities into three levels ; strategic planning level, management control and tactical planning level, and operational planning and control level.

The three levels of management activity can be differentiated on the basis of the planning horizon for each level. Strategic planning deals with long-range considerations. Management control and tactical planning has a medium-term planning horizon. And, operational planning and control activities are related to short-term decisions for current operations.

The decisions related to each planning horizon can be

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* SIGN is intended to be used in an all-embracing manner to include the numerical and alphabetical characters, words, sentences, messages of any length as well as all the actions which, through custom or convention, have acquired some recognisable interpretation. And, it affects a person's behaviour indirectly by conveying information to him or her, either consciously or unconsciously. (Stamper [51] ; [52])

thought of with respect to the structure that can be provided for making them. A highly structured decision can be preplanned or prespecified, whereas a highly unstructured one cannot. A structured decision can be said to be programmable, in the sense that unambiguous decision rules can be specified in advance. An unstructured decision is said to be nonprogrammable. The structured, programmable decision tends to be routine and frequently repeated ; the unstructured decision tends to occur with less frequency and to be nonroutine. Thus, unstructured decision contains uncertainty about how to represent the structure of the decision problem (how should consequences of courses of action be conceptualised, what other acts and events might intervene before consequences are reached, and so on).

The majority of decisions at the operational level are relatively structured and those at the strategic level are relatively unstructured, although the activities and information processing for the three levels are interrelated. Therefore, there is a marked contrast between the characteristics of information requirements for the strategic level and those for the operational level, with the management control and tactical planning level being somewhat in the middle (see Gorry & Scott [12] ; Humphreys & Berkeley [18]).

Given these differences, information system support for the strategic level (for unstructured decisions) should be quite different from that for the operational level (for structured decisions).

According to Phillips([40] ; [41]), the type of information systems appropriate to different levels within an organisation depends on the balance between discretion and rule-based work in particular job roles, because the shift in the way discretion is exercised from one level to the next alters the nature of decision support required.

2. Are true DSSs for top managers available now in the real world?

A recent report from International Data Corporation, "Requirements for Decision Support In The 1980s" [23], defines Decision Support Systems (DSSs) as the marriage between computers and management science ---- and focuses on the support such systems provide to managers working within different levels of an organisation, thus having different information requirements.

Although DSSs can be used for a wide variety of decisions from structured to unstructured, the decision support concept can be applied better to some types of decisions than to others (see Ahituv & Neumann [1] ; Davis & Olson [9]).

Keen ([24] ; [25]) claims that the concept of DSSs is based on several assumptions about the role of the computer in effective decision making :

(1) The computer must support the manager but not replace his or her judgment. It should ,therefore, neither try to provide the "answers" nor impose a predefined sequence of analysis.

(2) The main payoff of computer support is for semistructured and unstructured problems, where parts of the analysis can be systematised for the computer, but where the decision maker's insight and judgment are needed to control the process.

(3) Effective problem solving is interactive and is enhanced by a dialogue between the user and the system. The user explores the problem situation using the analytic and information providing capabilities of the system as well as human experiences and

insights.

Davis and Olson [9] argue that DSSs represent an approach to information system support for semistructured and unstructured decisions, that is different to that which is typically provided.

Sprague and Watson [49] define a DSS as "an interactive, computer based system which supports managers in making unstructured decisions".

The various definitions of DSSs above have one common characteristic. That is, that DSSs are designed for semistructured and unstructured decisions.

So, are the DSSs which have been proposed for use at the strategic planning level, usually requiring people to make unstructured decisions, available now in the real world ?

Based on <u>Stratified Systems Theory of Elliott Jaques*</u>, Humphreys [17] provides us with clear answers of the question above (see Table 1-1).

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* STRATIFIED SYSTEMS (or WORK STRATUM) THEORY

(Gould[13] ; Jaques[21],[22] ; Macdonald[34] ; Phillips[38] ; Stamp[50])

The theory sees organisational structure as a consequence of qualitatively different levels of work in organisations. It offers a particular view of the interactive dynamics between the needs of an organisation and the capabilities of individuals. In his theory, "work" is defined as the exercise of discretion within prescribed limits in order to achieve a goal within a maximum target completion time. And, organisational structure is seen as a consequence of the nature of work, which in turn is a reflection of human capacity to do work. The structure has up to eight levels or strata, with the boundaries between strata representing the demand characteristics of the tasks carried out by decision makers located at the various levels within the hierarchy of an organisation. Associated with the boundary between each stratum is what Jaques calls the "time span" as the measuring instrument for levels of work. This indicates how far away the decision horizon is set for tasks for which the decision maker is held responsible within the organisational context.

A full explanation of Jaques' Theory would need to describe the complete societal system involving the individual's relationships to other people, to the social system as a whole and on the physical and technical resources available. For the purpose of this paper ,however, it is sufficient to describe the demand characteristics of tasks at each stratum to derive the main implications for DSSs (see Table 1-1).

Note that the ideas of Stratified Systems Theory have been

Table 1-1 shows us that computer based information systems are readily available for strata 1 to 3. But, it also identifies an almost complete absence in practical applications of interactive systems with capabilities at stratum 4 and above (i.e. ability to handle the full complexity of discretionary activities in an integrated way).

Senior managers at stratum 4 and above are required to rely much more heavily on their judgment and intuition.

Managers at stratum 4 need to cover a number of subsystems involving a mixture of types of problems. Each subsystem has its own culture and structure. A DSS for stratum 4, therefore, needs to be able to handle concepts that encompass a variety of structures. A DSS for stratum 5 should help to articulate the principles that guide the setting of goals. As for strata 6 to 8, it is not even clear what would constitute a useful decision support aid to handle such complex dicretionary work.

Phillips [41] and Humphreys [17] argue that they know of no stand alone computer programmes or integrated systems in the mid 1980s aimed at aiding decision making activities represented at stratum 4 and above which have, so far, been successfully implemented.

Table 1-1 : Comparison of demand characteristics of tasks facing personnel having responsibilities at a given organisational level with structuring capabilities required in representing decision problems at that level

(characteristics of levels 8 to 10 can, in theory, be ascertained by extrapolation from levels 3 to 5 respectively)

	Level number	Organisational level in employment hierarchy. (stratum)	Time span inherent in problem representation at given level.	Demand characteristics of tasks facing personnel with responsibility at given level	Structuring capabilities required in representing decision problems at given level (decision support must also include capabilities at all lower levels).	Number of existing DSS incorporating support formalised at given level.
Socio-cultural decision making: goal-closed small worlds structured within cultures (in theory, up to level 10).	7	Chairman M/D of corporate group; head of large government department.	20-50 years	Anticipation of changes in sociological, technological, demographic and political development; leading corporate strategic development to meet them.	Isomorphic with level 2, except can conduct sensitivity analysis simulating changes in level 5 representations; assessing their impact within cultural structure.	None
	6	Corporate group/ sector executive.	10-20 years	Co-ordination of social and theoretical systems; translation of corporate strategic development into business direction.	Isomorphic with level 1, except each node is now a level 5 problem representation within fixed cultural structure.	None
Individual decision making under uncertainty: uncertainties and preferences structured within goal-closed small worlds.	5	Corporate subsidiary/ enterprise managing director	5-10 years	Problem not dealt with in context set wholly from above; can modify boundaries of business within policy i.e. define work system.	Articulation of principles for conditional (goal) closing of an open system, and/or re-opening of a conditionally closed system (e.g. through scenario generation).	None
	4	General management, (of e.g. development, production *or* sales, within work system).	2-5 years	Detachment from specific cases, seeing them representative examples of issues calling for development of a system.	Selecting/interfacing capability between structural types (requires use of problem structuring language).	Very few (prototypes)
	3	Department Managerial/ principal specialist.	1-2 years	Control of trend of tasks and problems arising. Extrapolation from trend to ways of formulating problems.	Re-structuring capability within single fixed structural type (e.g. attribute generation in multi-attribute model).	A few
	2	Front-line managerial/ professional.	3 months to 1 year	*Formal operational*, can anticipate changes in tasks due to any *one* of: demand, object, production resource, pathway, or pathway resource.	Manipulation of data on one variable at a time within fixed structure (e.g. sensitivity analysis).	Many
	1	Shop and office floor.	less than 3 months	*Concrete operational* limited to tasks concretely and physcially at hand.	Estimation of values at nodes within fixed structure (e.g. information retrieval system).	Many

Source : Humphreys [17]

3. The requisite DSSs for top executives in an organisation

These facts suggest we need to develop "different" DSSs from the usual ones, for senior managers at stratum 4 and above (managers at strategic planning level in Anthony's terminology), who mostly engage in more discretionary activities and in making more unstructured decisions than do those managers in lower strata.

As Milter and Rohrbaugh [35] explain, strategic level decisions are made in turbulent and uncertain organisational environments in which specific pieces of information can never reliably direct policy and programme choices. Typical applications of MIS and DSS do not ever begin to capture the full complexity of circumstances. Information most important to strategic level decision making may never be stored in a computer file. The use of formal systems is impeded by an executives' necessary reliance on "soft" and "volatile" information. Thus, it is unwise to attempt strategic decision making with only a limited range of quantitative data and a preprogrammed sequence of analytical techniques. In strategic decision making the challenge for executives, therefore, is to take advantage of the benefits of well-designed Management Information System (MIS) and DSS while making full use of their well-aided judgment and intuition.

Phillips ([41] ; [43]) argues that the true DSS for managers at higher levels (stratum 4 and above in Jaques' clarification) must support executives to use preference technology* and consist of three main parts :

---

* Preference Technology (Phillips [41] pp80-83)

When computers are used to help people form preferences, make judgments, and make decisions, the technique is called preference technology. Information technology is data oriented and concerned with the past and the present ; preference technology is judgment oriented and concerned with future.

(1) Decision makers and major problem owners.

The people who have informations and preferences relevant to the problem and who have some responsibilities for it.

(2) Computer system.

Hardware and software that facilitate modelling and sensitivity analysis ; decision makers and problem owners do not interact directly with the computer system but they monitor its output.

(3) Specialists, in the shape of facilitator and decision analyst.

They are experts in problem solving techniques who help the problem owners to formulate and structure the problems, express preferences and make judgments in quantitative form ; the facilitator does not ,however, tell the problem owners what to think. The analyst attends to computer modelling and assists the facilitator.

It is the integration of these three elements which is needed for true decision support for top executives.

Comparing his contention with Keen's concept of DSSs ([24] ; [25] ; [26]), we find that they coincide in all respects except one, that is, the interaction between the problem owners (user) and the system.

Phillips says that problem owners interact indirectly with the computer system through specialists. Whereas, Keen says that effective problem solving is interactive and is enhanced by a dialogue between the user and the system. The main difference between two arguments lies in the existence of specialists.

I think that this difference can be reconciled by adopting Moran's definition of User-System Interface (USI) and Smithson's argument about USI.

Moran [36] defines that the user interface is that part of a system that the user comes in contact with physically, perceptually or conceptually.

Smithson [47] argues that USI is between end-users and the computer based information system, in the shape of both computers and specialist personnel.

Combining Phillips' contention with Smithson's , I think that we can draw one figure as follows :

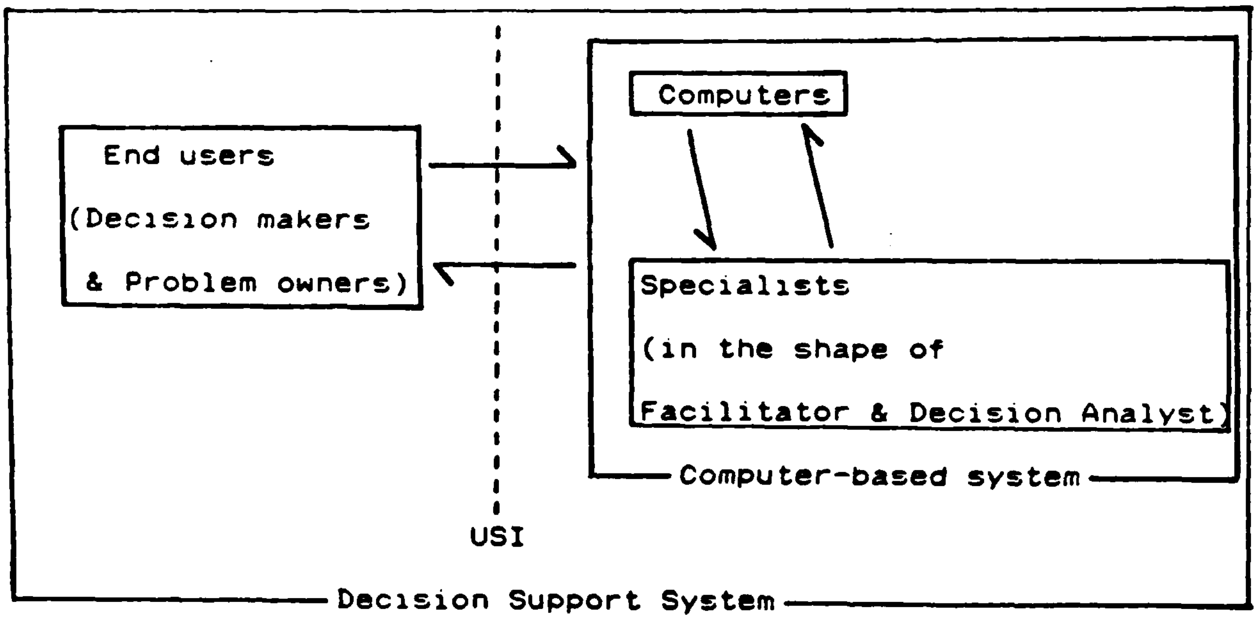


Fig. 1-1 : a requisite DSS for Executives

(Adapted from Phillips[41])

Based on this Fig.1-1, I would like to say that in a requisite DSS, problem owners do interact directly with the computer-based system, in the shape of both computers and specialists.

Note that as we shall see in the next chapter, Decision Conferencing is comprised of these two main parts : problem owners and computer-based systems, in the shape of computers and specialists.

4. Decision Conferencing

<Overview>

One approach toward the "true" decision aiding system for senior managers including executives at strata 4 to 8, which has been used successfully in a number of organisations is called Decision Conferencing (DC), Automated Decision Conferencing (ADC) (Quinn & Rohbaugh [45]) or Computer Supported Conference Rooms (Kraemer [28]). When people working in a group use preference technology, the collection of people, computers, and software becomes a Group Decision Support System (GDSS) [43]. Meanwhile, DeSantics and Gallupe[11] define GDSS as a combination of communication, computer, and decision technologies to support problem formulation and solution in group meetings. They also explain that the aim of GDSS is to improve the process of group decision-making by removing common communication barriers, providing techniques for structuring decision analysis, and systematically directing the pattern, timing, or content of discussion. Within the information-exchange view of group decision making, they suggest three approaches to supporting the group : Level 1, Level 2, and Level 3 GDSSs. According to their approaches, DC can be categorised as Level 2 GDSSs.

According to Milter and Rohbaugh [35], DC refers to computer-supported meetings in which several decision makers develop an explicit framework or structure for organising their thinking about an important, non-routine policy or programme choice. This framework does not pre-exist as an algorithm for computers (as in typical DSS) nor is the framework limited to the contents of a pre-existing database (as in MIS).It is an intensive two-day problem-solving session attended by a group of people who are concerned about some complex issues facing an organisation. It helps the manager to form sound judgments, clarify preferences and take decisions, not just to extract information and manipulate relatively limited models. Different perspectives of the participants are combined in one computer model that is generated on the spot, interactively with the group. By examining the implications of the model, then changing it to try out different assumptions, participants deepen their understanding of the problem and are helped to reach agreement about what to do.

<Purpose>

The purpose is to help a management group to develop fresh insights into problems, generate a shared understanding of the issues, and create a sense of common purpose. In other words, it is to make a decision that will be implemented.

<Foundations of DC>

DC draws on experience and research from three disciplines : decision theory, group process, and information technology [44].

(1) Decision theory

This contributes the development of the model, ensuring its internal consistency, so that subsequent changes to one part of the model do not require alterations to other parts that are considered satisfactory.

(2) Group process

Research on group process has identified conditions and situations that increase the ability of groups to solve problems effectively. Knowledge of group process is used by the facilitator to help the group achieve its goals.

(3) Information technology (IT)

IT in the form of a computer, computer programmes and a projection system allows the model created by the group to be implemented on the spot, and provide the means for immediately showing the results. Thus, participants can try out different judgments, see the results without delay, and so modify their views or the model until a satisfactory representation of the problem is obtained. Intuitions and experiences play important roles in decision making, and IT helps to make these factors explicit.

<Three components of DC>

DC is comprised of problem owners and a computer-based system in the shape of computers and specialists.

(1) Problem owners

They contribute to the vital ingredient : content.

(2) Computers

Computer modelling is used to put together all the pieces of the problem in one framework and to show the problem owners the implications of their judgments.

Two software programmes, HIVIEW and EQUITY developed by Dr.Barclay,S. ([8] ; [19]), are used for DC.

HIVIEW(formerly HIVAL) assists the user in evaluating several alternative options in the face of many evaluation criteria. It enables the user to arrange a large number of criteria in a hierarchical fashion. Creating a hierarchy of evaluation criteria is advantageous, because it enables the user to disaggregate highly complex problems and generate criteria into their measurable components. The user systematically judges on each criterion the relative value of each alternative, bearing in mind the value of each criterion to the whole. HIVIEW performs the necessary structuring, elicitation, calculation, display, and editing as the analysis progresses.

EQUITY(formerly DESIGN) facilitates the systematic allocation of resources among a variety of expenditure items, such as competing projects, purchases, or system components. It assists decision makers in making efficient allocations for their limited resources. The first step is to define the competing projects or purchase items, identifying several levels of expenditure for each, ranging from the least costly to most costly. Next the cost of each level and the benefit of each level is assessed (either may be assessed on multiple dimensions), and the relative benefits of the alternative budget categories determined. Once the model has been structured and the values entered, EQUITY identifies the set of efficient allocations from all of the possible allocations, that is the set of allocations which have the maximum benefit for a given level of cost, and the minimum cost for a given level of benefit.

HIVIEW and EQUITY are available in the following form [8] :

IBM-PC, XT, AT, or compatible

Requires MS-DOS 2.1 or later, at least 320k RAM, a colour graphics card (CGA or EGA), a microsoft compatible mouse, and an IBM Graphic printer, an Epson FX printer, or an HP Thinkjet.

(3)Specialists : facilitator and decision analyst

Phillips ([41] ;[43]) argues that true decision support for top managers requires the services of specialists in problem formulation and solution through computer.

The facilitator helps the participants to structure their discussion, think creatively and imaginatively about the problem, identify the issues, model the problem and interpret the results. The decision analyst attends to the computer modelling and helps the facilitator.

<Stages in DC>

1. Initial introduction by the facilitator

2. Group is asked to discuss the issues and concerns that are to be the subject of exploration.

- An attempt is made to formulate the nature of the problem
- Evaluating alternative plans, ventures, systems, bids, or projects may be required, especially if objectives conflict.

3. Model construction

This is usually a simple, though not simplistic, representation of the group's thinking about the problem, with the form of the model drawn from decision theory and the content contributed by the participants. Both data and subjective judgments are then added to the model, and the computer output is projected onto a large screen so all participants can see.

4. Modifications

These initial results are rarely accepted by the group. Modifications are suggested by the participants and different judgments are tested. Many sensitivity analyses are carried out, and gradually intuitions change and sharpen as the model goes through successive stages. Eventually this process of change stabilises, the model has served its purpose, and the group can turn to summarising the key issues and conclusions.

5. Action plan

An action plan is created so that they can begin to implement the solution to the problem.

<Benefits of DC>

1.Great potential for supporting intuitive processes in decision making

Taggert and Robey's research [54] on the human brain demonstrates that the two hemispheres undertake quite distinct information processing activities : the left cerebral hemisphere is characterised by rational, sequential, and analytic processes ; while the right is characterised by intuitive, simultaneous, and holistic processes. While everyone at various times uses both sides, most people, because of their educational background and unique experiences, tend to emphasize one or the other.

Because of the inherent characteristics of the computer and the tendency for analysts and programmers to prefer analytic decision styles, computer based information systems have historically emphasized analytic approaches when supporting organisational decision making [60].

However, Issack [20] argues that many successful managers and executives seem to favour intuitive processing.

One of the most exciting aspects of DC is its great potential for supporting intuitive processes in decision making. The model developed in DC lends structure to thinking, and so allows all perspectives on a problem to be represented and discussed. The process facilitates communication (sometimes, constructive challenge) among participants, providing "a way to talk differently" [16], as one person put it. It brings out assumptions that are often different from one person to the next.

Because the model developed by the group shows what the organisation can do, rather than just describing what it does, creative and lateral thinking is encouraged.

2. Agreement can be reached much more quickly.

3. It helps a group to gain a commitment to action.

4. It allows decision makers to take a more balanced view of complex problems.

5. Even if Turoff and Hiltz [56] argue that high satisfaction and high decision quality cannot be simultaneously achieved, DC can ,at least, facilitate acceptable decisions (if not optimal ones) to the participants. So, it gives shared satisfactions to them.

In practice, organisations which have used DC say that it helped them to arrive at a better and more acceptable solution than they would have achieved using their usual procedures [16]. But, DC is not a panacea.

<Limitations> [35]

1. There are times when DC is not appropriate. For example, when problems emerge in crisis situations and require an immediate, intuitive decision, there is no time for any kind of analysis or explicit process.

2. Many problems are simply not important enough to justify two days of executive time.

3. DC is not likely to be very effective if there is no authority structure or if some participants are interested in sabotaging the process.

PART II

Aims of the Empirical Research

1. The first aim of the analysis of DCs described in this part is to find different management information requirements, according to the different levels in an organisation.

Therefore, the results of this research could be used to design effective and effcient stratum-specific computer-based information systems in an organisation. There is a growing body of opinion claiming that the main rationale for building expensive cooperative computer-based information systems is not to get the invoices out on the time, or to help reduce stock levels to a bare minimum. Rather, it is to ensure that the right information gets to the desk of the right manager at the right time.

2. The second aim is to develop a better understanding of group processes in DCs in order to improve specialists' understanding of how to aid them.

Thousands of studies of group process have been conducted over the last several decades (see Hare[15] ; McGrath & Altman[33]). Roughly, the conclusions of these studies can be divided into two main views : the pessimistic view and the optimistic one.

The researches of pessimistic view (see Davis[10] ; Lorge, Fox, Davitz, and Brenner[31] ; McGrath & Altman[33] ; Shaw[46] ; Steiner[53] ; etc.) have shown, for example, that for many tasks the pooled output of noninteracting individuals is better than that of an interacting group. Whereas, the researches of optimistic view ("assembly effect bonus" of Collins & Guetzkow[7] ; "brain storming" of Osborn[37] ; "team building activities" of Argyris[4] ; etc.) have shown that the human resources present in groups can, in fact, be harnessed and directed toward more effective performance than would be obtained from individuals alone.

Regardless of view point, most researches (for example, Borgatta & Bales[5] ; Taylor & Faust[55] ; Ziller[59] ; etc.) that involve analysis of group process have hitherto taken place in laboratory settings and use methodological strategies consistent with paradigmatic experimental social psychology. Hackman and Morris [14] suggest that various methodological tools and research strategies typically used in studies of group effectiveness may severely limit the kinds of understandings that can emerge from that research. Because group tasks and group norms are held constant in experimental studies of groups, it is nearly inevitable that the richness and diversity of interpersonal behaviour within groups will be reduced substantially.

However, for reasons to be suggested below, the richness and diversity of interaction within groups are assured in DC.

* No laboratory-settings

Only real, live and complex organisational problems are dealt in DC. In other words, DC does not i) take place in laboratory settings, ii) use methodological tools and research settings, and iii) prespecify tasks.

* It allows the variance of group norms.

In most cases, the participants in each DC have worked together for a certain time in one organisation. The group in each DC, therefore, has its own unique normative structure. Thus, the norms of a group participating in each DC are likely to vary much from DC to DC.

* Encouragement of interaction within group

The process in DC facilitates interaction (sometimes, constructive challenge) among participants, providing "a way to talk differently", as one person put it. It bring to the surface assumptions that are often different from one person to the next.

Because of these reasons, I think that the research of group process in DC can, if carefully studied, have the likelihood of obtaining more meaningful empirical correlates of group process measures than have those researches carried out hitherto.

Research method

The empirical basis for this research consists of records of managers' problem formulation and solution activities carried out within 47 DCs which were conducted by the Decision Analysis Unit (DAU) at LSE.

A variety of relations between the various features on these Conferencings has been investigated. A copy of the whole data of 47 DCs which constructed 34 EQUITY models and 16 HIVIEW models, is included as Appendix 1 in my Master's dissertation[27].

Following is a list of the relations between the various types of data on the DCs investigated in the dissertation :

*. Different preferences of participants for their various goals against their strata i.e., Across Criteria Weights in benefit criteria (in EQUITY model) against participants' strata.

*. Influential factors to model complexity.

*. Sensitivity analysis against group size.

*. Type of sensitivity analysis against participants'strata.

*. Sensitivity analysis against model complexity.

*. Group size and participants' strata.

1. How to measure EQUITY and HIVIEW model complexity

The rationale for the identification of model complexity may be :

1) to investigate the effect of human factors in DCs such as group size, strata of participants, etc. on the model construction.

2) to investigate the association between model complexity and human decision processes in DC such as number of sensitivity analyses, type of sensitivity analysis, etc.

So, What makes participants in DC feel the complexity of structuring their problems through the EQUITY model ?

Participants are required to evaluate several alternative strategies in the face of various evaluation criteria, through assessing Scores and Weights. Because most of the Scores and Weights are not only human judgments but also relative scales, participants may feel that assessing them is c_mplex. -----"A"

It is natural that human beings find more complexity in comparing, say, ten strategies in the face of a given evaluation criterion and assessing relative scales to those strategies than in doing so with, say, just two strategies. Thus, it is not unreasonable to assume that the more criteria, variables, and strategies we have, the more complexity we may find in constructing the model. ---"B"

The figures in cost criteria are based on real and absolute figures. Thus there are no Within Criterion Weights among the variables and in most cases, the same Across Criteria Weights are given to various cost criteria. Therefore, they have little to do with the Changing Weights activities. The number of cost criteria in various DCs is usually from 1 to 3, whereas the number of benefit criteria is usually from 1 to 7.

Considering the rationale for model complexity mentioned at the beginning of this chapter, I think the features of cost do not make any distinct difference in measuring the EQUITY model complexity amongst various DCs.

In the case of benefit, however, all of the figures in every criterion in the face of several alternative strategies are on relative scales, thus Within Criterion Weights among several variables in each criterion, as well as Across Criteria Weights among various benefit criteria are required to be assessed.

Thus, for the purpose of simplicity, I assume that EQUITY model complexity can be well explained by the features of benefit rather than those of cost. ----- "c"

Based on the three assumptions "A","B", and "C" above, I think that there are three elements which make participants feel complexity in constructing EQUITY model :

1) The number of Scorings participants have to assess

The greater the number of Scorings participants have to assess, the more complex they may feel the process of constructing the model is. The number of Scorings participants have to assess is determined by the number of strategies in variable i, the number of variables, and the number of criteria.

Thus, the number of Scorings =

1st criterion in benefit : no. of strategies in variable 1 + no. of strategies in variable 2 + ······ + no. of strategies in variable N

\+

2nd criterion in benefit : no. of strategies in variable 1 + no. of strategies in variable 2 + ······ + no. of strategies in variable N

\+

⋮

\+

mth criterion in benefit : no. of strategies in variable 1 + no. of strategies in variable 2 + ······ + no. of strategies in variable N

$$= \sum_{i=1}^{N} S_i \times m$$

S_i: number of strategies in variable i
N: number of variables
m: number of criteria in benefit

2) The number of Within Criterion Weights participants have to assess

The more variables participants have, the more complex they may find the process of assessing Within Criterion Weights. And, they have to assess Within Criterion Weights for every benefit criterion. So, the complexity in assessing Within Criterion Weights, which is found by participants can be expressed as follows :

$$N \times m$$

N: number of variables
m: number of benefit criteria

3) The number of Across Criteria Weights participants have to assess

The complexity found by participants in assessing Across Criteria Weights is dependent on the number of criteria. For example, participants may find more complexity in assessing Across Criteria Weights with ten criteria than doing so with, say, just two criteria.

Thus, the complexity of assessing Across Criteria Weights which are found by participants can be expressed by the number of criteria :

m (in here, number of criteria in benefit)

When we want to measure the complexity of the EQUITY model, we should sum these three elements, because they exist independently (it means that people cannot assess Scores, Across Criteria Weights, and Within Criterion Weights at the same time) and also affect together the complexity participants feel when they construct and evaluate the model.

Therefore, the equation of the complexcity participants find in constructing the EQUITY model can be as follows :

$$\sum_{i=1}^{N} S_i \times m + N \times m + m$$

$$= m\left(\sum_{i=1}^{N} S_i + N + 1\right)$$

m: number of criteria in benefit
S_i: number of strategies in variable i
N: number of variables

For the same reason,a measure of HIVIEW model complexity can be drawn from the number of attributes multiplied by the number of options.

2. Different preferences of participants for their various goals against their strata in an organisation i.e., Across Criteria Weights in benefit criteria (in EQUITY model) against participants'strata

Various benefit criteria in the EQUITY model represent the goals of participants in DC. And, different Across Criteria Weights among these benefit criteria represent the relative preferences of participants for their goals. Because Across Criteria Weights reflect the relative importance of the criteria ; the relativity of the number should be emphasised during the assessment process because people have a tendency to try to judge these in an absolute way, whereas they only reflect the value difference between the most and the least preferred strategies[44].

During my survey of 48DCs which developed 34 EQUITY models for their problem formulation and solution, I thought that various benefit criteria could be classified into two categories ; "hard" criteria and "soft" criteria.

"Hard" criteria usually include :

1) profits

2) revenue growth

3) short term financial goal (Sometimes, the term of financial goal has been used for representing profit and revenue growth together)

4) cost reduction

5) improvement of product quality and productivity.

"Soft" criteria usually include :

1) future potential - the potential for generating other benefits including profits and revenue in the longer term.

It is important to include future potential as a long term objective because it is possible over a short period to milk a bussiness for short-term profit and revenue, leaving it so weak that it is unable to generate other benefits including profit and revenue in the longer term ([44] ; [58]). Thus, it has something of a "trade-off" relationship with the short-term profit and revenue growth.

2) Risk (sometimes expressed as Safety-the inverse of risk)
It is the perception of risk measured by the probability of acheiving the benefit values for each level. It is a combin ation of regret and probability.

3) Synergy (sometimes Fit)

i) fit with the firm's strategic mission

ii) potential for synergy with other business

iii) a measure of the pull through business dependent on the area being considered.

4) Flexibility

It is judged by testing a particular set of strategies against the different scenarios.

5) Innovation

It is the search for future discontinuties. And it seeks the means to exploit them.

6) Customer satisfaction

7) Improvement of decision making

8) Leadership

9) Fun and Image

As Table 2-1 shows, higher stratum managers give more preferences on "soft" criteria than do those in lower stratum .

Table 2-1 : Normalised proportions of management preferences in benefit criteria against strata
(adapted from Appendix 1 in [27])

Stratum	hard criteria	soft criteria
6	39 %	61 %
5	55 %	45 %
4	58 %	42 %

For the purpose of cross-checking, the number of hard and soft criteria which were given the highest weights are examined, too.

The results show same phenomena ; higher stratum managers give the highest weights on one of the soft criteria more than do those in lower stratum (see Table 2-2)

Table 2-2 : The number of hard and soft criteria which were given the highest weights against strata
(adapted from Appendix 2 in [27])

stratum	hard criteria	soft criteria	balanced
6	2 (29%)	4 (57%)	1 (14%)
5	4 (45%)	3 (33%)	2 (22%)
4	6 (67%)	3 (33%)	

The next finding may be more interesting than the former one. As we defined above, the term of future potential has something of a trade-off relationship with short-term profit and revenue growth (sometimes, expressed as a short-term financial goal). Let's see the relationship between these two criteria against participants'strata. Note that these criteria are regarded as the most important concerns by the participants in every DC, because as we can see in Table 2-3, the normalised proportions of the weights of these two criteria to the sum of across weights over the benefit criteria are more than 80 %.

Table 2-3 : Comparison of participants' preferences between short term financial goal and future potential against their strata
(Abstracted from Table 2-6 in [27])

strata	proportion of the weights given to STF to the sum of ACW in benefit criteria	proportion of the weights given to future potential to the sum of ACW in benefit criteria
6	37%	40%
5	55%	34%
4	58%	31%

STF : short term financial goal
ACW : across criteria weights

As Table 2-3 shows, the higher stratum managers increase their concerns on future potential and decrease their concerns on short term financial goal, whereas the lower stratum manager are vice versa.

We can easily expect that longer-term objectives include more risk than do short-term objectives. Then, what is the relationship between risk and strata ? In my survey, there were 7 DCs with stratum 6, 9 DCs with stratum 5, and 9 Dcs with stratum 4, which developed EQUITY model. The number of DCs which included risk as one of benefit criteria are as follows : 4 out of 7 with stratum 6 , 2 out of 9 with stratum 5 and 1 out of 9 with stratum 4.

Thus, we can say that higer stratum managers concern with longer term objectives and regard risk as one of their crucial concerns more than do those in lower stratum.

In conclusion, higher stratum managers give more preferences on "soft" goals than on "hard" goals, increase their concerns on future potential and at the same time decrease their concerns on short term financial goal, and include risk as one of their crucial concerns more than do those in lower stratum.

These findings may suggest that it is necessary for an organisation to develop stratum-specific information systems.

3. Influential factors to model complexity

As shown in Table 2-4 there appears to be an almost no effect of stratum on the complexity of the model developed.

Table 2-4 : Model complexcity against stratum
(adapted from Appendix 1 in [27])

stratum	model complexity (mean value)	
	EQUITY	HIVIEW
6	122	104
5	146	87
4	136	132
3	_	73

Again, it seems to me that group size has very little effect on the complexity of the model developed ('see Table 2-5).

Table 2-5 : Model complexity against group size
(adapted from Appendix 1 in [27])

group size	model complexity in each Decision Conferencing	mean of model complexity
EQUITY		
16-19	67,180,280	176
12-15	39,43,123,140,164,188,196	128
8-11	24,38,62,95,96,102,123,123,126, 140,155,156,159,196,258,309,315	146
4-7	34,49,83,84,93,154	83
HIVIEW		
16-19	40,102	71
12-15	33,108	71
8-11	51,60,72,102,108,175	121
4-7	77,120,143,144	121

Note that, in case of HIVIEW, Table 2-5 shows mild negative relationship between the complexity and the group size. But, as we see from Table 2-5, the available number of the data for the group size 12-15 and 16-19 are just two. So it seems to me that it is unreasonable to lead to generalisations that HIVIEW model complexity has a negative relationship with group size.

Then, what are the major influential factors to determine the model complexity ?

To find this, two cases of DC in same stratum will be compared :

	case "A"	case "B"
Date :	6 May 1986	30,31 Oct 1985
Group size	10	8
Stratum	6	6
Complexcity	62	140
Model	EQUITY	EQUITY

Despite of bigger group size, case "A" generated simpler models than case "B".

Why ? There were "soft" reasons during the DC of case "A". Because of the time constraint (only one day was available at that time), only two benefit criteria were assumed to be used in case "A".

These results has forced me to think that model complexity may be more dependent on "soft" factors (such as circumstance constraints and atmosphere during DC, attitude and willingness of participants to contribute to model construction etc.) than on just "hard" factors (such as group size or participants' strata).

4. Sensitivity ananysis against group size

As shown in Table 2-6 below, there is a strong tendency for larger groups to investigate the implications of both models more thoroughly through more comprehensive sensitivity analyses.

Table 2-6 : Number and type of sensitivity analysis against group size (adapted from Appendix 1 in [27])

EQUITY — no. of models : 34

group size	no. of S.A. in one DC (mean value)			total no. of S.A.
	R	W	S	
16-19	2.7(15%)	8.7(49%)	6.3(36%)	17.7(100%)
12-15	0.5(5%)	7.1(67%)	3.0(28%)	10.6(100%)
8-11	1.1(15%)	4.1(54%)	2.4(31%)	7.6(100%)
4-7	0.3(7%)	3.0(65%)	1.3(28%)	4.6(100%)

HIVIEW — no. of models :11

group size	no. of S.A. in one DC (mean value)			total no. of S.A.
	R	W	S	
16-19	0.5(6%)	5.0(56%)	3.5(38%)	9
12-15	1.0(14%)	4.3(61%)	1.7(25%)	7
8-11	0.6(12%)	3.5(71%)	0.8(17%)	4.9

S.A. : Sensitivity analysis
R : Restructuring
W : Changing Weights
S : Changing Scores

Meanwhile, in his early study about the group performance, South [48] suggested that the judgmental tasks required the group to reach a compromise ; to the extent that more discussion is needed in order to reconcile a wider variety of initial opinions. Under the belief that larger groups are likely to embody more and more diverse perspectives, the results of Table 2-6 supports South's suggestion.

One thing may be interesting from Table 2-6 is that there seems to be no consistency in the type of sensitivity analysis* against group size.

It seems, therefore, to me that group size has a positive effect on the number of sensitivity analyses, whereas it has no association with the type of sensitivity analysis in both models (EQUITY, HIVIEW).

---

* TYPE OF SENSITIVITY ANALYSIS
(Stuart Wooler [57])

This is about distinguishing three types of manipulation of models which the management group may demand within the sensitivity analysis phase of DC.

There are three types :

1) Changing Scores, where the group revises its judgments about evaluations of strategies on some dimensions of cost or benefit.
2) Changing Weight, where the group wishes to test out the effect of revising its original assessment of the distribution of importance weight across the dimensions of the model.
3) Restructuring the model, where the group wishes to make more fundamental changes to the model by not merely giving different values to its parameters but revising the parameters themselves. It consists in such an activities as adding/deleting/redefining an attribute dimension or a strategy. This is a higher level cognitive activity than either Changing Weights or Changing Scores.

5. Sensitivity analysis against participants' strata

As we can see in Table 2-7, higher stratum managers show a tendency that they maintain balance among Restructuring, Changing Weights and Changing Scores in revising their models more than do those in lower levels. Whereas, lower stratum managers rely too much on just one type of sensitivity analysis(Changing Weights) in revising their models. And in doing this, higher stratum managers steadily increase the proportions of Restructuring and Changing Scores as part of the total of sensitivity analyses.

Table 2-7 : Number and type of sensitivity analysis(S.A.) against participants' strata (adapted from Appendix 1 in [27])

no. of models : 45

Stratum	no. and type of S.A. in one DC (mean value)			total no. of S.A.
	R	W	S	
6	1.1(13%)	4.3(52%)	2.9(35%)	8.3(100%)
5	0.9(11%)	4.5(54%)	2.9(35%)	8.3(100%)
4	1.1(10%)	6.6(64%)	2.6(26%)	10.3(100%)

It means that higher stratum managers engage more in revising their judgments about evaluation of strategies on some dimensions of cost or benefit and in adding/deleting/redefining benefit, cost criteria or strategies than do those in lower stratum. And, lower stratum managers mainly concentrate in testing out the effect of revising its original assessment of the distribution of importance weights across the dimensions of the model. Note that stratum, however, appears to have no association with the number of sensitivity analyses.

6. Sensitivity analysis against model complexity

To find any association between model complexity and the number of sensitivity analysis, I used computer based regression modelling as well as graphic presentation (Part II-8 in [27]). Results of both methods show that there seems to be no association between model complexity and the number of sensitivity analyses.

7. Group size and participants' strata

Two approaches are used for the purpose of cross checking of the relationship between strata and group size : one is the effect of group size on the stratum and the other is the effect of the stratum of participants on group size.

As we can see in Table 2-8, there seems to be no consistent effect of group size on the stratum of participants.

Table 2-8 : The stratum of participants against group size (adapted from Appendix 1 in [27])

group size	no.of DCs comprised of stratum i					average stratum
	6	5	4	3	total	
16-19	1(25%)	1(25%)	1(25%)	1(25%)	4(100%)	4.5
12-15	2(22%)	3(33%)	4(45%)	.	9(100%)	4.8
8-11	8(36%)	7(32%)	7(32%)	.	22(100%)	5.1
4- 7	1(9%)	1(9%)	7(64%)	2(18%)	11(100%)	4.1
Total	12(26%)	12(26%)	19(41%)	3(7%)	46(100%)	4.7

CONCLUSIONS

Analyses so far indicate that :

1. Higher stratum managers give more preferences on their "soft" goals than on "hard" ones, increase their concerns on future potential and at the same time decrease their concerns on short term financial goals, and include risks as one of their crucial concerns more than do those in lower strata.

2. The group size shows a positive effect on the number of sensitivity analyses, whereas it appears to have no association with the type of sensitivity analysis in both models (EQUITY, HIVIEW).

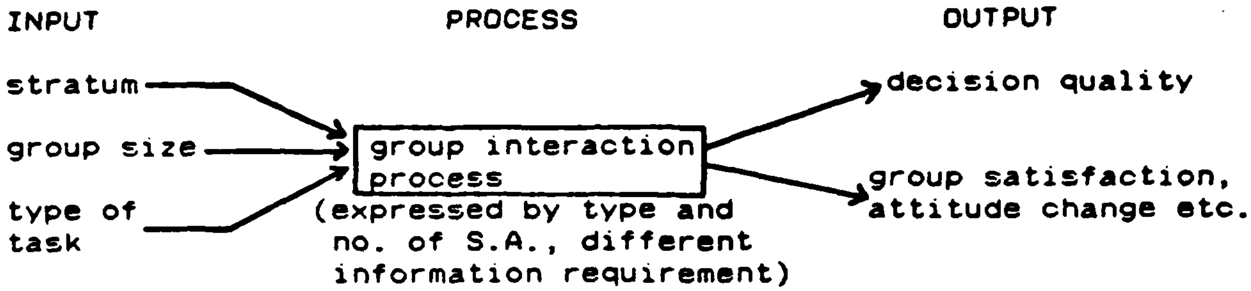
3. Stratum has an effect on the type of sensitivity analysis ; higher stratum managers maintain their balance in revising the models through increasing the proportions of Restructuring and Changing Scores as part of the total of sensitivity analyses. Whereas, lower stratum managers rely too much on just one type of sensitivity analysis (Changing Weights) in revising their models.

On the basis of this riview it is apparent that stratum has significant effects on the specific information requirements, and on the revision of their problem formulation and solution. Thus, it is necessary for an organisation to develop its own stratum-specific information systems.

Group size has effects on the nature of group interaction process in terms of the number of sensitivity analysis. This suggests that the variable of group size should be also included in GDSS design.

It is concluded furthermore that future research on DC design may proceed systematically according to three dimensional paradigms : group size, stratum of participants, and type of tasks (see Fig.2-1 below).

Figure 2-1 : A paradigm for analysis of group process in DC as a mediator of performance outcomes



Adapted from McGrath [32]

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Working Paper 88-2

Analysis of Decision Conferences (DC): The impact of the group's cognitive pressures in problem recognition stage on their problem formulation (model building) activities during DC

K J Chun

Analysis of Decision Conferences (DC)

The impact of the group's cognitive pressures in problem recognition stage on their problem formulation (model building) activities during DC

Ki Jeong, Chun.

June, 1988.

Introduction

The first perceptions of the group about their problems can strongly affect their cognitive activities during their decision-making processes.

Poole (1981) argued that it is the members' perceptions of task requirements that guide the group's work. And, he added that the group's task representation sets boundaries on acceptable interaction styles and behaviour strategies. In practice, Abric (1971) showed that performance on two experimental tasks depended on the group's task representation.

The first perceptions about the problem may be strongly affected by the relationship between the group's present situation and their mission. To make it clear, Let's see two cases as follows :

<u>Case "A"</u>

To improve an already secure situation, such as the introduction of a new product to enlarge an already secure market share.

<u>Case "B"</u>

When organisations have to respond to intense pressures.
(Eg. seeking a merger to stave off bankruptcy)

It is certain that people in Case "A" would feel much less cognitive pressures than do those in Case "B".

So, the main purpose of this paper is to find whether or not, and how the degree of cognitive pressure in problem-recognition stage can affect the group's decision-making processes.

The empirical basis for this study consists of records of groups' problem formulation and solution activities carried out within 12 DC which were conducted by DAU at LSE. A copy of the whole data of 12 DESIGN models is included as Appendix 1 and Appendix 2.

1. The degree of cognitive pressure in problem-recognition stage

This may be differed by the stimuli that evokes it along a scale.

	cognitive pressure
low ←	→ high
secure situation	urgent situation
low stimuli	high stimuli
voluntary decision-making	compelling decision-making
low constraints	high constraints

Meanwhile, Mintzberg (1976) categorised decisions by the stimuli that evokes them along a continuum as follows :

(1) Opportunity decisions

These decisions are initiated on a purely voluntary basis, to improve an already secure situation.

(2) Crisis decisions

When organisations have to respond to intense pressures. Here a severe situation demands immediate action.

Thus, opportunity and crisis decisions may be considered to form the two ends of the continuum.

(3) Problem decisions

Those fall in between, evoked by milder pressures than crises.

Although I am not satisfied with using his terminology to clarify the degree of the group's cognitive pressure in their problem-recognition stage, I am forced to borrow his in this paper until I find more appropriate ones. (please suggest me, sir!)

Thus, every DC could be categrised by the degree of group's cognitive pressure in their problem-recognition stage as follows:

```
                           cognitive pressure
low <------------+------------+------------+------------> high
opportunity   opportunity    problem      problem        crisis
              -problem                    -crisis
```

The judgment of categorisation can be based on referring the section of background, key issues, missions, assumptions and constraints, and sometimes management summary in DC documentation. The rationale to cla~~r~~ssify each DC by the degree of cognitive pressure in problem-recognition stage can be found in Appendix 2. However, two examples of the cla~~r~~ssification are provided as follows :

* Opportunity cognitive pressure

1-2 May '86 PACTEL

- PA's business lies at the leading edge of IT, in helping major companies and organisations to exploit the technology successfully for efficiency and effectiveness.
- Ignore investment constraint.
- Assume that any growth will go well.
- Assume that we can have anything we wanted.

* Problem-crisis cognitive pressure

9-10 June '87 ICL-Group Information Services

- Now something is radically wrong.
- Group expressed dissatisfaction with the current strategy,-- -----------.

2. Total number of options or the number of options per pot ?

As we can see in Table 1 and Appendix 1, the number of pots seems to have no association with group size, stratum, or initial cognitive pressures.

Table 1 : the number of pots against group size and stratum

number of pots	group size	stratum
17	11	5
14	11	4
13	18	6
8	13, 14, 19	4, 5, 5
7	6, 11, 12	4, 4, 5
6	9, 9	5, 6
4	7	3

Rather, it seems to me that the number of pots is strongly influenced by a certain group's own business field and the theme of the problem with which the group deal during DC.

The following examples support this conjecture persuasively.

	number of pots	group size	stratum	initial cognitive pressures
Case "C" 4-5 Mar.'85 Office Systems	7	11	5	Oppor-problem
Case "D" 7-8 Mar.'84 European Div.	17	11	5	Problem

Both cases have same group size (11 persons), same stratum (5), similar initial cognitive pressures (opportunity-problem, problem), and in same organisation (ICL). But, the number of pots produced in each case shows such a big difference (7 vs. 17). Why ?

<u>Case "C"</u>

The pots were based on the main product types with which the Office Systems Div. dealt. (Eg. DRS 20, DRS 300, PC, General Systems, and etc.) The group agreed that they had 7 main product dimensions which they needed to consider in DC.

<u>Case "D"</u>

European Div. covered ICL's European market which consisted of 17 countries. So, they agreed that the case would be based on 17 operating units(pots). (Eg. France, Germany, and etc.)

This fact forces me to think that the number of pots are strongly affected by the group's own business field and the theme of the problem with which the group deal in DC rather than group size, stratum, or initial cognitive pressures. In other words, the type of pots may have less association with the group's cognitive activity during DC. In practice, there were several DC which had the predetermined dimensions of pots before DC.

Why do I bother with the number of pots ? Because I am interested in finding whether or not such factors as stratum, group size, initial cognitive pressure, and etc. have any association with the number of generated options during DC.

Previous studies tried to find the association between the group's model building activity and such factors as stratum, group size, and etc. through the concept of "model complexity". And, the total number of options were one of the major "ingrediants" to determine the degree of the model complexity.

However, under the belief that the number of pots ~~are~~ is more influenced by a certain group's own business field and the theme of the problem with which the group deal during DC, and so sometimes are predetermined before DC, then the total number of options cannot be used as a variable to measure the association between the particular group's model building activity and such factors as stratum, group size, initial cognitive pressure, and etc. Because, generally speaking, the more pots we have, the greater the total number of options we have (see Table 2).

Table 2

number of pots	total number of options	number of options per pot
17	86	5.1
14	89	6.4
13	53	4.1
8	47, 40, 34	5.9, 5.0, 4.3
7	41, 37, 32	5.9, 5.3, 4.6
6	36, 34	6.0, 5.7
4	17	4.3

Thus, I think that the number of options per pot may be more appropriate variable which could be used as one measurement to investigate the effect of group size, stratum, initial cognitive pressure, and etc. on the group's model building activity. As we can see in Table 2 , the number of options per pot seems to be independent of the number of pots, whereas the total number of options are strongly dependent on the number of pots.

3. The impact of initial cognitive pressure on the group's problem formulation (model building) activity

The number of Benefit criteria and the number of options per pot generated during DC seem to have very consistent association with the degree of cognitive pressure in their problem-recognition stage (see Table 3).

Table 3 : Initial cognitive pressure against model building activity

Cognitive pressure	Date	Number of Benefit criteria(A)	Number of options per pot(B)	A X B	Number of sensitivity analysis
opportunity	1-2 May '86	6	6.0	36	5
	16-17 Feb'87	5	5.9	30	11
		Ave. 5.5	6.0	33	
opportunity -problem	4-5 Mar '85	4	5.9	24	10
	28-29 May'87	4	5.0	20	20
	25-26 Mar'87	4	5.3	21	21
		Ave. 4	5.4	22	
problem	4-5 Feb '85	3	4.6	14	24
	22-23 Apr'85	4	4.3	17	4
	18-20 Jun'85	3	6.4	19	16
	3-4 Jun '85	3	5.7	17	20
	7-8 Mar '84	3	5.1	15	5
		Ave. 3.2	5.2	16	
problem -crisis	9-10 Jun'87	1	4.1	4	33
	1-2 Oct.'84	1	4.3	4	3
		Ave. 1	4.2	4	

When they feel less pressure, they not only produce more options to tackle their problems, but also evaluate the options in the light of the more broad dimensions of value (number of criteria). It is the Benefit criteria that give the yardstick of the comparison to the group when they develop a prioritised ordering of options.

There are two main reasons why I exclude Cost criteria here. 1) The figures in Cost criteria are based on real and absolute figures. Thus there are no Within Criterion Weights among pots and same Across Criteria Weights are given to various Cost criteria. It means that there is no preference trade-off among Cost criteria.

2) In fact, the kind and the number of Cost criteria do not differ much from one DC to another DC. Usually, costs were assessed by year-based criteria, or by operating and capital expences criteria, or by simply (operating) costs criterion.

Note that, however, the number of sensitivity analysis seems to have no association with the degree of cognitive pressure. In fact, as we saw in previous studies (Wooler '86 ; Chun '87), it seems to have the positive relationship with group size.

These findings are supported by Table 4, in which the number of Benefit criteria and the number of options per pot seem to have no association with group size and/or stratum.

Table 4 : Number of options per pot against group size, stratum

Number of options / pot(x)	group size	stratum
$6.0 \leq x < 6.5$	9, 11	4, 6
$5.5 \leq x < 6.0$	9, 11, 19	5, 5, 5
$5.0 \leq x < 5.5$	6, 11, 13	4, 5, 5
$4.5 \leq x < 5.0$	12	4
$4.0 \leq x < 4.5$	7, 14, 18	3, 4, 6

Number of Benefit criteria	group size	stratum
6	9	6
5	19	5
4	6, 7, 11, 13	3, 4, 5, 5
3	9, 11, 11, 12	4, 4, 5, 5
1	14, 18	4, 6

Number of B criteria X Number of options/pot	group size	stratum
36	9	6
30	19	5
24	11	5
21	6	4
20	13	5
19	11	4
17	7, 9	3, 5
15	11	5
14	12	4
4	14, 18	4, 6

The number of criteria, the number of options per pot (not total number of options !), and the number of pots are all together major elements to determine the model complexity. My previous study found no association between model complexity and group size, stratum. And, this was proven again in this paper. But, at that time, I could not find what was an influential factor to determine the model complexity. Now, we could say that the model complexity may be strongly affected by the initial cognitive pressure of the group about their problem, and the group's own business field and the theme of the problem with which the group deal in DC.

These findings with previous ones (Wooler ; Chun ; Oldfield) can give more comprehensive picture to understand the group's decision-making activities during DC.

Those are :

1) Although some changes of the model structure may be attributed by group's stratum in light of Restructuring activity, the main

"skeleton" of the model (the number of criteria, the number of pots, and the number of options per pot) may be affected by the degree of the group's cognitive pressures in their problem recognition stage, the group's own business field, and the theme of the problem with which the group deal during DC.

2) Meanwhile, the "flesh and blood" of the model (Scores, Weights, and Sensitivity analysis) may be affected by group size, and stratum.

* Higher stratum managers regard the decision problem differently from lower stratum managers, they give more preference to "soft" dimensions of value such as future potential, risk, and synergy than to "hard" ones such as financial goal, cost reduction, etc.

* Higher stratum managers increase their preferences on future potential and at the same time decrease their concerns on short term financial goals and also include risk as one of their crucial concerns.

* Higher stratum managers revise their models more extensively than lower stratum, in carrying out sensitivity analysis.

* Group size has a positive effect on the number of sensitivity analysis.

4. Next research

1) Expansion of this study to HIVIEW model

2) To develop a general model which can describe the decision-making processes in DC

(Eg. Multiple sequence model based on simple sequence model)

3) Options may be categorised as follows:

(i) Ready-made options

The options may be found ready-made, that is, fully developed, in the environment during DC.

(Eg. to determine the site at which new plant might be located)

(ii) Custom-made options

The options may be developed especially for the decision.

(iii) Modified options

The options may combine ready-made and custom-made features - ready-made options are modified to fit particular situations.

People may think that ready-made options are more "visible" than custom-made ones. So I shall try to investigate the effect of these differences in options on the group's decision-making activities, such as the number of sensitivity analysis, type of sensitivity analysis, stratum, and etc.

Appendix 1 :

Cognitive pressure in problem-recognition stage against model building activities

cognitive pressure	DC	Benefit criteria	options per pot	criteria X no. of options per pot	of pots	number of options	group size	Stratum	of sensitivity analyses
opportunity	1-2 May '86 PACTEL	6	6	36	6	36	9	6	5
	16-17 Feb '87 ICL	5	5.9	30	8	47	19	5	11
opportunity -problem	4-5 Mar. '85 ICL	4	5.9	24	7	41	11	5	10
	28-29 May '84 ICL	4	5	20	8	40	13	5	20
	25-26 Mar. '87 ICL	4	5.3	21	7	37	6	4	21
problem	4-5 Feb. '85 ICL	3	4.6	14	7	32	12	4	24
	22-23 April '85 ICL	4	4.3	17	4	17	7	3	4
	18-20 June '85 Mars	3	6.4	19	14	89	11	4	16
	3-4 June '85 ICL	3	5.7	17	6	34	9	5	20
	7-8 Mar. '84 ICL	3	5.1	15	17	86	11	5	5
problem -crisis	9-10 June '87 ICL	1	4.1	4	13	53	18	6	33
	1-2 Oct. '84 ICL	1	4.3	4	8	34	14	4	3

Appendix 2 : The rationale for the clarification of DC according to the cognitive pressure in problem-recognition stage

<Opportunity cognitive pressure>

1. 16-17 Feb. '87 ICL - International Operations

- To secure for ICL a strong position in high-growth international markets and generate a consistently growing contribution to Group revenues and profits.

2. 1-2 May '86 PACTEL

- To develop PA's IT services, as an international business within corporate guidelines

- PA's business lies at the leading edge of IT, in helping major companies and organisations to exploit the technology sucessfully for efficiency and effectiveness

- Ignore investment constraints

  Assume that any growth will grow well

  Assume that we can have anything we wanted.

<Opportunity-problem cognitive pressure>

1. 25-26 Mar. '87 ICL - Public Services Business

- We are already international in Regional Government, we want to be international in Health Care, we want to be big in Law & Order where there is no dominent international supplier.

- Becoming international was a problem, particularly in light of restricted resources.

2. 28-29 May '84 ICL - Asia Pacific Div.

- How can we develop ICL's position in Asia Pacific to one of significant strength while at the same time generating increased profitability and achieve all our objectives.

- Need to define "significant strength"

Does strength mean being in the top three in each country in which we operate ? Or does it mean No. 1 in profit in each selected market segment ?

- How to achieve profitable growth with a limited resource.

3. 4-5 Mar '85 ICL - Office Systems

- To make ICL the leading supplier of quality office systems to companies in W. Europe with a profitable turnover greater than 100 M p.a.

- Match industry leaders in development and sales productivity

- We have a long term objective to reach 20 % PBT. In 1985, we are targetting only 6 %.

- Insufficient funds from outside Office Systems

<Problem cognitive pressure>

1. 4-5 Feb. '85 ICL - Central Government Sales

- To improve the efficiency and effectiveness at a profit, of UK Central Govt., the agencies funded by Treasury and pull through of ICL products.

- There was a need for sustained profit, whilst maintaining a short term profit stance and a lack of support for the Group's particular needs from Business Centres.

- There was a need for the Group to be more responsive to external development/collaboration.

2. 22-23 April '85 ICL - End User Computing

- Short term profit problems

  To get the right balance on short and long term

- Difficult to move away from what is inherited.

- Company culture is still box and not solution oriented.

3. 18-20 June '85 Mars - R&D Div.

- Overall, there was a sense of a Div. that operated in the past in a somewhat fragmented fashion, with current pressures of resources requring a more overall view of the Div.'s activities.

- Both money and people resources are more scarce now than in the past.

4. 3-4 June '85 ICL - Applied Systems

- To develop a method of prioritising AS activities by markets, types of spend, people, quality, etc and interdependence with other groups, as well as by product

- People are accountable for things they do not have sufficient authority for. This creates inefficiency and serious disfunctions in the Company.

- Net spend must be less than 24M for '85 and 24.3 for '86.

5. 7-8 Mar. '84 ICL - European Div.

- To reach a decision on how to deploy ICL - ED resources to achieve the "grow in the Europe" strategy

- ICL cannot achieve corporate growth by growing uniformly because much of the business in Europe is non-profitable.

<Problem-crisis cognitive pressure>

1. 9-10 June '87 ICL - Group Information Services

- Now something is radically wrong.

- Group expressed dissatisfaction with the current strategy, and indicated that it needed to be improved so as to provide more integration nationally, to facilitate administration and to provide support to ICL's salesmen and customers.

2. 1-2 Oct. '84 ICL - Professional Services

- Significantly to increase ICL's revenue and profit ; This led the group to consider only one criterion "financial goals".

Technical Report 88-2

Analysis of Decision Conferences: Differences in problem handling by management stratum

A I Oldfield & R S Wooler

SUMMARY

The work reported here explores the hypothesis that problem handling in decision conferences by groups of managers is determined by the organisational strata they occupy, that is, problem formulation and resolution is largely dependent on their position in the hierarchy of their organisations.

Decision Support Systems, although of major support to mamagers in organisational decision making during the process of decision conferencing, have limitations and thus fail to meet the need of senior or higher stratum managers.

It is argued that senior managers, due to their organisational roles and motivations, take a more global perspective of decision problems than their lower ranking counterparts. Senior managers also consider long term objectives more seriously and are more likely to regard startegic issues more prominently than managers lower in the organisational hierarchy. It is further argued that decision processes incorporate two types of cognitive structures in problem handling, *strategic* and *tactical* planning. Strategic being the abstract conceptualisation of the problem of how to reach the goal, while tactical planning being the operationalistaion of such conceptualisation, that is, what to do in order to reach the goal.

In order to develop more sophisticated Decision Support Systems to meet the needs of these higher stratum managers, it is necessary to identify the underlying decision making processes utilised by managers in Decision Conferences.

The focus of this study is to identify such conceptual processes and the extent to which these interact with management strata during decision conferencing.

A useful way of eliciting participants' problem handling is through text analysis methods. Text analysis enables the identification of areas of concern to participants. This concern is reflected by the extent to which exploration of particular domains of the decision problem occurs. The nature of those domains determine the nature of the conceptual framework they employ in representing the problem.

The method of elicitation employed has enabled the identification of domains of major concern to the participants in decision conferences, reflecting the extent of their interest in particular issues, and through identification of these issues it is possible to ascertain their approach to the decision problem.

Analysis of results confirm the basic hypothesis that problem handling is management strata specific. Higher strata managers employed better structuring processes in their problem handling, they proposed less strategic issues and more tactical issues both at the beginning and at the end of the decision conference.

The group of managers at stratum 3 also confirmed the hypothesis that they fail to structure the decision problem adequately at the initial phase, they tended to explore a greater number of issues which was irrelevant to their decision problem, reflecting the lack of refinement in problem formulation.

Analysis of results from stratum 4 managers, however, did not confirm the expected hypothesis, that their problem handling would occupy and intermediate position between stratum 5 and stratum 3 in terms of problem formulation and resolution, however, we were able to show that the decision conference process was successful in aiding problem identification and formulation.

Our future work will examine in more detail the characteristics of the issues and the underlying quality of these issues which will allow us to build on our current methodology in examining in detail the differences in problem handling of level 4 managers.

CONTENTS

ANALYSIS OF DECISION CONFERENCES: DIFFERENCES IN PROBLEM HANDLING BY MANAGEMENT STRATUM

1. INTRODUCTION

Previous work of Decision Conference analysis has revealed associations between the stratum of the management team and the extent to which problem revision occurs, also, concern over specific areas is greater at some levels of organisation (Wooler, 1987). The findings suggest the need to focus on exploring the precise nature of the differences in problem handling in decision conferences by management stratum as well identifying factors that influence the process.

1.1 Objectives

The focus of this report is to identify significant aspects oi the cognitive processes utilised by managers in arriving at their 'decision making destination' from the initial problem definition/structuring phase in Decision Conferences, in order to provide a better understanding of the effects management level or stratum has on the solution of decision problems.

The objective of the study is to identify significant aspects of problem handling by managers in Decision Conferences by exploring the following:

- the kinds of issues that participants bring to the debate
- the ways that management groups structure decision problems at the beginning of the conference

- the extent to which management levels/strata (Jaques, 1983) affect the structuring of decision problems
- the nature of differences in the problem structuring process across management strata
- effects of the decision conference process upon problem resolution

A better understanding of these processes would enable the development of computer based decision aiding systems that could facilitate improved problem formulation and structuring leading to superior decision making. Ill defined problems have consequences not only for decision making processes but also for final solutions. Decision Support Systems (DSS) rely heavily on modeling the problem and in the case of ill defined problems, it is difficult to know what to model at the very beginning and then how to structure it. Thus, if interest groups differ about what they choose to model, the frame they set for the problem, any differences can intensify/increase during the process of examining alternative actions, uncertainties and possible consequences.

A crucial issue in examining managers' problem formulation activities concerns the domains they explore within problem formulation debate. A domain may be defined as a conceptual area within which specific issues relating to a topic are located, e.g. safety is a domain within which topics such as technology may be considered. Individuals tend to handle problems through exploration of the relevant domains, with more exploration within those domains that represent to them the greatest concern relating to the problem (Humphreys et al., 1987).

DSS for ill structured problems will incorporate different type of "knowledge systems" to those of well structured problems (Bonczek et al.,1981). There is some debate whether it is important or practicable to identify all the domains relevant to the decision problems brought to Decision Conferences. It has been argued that rather than identify all these it is better to concentrate instead on computer based resources to focus on developing methods for structuring the problem, assessing the participants' existing knowledge base, simulating alternatives and performing interactive sensitivity analyses to provide an informed basis for choice (Humphreys et al.,1983).

1.2 Decision Support issues

It is widely believed that decision aids such as computers and specialised software enable groups of decision makers to make better and faster decisions. They help decision makers gain alternative perspectives of the problem and also generate a shared understanding of the issues. However it is recognised that they have major limitations and as such they are of limited advantage to senior managers. Phillips (1986), argues that while people are future oriented in their thinking, presently available computer software is predominantly based on data from the past. This is especially the case for Information Technology Aids, which are predominantly data oriented (information from the past). On the other hand, Preference Technology is more flexible in that it aids decision makers to develop preferences between alternatives, to form value judgements. Although most available technology has been useful, these aids are still inadequeate in meeting the requirements of many managers and executives, as it fails to provide the necessary database on the future and thus managers and executives still rely heavily on their own 'intuitions' and past expertise because computers are limited in being able to generate as many feasible and novel scenarios or solutions as the executive is able to do, especially at higher strata. Long term prospectives of a problem are more readily incorporated by managers who occupy posts at higher strata in organisations.

DSS should be more akin to human processing systems. Human 'software' is much more flexible and dynamic as it is able to generate novel scenarios (Toda, 1983). If we are to develop more sophisticated DSS to aid human decision making then it is crucial to consider how human problem solving occurs. Toda postulates that there are two parallel processing systems operating within the human mind, System I and System II. System I operates on the 'frequency' principle, where data from past events are stored within memory and used as a data base in future evaluation of events and experiences, it is a static system only able to operate on past information. System II, is more dynamic in that it is able to *generate* unlimited number of *novel scenarios* and futures utilising the data base of System I.

It could be argued that Information Technology is akin to System I, where possible permutations can be elicited from the limited data base. Preference Technology on the other hand could be said to support System II more effectively in that it facilitates the generation of value judgements and possible alternatives. Its value lies in its ability to interact. Ideally, successful DSS would be more like System II, able to generate infinite novel future scenarios. This kind of system would be particularly useful for higher stratum managers, whose problem solving needs are not met by present available aids as these constrain them especially in terms of time frame projections. There is evidence that higher stratum managers in decision conferences often made references to consequences beyond the model's time frame (Phillips, 1986).

Senior managers who occupy the higher strata of an organisational hierarchy tend to handle qualitativiely different problems than do lower stratum managers, as they deal with more long range strategic issues. Because of their position within the organisation they have to consider more global perspectives of the problem in order to consider more wideranging scenarios, and thus they generate novel solutions to problems from the available database.

1.3 Organisational issues

The importance of developing DSS to aid the dynamic processes of problem structuring, helping to look for alternatives, has been discussed by Humphreys (1986), highlighting the extent to which it is important to focus on the *problem owners* (Checkland, 1984), in order to understand *their* conceptualisation of the *problem* and also the influence the problem owner may have within the organisation, as this will be an issue in modelling the organisational context of the problem and the implementation process.

Senior managers tend to work actively within their environment rather than reactively, their job is to manage resources utilising the available data from past and present to direct their future actions in creating a more effective organisation in the future. In many situations they have to choose between options, they need to be able distinguish between the desirability of these options and their effects for the future. In this respect Preference Technology has already provided effective support and it is particularly useful in group decision support systems (GDSS), but it still fails to provide the necessary database on the future. Furthermore, it relies very heavily on information provided by the user about the past (Phillips, 1985). This is a point which we make also in technical report 88-1, where we identify an urgent need for organisational modelling tools which will enable the construction of such databases for "conceptual models" about the future. Decision makers who occupy senior positions in an organisation are unwilling to accept the degree of constraint imposed by classical decision modelling. They prefer to use their discretion in modeling problems in a way that contradicts the central assumption of decision theory, that decision problem solution should aim at maximising expected utilities between alternatives represented in the decision model. In actual fact their principal goal may be more concerned with the centralisation of power and executive agency (Vari & Vecsenyi, 1983).

In addition people employed at different levels within an organisation require different types of knowledge about the organisation ranging from how to perform tasks at the lowest, operative level, to the type of knowledge which allows major restructuring of the organisation at higher levels. While it is possible to talk in abstract terms about a single set of organisational goals, in practice the goals, responsibilities and perspectives of the various stakeholders in a problem situation may vary considerably and perhaps in conflicting ways (Vari & Vecsenyi, 1984a). Stakeholders occupying different roles are likely to explore the scenarios which to them represent their views of the problem within different 'small worlds' (Toda, 1976).

Vari and Vecsenyi (1984a, 1984b) and Lock (1983) describe how problem owners' organisational roles and responsibilities interact with their motivations indetermining the way they formulate the problems they own.

Moreover, the way in which they elaborate their initial scenarios will vary according to their knowledge about the organisation and the degree of discretion available in the way they can act on the organisational structure itself.

Central to organisational decision making is the competence of the decision maker/executive for it is their capacity to handle and formulate the problem that determines the quality of the outcome. Large organisations are usually hierarchically structured, with higher level ability managers at the top of the hierarchy (Jaques, 1983). Ideally, the ability of a manager/executive to handle and structure problems should be reflected in the position/stratum he or she occupies within the organisation.

1.4 Planning levels

Organisational planning can be viewed through their hierarchy of decision making and classification of management activities, which can be classified at three levels (Anthony 1965):

1. Strategic planning
2. Management control and tactical planning level
3. Operational planning and control level

Strategic planning deals with long range issues, management control and tactical planning is concerned with medium term issues while operational planning and control activities involve shorter term decisions for current operations. Hierarchical Divisions within organisational work spheres are usually established to meet those particular operational needs (see Technical Report 87-1 on this project, and Humphreys, 1984 for a fuller discussion of this in the context of Jaques' 1976 Theory of Bureaucracy).

The majority of decisions at the operational level are relatively structured and those at the strategic level are relatively unstructured. Information requirements are different for the strategic and operational levels, thus information support for the unstructured strategic level would need to be different to that for the unstructured operational/tactical level.

The concept of strategy is very difficult to define and although we cannot offer a tightly bounded definition distinguishing between strategy and planning, our criteria of time and structure provides a workable basis for distinguishing the two.

At a more conceptual level, strategy can be regarded in terms of a cognitive process of organising actions/plans in order to reach a particular goal. Strategy is used in relation to goal directed human action. The term strategy has been extensively used in Decision Making, especially where concern is with optimality of reaching goals. van Dijk and Kintsch (1983) differentiate between goals and plans, regarding plans as a series of 'macroactions' resulting in the goal. While strategy is a *means* of reaching a goal and it dominates lower level decisions and actions in the process. The process of reaching the final goal will depend on the way the goal is characterised, that is the type/nature of the concept utilised in connection with the goal, e.g. "fast" concept will dictate the quickest way to reach the goal, while "optimal" concept will dictate least expenditure in reaching the goal. Once a specific concept has been selected, it will dominate all other concepts in the course of action, that is if fast has been selected then it will dominate optimality and speed will be paramount rather than economics of actions.

2. PROBLEM HANDLING BY MANAGERS IN DECISION CONFERENCES

Decision Conferencing is an intensive two-day problem-solving session attended by a group of people who are concerned about some complex issue facing an organisation. A unique feature of this approach is the creation of a computer-based model which incorporates the differing perspectives of the participants enabling them to evaluate alternatives by examining the models generated through various stages of the process with the aid of a facilitator and a decision analyst and thus reach a shared agreement about future actions.

Decision Conferences can be regarded in terms of change, a change of the way participants variously understand the presenting problem over the two day period between the beginning and end of a Decision Conference as a result of the conferencing process. However it is difficult to generalise from individual findings of such changes because they are also determined and affected by the participant in the event and the skills, experience and competence and knowledge base they, as individuals, bring to the debating table.

Attempts to develop a theoretical framework for aiding higher stratum decision makers have identified some differences between management strata in their utilisation of available software in the process of decision conferencing (Chun, 1988). It was shown that higher stratum managers increased their preferences on future potential and at the same time decrease their concerns on short term financial goals and also include risk as one of their crucial concerns. Higher stratum managers revise their models more extensively than do lower stratum managers when carrying out sensitivity analysis. The results and those presented in Humphreys (1984, 1988), suggest that information and thus decision support systems requirements are different for each stratum of management, thus it is important in developing a DSS to identify how each stratum handles decision problem. The latter is the major focus of this report.

One of the major questions is to what extent higher stratum/level managers handle decision problem differently in a decision conference. Whether there are any differences in the number of issues both at the beginning as well as at the end of a conference. It could be argued that higher strata managers have already structured their decision problems and thus do not propose as many different kind of issues, while lower strata mangers may not be able to formulate the problem into succinct clearly defined issues. The objective of the decision conference is to aid decision makers to identify and structure their problems, if the process is successful then both the frequency and the nature of the issues at the end of the conference would be different from the initial phase. The number of issues raised at the end of a conference is expected to be less than at the beginning or at least not more, showing that the process has been successful in aiding problem structuring and decision making.

Should such *differences* exist, the type of issues need to be identified in order to establish the major areas of concern to the participants in order to identify their perspectives as these show the way they have defined and conceptualised the problem. Identifying these cognitive representations would enable comparisons to be made between the perspectives of decision makers, particularly relevant when dealing with managers from different organisational strata.

The nature of issues needs to be explored, not only in terms of which particular areas or domains are important to the participants, but also in regard to the nature of each particular domain, that is, what aspect of the domain is more prominent in handling the problem. Such issues may be considered in terms of either abstract or concrete concepts. Abstract issues representing strategic aspect of the problem handling, while concrete issues representing tactical/operational handling of the problem. Identification of these would reveal not just *which* issues are important but in *what way* they are important. This would enable the development of a more sophisticated model of the decision problem.

The basic hypothesis investigated in this report is that higher stratum managers employ more sophisticated structuring processes whereby they incorporate many of the minor issues into well developed better inegrated definitions of the problems and thus would propose fewer issues than lower stratum managers. It is further hypothesised that lower stratum managers propose more issues, especially at the initial stage of the Decision Conference called Key Issues, by Phillips (1986) and equivalent to stge S2 in the general conceptual schema presented in Technical report 87-1 and 88-1 on this project. These initially proposed issues would in fact represent the unstructured components of the overall problem for which a solution is sought.

It is further hypothesised that more abstract issues would be offered at the initial stage of a decision conference: concrete issues will arise subsequent to abstract ones in as much that abstract issues reflect strategic planning while concrete isssues refelect operational planning. Thus when problem structuring is organised top down abstract concepts are dealt with before concrete ones. Further, more concrete issues should emerge at the end of the conference reflecting the operationalisation of the abstract.

3. ANALYSIS OF MATERIAL OF DECISION CONFERENCES

An approach considered useful in identifying such differences is through the analysis of procedures of Decision Conferences. Previous work has shown that analysis of discourse processes can be useful in eliciting those issues that represent those aspects of the problem which are of most concern to the participants by identifying the extent to which they raise those issues as well as the composition of those issues (Humphreys et al., 1987).

In order to establish areas of concern and the nature of such concern to decision makers and stakeholders in a decision conference, it is necessary to identify the most prominent issues. This can be achieved through text analysis, that is by categorising linguistic units into domains, or coginitive space of exploration. Areas of concern can be identified by the frequency with which specific issues located in particular domains of concern are raised during the problem formulation stage ('key issues' raised) and the final decision making stage ('action list') of the conference. Identification of these prominent issues can be carried out through classifying them, initially into domains and then into types: strategic (abstract) or tactical/operational (concrete). The extent to which a particular domain is of actual concern to the stakeholders within a particular conference would be reflected in the proportion of issues raised within that particular domain, relative to other domains.

Hence the analysis adopted here focussed on the type and number of domains stressed by participants in specific decision conferences and the nature of those domains. That is: for each group of managers, participants in a conference, we analysed the number of strategic and tactical issues per domain both at the *Key*

Issues stage (beginning) and *Action List* stage (end) of the conference. Note that *key issues* stage corresponds to stage S2 in the general procedural schema presented in Technical Reports 87-1 and 88-1, whereas the *action list* stage marks the end of the cycle in that schema (i.e. output of stage S7).

3.1 Procedure

Data consisted in material from eight (8) Decision Conferences. These materials in turn comprised reports of the Decision Conferences provided to the management teams, participating in each conference, notes taken by the conference decision analyst during the progress of the conference and the problem modelling developed by the analyst themselves within these notes. The eight Decision Conferences were selected to represent three levels of management within the International Computers Ltd (ICL) organisation - in Jaques' terms, levels 5, 4 and 3. (An explanation of these levels and how they relate to typical occupational grades can be found in Jaques, 1983 and are summarised in Humphreys. 1984 and Technical report 87-1). At each of levels 5 and 4 three decision conferences were analysed and at level 3 two decision conferences were analysed.

A classification scheme was developed according to which issues debated within the groups were classified as follows:

1. Organisational issues
2. Economic issues

3. Product/development issues
4. Marketing issues
5. Image
6. Risk

Each of the first four categories were further subdivided into:

a. Strategic/abstract issues
b. Tactical/operational/concrete issues

These categories were determined on the basis of a pilot analysis, which revealed that great majority of the issues discussed in decision conferences fell into one or other of these types. This categorisation scheme is necessarily judgemental. Following is a description of each category backed up by examples. (Two judges working independently have been responsible for classifying the issues under discussion in each of the decision conferences).

Criteria for categorisation

These were as follows :

Organisational: all those issues that were considered to bear some relationship to the internal mechanisms of the organisation/company, involving the structure of the company.

Organisational strategic: issues that involve consideration of possible strategies and manipulations that the company would have to or was utilising in order to further its purposes as an organisation. Issues relating to the ways in which the management and distribution of work within the company affects its ability to reach long term company goals.

e.g. What business are we in and what as a business centre are we looking to control?

Organisational tactical: issues that involve structuring and operationalising any of the components of issues concerning the organisation.

e.g. Produce a list of current offices, the number of people in each and their role, including how these offices are shared.

Economic: any issue that relates directly to cost or benefit.

Economic strategic:

e.g. How to become profitable and how to become self funding particularly in the short term.

Economic tactical:

e.g. Need feedback on the financial situation concerning VANS.

Product/development: issues that relate to products or their development

Product development strategic

e.g. What products do we sell?

Product development tactical:

e.g. We have no products which take advantage ofour retail/finance linkage.

Market: any issues that relate to the product market.

Time / Type

Key Issue/Strategic

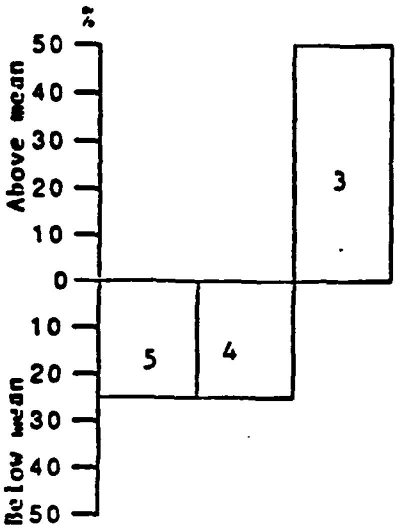


Fig. 1 Management Stratum
(5,4 & 3)

Time / Type

Key Issue/Tactical

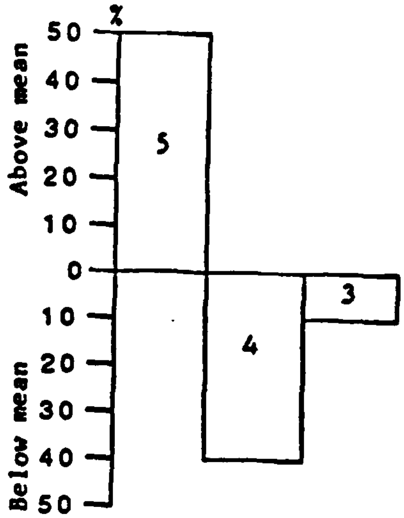


Fig. 2 Management Stratum
(5,4 & 3)

Time / Type

Action List/Strategic

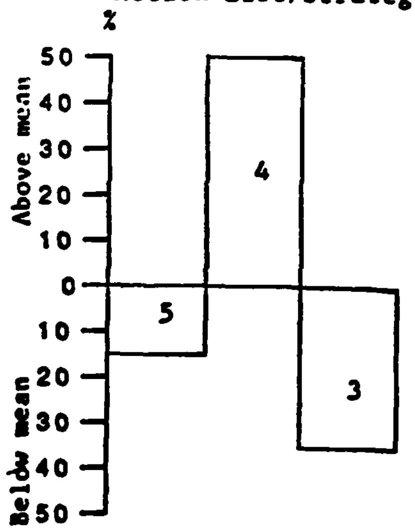


Fig.3 Management Stratum
(5,4 & 3)

Time / Type

Action List/Tactical

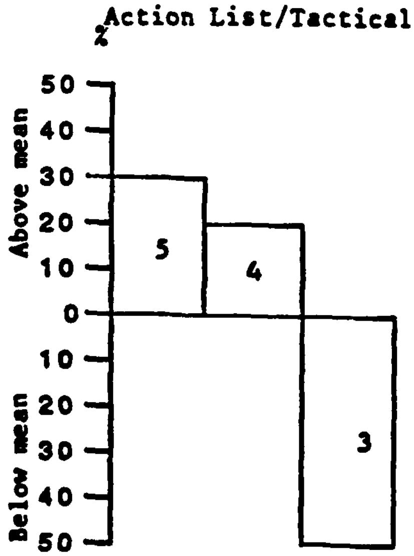


Fig.4 Management Stratum
(5,4 & 3)

Figs. 1 - 4 Relative Importance of Issues by Management Strata (Standardised Frequencies)

Market strategic:

e.g Define the opportunities which currently exist, if any, that would be created from the integration of the existing businesses.

Market tactical:

e.g. Request regional sales managers to nominate the top accounts with network opportunities.

Image: concern with external image, the commercial world's image of the company, it did not include the perceived image by members of staff.

e.g. How we establish an image in the market place as a company.

Risk: concern with risk aspects.

e.g. Ways of reducing risks on the revenue and profit projections.

Thus all categorisable issues were classified into one or more of the above 10 categories at the *key issues* stage as well as at the end of the conference, at the *action list* stage.

3.2 Results

Figures 1 - 32 (shown in section 3.3) display the relationship between domains and groups after linear transformation (the percentage deviation above or below the mean of the absolute frequency of number of issues raised within each domain).

The relative importance of strategic and tactical issues per management level can be seen in figs. 1-4. Figures 5 - 20 show the relative importance of specific domains across management strata. The relative importance of issues for each management stratum can is shown in figures 21 - 32.

The proportion of issues raised in each domain by managers in each management stratum is shown in fig. 33 for the 'key issues' stage of the decision conference and fig. 34 for the action list stage. Tables 1 and 2 summarise the mean frequencies of strategic and tactical issues raised within domains of concern by management strata at the 'key issues' and 'action list' stages of the decision conference.

The frequencies were grouped according to the management level of conference participants (5, 4 or 3 according to Jaques' 1976 classification of levels). The chi-square statistic was used to test for differences in frequencies across management strata. Separate analyses were carried out for strategic (S) and tactical (T) issues. For strategic issues, the differences across strata are significant at the 5% level at *key issues* stage, and at the 1% level at the *action list* stage. However, for tactical issues there were no significant differences across strata at the *key issues* stage but became significant at the 2.5% level by the *action list* stage.

3.3 Interpretation of results on differences across strata

Managers at stratum 5 were most concerned (in relation to the other groups): with organisational issues that were mainly tactical in nature, both at the *key issues* and *action list* stage. For this group of managers, strategic issues raised were genrally in the *organisation* domain, particularly so at the *action list* stage.

The tactical issues that were raised concerned:

economic, product and market issues at the *key issues* stage
organisation and market issues at the *action list* stage.
(See Figs. 29-32, for details).

Managers at stratum 4 were most concerned, in relation to the other groups, with strategic issues, especially at the *action list* stage, the most prominent being *product* and *market* issues. The remaining strategic issues were in the domain of *market* and to a very limited extent, *organisation*. The tactical issues concerned mainly into *market* at the key issue stage and *economic* at the *action list* stage, with very little concern being shown over product. At the *key issues* stage they were least concerned with *economic* issues, and at the 'action list' stage they were least concerned with *economic* and *organisation* issues (See Figs.25-28).

Although this group is least prominent in terms of the number of issues considered at the *key issues* stage, it is the most prominent in terms of strategic issues at the *action list* stage.

Time / Type

% Key Issues/Strategic

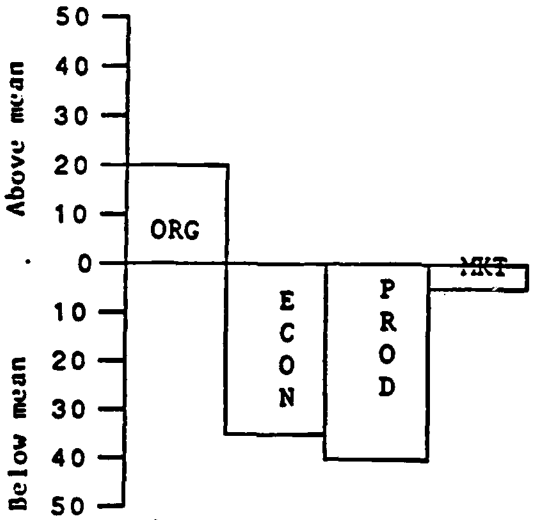


Fig. 29

Time / TYpe

% Key Issues/Tactical

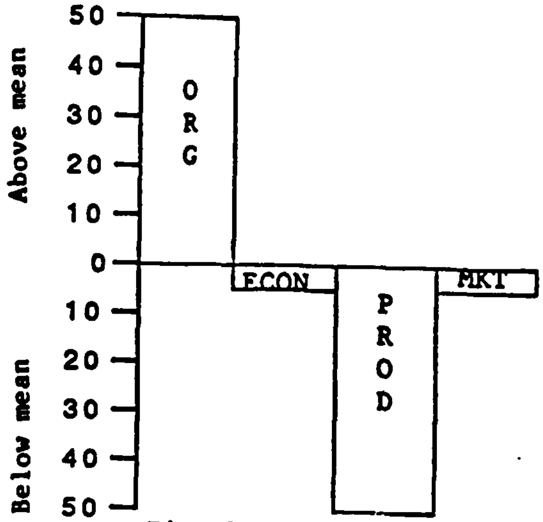


Fig. 30

Time / Type

Action List/Strategic

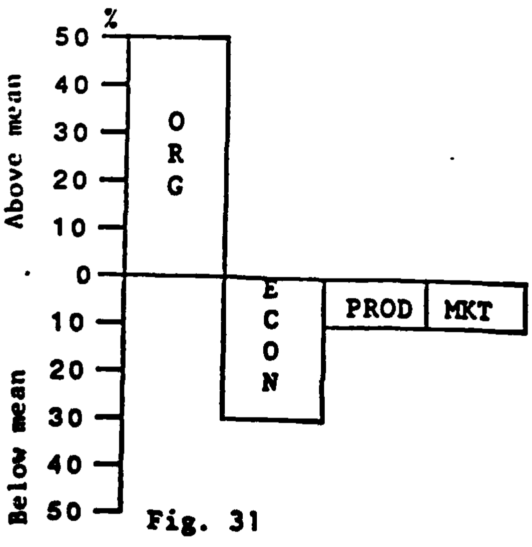


Fig. 31

Time / Type

% Action List/Tactical

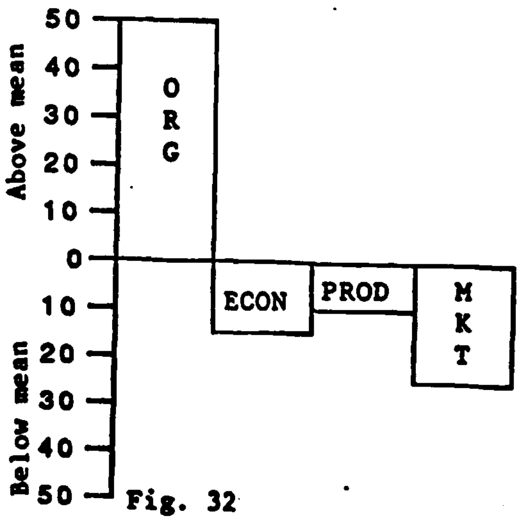


Fig. 32

Figs. 29 - 32 Relative Importance of Issues to Level 5 Managers

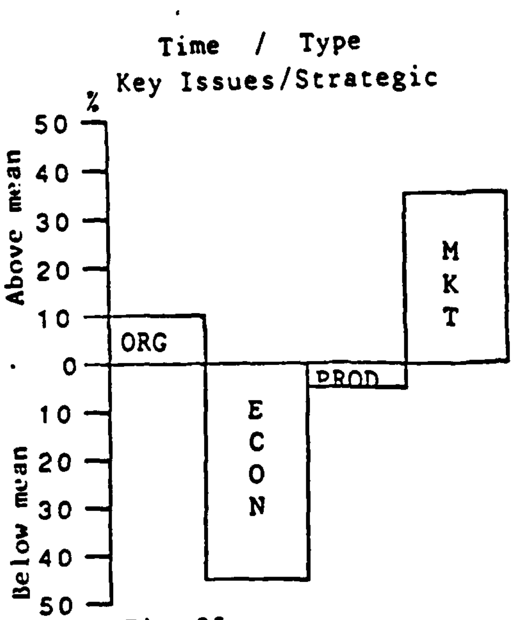


Fig. 25

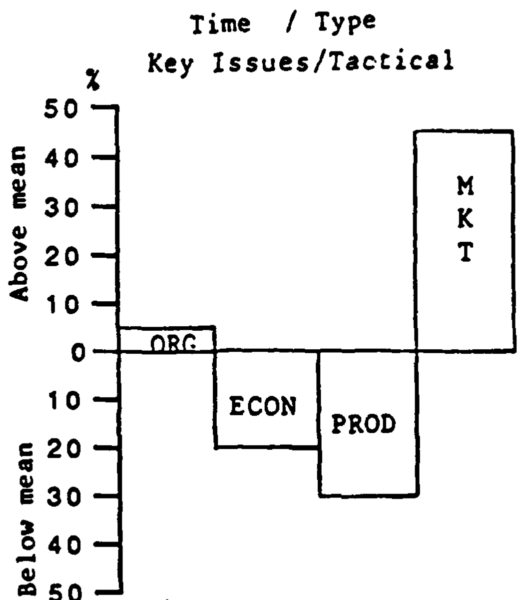


Fig. 26

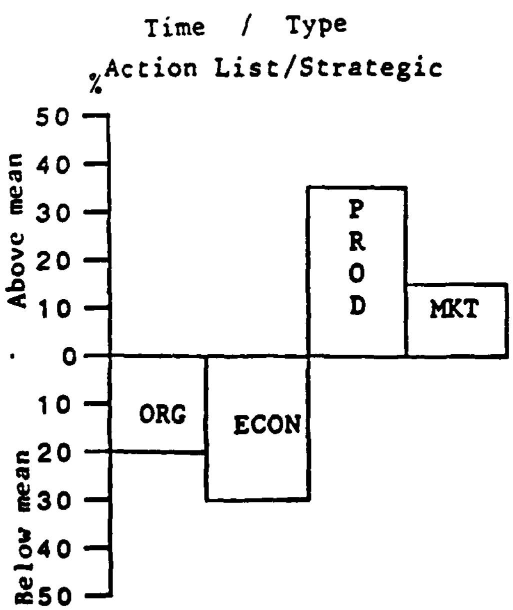


Fig. 27

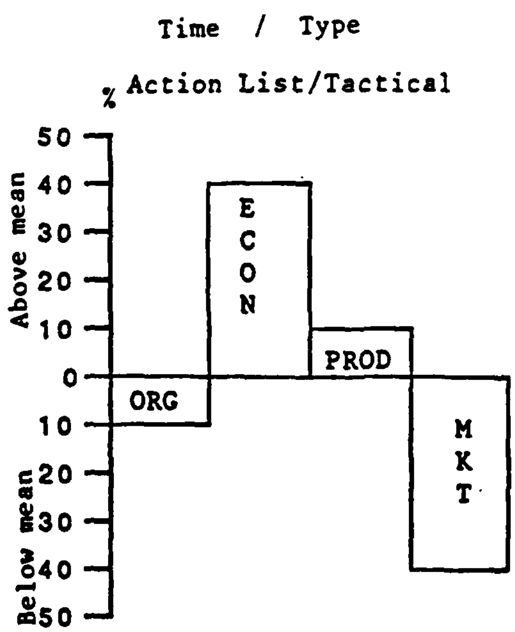


Fig. 28

Figs. 25 - 28 · Relative Importance of Issues to Level 4 Managers

Time / Type

Key Issues/Strategic

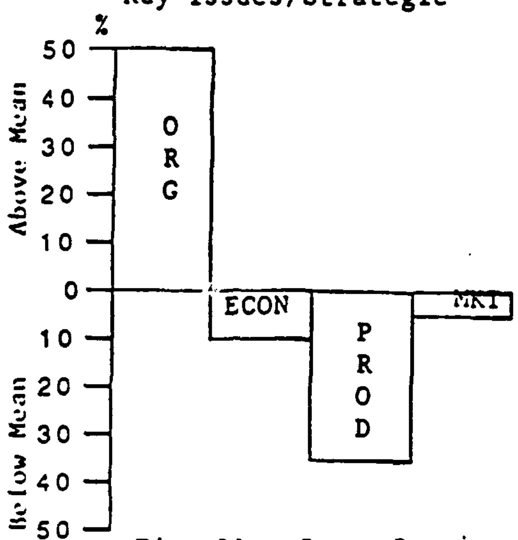


Fig. 21 Issue Domain

Time / Type

Key Issues/Tactical

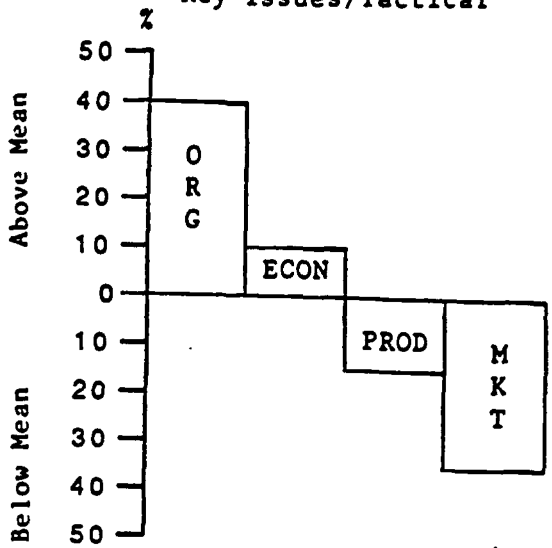


Fig. 22 Issue Domain

Time / Type

Action List/Strategic

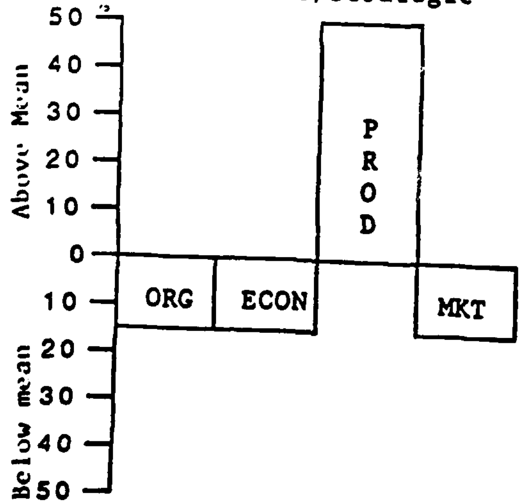


Fig. 23 Issue Domain

Time / Type

% Action List/Tactical

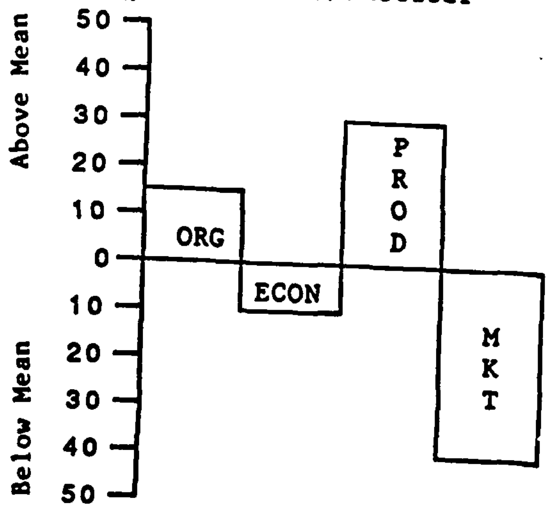


Fig. 24 Issue Domain

Figs. 21 - 24 Relative Importance of issues for Level 3 Managers

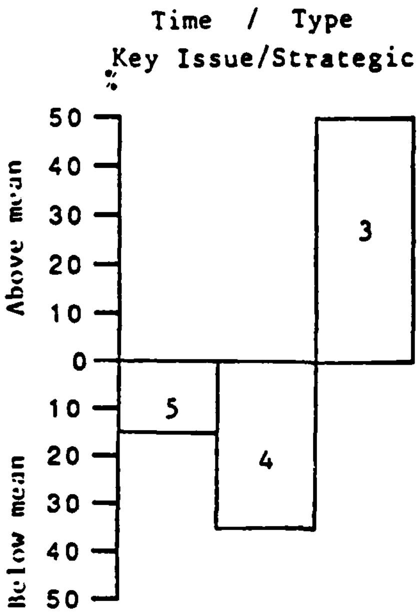


Fig. 5

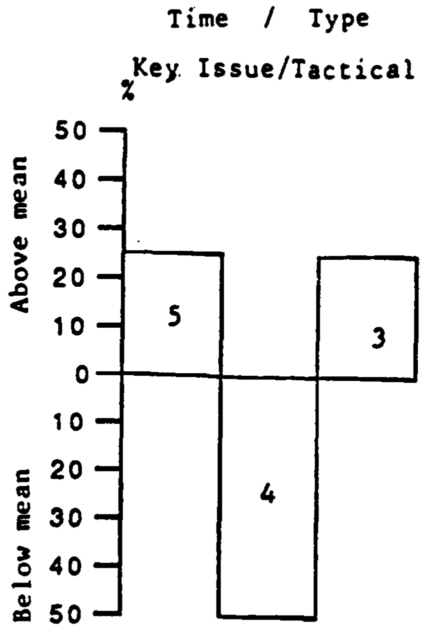


Fig. 6

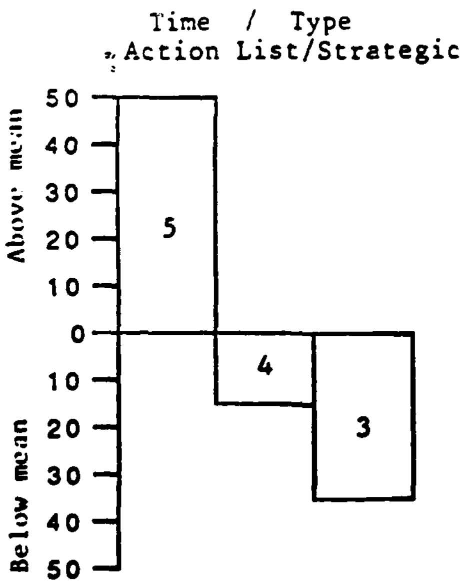


Fig. 7

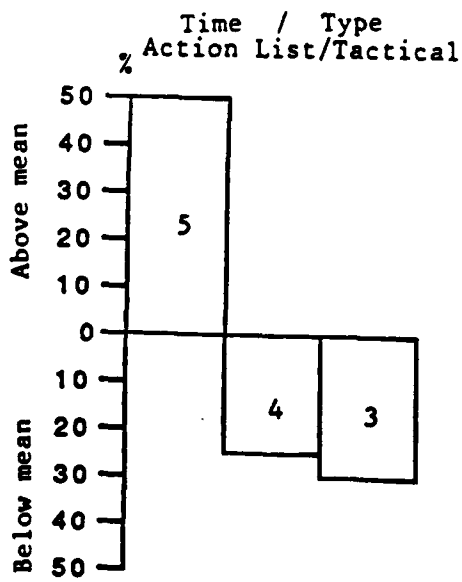


Fig. 8

Figs. 5 - 8 Relative Importance of Organisational Issues by Management Strata

Management at stratum 3 offered most issues at the 'key issue' stage in strategic areas and is least prominent at the 'action list' stage at the tactical level. The strategic issues that concern them are in the organisational domain at 'key issue' stage but product/development domain at the 'action list' stage. Thus at the beginning they are concerned with strategic organisational issues and tactical organisational issues but at the end they are predominantly concerned with product development issues. Thus this group seems to concern itself with organisational issues at the beginning of the conference both strategic and tactical while product and market issues are of least concern. However at the *action list* stage product development becomes most important both strategic and tactical (Figs. 21-24).

3.4 Interpretation of results on domains of concern

When the actual domains of concern in which issues were raised are considered, the following findings emerge:

Organisational issues:

At the key issue stage the group of managers at stratum 3 are most prominent in terms of the number of issues raised at the strategic level, while at the tactical level both the groups of managers at strata 5 and 3 were equally prominent. At the *action list* stage the group of managers at stratum 5 emerged as prominent both at the strategic and tactical level and the group of managers at stratum 3 were least concerned with this domain (See Figs. 5-8).

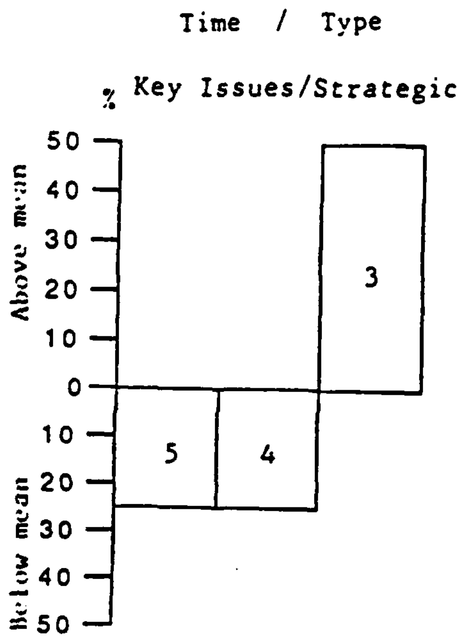


Fig. 9

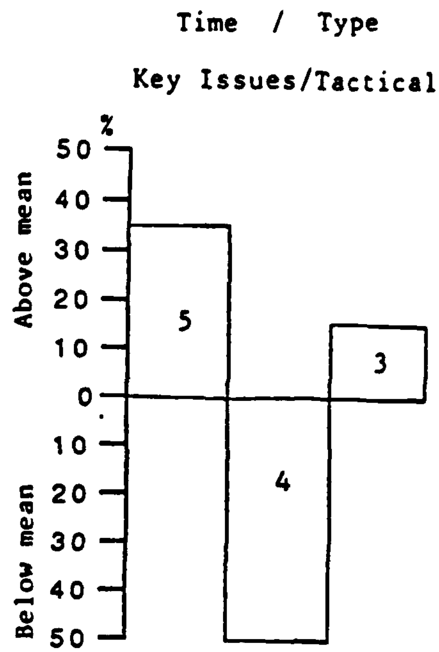


Fig. 10

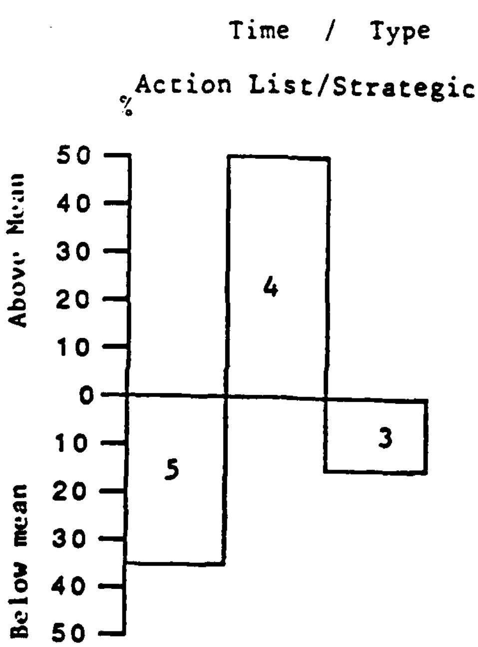


Fig. 11

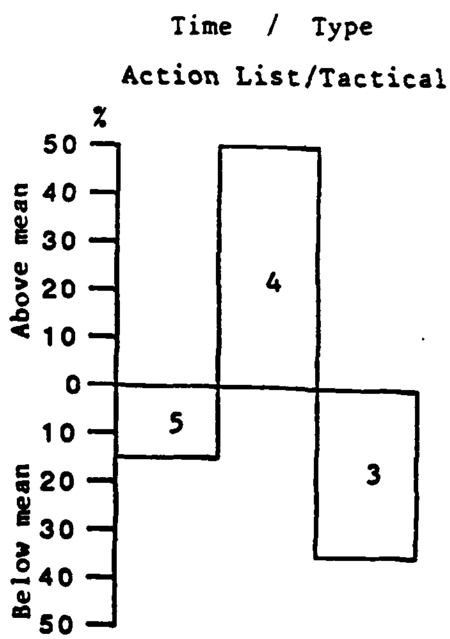


Fig. 12

Figs. 9 - 12 Relative Importance of Economic Issues by Management Strata

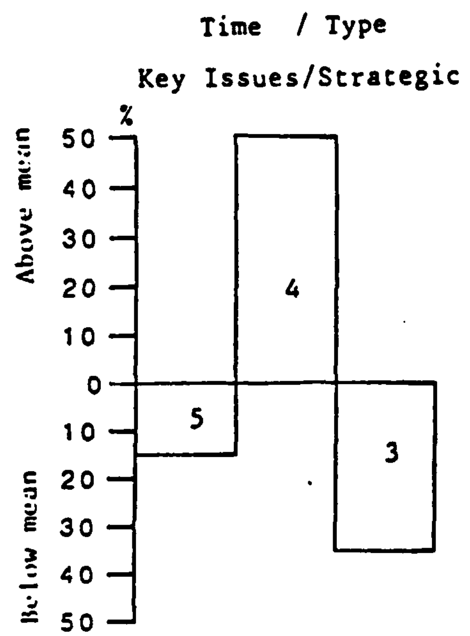


Fig. 13

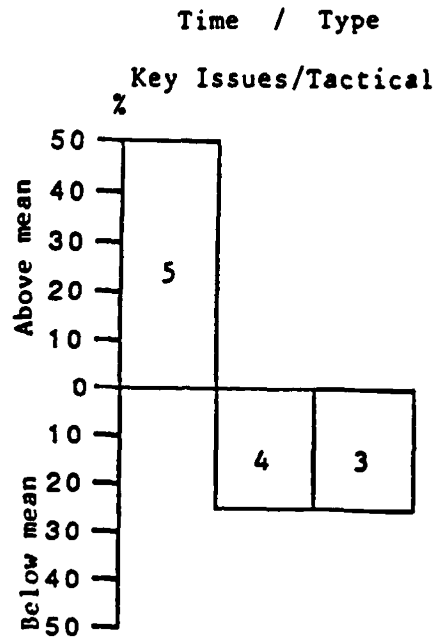


Fig. 14

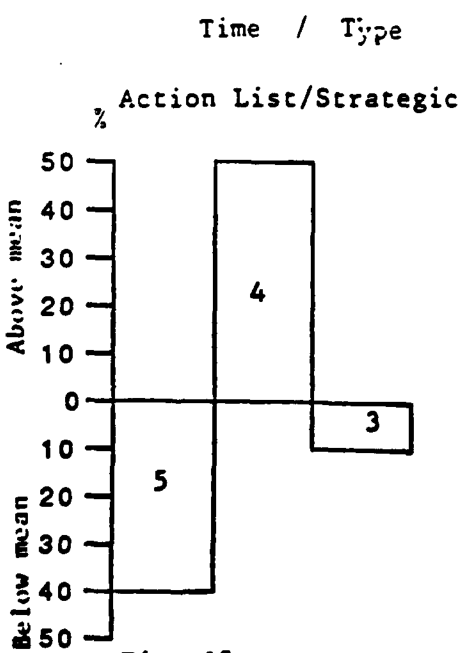


Fig. 15

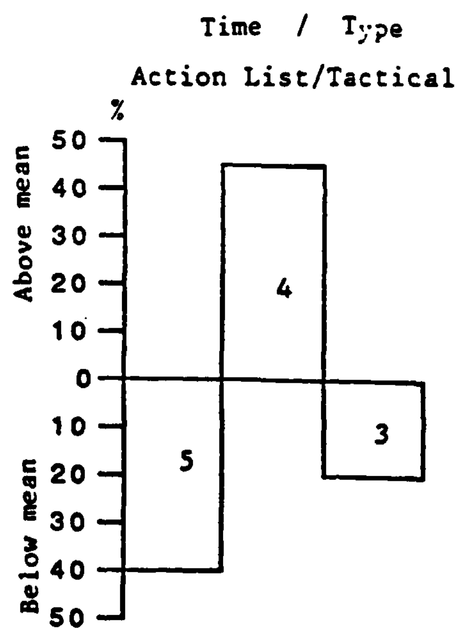


Fig. 16

Figs. 13 - 16 Relative importance of Product Related Issues by Management Strata

Time / Type

Key Issues/Strategic

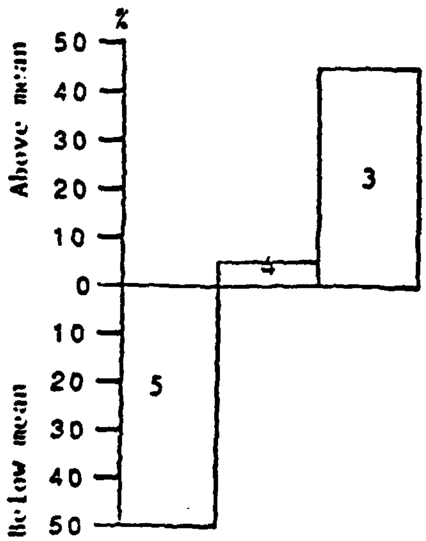


Fig. 17

Time / Type

Key Issues/Tactical

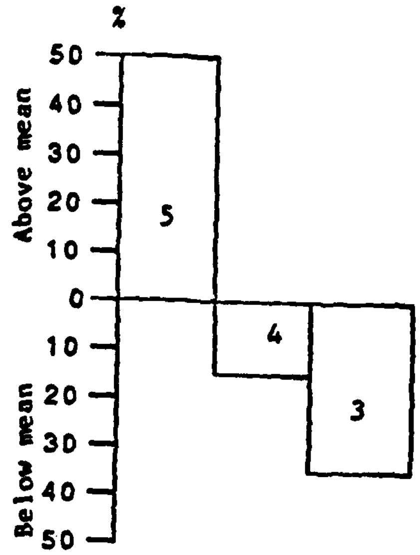


Fig. 18

Time / Type

Action List/Strategic

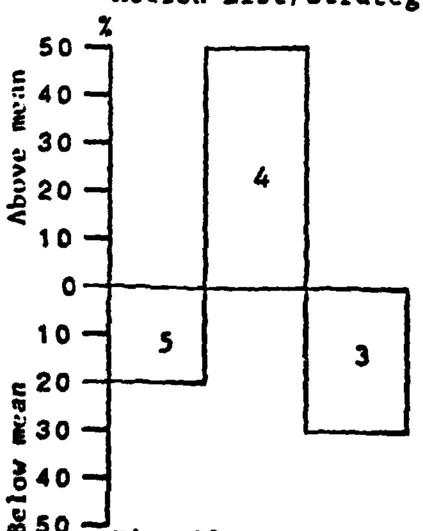


Fig. 19

Time / Type

Action List/Tactical

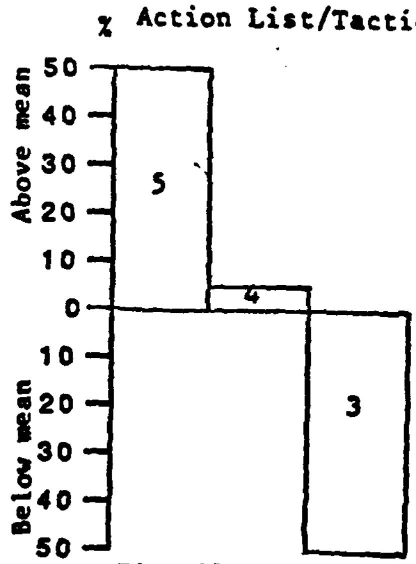


Fig. 20

Figs. 17 - 20 Relative Importance of Market Issues by management Strata

Economic issues:

The group of managers at stratum 3 were again most prominent in the number of issues raised at the strategic level at the 'key issues' stage of the decision conferences, however at the tactical level the group of managers at stratum 5 were more prominent. Group 4 is least concerned in this domain. At the 'action list' stage of the decision conferences, the group of managers at stratum 4 was most prominent in their concern with both strategic and tactical issues, managers at level 5 raised fewest strategic issues, and managers at level 3 fewest tactical issues (See Figs. 9-12).

Product/development:

At the key issue stage the group of managers at stratum 4 raised most issues at the strategic level, while the group of managers at stratum 5 raised most tactical issues. However, by the 'action list' stage the group of managers at stratum 3 raised most issues overall, while the the group of managers at stratum 5 raised the fewest issues overall in this domain of concern (See Figs. 13-16).

Market

In this domain of concern, the group of managers at stratum 3 raised most strategic issues at the *key issues* stage, with least concern being shown by the group of managers at stratum 5 at this stage, who raised the fewest strategic issues at the beginning of the conference in this domain of concern. This group, however, showed most concern with tactical issues both at the 'key issues' and 'action list' stage. The group of managers at stratum 4 in this domain of concern raised most strategic issues by the *action list* stage.

Table 1: Mean frequencies of issues raised at "key issue" stage by managers at each stratum

Management Stratum	Domain											
	Organisation		Economic		Product		Market		Image	Risk	Total	
	S	T	S	T	S	T	S	T			S	T
5	4.3	5	1.3	3.3	1	1.7	3	3.3	1.7	-	9.67	13.3
4	2.7	3.7	1.3	1.7	2.3	1	3.3	0.7	0.3	0.3	9.67	7
3	9	5	3	3	0.5	1	3.5	-	3	-	16	9

S = Strategic issues

T = Tactical issues

Table 2: Mean frequencies of issues raised at "Action List" stage by managers at each stratum.

Management Stratum	Domain											
	Organisation		Economic		Product		Market		Image	Risk	Total	
	S	T	S	T	S	T	S	T			S	T
5	3.7	6.3	0.3	2	1	2.3	1	1.3	0.67	-	6	12
4	2	2.3	1.3	5	5.3	3.3	4.3	0.67	-	0.3	13	11.3
3	0.5	2	0.5	1	2.5	2.5	0.5	-	-	0.5	4	5.5

S = Strategic issues

T = Tactical issues

KEY ISSUES

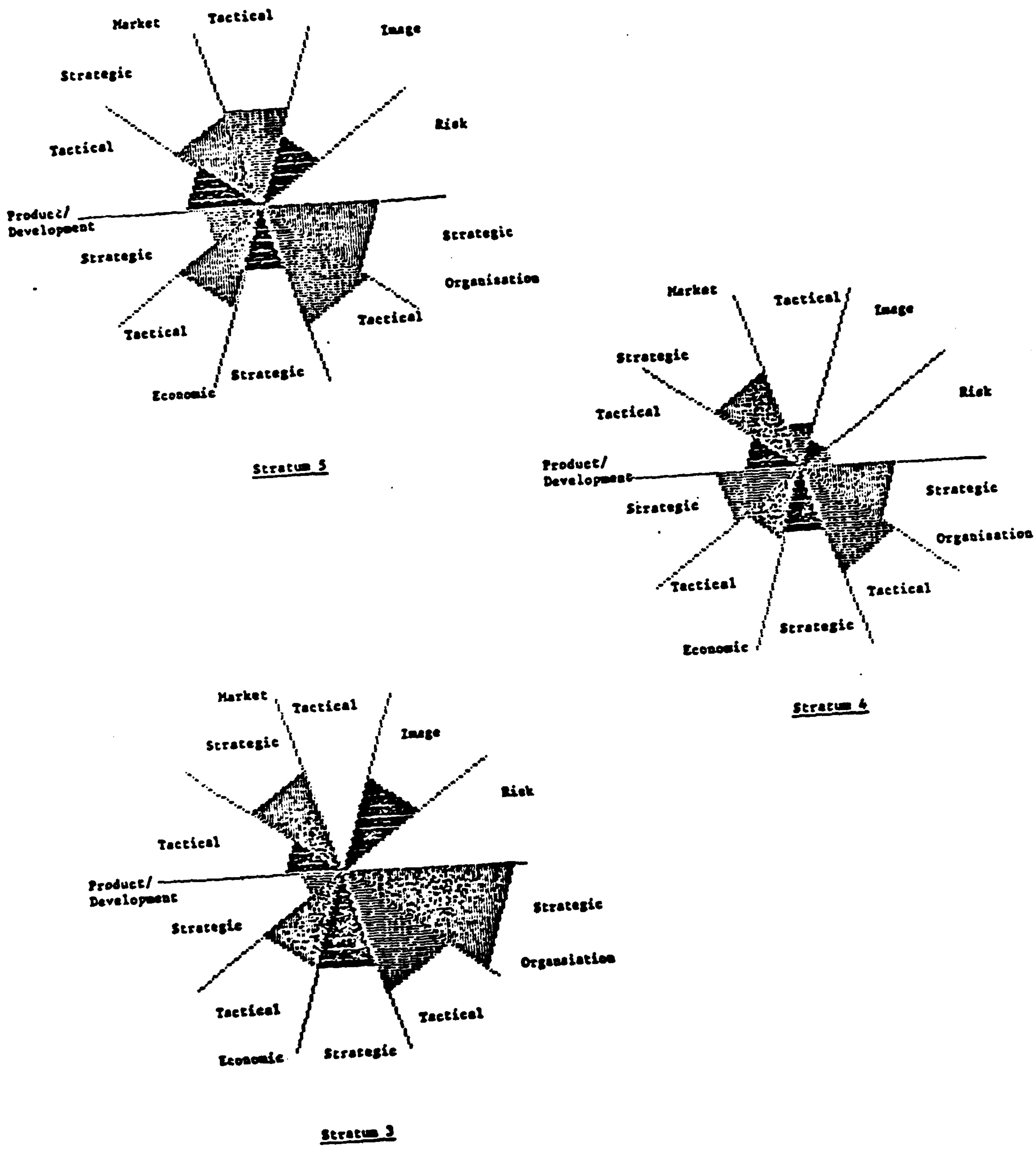
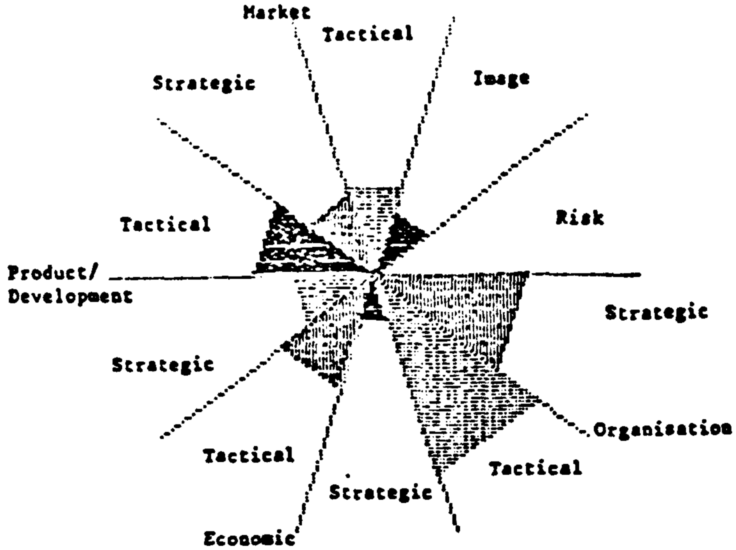
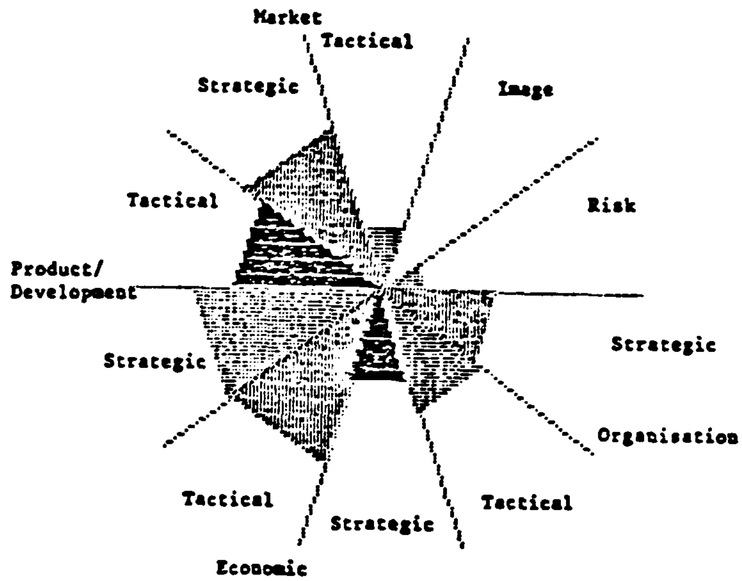


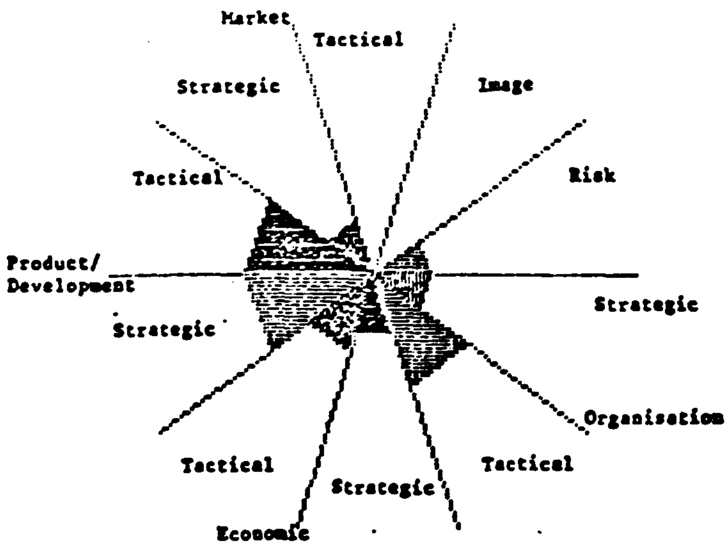
Figure:33 Proportion of issues raised in different domains per management strata



Stratum 5



Stratum 4



Stratum 3

Figure 34: Proportion of issues raised in different domains per management strata

Image and *risk* were not analysed in greater detail as relatively few issues were offered, however it is worth mentioning that whilst *Image* appeared to be most important to the group of managers at stratum 3, especially at the *key issue* stage, this issue was not raised again at the *action list* stage. While the group of managers at stratum 5 did raise some issues relating to this domain at the beginning, they did not consider this domain to the same extent at the end of the conference. Risk was not considered at all by the group of managers at stratum 5 and only a few isses were raised in this domain of concern by the groups of managers in strata 4 and 3 (See Tables 1 and 2).

The group of managers at stratum 5 represented the highest level management capabilities (amongst this group of companies) and therefore it was expected according to the hypothesis, that higher stratum managers would be better able to structure and assess decision problems, should offer a smaller number of issues in all domains of concern. The group of managers in stratum 5 infact offered more issues for debate at the *key issue* stage than managers in stratum 4 but less issues than the managers in stratum 3. However by the *action list* stage stratum 5 managers raised less issues than stratum 4 managers but more issues than stratum 3 managers (see Tables 1 & 2 and Figs. 33 and 34).

If we consider *strategic issues* at the *key issues* stage (See table 1), we found no significant difference in the number of issues raised between managers at strata 5 and 4 (9.67), however managers at stratum 3 raised considerably more issues in relation to the other two strata (16). At the *action list* stage (See Table 2), least number of strategic issues were raised by managers at stratum 3 (4). The group of managers at stratum 5 raised only a few more strategic issues (6), however, the group of managers at stratum 4 raised more than twice the number raised by stratum 5 managers (13).

For *tactical issues*, the group of managers at stratum 5 raised the most issues at both *key issues* and *action list* stages. The group of managers at stratum 4 raised almost as many tactical issues, but only at the *action list* stage. The group of managers at stratum 3 raised relatively few tactical issues either at the beginning or at the end of the conference.

Figures 33 and 34 provide a clear visual display of the extent to which domains of concern have changed as a result of the decision conference process. They show that managers at stratum 5 reduced the extent oftheir concern on most domains but expanded on *organisational*/tactical issues, which was their most dominant concern at the *action list* stage. Managers at stratum 4, however, shifted their emphasis from organisation issues to *economic*/tactical issues and *product development*, both at the tactical and strategic level.

The group of managers at stratum 3 showed the most change as a result of the decision conference process: while their major concern at the beginning focussed on *organisational*, *economic*, *market* and *image* issues, as a result of considering these through the conferencing process, they seemed to recognise that infact their areas of concern should concentrate on *product development*. While *image* was a major concern to them at the beginning, this domain was not considered at all by the end of the conference, suggesting that once the decision problems had been structured and evaluated, it was recognised that this domain was not of major concern after all.

4. DISCUSSION

Our results indicate that the managers at stratum 5, studied in the eight decision conferences, confirmed the hypothesis that this group of managers would raise fewer strategic and more tactical issues both at the beginning *(key issues* stage) and at the end *(action list* stage) of a decision conference. Additionally, the number of tactical issues raised in proportion to the strategic issues (twice as many) by the end of the conference further reflects the managers' ability to *refine* the decision problem, the development of a number of plans or macroactions to reach their goal. Managers at this stratum were able to reduce the number of strategic issues raised, as a result of the decision conference, at the *action list* stage again displaying their ability to refine decision problems.

According to the original hypothesis, the group of managers at stratum 3 were not expected to be able to refine their decision problems to the same sophisticated level as stratum 5 managers and were thus expected to raise more strategic issues especially at the beginning of the decision conference, indicating their lesser ability to refine and structure the problem. The results confirmed this hypothesis, the group of managers at stratum 3 did, in fact, raise a greater proportion of strategic issues at the beginning of the decision conference (*key issues* stage, 16:9). By the *action list* stage, they raised very few *tactical* issues (as well as very few strategic issues), thus reflecting the extent to which they had not been able to develop plans to operationalise their strategies. However they were, as a result of the decision conference process, able to identify those domains which they needed to focus upon.

Our results for the group of managers at stratum 4, however, confounded the hypothesis that they should perform in a manner lying between the style of the level 3 managers and the style of the level 5 managers. We had expected that, *if* a hieracrhical structure of competence holds across management strata, then the results should have followed a linear relationship, with the group of managers at stratum 4 raising issues in proportion to the other two management strata, that is, this group of managers should have displayed results that would have placed them in rank order between management strata 5 and 3. However, they ranked *lower* than the group of managers at stratum 3 at *key issues* stage by raising fewer tactical issues than stratum 3 managers, but they also raised fewer than expected strategic issues than stratum 5 managers. The group of managers in stratum 4 also *increased* the number of strategic issues that they raised by the end of the conference at the *action list* stage. However, they failed to increase the number of tactical issues raised by this stage of the decision conference. This implies that they did not handle strategic issues during the course of the decision conference in the same way as stratum 3 and stratum 5 managers. Although stratum 4 managers did raise more tactical issues than stratum 3, as expected, suggesting that, at the tactical level at least they confirmed the hypothesis concerning their intermediate position in the management stratum hierarchy.

In a recent pilot study of Decision Conference processes carried out at the Decision Analysis Unit, Chun, (1988) has shown that higher stratum managers regard the decision problem differently from lower stratum managers, they gave more preference to 'soft' options such as future potential, risk and synergy (fit with the firm's *strategic* mission). Further, they tend to increase concerns on future potential and decrease their concerns on short term financial goals. This complements the findings of this study that higher stratum managers are more abstract in their problem handling, generate more *novel* options and take into account long term perspectives more frequently, propose more strategic issues than lower strata managers.

5 INTERPRETATION AND FUTURE WORK

Preliminary findings do show that management strata in decision conferences does determine the extent to which decision problems are explored and structured and therefore effect the decision making process and possible solutions. Taking an alternative approach (Chun, 1988) in identifying stratum specific differences in Decision Conferences has reached similar conclusions concerning specific aspects of higher stratum participants. However our method of analysis is able to identify specific characteristics, that is whether the participants handle the problem in a strategic or opertaional/tactical manner by identifying the most important issues that managers bring to the conference table. Unfortunately the quality of the material available from these decision conferences was not sufficient to allow us to employ a methodology which could be successful in identifying precisely the *characteristics* of the issues and the *underlying quality* of the issues. It is in this direction that research will be directed in the next phase of this project, to identify the *characteristics* and underlying quality of the issues submitted for decision making, to establish if higher level management do actually structure the problems in a more *sophisticated* manner, while the current results into the development of Decision Support Systems indicate the need for stratum specific decision aids, we will defer a detailed discussion of the exact nature of these aids and how they will support the managers, until the final report next year, where we will have the benefit of this detailed information.

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Handling Decision Problems: A Structuring Language and Interactive Modules.

Final Report

PART III

Technical Report 89-3

Displaying differences across domains in problem representation between stakeholders in social decision making

A I Oldfield & P C Humphreys

CONTENTS

SUMMARY

In this final report we update and consolidate our previous work in which we dealt with the experimental part of the project and identified the issues concerning processes in problem handling in social decision making situations.

Variance in opinion based on different perspectives, roles and interests of stakeholders is seen as a major stumbling block in the process of reaching a shared agreement. In the context of our study which examined the opinion of various stakeholders influenced by the development of risky and hazardous technologies the issue is pertinent. Disagreement between stakeholders can result in the limitation of the use of such technologies which may be based on unresolved conflict rather than a consensus opinion about any disbenefits that may accrue through the implementation of such technologies.

In our initial study (Humphreys et al., 1987), we developed a methodology for eliciting differences and showed that by controlling the boundary within which a stakeholder is expected to perform, through the initial problem statement, exploration of the problem can be enhanced or restricted. We imposed five different points of reference from which our subjects where invited to begin their exploration.

The follow up study undertook to examine more closely the issues involved by concentrating on a single level (Oldfield and Humphreys, 1988). The study looked at how different groups of stakeholders handled a common problem to see if specific domains of concerns exist. The results indicated that identifying different stakeholders' perspectives and mapping them against each other is a useful technique to reveal areas of differences.

The elicitation of different perspectives to a decision problem would enable the identification of areas of shared agreement and more importantly, highlight those perspectives which are not shared. It is important to recognise that a major issue in identifying differences in perspectives amongst stakeholders is the extent to which the stated objectives are the *real* objectives and truly the views of the problem owners. Previous methodologies have not been successful in locating these. Central to our work is the reliability of the methodology in displaying the *real* perspectives or rather *small worlds* of the stakeholders.

It is within these small worlds that the problem exploration takes place, where events and consequences are considered in terms of scenario exploration. Where domains are not shared, the exploration within the unbounded scenario of another problem owner may be anxiety provoking and therefore can result in rejection. Thus techniques are needed which will handle conflicting factors generated by the existence of uncommon domains.

We propose that rather than extending the terms of reference in order to reach a shared definition and understanding of the problem, we consider ways to extend the background of safety within which problem exploration takes place. This would enable stakeholders to explore unbounded scenarios, previously not within their terms of reference. We consider that psychodramatic techniques would be particularly useful for this exploration.

DISPLAYING DIFFERENCES ACROSS DOMAINS IN PROBLEM REPRESENTATION BETWEEN STAKEHOLDERS IN SOCIAL DECISION MAKING

1. INTRODUCTION

Over the past few years we have carried out a programme of work aimed at gaining a better understanding of the different ways decision problems in social situations are perceived by various stakeholders and subsequently, how recognition of those differences can be effectively utilised in a consensus mode to reach a shared agreement. We identified different perspectives adopted by stakeholders and suggest that awareness of the various perspectives of a decision problem can be instructive in the communication and the understanding of the different ways in which a problem is being represented and the relative stakes involved.

In our previous work in Technical Report 87-3 on this project (Humphreys et al, 1987) we reported on the successful development of a methodology for identifying problem handling at different levels of knowledge representation among stakeholders in the context of hazardous waste disposal (This report is reproduced as Appendix A). The study also demonstrated how exploration of the decision problem is facilitated or restricted by setting constraints at a particular decision making level in terms of the initial problem statement. The posited method of problem handling elicitation utilises content analysis as a means of determining domains of concerns to individuals and represents the characterisation of the problem, has been considered particularly suitable for identifying differences between stakeholders in the decision problem.

Decisions arrived at in social policy formulation and implementation, which do not take full account of all the perspectives and problem conceptualisation of the different stakeholders can often lead to conflict and consequently to possible failure in the implementation. If there is no shared agreement of the problem then some of the parties' view of the problem will not be represented in the decision making process, leading to possible discontent as well as incomplete information for structuring the decision problem. In order to reduce such possible conflicts as well as to enable stakeholders or interested parties to reach a shared understanding of the problem in question, and consequently to reach the optimum decision for all concerned, it is necessary to identify existing differences in the problem handling process. This is crucial, so that appropriate support may be provided to enable the parties concerned to resolve differences, establish lines of communication and arrive at a shared definition and understanding of the problem.

The type of support required, however, is determined by the particular problem handling processes which are at variance. Whilst it is recognised that stakeholders in a decision making process and especially in the case of societal decision making, do have different perspectives and these perspectives have to be taken into account, the problem is not with identification of views alone, but with the adequate exploration of the underlying cognitive processes employed when engaging in problem handling work. By identifying the processes involved in exploration of the decision problem, it is possible to provide appropriate support, for this, representation techniques are needed which indicate the domains which stakeholders wish to explore in their initial exploration of the, as yet unstructured situation within which the problem will be located.

We can think of problem owners' exploration of the situation as being carried out within the *small world* which defines the bounds of the material which the person is prepared to retrieve and attempt to structure in locating and exploring problems relating to the organization in transition (c.f. Toda, 1976). Farago, Oldfield & Vari (1988), Humphreys and Berkeley(1986), and Wagenaar and Keren(1988) have described how problem owners with different interests due to their different organizational and social roles explored the small world they personally considered relevant in very different ways, according to their interests and, by extension, their roles.

Moreover, for the reasons we give in Section 2, problem owners who are not used to exploring particular domains in defining the situation may have difficulty communicating with other problem owners and stakeholders who would like to focus attention on such domains in locating problems to be faced. We discuss there how problem owners' need for a *background of safety* underlies this difficulty, and suggests interactive procedures which should help in resolving it by extending the background of safety.

Computer based support for such procedures has been found to be most effective in terms of displaying graphically (within a slice-diagram) the different degrees of exploration across domains carried out by the various stakeholders party to the decision. Examples of this type of display are presented in Technical Reports 87-3 and 88-3 on this project, which are reproduced in Appendices A and B. In subsequent work, beyond this project, we plan to develop these computer-based display techniques into a tool for Displaying Differences across Domains (DDD) as a means of supplying support at this stage within the situation definition cycle.

1.1 Problem *structuring* in *social* decision making.

A number of incidents in recent years has led to an increased level of fear and concern over catastrophies occurring in some industrial processes. The catastrophies have increased the level of apprehension in the public's mind over the risks involved in some technologies, resulting in a certain amount of alienation and conflict toward industry. This conflict can be harmful to the development and expansion of these industries, by the application of pressure on government and industry to limit and control development of technology. In recent years pressure groups have played a major role in bringing about policy changes. As a result of public concern, social policy planners are finding it increasingly more difficult to obtain the public's agreement to the development of hazardous and risky technologies. Thus the role of the public and need for their co-operation has become an important variable in Hazardous Waste Disposal. The need to recognise the issue of public acceptance of policies concerning risky and hazardous technology has been emphasised previously (Freudenberg & Rosa, 1984). However, in conflicting social decision situations, the parties concerned recognise that decisions relating to these have to be made and therefore a better understanding of each other's position are essential (Cats-Baril & Gustafson, 1986).

A major problem in obtaining consensus on societal policies is due to the conflicting interests and perspectives adopted by stakeholders in the decision making process. Studies which looked at problems of decision making over siting and policy (Kunreuther, 1982), highlighted a major theme: that areas of conflict arise due to the subjective views of stakeholders as well as their roles, goals and motivations within the process as stakeholders in risky technology bring different subjective views to the decision making table (von Winterfeldt, 1982).

In order to reduce conflict and ensure successful social policy development of hazardous or risky technologies by resolving differences and reaching consensus among stakeholders, it is important to identify where differences as well as agreement occur within the problem handling processes of all interested parties or problem owners. In many cases interested parties feel that *their* views are not recognised or accepted by the other stakeholders and therefore their interests are not properly represented.

In Technical Report 87-3 we identified how problem structuring for the stakeholders is facilitated or impaired through setting constraints at each of the five levels of cognitive representation of the problem being handled (Humphreys et al. 1987). The methodology developed was based on identification of areas or domains of concern raised by the subjects, revealing the extent to which particular issues formed the basis of their problem definition and structuring, the extent to which they *explored* the issue. This exploration represents their subjective judgement of the decision problem or issue in hand, of how an individual "tests" the boundary of his/her "small world".

1.2. Exploring the boundary of the "small world" within which the problem is located.

In making subjective judgements, material on which the judgement is based has to be retrieved from memory and then structured and explored in some way which allows a reasonably stable assessment of the material. In experimental settings of judgemental tasks, the experimenter's task instructions invite the subject to explore beyond what has been defined or given. This exploration may involve searching for ideas relevant in evaluating how the person feels about the consequences of offered options or may require searching previous experiences. Humphreys and Berkeley (1984) consider this exploration as being carried out within the *small world* which defines the bounds of the material which the person is prepared to retrieve and attempt to structure in handling the judgement problem (Toda, 1976).

1.3 *Analysis of differences between stakeholders in problem representation.*

Identifying stakeholders' small worlds enables the representation of their perspectives of the problem, which allows comparison of any existing differences in their conceptualisation of the problem. It is differences in problem representation among stakeholders that can lead to conflict over possible solutions of the problem. Successful resolution of conflict can only be achieved through a shared agreement not only about *what* the problem is but also *how* it can be resolved.

Results of the first study revealed the extent to which people were unable to handle and structure the problem of Hazardous Waste when either too constrained (level 2) or too free to explore (level 5). The findings revealed that problem handling was optimal at levels 3 and 4. At level 4, when presented with a scenario, people could explore the topic most widely: *across* levels. While at level 3, when the problem was constrained within a *frame*, the subjects were able to explore the topic in *depth* and did not venture outside the frame provided. The methodology is considered particularly useful to further expand the area of exploration of stakeholders' intuitive handling of decision problems and is particularly useful for identifying differing perspectives of the interested parties, as agreement can only be reached if the problem owners can recognise and explore each other's small worlds.

1.4 Resolving differences

Some attempts have been made to provide support for resolving differences through cognitive mapping procedures (e.g., Sevon, 1984; Friend & Hickling, 1987; Eden & Ackermann, 1989). However, in evaluating these mapping procedures we have found that, while they were quite good at eliciting material to be explored, they faltered at the point of expressing the exploration within the form of a map. At this stage in the situation definition process it is premature to employ a fixed structure - as in the geographical representation of a map - to show linkages between issues of interest to problem owners at particular points within a two-dimensional space. This premature imposition of structure by the mathematical techniques employed in cognitive map construction tended to lead to rejection of the whole map by problem owners. Also, the results often interfered with the process of conceptual model building in stage 4 of the procedural schema (Technical Report 89-1), which is the first stage where structured models may reasonably be developed and displayed.

Identifying and mapping differences in problem handling by stakeholders, especially in societal decision making have been a major focus of decision theorists in recent years. Several methods have been postulated which can usefully elicit the underlying cognitive structures utilised by stakeholders in their problem handling. Axelrod (1976) consider *cognitive maps*, in terms of a mathematical model of a belief system derived from what a person states and not from what he thinks. A cognitive map is designed to capture the structure of the causal assertions of a person with respect to a particular policy domain and generate consequences that follow from this structure.

Identification of differences in problem handling and representation can also be elicited through *argumatics*. Toulmin's (1958) uses of arguments is based on the premise that a man who makes an assertion puts forward a *claim*. The claim is implicit in an assertion and is like a claim to a right of argument which could be produced in its support. Whatever the nature of the particular assertion may be, in each case the assertion can be challenged and demand that attention be drawn to the grounds (backing, data, facts, evidence etc.) on which the merits of the assertion are dependent. Central to Toulmin's theory is the use of *grounds, warrants* and *backing*, for the claim or conclusion whose merits are to be established and the facts that are being appealed to as a foundation for the claim or data. The next step in the process may be to seek the relationship to the conclusion of the data already produced. Thus Toulmin's approach to argumentation is to establish, after having made the claim, upon what grounds that claim is based and what warrants are used to legitimise the grounds also what backing is utilised to strengthen warrants, that is, not just what people are saying but what information they use and the route they utilise in getting there. This method for displaying cognitive maps can yield useful data in establishing the extent to which people explore their boundaries at level 5.

This method of problem representation has been utilised by Hogberg et al., (1984), who argued that the standard rational model of problem solving, that is to choose the best alternative, did not apply to problems in social policies. They also suggested that when problems are ill-structured or 'messy', it is more fruitful to look at the problem solving processes in terms of analysing argumentation, as the form of arguments and the content of the conclusions are interdependent. This means that interest groups or stakeholders with conflicting conclusions (common in public policy issues) use different forms of argumentation and that this blocks creative problem solving. Their methodology for analysing arguments in debates was applied to the nuclear energy debate (in Sweden). Through the use of their methodology they were able to identify systematic differences in the use of decision criteria, scientific logic and confidence in "established scientific knowledge" between opposing stakeholders in the debate. One of their major conclusions claimed that stakeholders with opposing interest will not "listen" to each other's arguments, and pointed future research toward identifying differences in problem conceptualisation.

Application of Hogberg's methodology to determine differences of problem handling between stakeholder groups in a social decision problem (hazardous waste disposal in the U.K.) has supported his findings that experts tend to use more facts and theories to support their argument in a public issue debate while lay people and pressure groups use more value judgements to support their arguments in a debate (Allan, 1987, Vari et al., 1986).

However, while this methodology is useful for identifying the *type* of argument utilised in the debate, it fails to identify as successfully the specific perspective utilised by different stakeholders or interested parties within such debates. An explanation of how stakeholders in, especially, social decision making situations *conceptualise* the problem, on what *kind* of issues they base their arguments and only displays how people *argue* and not on how they *view* the problem. In order to be able to argue the process it is necessary first to reach agreement on what is the problem. A prerequisite to a successful argumentation process must be agreement on what the argument is about. The methodology developed on this project and detailed in Technical Report 87-3 proves more useful in identifying individual stakeholder's perspectives in handling the problem. The identification of stakeholder's perspectives is the first step towards developing strategies for supporting exploration of the situation of concern and routes of communication, essential in risky and controversial technologies and issues (Farago et al., 1987). We discuss this issue further when we consider the implications of our experimental findings in the next section.

2. IMPLICATIONS FOR SUPPORTING EXPLORATION AND NEGOTIATION OF THE DOMAINS OF CONCERN

2.1 Scenario exploration

In the course of defining the situation, problem owners may find that exploration of domains given prominence by other problem owners, with interests and experience different from their own, may be much more threatening than exploring consequences, even negative ones, than exploring their own familiar domains. They may have to explore other people's scenarios, which, for the explorer, are unbounded, that is, it is possible for them to imagine and consider events and consequences which are not bounded by familiar worst case scenarios. Such anticipation can arouse considerable anxiety about the possibilities of what might be encountered and would need to be *dealt with* if the problem owner were to undertake this exploration in his own mind, and in so doing going beyond his own *background of safety* (c.f. Sandler & Sandler, 1978; Humphreys, 1982). This in turn, can lead to a refusal to consider other stakeholders' views, not because of negative features, but just simply because it feels unsafe even to consider them.

In such cases, what should be done to bring problem owners with different interests together so that they may develop a shared definition and understanding of the situation? Without this shared understanding, problem solving cannot take place. We may consider three alternative strategies. The first two have to do with the way *terms of reference* are set for the issues which may be considered in a public way in the defining of the situation. The third relates not to terms of reference, but to the *background of safety*.

2.2 Extending the terms of reference

Extending the terms of reference for what can be considered in defining the situation and to admit material drawn from an enlarged *small world*, encompassing the small worlds that each participant would like to explore may well be an unrealistic solution to the problem of handling differences between stakeholders with different interests. Implementing this notion would involve each participant being required to engage in wider exploration, thus increasing the chance of encountering consequences which for them, if not for all the other stakeholders, would involve considering unbounded worst case scenarios. This could undermine the background of safety, which they need if they are to negotiate a shared knowledge structure, which they are then prepared to use in subsequent problem definition.

Moving to the other extreme is often recommended, that is *restricting* rather than extending what can be talked about within the frame of reference. This implies that scenarios in other areas might not be explored, thus reducing the level of anxiety that such explorations may induce (c.f., Mazur, 1984). Such a strategy is actually likely to be counter-productive, as it would simply throw such exploration into the realm of taboo issues wherein phenomena excluded from social debate, rather than being neutralised, are experienced as having special agency and potency (Douglas & Wildavsky, 1982)

2.3 Exploration techniques

Therefore we would suggest that an alternative and more promising solution would be to consider ways of extending the background of safety, helping problem owners develop and bound scenarios in areas, where, at present, they do not know how to think about what might be involved. To develop scenarios proposed by other stakeholders in the process of problem definition and handling, and to explore these constructively rather than through avoidance, as is often the case.

Techniques developed to deal with such exploration are based on drama, to provide support to help audiences to consider and face the unthinkable, from Greek tragedies handling issues that deal with death, bereavement, sacrifice and taboo. More recently these ideas have been adopted by social scientists to form the basis of techniques such as *psychodrama* which involves working with small groups facing various psychodynamic states such as personal anxieties and interpersonal conflicts etc., involving situation bounding. Moreno (1946) describes the use of role-playing within the context of psychodrama (exploring scenarios from the starting point of other problem owners' roles) to reveal things to problem owners that would otherwise be unavailable for exploration by them. Psychodramatic techniques (compared by Sampson, 1971 with Stanislavsky's theory of acting) are employed to provide a structured context which effectively extends the background of safety for the problem owner's exploration of the small world accessed through adopting the viewpoint associated with another's role in the problem expressing process.

Some techniques of this type are also employed within the strategic choice approach to organizational decision making (Hickling, 1974; Friend & Hickling, 1987) in order to help decision making groups deal with uncertainty about bounds of the small world within which the problem should be structured. However, the strategic choice approach focusses more on co-ordinating the boundaries of the small worlds shared by problem owners comprising the group, rather than exploring the potential conflicts concerning what may safely be encompassed within these boundaries.

Identifying other stakeholders' small worlds, especially those that are different or rather are not shared by other problem owners is crucial if any kind of support in terms of aiding scenario exploration is to be provided in order to extend the existing background of safety.

Implementation of psychodramatic techniques with the goal of extending the background of safety is a highly interactive process between problem owners and analysts. We do not suggest that such techniques themselves could be successfully programmed as compute-based functions of tools in class R1. However we have found that displays of the domains explored by different stakeholders (c.f. figures in Oldfield & Humphreys, 1988) can be very useful for providing the structured context which sets the agenda for the exploration through small worlds which the psychodramatic techniques may facilitate.

3 CONCLUSION

The results of the experimental work described in Technical Reports 87-3 and 88-3 on this project (reproduced in Appendices A and B) identify the extent to which stakeholder groups can reach agreement on their decision problem, and highlight the extent to which these groups are unable to communicate with each other. The analysis reveals that their background of safety, and thus the boundaries of the small worlds that they are able to explore are not shared. In order to reach a shared understanding of the problem it would be necessary to extend stakeholders' background of safety to include domains beyond the existing boundaries so that all perspectives may be shared by each stakeholder. We discuss ways of doing this in Part I of the final report on this project (Technical Report 89-1).

The identification of the domains of concern explored by interested parties within the issue of hazardous waste, facilitated the comparison of perspectives adopted by members of stakeholder groups who would occupy different, and potentially opposing roles in social decision making on hazardous waste disposal.

The method of analysis we described in the first year of work on this project, and described in Technical Report 87-1 has here been shown to be useful in eliciting the perspectives of different interest groups within a decision problem. It is able to identify *where* differences in perspectives occur and thus enable resolution of such differences by aiding the particular stakeholder groups to extend their background of safety and encourage exploration to take place within domains not previously explored. For this reason, we have proposed its development into a support technique within Class R1 of the *Organizational problem handling toolkit* described in Technical Report 89-1: i.e., as a technique which can facilitate organizational problem owners' expression of issues of concern in defining a decision problem. However, this technique should not be considered to provide support in a stand-alone fashion. Rather, it is an important adjunct to methods aiming at extending the background of safety, like those described in Section 2, above.

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Technical Report 87-3

Intuitive Handling of decision problems: A five-level empirical analysis

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SUMMARY

The research reported in this report posits and tests a theory that people's intuitive handling of unstructured deciion problems (that is, those problems in which neither the environment nor convention nor habit dictate an appropriate solution) consists in five levels of subjective, psychological problem structuring. The key features of these five decision making levels are:

(1) what is qualitatively different at each decision making level are the operations carried out in forming judgements about how the problem is to be handled and solved, (2) the results of the operations caried out on a particular level constrain the ways operations are carried out at all lower levels, and (3) any decision problem is potentially represented "in the real world" at all levels. Therefore, levels cannot be treated like a taxonomy for classifying decision problems; instead, the handling of problems at each decision making level has to be examined.

In the study reported, four of these five decision making levels were manipulated under four different experimental conditions. Within these conditions, subjects' discussions of a topic having significant real-life impact for them (local hazardous waste disposal) were constrained in one of four ways by interviewer-imposed constraints, each constraint corresponding to one of the posited decision making levels.

A major empirical question addressed in this report is the extent to which intuitive decision making is impaired or facilitated by setting constraints externally, as terms of reference or as an initial problem statement, at a particular decision making level. No previous empirical research on judgement and decision making has dealt with this problem. The posited five decision making levels provided not only the rationale for the experimental design but also different ways of analysing transcripts of subjects verbal handling of the problem. These analyses led to the following conclusions:

1. Imposing the minimum constraint of only specifying the problem area asks too much of people; their exploration of the problem is very limited. To help them get started in their thinking, priming them with either a bounded scenario or a frame within which to represent the problem proved very successful.

2. The main trade-off in practice has to be made between priming subjects with scenarios (level 4) or frames (level 3). Priming with a frame within which to represent the problem tended to encourage more "depth" (structuring within the offered frame). Priming within a scenario encouraged more "breadth" (exploring across intuitively selected frames). In each case, though, subjects still explored more beyond the areas in which they were primed than within the areas in which they were primed.

3. Constraining subjects by giving them a fully-structured problem frame (level 2), typical of psychological experiments on judgement under uncertainty, is counter-productive. Subjects became frustrated and apathetic: they explored less, both within and

outside the frame in which they were primed, and this was not compensated for by encouraging them to give more judgements within the frame. In other words, constraining people at this level clearly underestimates their intellectual abilities, and they respond by failing to display much of what they are capable of at any level. Thus, the conclusion made by many judgement researchers, that people are "intellectual cripples" when dealing with uncertainty, may be an artifact of the experimental constraints imposed on subjects.

4. Overall, this research shows the impossibility of maintaining an objective stance on the part of the experimenter in judgement research. The act of stating the problem and what is required of the subject has a profound effect, well beyond the error variance associated with experimenter-induced biases, on the way subjects think about the problem. In addition, the approach used by the experimenter in analysing the data imposes its own constraints on the conclusions that are drawn. Thus, judgement researchers will need to consider new paradigms that recognise the inseparability of experimenter and subject in investigations of problem-solving for ill-structured situations.

CONTENTS

1. INTRODUCTION

The nature of stakeholders' intuitive handling of social decision problems has become an important issue when forecasting the success of strategic or regulatory policy making on issues of social concern where social consensus or, at least, acquiescence is required to ensure the policy's success. In such cases, views of interested parties or stakeholders are frequently sought through public enquiries or opinion surveys (e.g., Otway et al, 1978). The resulting differences in views are often attributed to one or more of the parties consulted possessing intrinsically defective or restricted capabilities for handling decision problems, especially when one of the parties is the general public: lack of ability to handle expert knowledge is assumed to lie behind the public's objection to certain policies under the assumption that "if the public could take the facts properly into account, public opposition would fall away" (e.g., Davis, 1984; Szalay, 1984).

Attributing public discord or disquiet to lack of knowledge or biases in intuitive handling of decision problems precludes an understanding of the source of the dispute from any perspective other than the one put forward by particular stakeholders who are in a position to define their view of the problem as the view of the problem. This in turn may lead to effective disfranchisement of other legitimate stakeholders.

This report aims to address the issue of how one should conceptualize the processes involved in intuitive decision making in a way that allows us to evaluate intuitive decision making independently of any assumption of what is the "correct" way to handle a problem. The methodology involved is also intended to pave the way towards the development of effective techniques for displaying the differences between the ways different stakeholder groups intuitively handle social decision problems in such a way that will facilitate the resolution of these differences, rather than promote claims by particular stakeholders that other stakeholders are simply 'biased' or incompetent in the way they handle the problem.

1.1 Evaluating stakeholders' intuitive handling of decision problems.

Evaluation of other people's performance in intuitive decision making is a common preoccupation of psychologists. Usually standards for such evaluations are drawn from what is classified as the "normal" performance on the specific decision task; norm in this case tends to refer to the statistical norm. Research on judgement is exceptional in this respect as here the standard for comparison is usually derived from the normative model prescribed within the particular theory which, according to the researchers's opinion, should apply to the decision task being investigated. This practice relies on the assumption that the decision task can be represented in only one way and that the answers to questions about the decision task are prescribed within the confines and under the assumptions of the model which is used as the standard for the evaluation (Berkeley and Humphreys, 1982).

Such an approach to evaluation is, however, based on an oversimplification of the process of judgement since basing such evaluations on the products of this process misses out the creativity and innovation inherent in the process itself and assumes that there is such a thing as a self-evident objective reality to which everybody relates in the same way. Lichtenstein et al (in press) make a similar suggestion and recommend that researchers should test their own intuitions rather than accept them ipso facto as explaining the phenomena they study.

There have been a number of critiques of how experimental psychologists judge their subjects' inferential reasoning as defective (e.g., Berkeley and Humphreys, 1982; Edwards, 1983; Christensen-Szalanski and Beach, 1984) and of how experts (or those who employ experts) judge lay people's risk judgements as defective. However, it would be wrong to consider that this tendency is restricted to experimental psychologists: generally in social decision making situations involving groups with differing and potentially conflicting goals or interests, each group tends to consider the other group's judgements in handling the problem to be defective, biased, incomplete, while their own judgement is consider much more appropriate. How can we resolve this contradictory state of affairs? There are three viewpoints about this:

- The authoritarian view which is based on the belief that only certain stakeholders can handle a decision problem appropriately due to some external criterion, e.g.,
  - they have the service of experts,
  - they belong to a more knowledged elite,
  - they have the right (or gift) to decide for political or religious reasons.

- The pessimistic view which is based on the belief that No one can handle intuitive decision problems effectively, e.g.,

  "Our cognitive limitations, not only result in poor judgement, but they prevent us from seeing just how poor it is..." (Dawes, 1976).

- A relativistic view which supports the idea that stakeholders may have the capabilities to handle intuitive problems effectively (but only from their own perspectives.)

In the following we shall examine what is involved if one wishes to adopt the relativistic view. There are two reasons why this view is attractive to us: (1) it fits with Beach et al's (1987) view that the question of the quality of judgement can never be settled in a general, that is, absolute sense, and (2) it provides the possibility of using the judgements that each person or stakeholder group makes from within their own perspective in handling a shared social decision problem in a constructive way. We shall consider first what is implied by the caveat "from within their own perspective" and then describe how we can understand intuitive decision making in a way that will allow us to display, and maybe attempt to resolve differences in perspectives.

1.2 Perspectives in judgement

The notion of perspective should be understood here in a metaphorical rather than literal sense. Thus, the analogy it implies is different from the analogy made by Tversky and Kahneman (1981) between "correct" judgement and veridical perception. In their analogy, visual perspective is taken to be correctly interpreted in, for example, making out the "true" heights of mountains at different distances in one's view. The claim that we would like to make here is that this perceptual analogy is not sufficient to understand properly what is meant by a person's own perspective in judgement. In judgement, what one "sees" is a function of what one has "seen" in the past, how what one is facing now is going to affect one's own future, and so on. It is insufficient to try to explain the differences in judgement stemming from different perspectives by making an analogy between differences in perception of an objective, physical world. It is equally inappropriate to extend this analogy by attempting to construct a map showing the range of knowledge about a particular situation which may or should be taken into account by anyone forming a judgement.

At first sight, this mapping idea looks attractive, but what is assumes is that the differences in perspectives and the results of their operations could be represented in just one map, one knowledge representation structure; all one has to do is to find out what this map looks like. A number of people have tried to make maps (e.g., Axelrod, 1976; Eden et al, 1981) or equivalent non-spatial representations of this type. The problem, however, with this enterprise is that most people fall into the trap of believing that differences that exist between the knowledge representations of the various stakeholders can unequivocally be expressed in one structure constructed at just one level of knowledge representation.

1.3 Five decision making levels

Previously we have advanced the thesis that no less than five qualitatively different decision making levels have to be taken into account in understanding how people structure their intuitive judgement in handling decision problems (Humphreys and Berkeley, 1983; 1985). Table 1 shows the operations involved at each of these levels in handling intuitive decision problems. Related accounts of this scheme focussing on organizationl problem handling, have been given by Jaques, 1983 and Phillips, 1984. We have also suggested that the use of this scheme is essential in any attempt to handle differences in judgement between different individuals or different interest groups in social decision making, if we are to avoid unnecessarily negative and restrictive evaluations of the whole process of the stakeholder's intuitive decision making.

Humphreys and Berkeley (1987) describe practical examples from case sudies of displaying differences at each level, but these, of necessity were taken from a number of studies in different settings. The objective of the present study is to make use of the methodology described by Humphreys and Berkeley (1987), within a comprehensive empirical study of the way in which 'non-expert' stakeholders form judgments in handling an intuitive decision problem.

Table 1: The operations involved, and means for displaying and resolving differences in judgement in decision problems, classified by decision making level

Level	Operations represented at this level involve	Means of handling differences in judgement between individuals or interest groups involved in the decision making task
5	Exploring to find the boundary of the small world in which the problem is located	Extend "background of safety"
4	Problem structuring language: selecting and linking variants of judgement structures	Analyse differences in content of problem structuring language - not the amount
3	Developing structure within a particular judgemental frame	Analyse differences in the emphasis they place on each component of the structure
2	Asking "what if" questions	Sensitivity analysis
1	Making "best assessments"	Deciding who is most competent to make each assessment

(Source: Humphreys and Berkeley, 1987, Table 2)

2. Operationalization of the five decision making levels in a study of how people handle problems involving hazardous waste.

Three formal properties of the levels scheme described by Jaques (1983), Humphreys and Berkeley (1985, 1987) and Phillips (1984b) and introduced in the previous section, are of key importance in specifying the methodology for this study of intuitive handling of decisio problems.

These are as follows:

1. What is qualitatively different at each decision making level are the operations carried out in forming judgements about how the problem is to be handled and solved.

2. The results of the operations carried out on a particular decision making level constrain the ways operations are carried out at all lower levels.

3. Any decision problem is potentially represented "in the real world" at all levels. Therefore, we cannot treat decision making levels like a taxonomy, classifying decision making problems as level 1, level 2, etc. We have to examine how each problem is handled at each level.

In laboratory experiments on intuitive decision making tasks, material on which the judgement is based has initially to be retrieved by the judge from memory and then structured and explored in some way which allows a reasonably stable assessment of whatever one has been asked to judge. The task instructions provide a guide - sometimes misleading - about what may or may not need to be searched in memory, and how it should be structured. Instructions are never self contained, however, for if they were, there would be no element of judgement involved: in the task assigned to subjects the answer would always be given within the questions. The question instructions thus invite one to explore beyond what is given searching for ideas relevant in evaluating how one feels about consequences of offered options, or for a previously learned statistical principle which would provide the needed link to make the demanded inference.

Outside of the laboratory, in the absence of such task instructions, more elaboration or exploration may be necessary on less well-structured initial problem statements, and there may be less constraints on generating novel solutions containing elements not within the constraints provided by initial instruction sets in the typical laboratory experiment (e.g., Tversky & Kahnemann, 1981). These laboratory versus 'real life' differences refer, however, to the amount of elaboration or exploration which may be necessary.

Research on intuitive decision making within the "conversational" paradigm (Kahneman and Tversky, 1982) typically relies on making the comparisons shown in figure 1 between subjects' responses in a decision making task and the output of a normative model.

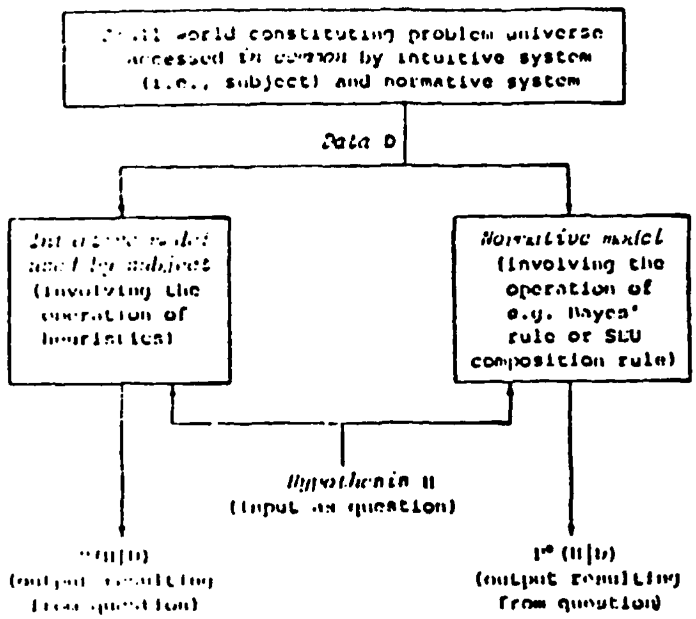


Figure 1: Comparison procedure used in generating data for empirical testing of a decision theoretic composition rule

This comparison procedure to have any validity, however, two conditions must be met: (i) comparisons must be made at one, and only one, of the decision making levels shown in table 1 and (ii) for a comparison to be made at any particular level, there must be a common understanding about how the structure of the problem representation is to be fixed at all higher decision making levels (that is, if the procedure in figure 1 were to be applied at these higher levels, there would be no difference in the two outputs).

These two conditions together imply that we should start at the highest decision making level at which there is a possibility of the existence of differences, and then work down, level by level, interpreting the differences in output comparisons shown in figure 1 at the highest level at which they occur.

Figure 2 (from Humphreys and Berkeley, 1983) outlines the general procedure. In the present research (detailed in section 3) we investigated problem handling within groups of stakeholders drawn from the same population of people living on a housing estate located between 1 - 1.5 miles from a commercial hazardous waste incinerator, which share a common (Western) culture and so the research will concentrate on the representation and analysis of differences in problem handling at level 5 and below.

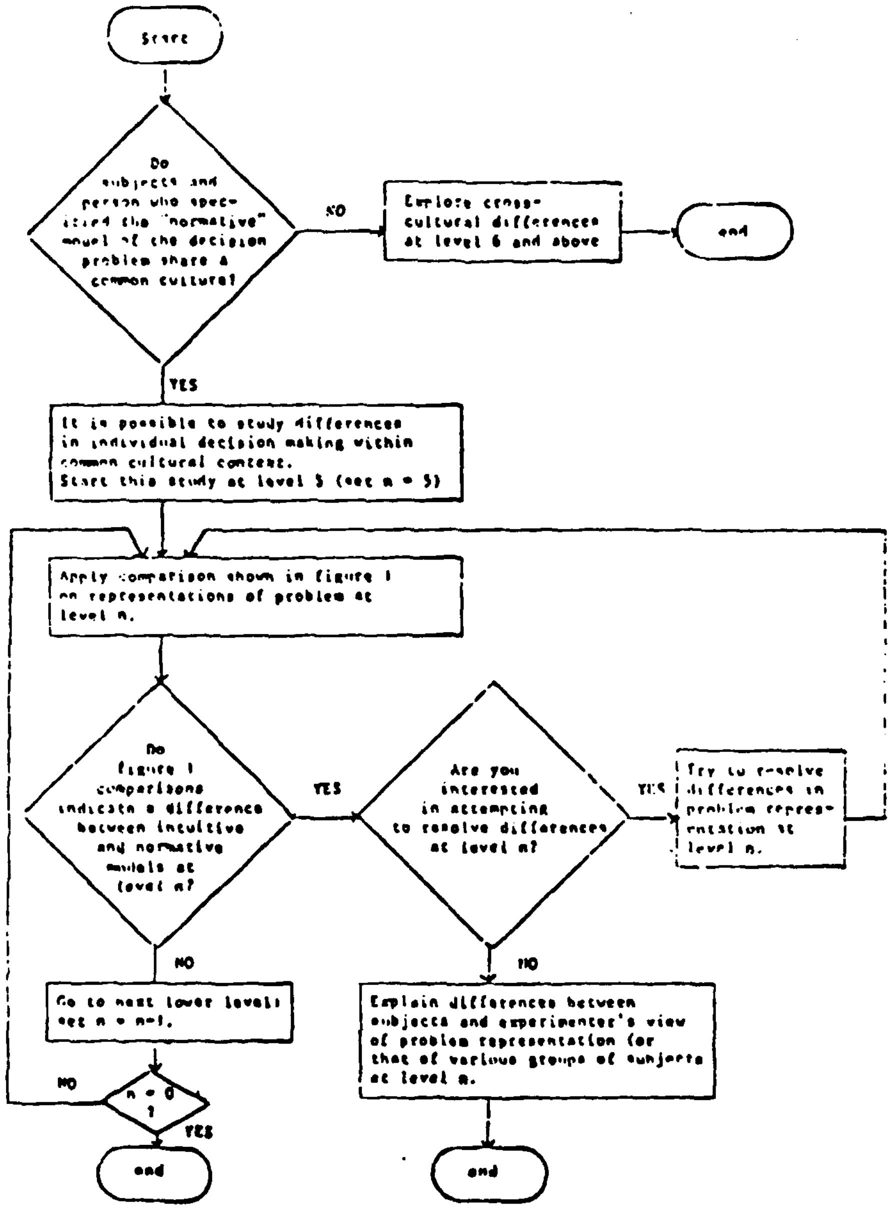


Figure 2: Multi-level comparison procedure for investigating differences between "intuitive" and "normative" problem representation.

The objectives for our research required a controlled experimental design where the constraints on how subjects were expected to handle a decision making problem were expressed through task instructions which define how the problem should be handled at certain levels, but left the way the problem is handled at other levels for subjects to decide for themselves. Details of the experimental design are given in section 4 after we have reviewed, in section 3, the necessary preparatory work through which it was refined.

For reasons of consistency of comparisons between and across decision making levels, the design requires that all questions at all levels should lie within the same general domain. We chose as the domain: issues involved in disposal of hazardous waste (both new and familiar). The three principal reasons for this choice were: (i) it is a domain where considerable difference exist between individuals at all levels in the way they conceptualize the decision problem involved (Lathrop and Linnerooth, 1983), (ii) there is recent work on the nature and content of the issues which can be effectively addressed through questions in exploring intuitive decision making, (Jungermann, 1983) and (iii) Phillips (unpublished) has previously conducted a pilot study involving 75 subjects which identified the range of scenarios they wished to employ within this domain.

3. Preparatory work

The general aim of the pilot studies described in this section was to establish the way in which stakeholders explored the problems of hazardous waste, in order to establish the domains within which their explorations could be represented.

3.1 Pilot studies

The necessity for this pilot work had become apparent during a pre-pilot study of university students, where we found that they carried out very little exploration because they were insufficiently interested in the subject area. In addition, they were not directly involved, so did not consider the subject at length. Hence in seeking interested stakeholders to serve as subjects in the pilot study, we decided to turn our attention to the process of hazardous waste disposal.

We selected the following groups:

(i) managers within a commercial concern dealing with hazardous waste, (ii) inspectors involved with regulations of hazardous waste disposal, (iii) local politicians, (iv) three members of a local residents' associations, (v)university lecturers and researchers on hazardous waste and (vi) members of the media who had been involved in the production of programmes on hazardous waste disposal. It was considered that this range of experts would yield adequate information about the various domains to be considered due to their diverse subjective involvement.

3.2 Hazardous waste technology chosen as focus for study of scenario.

The plant selected was a Hazardous Waste Incinerator sited on the sea-shore next to a large oil refinery. The plant was originally built at the site to handle waste from the refinery but expanded more into handling other hazardous wastes, including imported hazardous waste. The plant had been a subject of intense media attention due to increased public concern and controversy over safety and environmental damage as a result of emission of dioxin through the incineration of polycarbonatebiphenyls (PCB). A similar plant in Scotland had already been closed down as a result of public pressure. The company operating the plant had been recently taken over by its management as a result of fluctuating fortunes due to the controversies over safety and environmental damage. Thus, the managers were not just employers but also owners with considerable investment.

3.3 Domains selected for study

The interviews with the experts in the pilot study were transcribed and analysed according to the different propositions employed by each expert. Three judges independently sorted the total propositions from all subjects into domains, reflecting different areas of concern, and then discussed the resulting classification schemes, reducing them to a single set of ten domains which all judges agreed adequately and fairly captured the diversity of areas explored by the experts. These ten domains were as follows:

1. Locations of hazardous waste disposal facilities (siting of plant, near high density population, where it should or should not be. Not in my back yard - NIMBY).

2. Effects on people (nuisance or detrimental to health).

3. Plant systems safety (issues of safety of method and plant systems).

4. Regulation (how incineration methods should be controlled, safety ensured, etc.).

5. Provision of information (whether information is available or should be).

6. Trust (trust or belief in expertise, tecnology and decision makers).

7. Acceptance/protest (for or against concept of hazardous waste disposal).

8. Long term prospects (or effects of waste disposal on people/environment and other future scenarios).

9. Effects on the environment (immediate or in the future).

10. Disposal methods (reference to methods of disposal).

4. Experimental Design

Four groups of 10 subjects per group were thus divided according to the way in which the task instructions they were given constrained the way in which the problem should be handled at particular decision making levels, while leaving them free do handle the problem in any way they wished at lower levels. Group A was thus constrianed at decision making level 5, group B at level 4, group C at level 3, and group D at level 2. (We did not include a group constrained at level 1 as previous pilot work had demonstrated that this resulted in an overly artificial problem description, which was likely to be rejected as unrealistic by subjects). Details of this design are given in table 2.

We did not assume that subjects would necessarily adhere to these constraints when handling an intuitive decision problem. Hence our analysis involved investigating how subjects in each group dealt with the presented problem at each of the five decision making levels, enabling us to ascertain:

(i) The extent to which subjects in each group used the information actually given in the problem statement to structure the problem at that level.

(ii) The extent to which relevant information in the problem statement was ignored or rejected as inappropriate by subjects in each group.

(iii) The extent to which - and the manner in which - subjects in each group elaborated beyond the problem statement in structuring the problem.

Details of the analytic procedures involved are given in section 7, below.

Table 2: Four groups experimental design: constraints set at each level for each group.

Decision making level	Constraints set at this level	Interview format when constraint set at this level	Whether constraint set for group A	B	C	D
5	- Subject of hazardous waste disposal	Problem area specified only (subjects are encouraged to explore whatever scenarios they wish in elaborating problem),	YES	YES	YES	YES
4	- Scenario exploration: - plant location - regulation - provision of information - disposal method	A bounded problem scenario is supplied (subjects are encouraged to identify the frames they consider relevant in representing the decision problem within this pre-specified scenario).	NO	YES	YES	YES
3	- MAU plant-location frame	A particular problem structuring frame is supplied (subjects are encouraged to develop representation of the problem within the frame).	NO	NO	YES	YES
2	- MAU plant location with 3 options and 3 criteria fixed	A complete representation of the problem is supplied within a single frame (in this case, a "multicriteria frame) pre-specification of criteria. Subjects are able to explore characteristics within the structure, through examining implications of changing values at particular nodes in the frame.	NO	NO	NO	YES

5. Subjects

40 subjects were interviewed, ten in each group. Subjects were randomly selected from the electoral register recording the adult inhabitants of housing estates located within 1 - 1.5 miles of the hazardous waste incinerator (20 subjects were men and 20 were women, but sex differences were not investigated in this study). Subjects were interviewed in their own homes. The choice of location was important as it provided a selection of people who could be expected to be interested in the problem of hazardous waste disposal.

6. Procedure

Each subject in each group was interviewed individually, and alone. The subject was informed that the interviewer was conducting a research study for London University on Hazardous Waste. Once the subject had agreed to participate by being interviewed, the interviewer introduced the topic with the appropriate constraint for the group to which the subject had been assigned, as follows:

6.1 Group A: constraint set at decision making level 5

Subjects assigned to group A were asked by the interviewer:

> "Could you tell me what are your views on hazardous waste".

No further prompts were provided.

6.2 Group B: constraints set at decision making level 4

For subjects assigned to group B the interviewer read aloud the contents of Card A:

> "These are the 3 main methods of disposing of hazardous waste:
>
> 1. Landfill (depositing on unused land).
> 2. Incineration.
> 3. Storage (short and long term, including sea dumping)."

Card B was next given to the interviewee, and the interviewer read the card:

> "We would like you to talk about the following aspects of hazardous waste disposal:
>
> 1. Regulation.
> 2. Siting.
> 3. Advantages of incineration compared with other methods.
> 4. Availability of information."

The subject was then asked:

> "Would you like to talk about these aspects of Hazardous Waste Disposal?"

No further prompts were given, except in cases where the interviewee strayed from the topic.

6.3 Group C: constraints set at decision making level 3.

For subjects assigned to group C the interviewer started the interview with the following statement (read from a clip-board):

> "One of the drawbacks of modern technology is the production of substances such as certain chemicals which may be dangerous to the environment. One way of disposing of such waste is by incineration. The incineration plants must be sited somewhere and there are advantages in choosing any given site. If you were in a position to choose a site for the burning of potentially dangerous/hazardous waste, what sort of site would you choose?"

Prompts were offered on aspects within the frame of siting in the case where the interviewee expressed incomplete statements. The interviewer's guidelines for prompts stressed that they should be restricted to the nature of siting, e.g., where a facility might be sited, characteristics of potential sites, choosing between sites, advantages, alternative sites, why is Fawley a bad site if at all?

6.4 Group D: constraints set at decision making level 2.

For subjects assigned to group D the interviewer started the interview by presenting a card to the interviewee on which the following was printed:

SITING OF INCINERATORS: (Burning dangerous waste)

	Fawley	Dartmoor/ Exmoor	(Industrial North: Inland) Bradford
Provides employment	+	-	+
Safe transport ie, by sea	+	-	-
High population density	-	+	-

On presenting the card, the interviewer said:

> "The experts claim that siting incinerators at these locations has advantages and disadvantages marked by positive (pluses) or negative (minuses). Would you agree with this?"

No further prompts were offered.

6.5 De-briefing of subjects

The interviewer concluded at the point the subject indicated that he or she had nothing more to say. At the end of each interview the respondents were asked if there was anything further they wished to add as a form of de-briefing, especially at levels 5 and 2, as these were the most frustrating to respondents. This further information was not used in the analysis.

7. Analysis of results

The methods we used for the content analyses of the transcripts of the interviews with subjects were developed from Toulmin's (1958); (Toulmin, Riecker and Janik, 1979) use of "frames" and "claims" in his theory of argumentation, which will be discussed in section 8.3.

In developing these analyses we incorporated also some of the techniques advanced by Mitroff (1983; Mitroff, Mason and Barabba, 1983) and Vari, Vecsenyi and Paprika (1987). We expanded these ideas further through the inclusion of the analytic categories of "domains", "propositions" and "judgements" to provide a more flexible analysis appropriate to the underlying design of the study.

All 40 interviews with subjects were transcribed, and the results for each subject in each of the four groups were coded according to indices on how he or she handled the hazardous waste problem at each of the five decision making levels outlined in Table 1. The index on which we focussed at each level in conducting this analysis is shown in Table 3.

Table 3: Indices analysed at each level

LEVEL	HANDLING OF PROBLEM	INDEX
5	Explore small world	Number of different propositions/domain
4	Identify relevant structures	Number of propositions->claims Number of claims-> frames
3	Develop structure within frames	Number of frames within which structure developed.
2	Make judgements within frame	Number of conditional judgements
1	State "what is" in unqualified way	Number of unconditional judgements

Definitions of indices cited in Table 3:

Claim: Conclusive statementcontaining structure.

e.g. Incineration is the best method because the waste is then gone and is not hanging around for contamination.

Domain: An area or topic raised in relation to the issue/problem, it is free of structure.

e.g. "The people should be told everything." domain - information

Frame: Overall area within which any propositions/claims are structured and processing takes place.

(3 frames only used)

e.g. "Who is to say that emissions that come out now will not cause damage, in years to come." frame - future scenario

Judgements: Statements of good, bad, acceptable or not, with or without qualification.

e.g. Incineration must be the best method.

Proposition: A statement about the problem without structure.

e.g. The seepage concerns me a lot.

7.1 Coding of transcripts

Coding of transcripts involved the following steps for each group:

For level 5 analysis:

1. Identification and listing of propositions.
2. Classification of propositions into the 10 domains (Section 3.3).

Example:

Proposition	Domain
" People should be told everything." -	Provision of information

For level 4 analysis:

3. Classification of those propositions that led to claims, into domains.

Example:

Proposition leading to claim	Domain
"That Re-Chem up there, I'm sure it causes all these coughs and colds I'm always having." -	Effects on people

4. Classification of claims that led to frames.

Example:

Claim	Frame
"It seems to me that the regulations may be tight in theory but in practice things are dumped that should not be and no-one knows what is there." -	Regulation

For level 3 analysis:

5. Identification of overall frames.
6. Identification of elements in frames.

Example:

"Wherever it is sited (1) it should not be near housing, (2) near children, (3) should be safely fenced to (4) keep anybody out that should not be there."

4 elements identified (1---4) within a rule-based regulation frame.

7. Identification of type and number of frames used per subject and per group.

For level 2 analysis:

8. Identification of conditional judgements made (i) inside and (ii) outside the frame identified for each subject.

Example:

> "Re-Chem across the road there and if you have a place like that in a place where there are a lot of people living - that's bad."
>
> (conditional qualification to the judgement is underlined).

For level 1 analysis:

9. Identification of unconditional judgements in and out of frame.

Example:

> "I do not want landfill."
>
> (no conditional qualification to the judgement)

7.1.1 A Comprehensive example of text analysis:

The various analyses described above were each performed sequentially on the same, full set of interview transcripts. Hence, each portion of the transcripts can yield information at a number of levels. The following illustrates this on a short extract from a transcript:

> "I am against sea dumping anyway because, although you might say it is somewhere people are not going to use it, on some sort of land, I expect in years to come our great, great grandchildren might have the misfortune of something happening to them from something that has been dumped hundreds and hundreds of years previously. Incineration is better because it destroys it completely."

Overall frame: - Future scenario

Proposition: "I am against sea dumping"

Domain: - method

Claim: "I am against sea-dumping because....
in years to come.. something happening to them."

Conditional judgement: "Incineration is better because it
destroys it completely.

7.2 Analysis at decision making level 5: exploring the small world

On the basis of previous interviews with 20 subject matter experts, community leaders and media personnel interested in hazardous waste issues, we divided the small world within which hazardous waste disposal issues may be explored into the 10 domains described in section 3.3. Samples of typical propositions located within each domain are as follows:

1. Siting - "The problem is nobody wants it anywhere near them."

2. Effects on people - "I've complained about the problems we've personally had with health."

3. Plant system safety - "If you look at hazardous waste disposal in this country over the last 12 years there's been one fatal accident attributable directly to hazardous waste handling."

4. Regulation - "Whatever was burnt should be safe, regulations should see it's safe."

5. Provision of information - "I think the public is denied an awful lot of factual information it should be given."

6. Trust - "There's a common feeling that the public are not to be trusted with factual information."

7. Acceptance/Protest - "I have no qualms about incineration at all."
   or,
   "If materials are not dealt with properly - then you've got a problem."

8. Long term prospects/future scenarios - "I expect in years to come, our great great grandchildren might have the misfortune of something happening to them from something dumped hundreds and hundreds of years previously."

9. Effects on environment - "I'm not happy about incineration because of the acids going into the air."

10. Disposal methods - "It's not only an incineration problem, it's a landfill problem."
    or,
    "Certain wastes can be safely disposed of by incineration."

For each of the four groups of subjects, the number of different propositions employed in each domain (an index of amount of exploration) was computed. This is shown in Table 4, and in graphical terms in 3 to 6.

Table 4: Analysis of number of different propositions explored in the ten domains by the four groups.

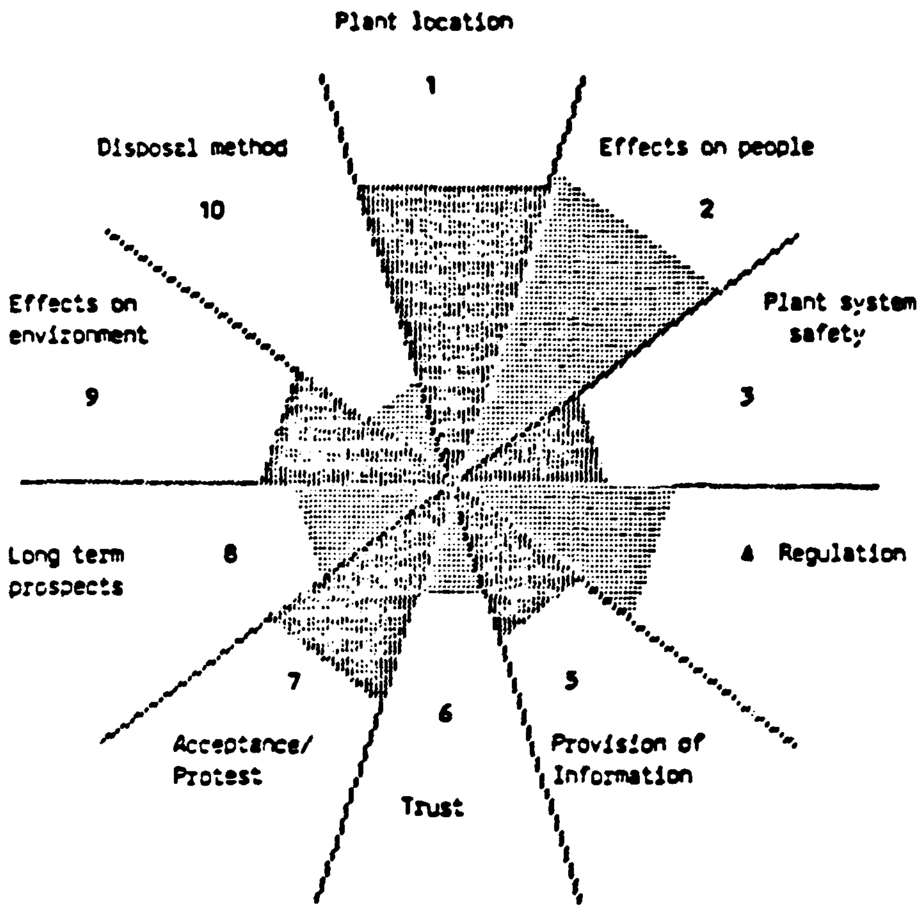
DOMAINS	PROPOSITIONS				
	GROUP A	GROUP B	GROUP C	GROUP D	TOTAL
1. PLANT LOCATION	8	◇14	□37	□17	76
2. EFFECTS ON PEOPLE	9	12	31	15	67
3. PLANT SYSTEM SAFETY	2	10	6	1	19
4. REGULATION	4	◇15	7	1	27
5. PROVISION OF INFORMATION	2	◇11	3	3	19
6. TRUST	1	27	6	1	35
7. ACCEPT/PROTEST	4	14	14	20	52
8. LONG TERM PROSPECTS	2	15	1	2	20
9. EFFECTS ON ENVIRONMENT	3	5	16	0	24
10. DISPOSAL METHOD	1	◇19	5	2	27
TOTAL	36	142	126	62	366

Key

◇ Subjects primed on this domain

□ Subjects given MAU frame, requires use of information from this domain.

Note: Inferences about the differences in numbers of propositions used by subjects in each group across all domains: a bracket connecting a pair of groups indicates that the 95% credible interval for the difference between these groups includes zero. No bracket indicates that the 95% credible interval for the difference between these groups does not include zero.



Group A

(constrained at level 5)

SMALL WORLD

Figure 3: Number of different propositions explored by subjects in group A within the 10 domains.

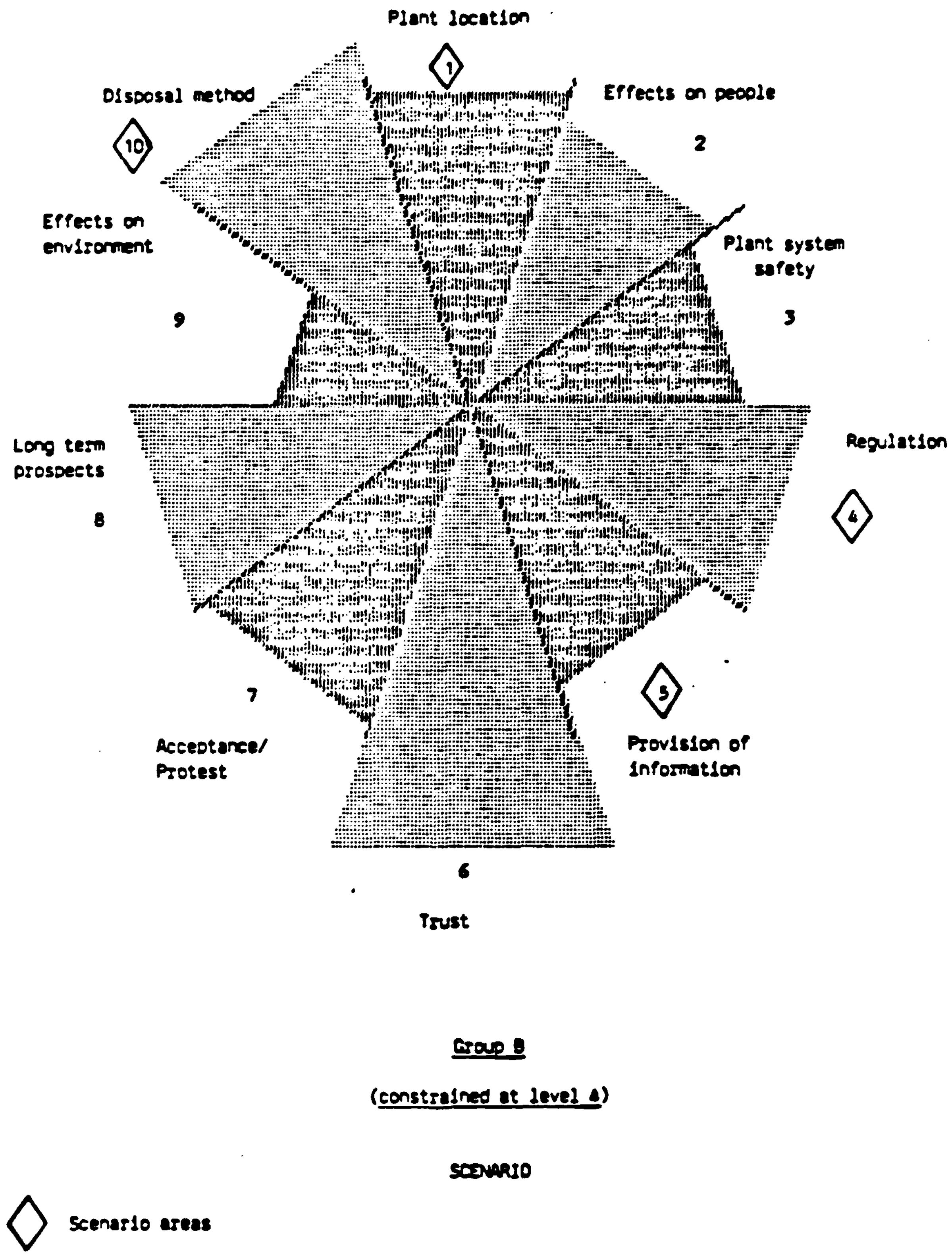


Figure 4: Number of different propositions explored by subjects in group D within the 10 domains.

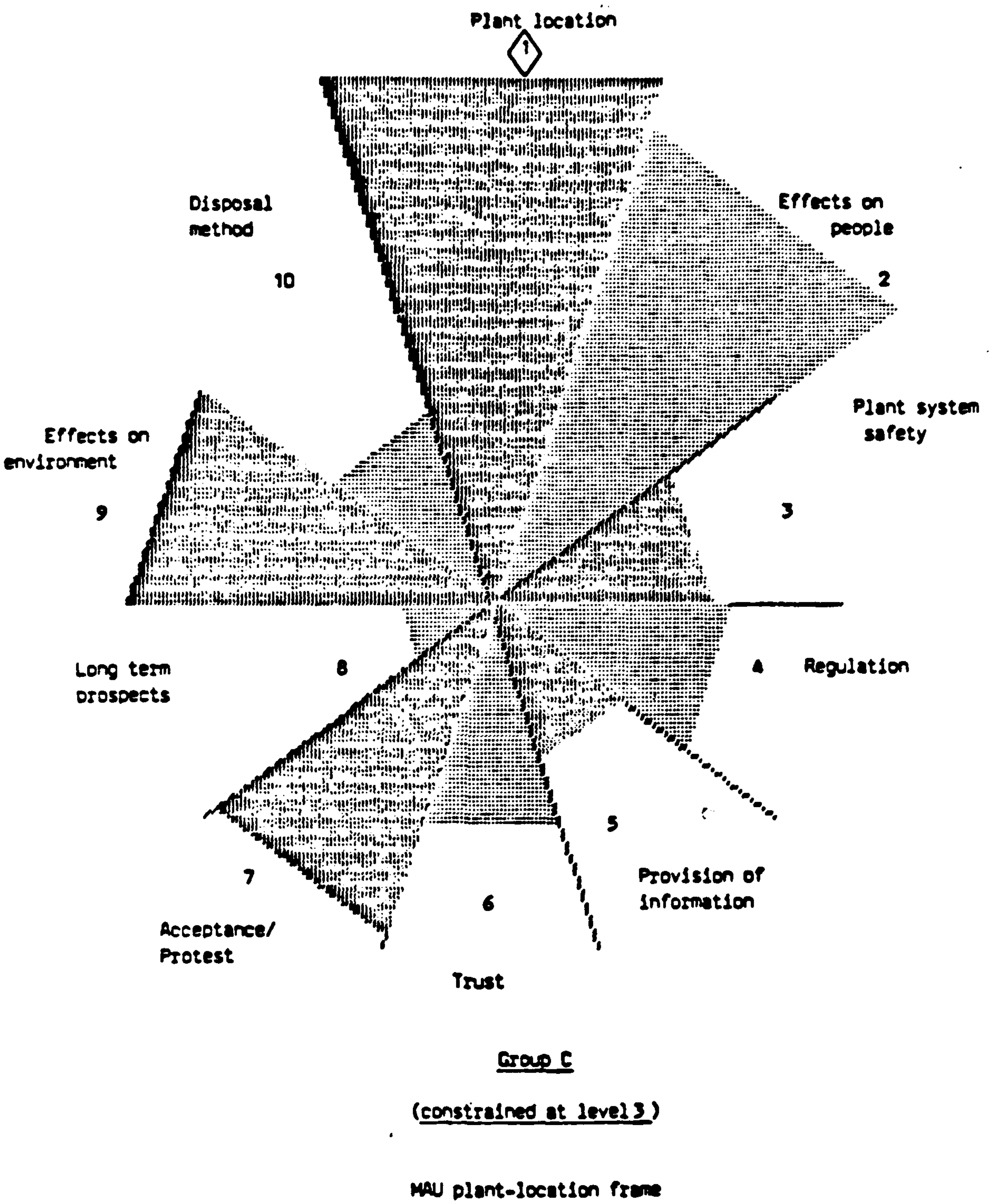
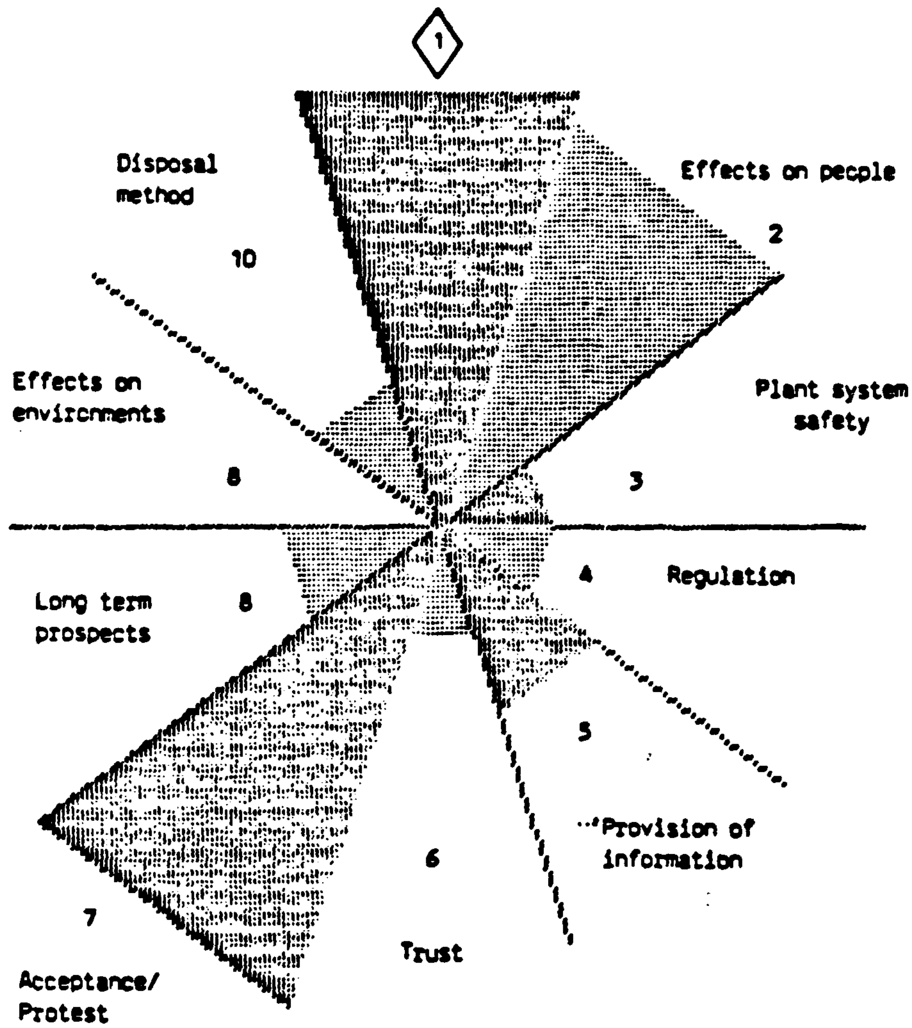


Figure 5: Number of different propositions explored by subjects in group C within the 10 domains.



Group D

(constrained at level 2)

MAU - 3 alternatives, 3 criteria

Figure 6: Number of different propositions explored by subjects in group D within the 10 domains.

The bounded scenario supplied to group C covered the domains shown in diamonds. Groups C and D were constrained to work within a multi-criteria frame requiring the use of information within the plant location domain (assessing alternative locations). While these manipulations undoubtedly influenced the pattern of exploration across domains, a two way analysis of variance found both domain and group effects, and the interaction between them to be significant at the 1% level, it is important to note that subjects made the majority of their explorations beyond those domains in which they were primed.

A one-way analysis of variance of number of propositions explored with each group indicated that the variance between the groups was significant at the 5% level. Inferences concerning differences between group means (shown at the base of Table 1) indicated that subjects explored most when constrained at level 4 or 3. Subjects constrained only at level 5 (that is, without the aid of being primed by a bounded scenario) soon ran out of issues to discuss, the frame of reference was too great for all possible exploration. Moreover, this happened also when subjects were constrained to explore (but not develop structure) within a frame (group D). Subjects in this group seemed to acquiesce to the constriction of the interview format. Interestingly enough, the main exploration here was in the domain of "accept/protest". (Maybe these interviewees were trying to tell the interviewer something about the terms of reference she had set for them through the task instructions.)

7.3. Analysis at decision making level 4: Problem expressing language

One way of displaying differences between stakeholders at level 4 is simply to list the frames that each person identifies as relevant in handling the decision. However, two other types of priorities are important in analysing the problem expressing language of those parties to a decision who know that other stakeholders may hold different views, and hence need to be argued with (Mitroff, 1983; Mitroff, Mason and Barabba, 1983), or persuaded about the issues which need to be taken into account. Hogberg (1984) and Vari et al (1987) have identified these as claims, warrants and backing, following Toulmin's (1958; Toulmin, Riecker and Janik, 1979)) argumentation theory. Here we will discuss only the number of claims made by subjects in each group (warrants and backing are analysed elsewhere, and will be presented in a further report where we will compare ways of displaying differences in the way stakeholders advance arguments in support of their views on aspects of a decision problem).

Table 5 and Figures 7-10 show the number of claims made by subjects in each of the four groups within each domain. The pattern is similar to that of total number of different propositions shown in Table 4.

Table 5: Level 4 analysis:

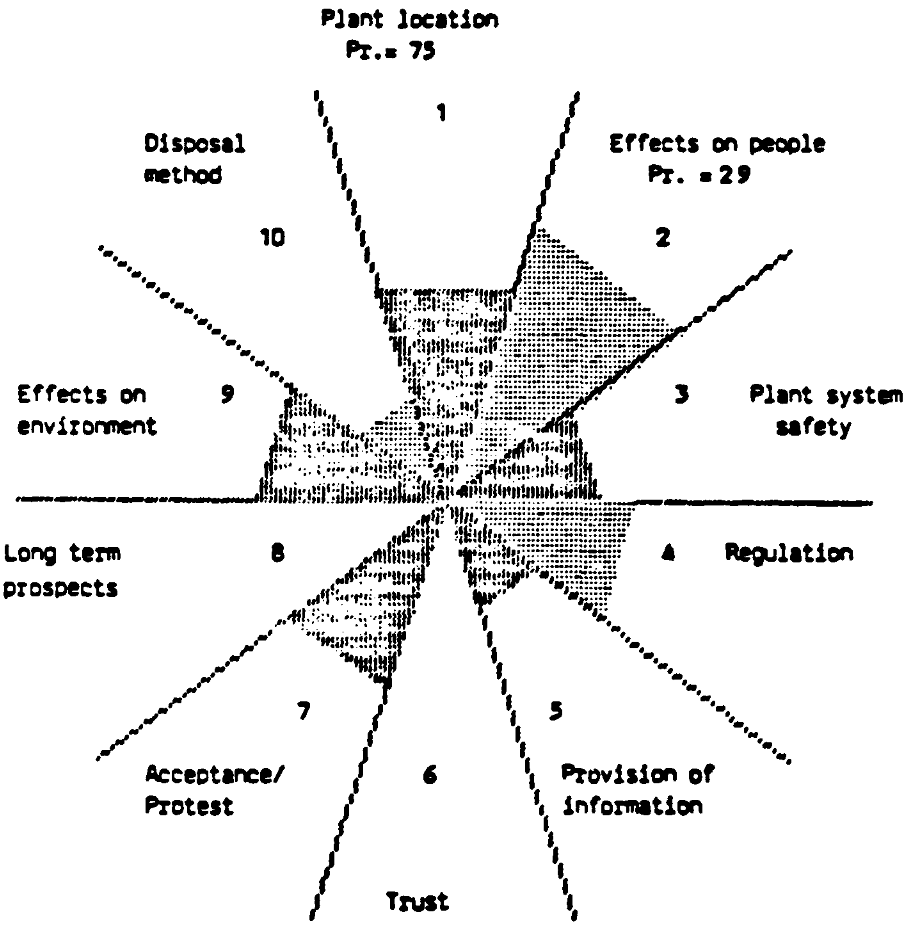
(i) Total number of propositions that are claims
(ii) Number of claims that lead to frames

	GROUPS							
	A		B		C		D	
DOMAINS	I	II	I	II	I	II	I	II
1. Plant location	4	3	8	1	33	16	17	14
2. Effects on People	7	2	16	4	22	9	9	5
3. Plant System/Safety	2	0	7	6	4	4	1	0
4. Regulation	3	0	8	5	2	2	1	0
5. Provision of Information	1	0	6	0	2	1	0	0
6. Trust	0	0	19	5	0	0	0	0
7. Acceptance/Protest	3	0	16	1	16	7	9	6
8. Long Term Prospects	0	0	8	1	2	1	2	1
9 Effects on Environment	3	0	6	0	9	4	0	0
10. Disposal Methods	1	0	6	2	4	1	1	0
TOTAL	24	5	100	25	94	45	40	26

I = Propositions that are claims
II = Claims that lead to frames

Primed on this Frame

N = 10 per Group

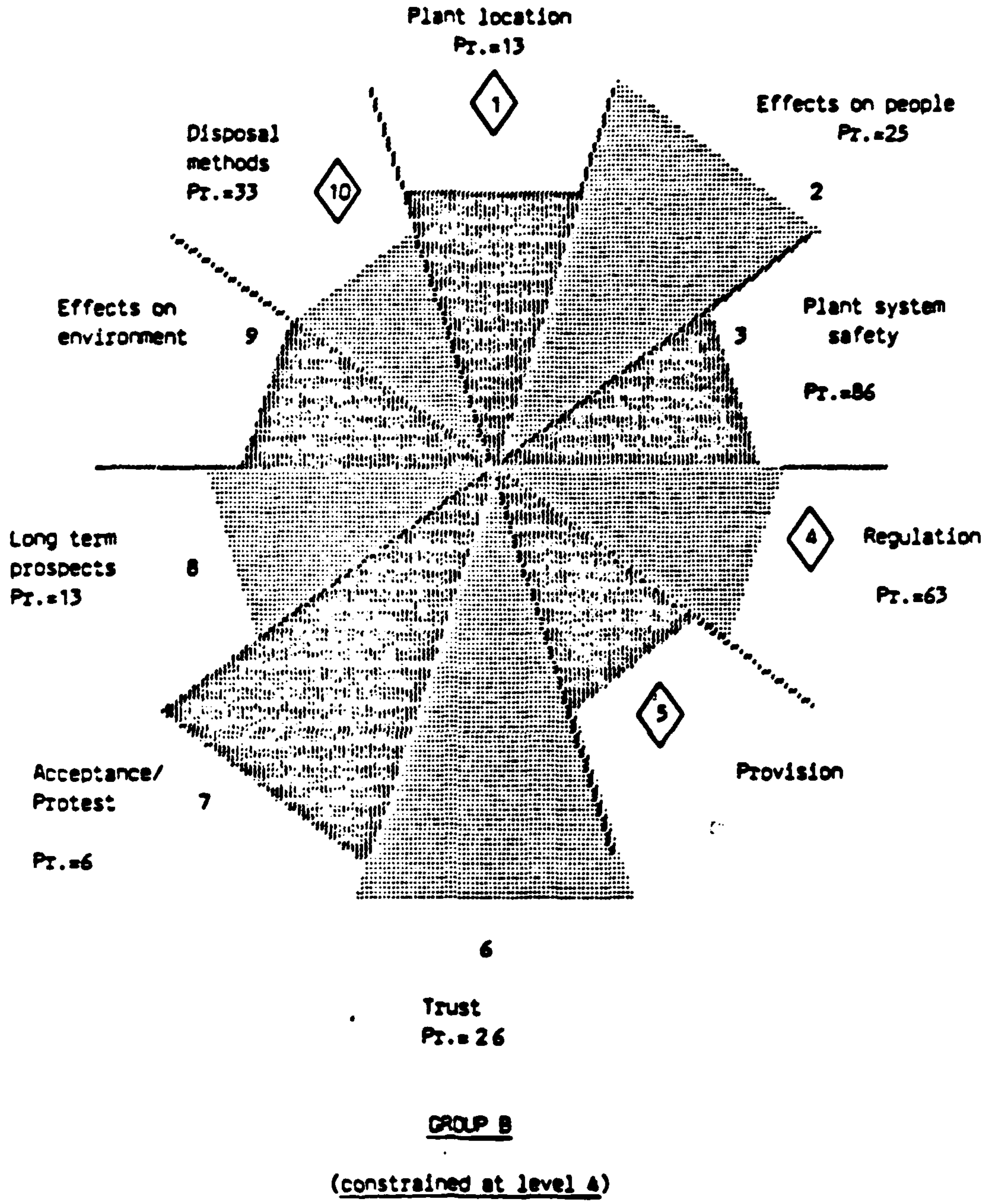


GROUP A

(constrained at level 5)

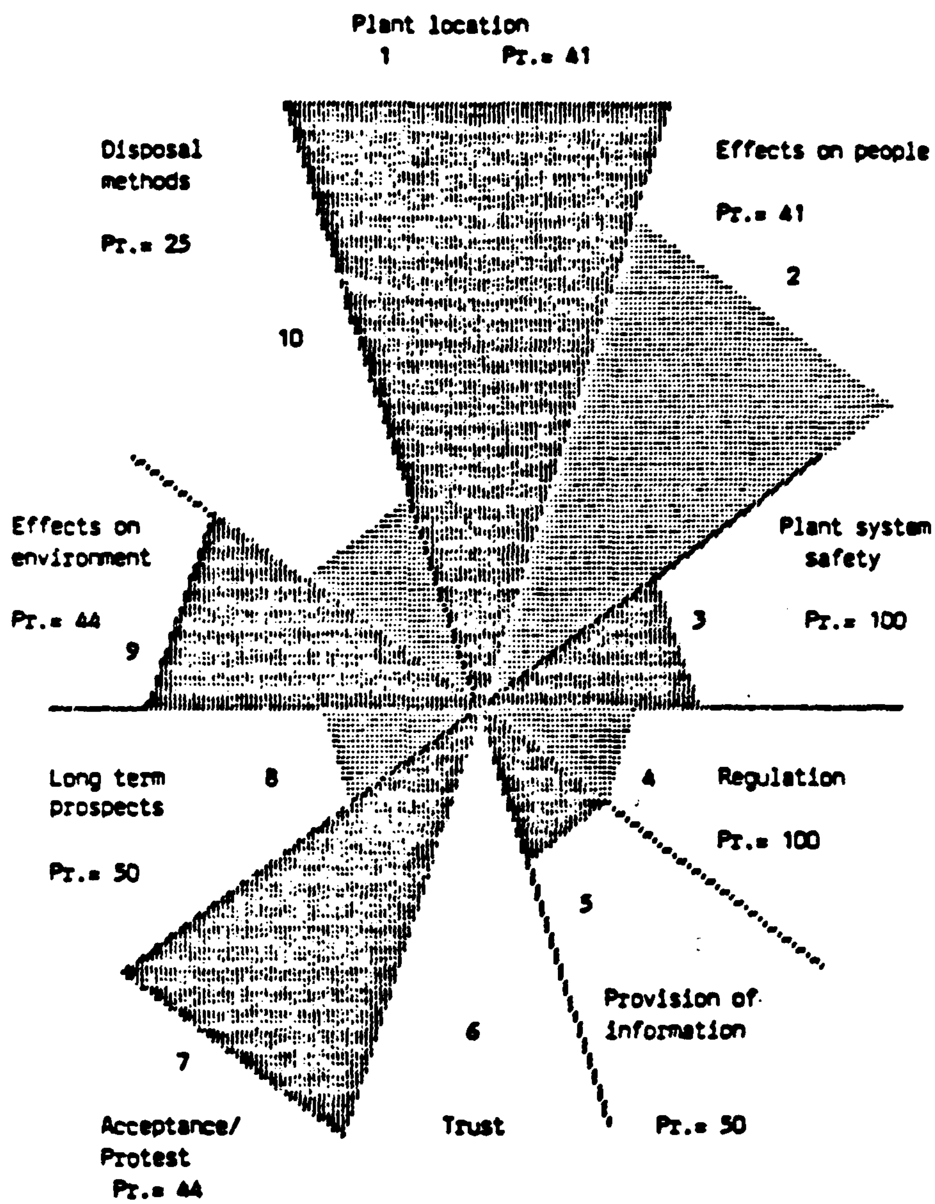
Pr. = Proportion of claims within the domain that lead to frames.

Figure 7: Number of propositions advanced by group A as claims.



Pr. = Proportion of claims within the domain that lead to frames.

Figure 8: Number of propositions advanced by group B as claims.

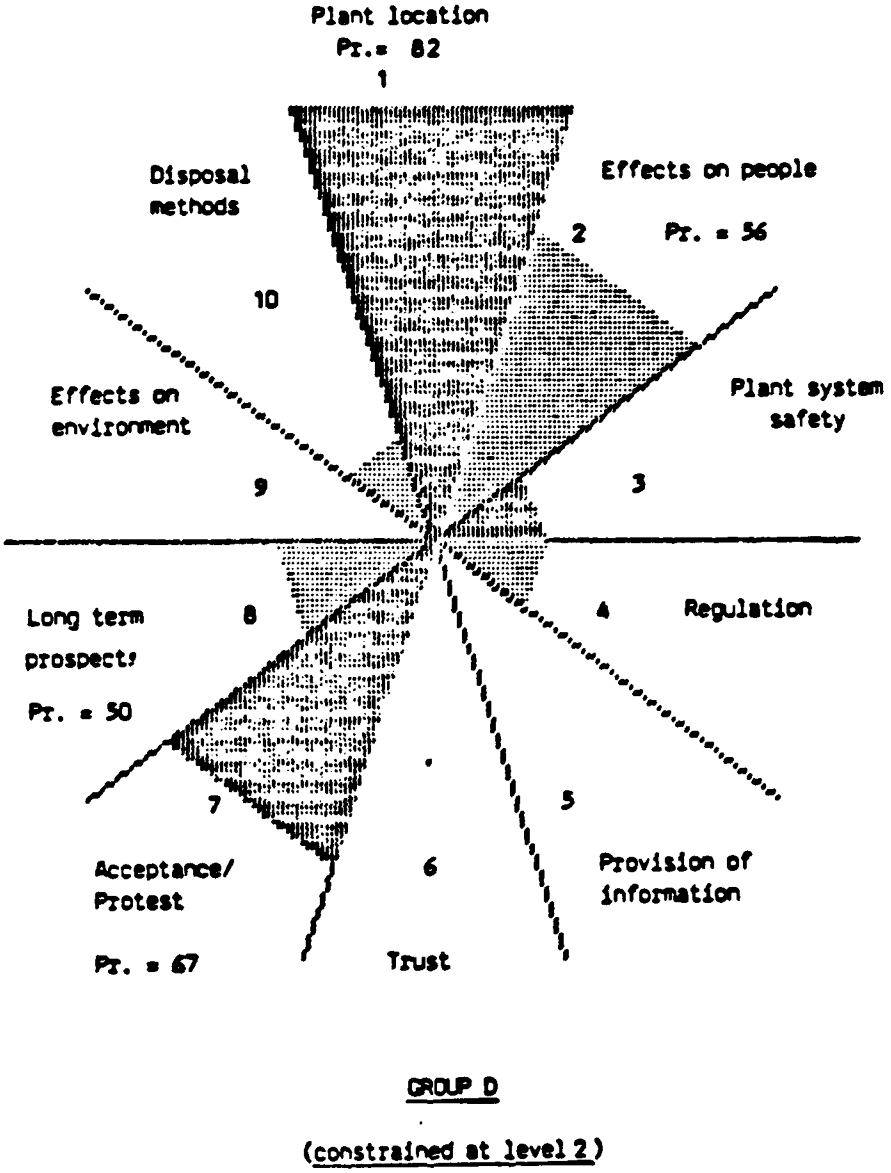


GROUP C

(constrained at level 3)

Pr. = Proportion of claims within the domain that lead to frames.

Figure 9: Number of propositions advanced by group C as claims.



Pr. = Proportion of claims within the domain that lead to frames.

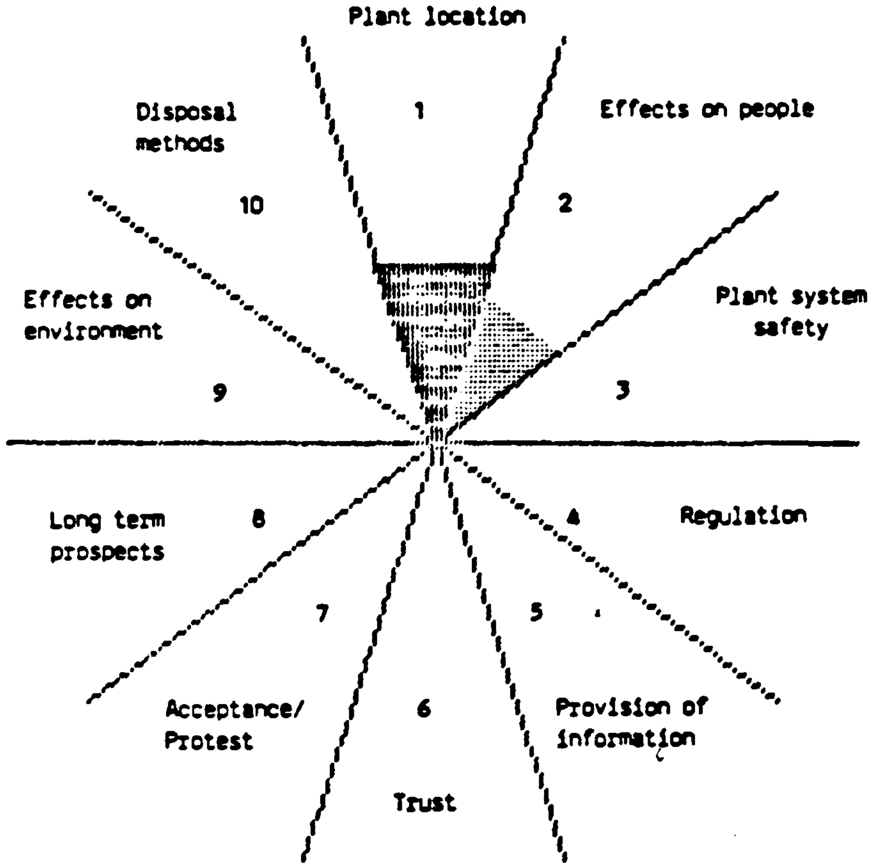
Figure 10: Number of propositions advanced by group D as claims.

However, the interesting part of the analysis is where we investigate the number of claims that led to frames. By this we mean that the claim actually formed the basis for exploration of structure within a particular frame (i.e., it was linked to, or traded off against at least one other claim within a particular frame).

In practice, only a proportion of the claims made by the subjects led to frames.

It is instructive to compare groups B and C in respect of the proportion of claims made by subjects within each group which led to frames. The total number of claims which led to a frame within group B was 25, (the four most frequent domains addressed by these claims were plant systems/safety, regulation, trust and effects on people). Group C, however, totalled 45 claims that led to a frame (the most frequent domain addressed by these claims was plant location - which was not surprising, since subjects were primed within this domain - followed by effects on people - and acceptance/protest - see Table 5).

Group B explored more widely than did group C, but group C was much more successful at developing claims into frames (particularly within the domain where they were primed). Hence there is a trade off between setting constraints at level 4 (this encourages breadth of exploration and claim making) and at level 3 (this encourages depth of structuring within the frame at some expense of breadth of exploration). Setting constraints at level 2 (group C) seemed to completely stifle exploration outside the frame, and also promoted significantly less exploration (95% credible interval for differences between numbers of claims does not include zero) within the frame than did setting the constraints at level 3 (group B). These results are illustrated in figures 7-10 for claims, and 11-14 for claims which led to frames.



GROUP A

(constrained at level 5)

Figure 11: Number of claims that led to frames within group A.

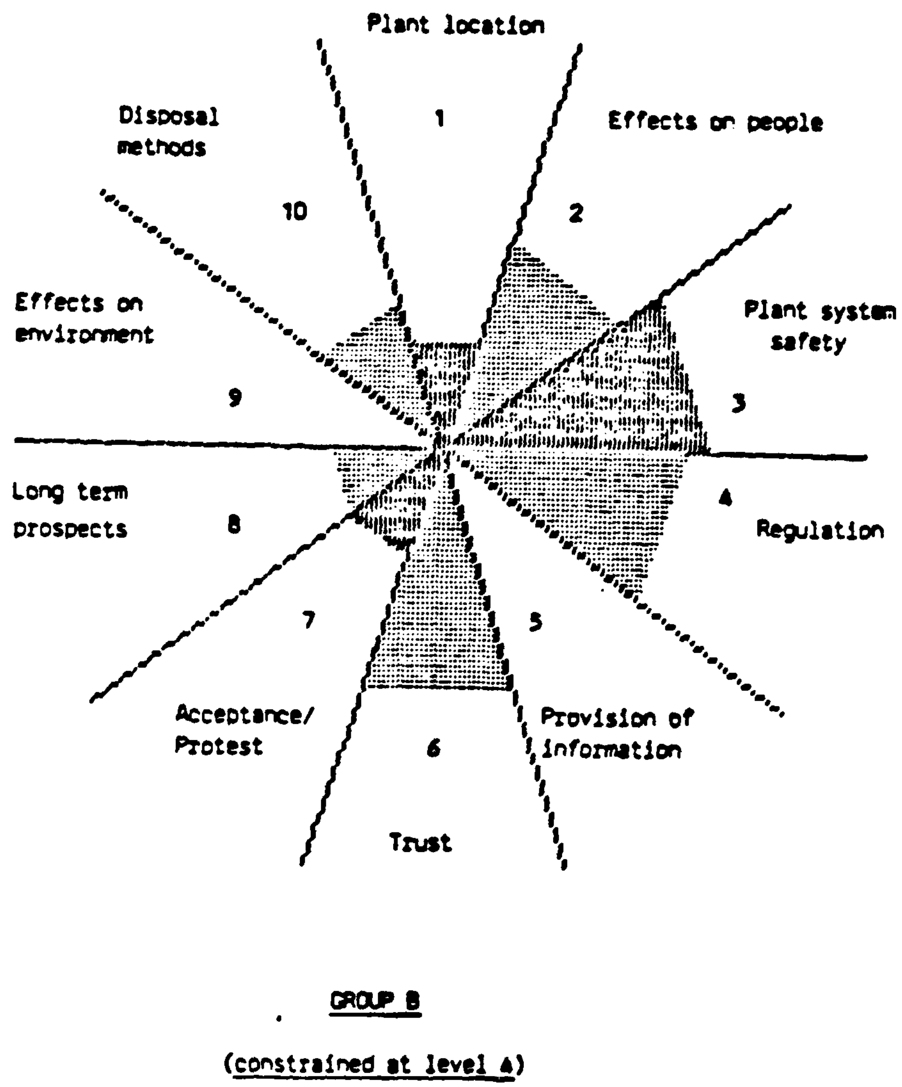


Figure 12: Number of claims that led to frames within group B.

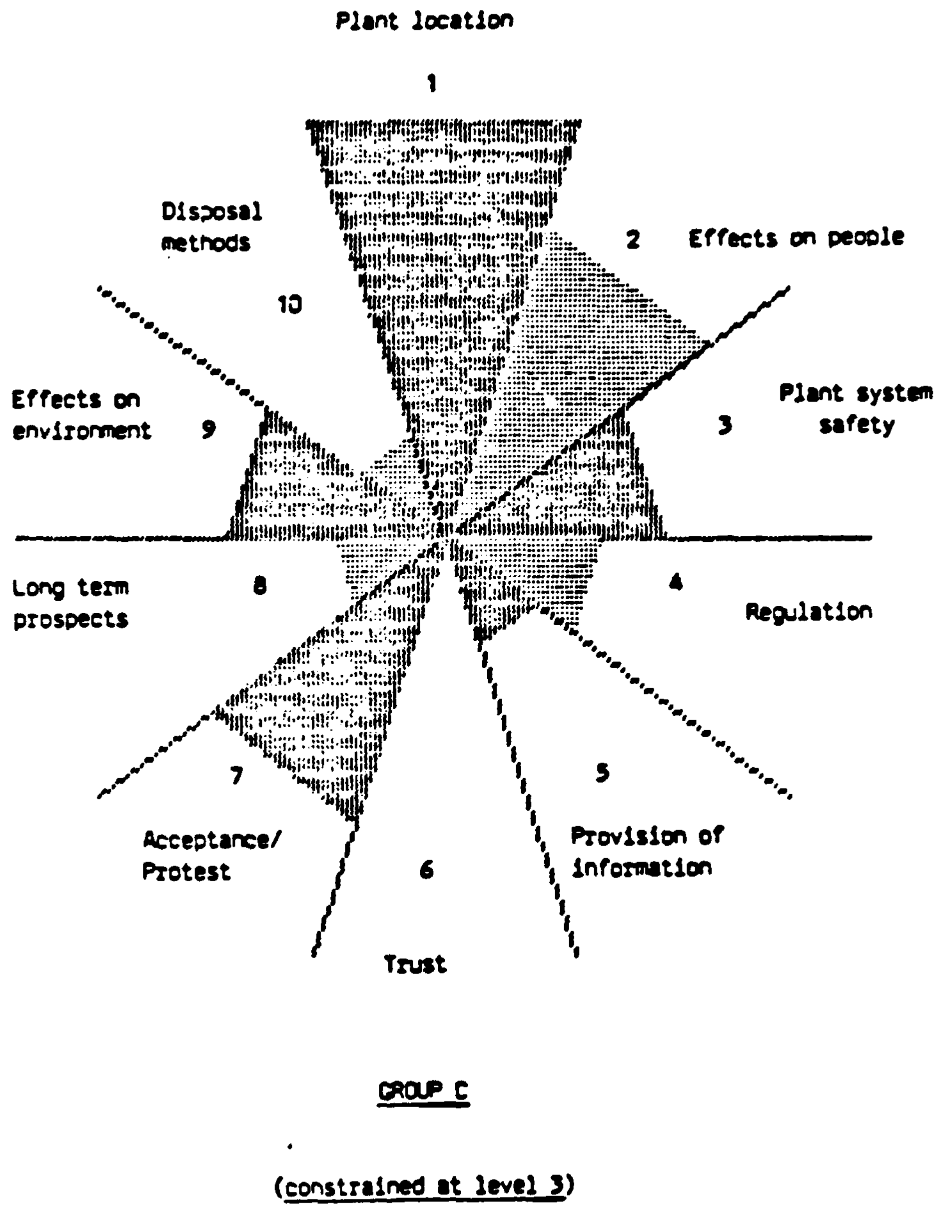


Figure 13: Number of claims that led to frames within group C.

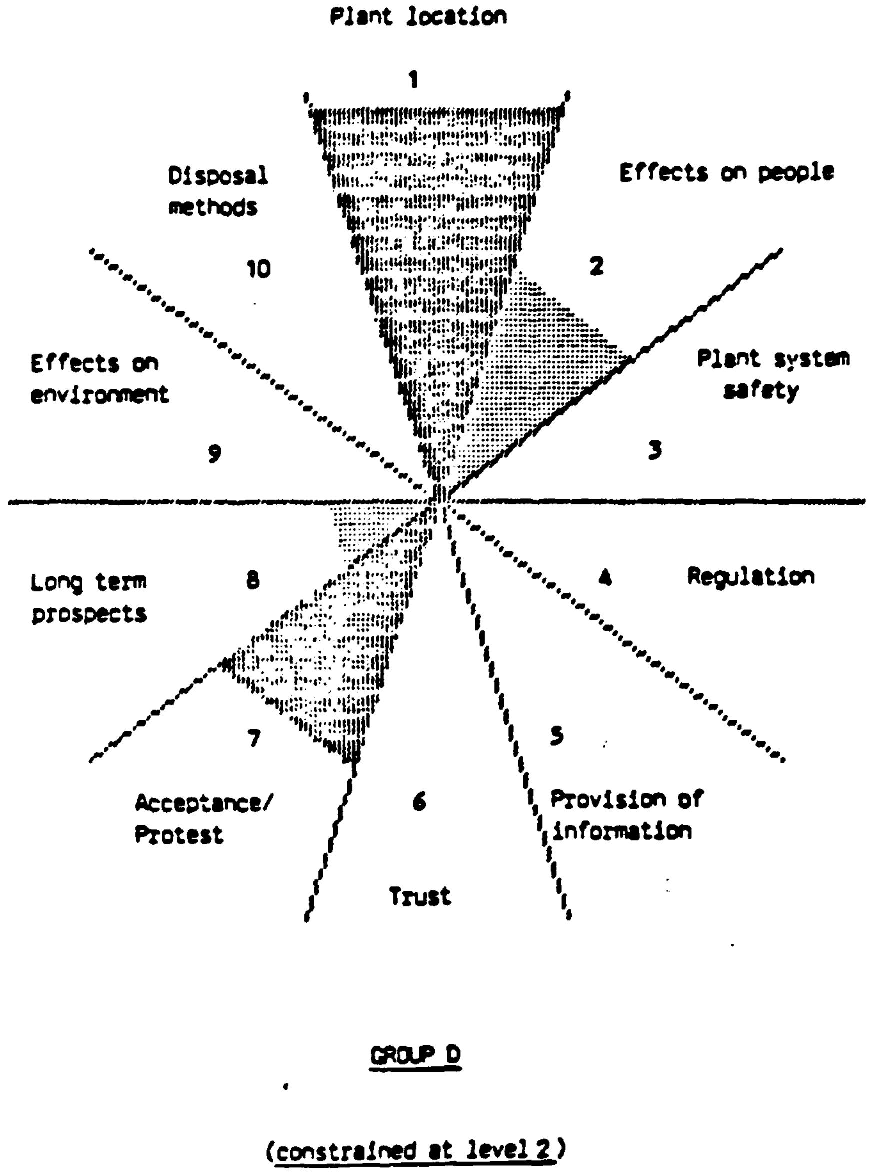


Figure 14: Number of claims that led to frames within group D.

7.4 Analysis at decision making level 3: Development of structure within each of 3 frames

We identified only three types of frames in the transcripts of our subjects as there was in every case a 1:1 correspondence between analytical characterization of each frame and its substantive characterization.

The 3 analytic frames representations were as follows:

	Analytic	Substantive
1.	Rule based	Regulation
2.	Multicriteria	Plant/method/siting
3.	Act-event sequence	Future scenarios

We present both classifications in Table 6.

Example:

> I am against sea dumping, I do not like that method, because we don't know enough about long term corrosion aspects, which would release chemicals into the sea.
>
> Multi-criteria - method, safety, siting.

The intere...ing part here is the comparison between groups C and D. Not surprisingly, groups developed structure within the frame on which they were primed to a very great degree. However, group D did not. They were apparently content to accept the structure (3 alternatives, 3 criteria, all pre-defined, and hardly every commented on the structure or suggest modifications for it, e.g., additional criteria). Moreover they did not attempt to develop any structure whatsoever in any other frame. Figure 15 shows the distribution of the number of frames employed by subjects in each group, confirming this distinction between group D and the other three groups.

Table 6: Level 3 analysis

ANALYSIS OF FRAMES

FORMAL	SUBSTANTIVE FORM	GROUPS A I	A II	B I	B II	C I	C II	D I	D II
Rule based	Regulation	0	0	4	4	4	5	0	0
Multi-criteria	Plant method/siting	1	3	3	5	20	37	2	4
Act event sequence	Future scenarios	1	1	5	9	2	2	0	0
	TOTAL	2	4	12	18	26	44	2	4

I = Total number of Frames
II = Total number of Elements

N = 10 per group

Primed on this frame

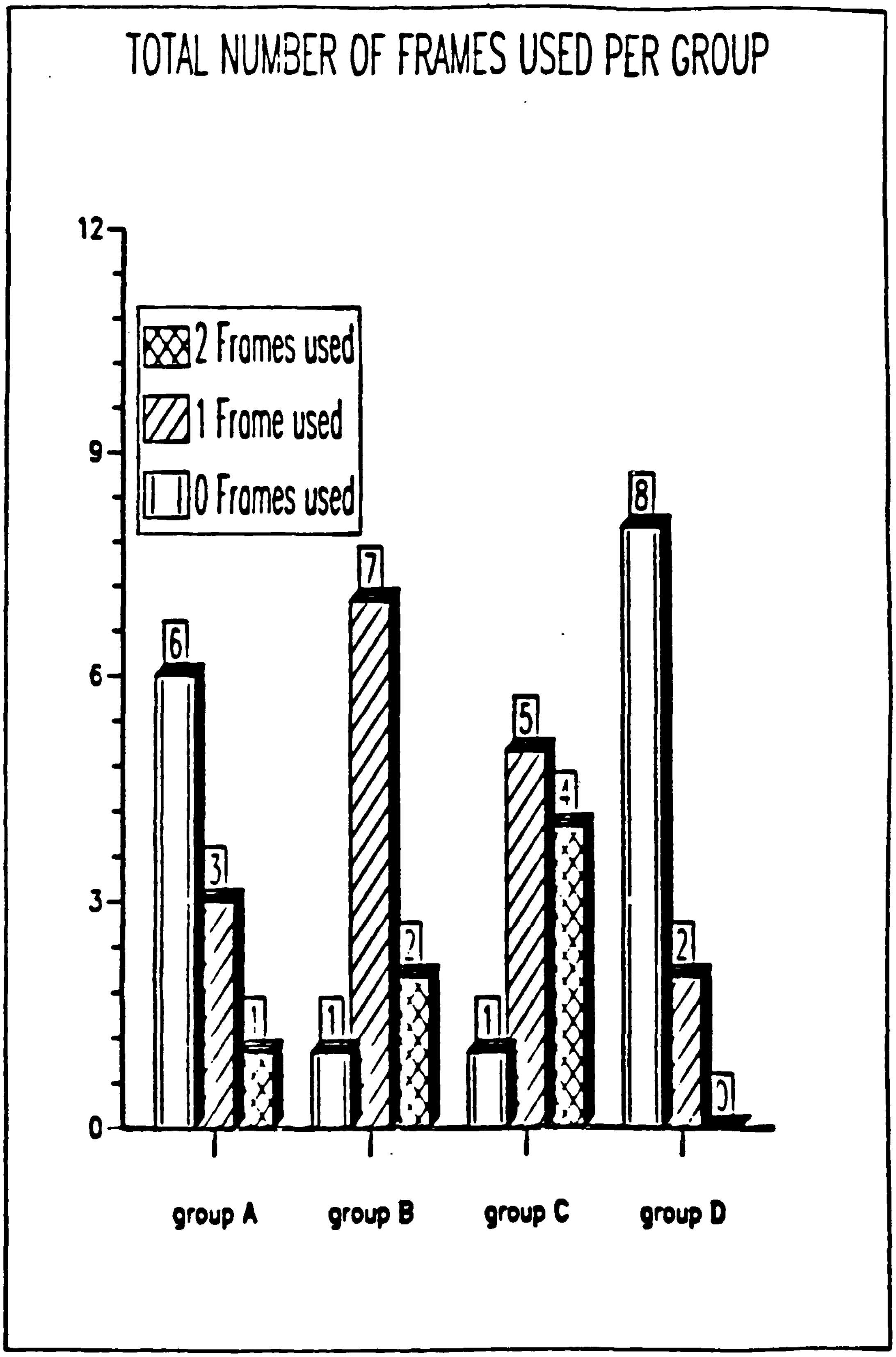


Figure 15: Level 3 analysis

7.5 Analysis at decision making level 2: conditional judgments.

At this level structuring is completed and judgements must be made, but they are given conditionally (so one can investigate what-if questions, explore differing points of view, etc.).

We analysed separately the number of conditional judgements made by subjects within each group: a) within any frame they were currently employing, and b) outside of any frame (i.e., attached to an unstructured claim). The results are shown in Table 7 and Figure 16. It is interesting to note that in both groups C and D significantly more conditional judgements were made outside than inside the frame. Moreover, setting constraints at level 4 (group B) or level 3 (group C) resulted in significantly more (over twice as many) conditional judgements within the frame than did setting the constraint at level 2, which is conventionally aimed at allowing conditional judgements within the frame, as the highest level of problem handling where subjects are given discretion.

Table 7: Level 2 analysis.

TOTAL NUMBER OF CONDITIONAL JUDGEMENTS

	GROUP			
	A	B	C	D
Within Frame	1	8	7	3
Outside Frame	3	7	19	10
TOTAL	4	15	26	13

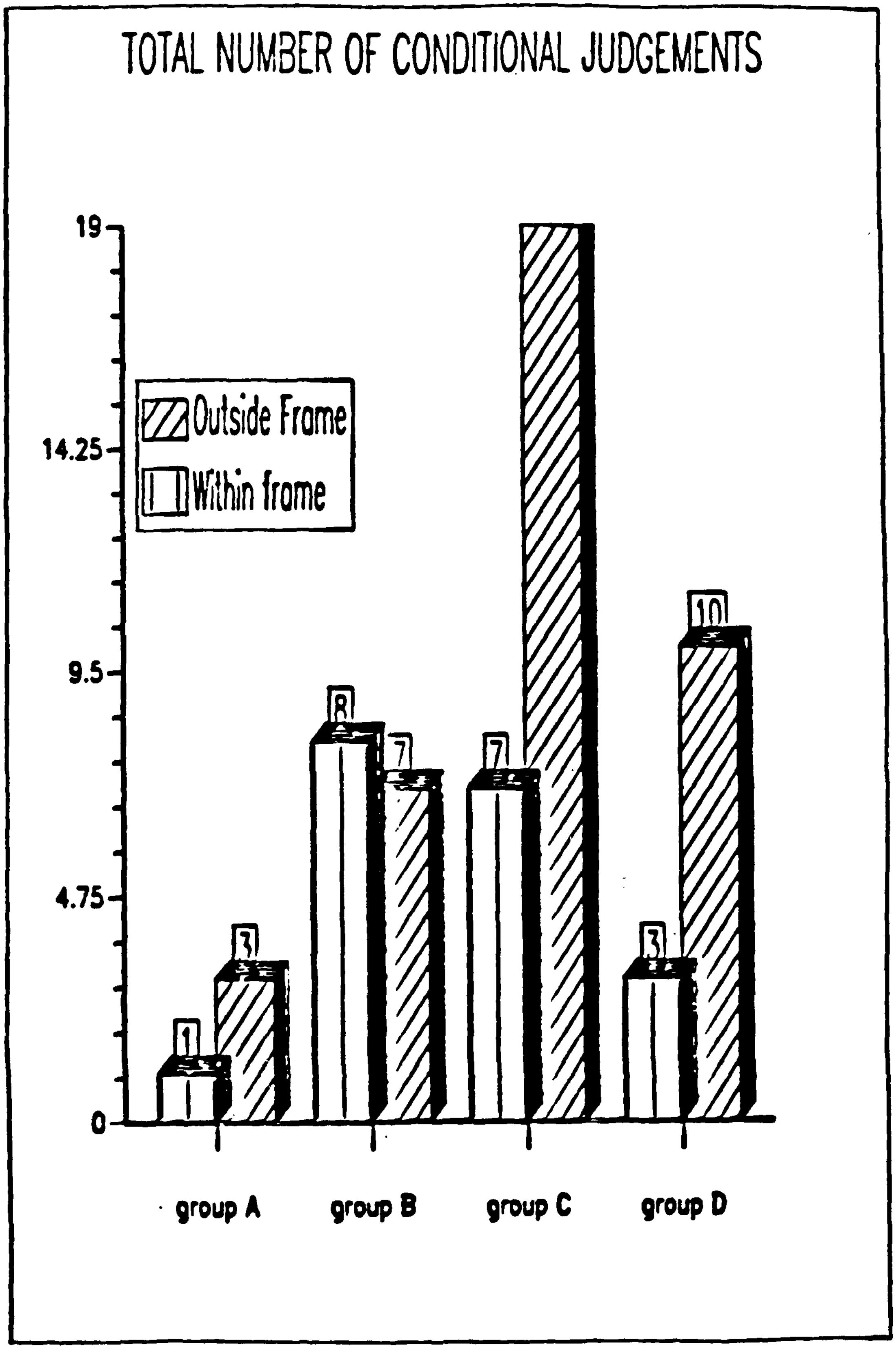


Figure 16: Level 2 analysis.

7.6 Analysis at decision making level 1: unconditional judgments

Finally, to complete the picture, we repeated the level 2 type of analysis, but this time counted unconditional (level 1) judgements (statements of "what is" in an unqualified way), instead of conditional (level 2) judgements.

The results are shown in Table 8 and Figure 17. The figures here are too small to permit statistical analysis, but follow the same general pattern as for level 2. The smallness of the number of unconditional judgements in our transcript is itself of interest: if our subjects were mainly operating at level 5, we would expect this number to be much larger than the number of conditional judgements, but it was not, thus suggesting that they were operating at a lower level.

Table 8: Level 1 analysis.

TOTAL NUMBER OF UNCONDITIONAL JUDGEMENTS

	GROUP			
	A	B	C	D
Within Frame	1	6	4	5
Outside Frame	0	2	3	0
TOTAL	1	8	7	5

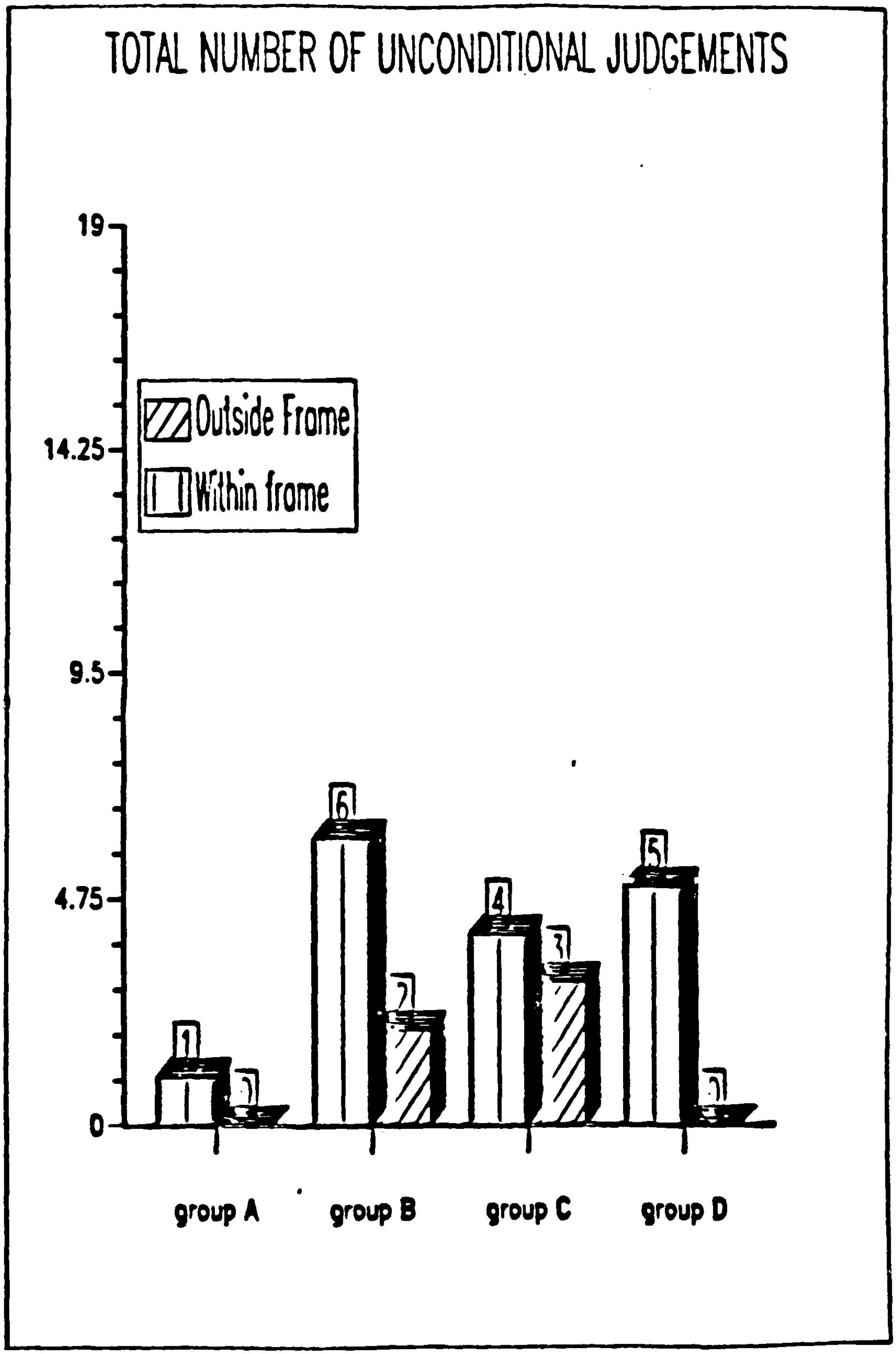


Figure 17: Level 1 analysis.

8. Conclusions

The results from the analyses described in section A, taken together, point to the following three conclusions concerning the effects, and desirability, of constraining subjects' intuitive decision making at particular levels:

(1) Constraining people at level 5 only asked too much of them. Providing only the area of exploration did not give them a point of reference from which to start exploration: priming them with a bounded scenario as a frame helped to get their thinking started.

(2) In practice, the main tradeoff for an investigator is between priming subjects with instructions constrained at level 4 or level 3. Level 3 constraints tend to encourage more "depth" (structuring within the frame), level 4 more "breadth" (exploring across frames). In either case, some subjects will explore more outside the areas in which they are primed than within the primed areas.

(3) Constraining subjects at level 2 (as do all the traditional psychological experimenters within the "conversational paradigm") is counter-productive. Subjects become frustrated and apathetic, they explore less, both within and outside the frame in which they are primed, and this is not compensated for by encouraging them to give more conditional or unconditional judgements within the frame. In other words, constraining subjects at this level (and these are ordinary lay people, not students) clearly underestimates their intellectual abilities, and they respond by failing to display much of what they are capable of <u>at any level</u>.

In the next stage of our research we will be developing (i) facilitatory techniques for displaying the differences in the domains explored by particular stakeholder groups in social decision making situations (level 5 analysis); (ii) techniques for exploring and displaying the ways in which claims are provided with warrants and backing, and whether this facilitates or impedes the way claims can lead to frames which can be shared across stakeholder groups within a social decision making process.

In the light of the above findings we will concentrate on the use and effects of such techniques in decision making situations where groups are constrained at level 4 (through supplying initial scenarios) and level 3 (through supplying an initial frame), as our research has shown that it is only in these situations that the use of such facilitatory techniques is likely to be welcomed and usable constructively by subjects in improving the quality of their own and other stakeholders' attempts to handle shared decision problems in the most effective way.

Overall, this research shows the impossibility of maintaining an objective stance on the part of the experimenter in judgement research. The act of stating the problem and what is required of the subject has a profound effect, well beyond the error variance associated with experimenter-induced biases, on the way subjects think about the problem. In addition, the approach used by the experimenter in analysing the data imposes its own constraints on the conclusions that are drawn. Thus, judgement researchers will need to consider new paradigms that recognise the inseparability of experimenter and subject in investigations of problem-solving for ill-structured situations.

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Technical Report 88-3

Differences between judgement of stakeholders in social Decision Making

A I Oldfield & P C Humphreys

SUMMARY

In recent years considerable concern has been shown by the public over the development of risky and hazardous technologies. This concern can result in the limitation of technological development and implementation of policies relating to it, due to pressure from the public leading to conflict.

In social policy implementation, an essential variable is public concensus. Lack of concensus may be due to conflict of interest, roles and perspectives of stakeholders in the decision problem. In order to ensure successful social policy development of hazardous and risky technology, it is necessary to obtain public concensus through reaching a shared agreement.

Conflict can occur, when interests of stakeholders are *not* shared. In order to reach a shared agreement of the problem, it is important to identify the perspectives, roles and interests of stakeholders so that any ensuing differences can be recognised. The research reported here focuses on identifying differences in perspectives of stakeholders in a risky technology, that of hazardous waste incineration in a real life setting, involving four groups of stakeholders consisting in industry, government (regulatory agency), lay people and a pressure group.

The methodology for eliciting any existing differences was developed in a previous study (Intuitive handling of decision problems:A five level empirical analysis. *Technical Report* 87-3), which showed that by constraining people externally in terms of initial problem statement, exploration of the problem can be enhanced or restricted. We applied the level 4 constraint of the methodology to the subject in this study. Whereas in the previous study each group of subject were constrained at different levels to enable comparison of problem handling according to level, in this present study we applied the *same* level to four different stakeholder groups in order to identify how *each* group handled the problem.

The elicitation of differences of perspectives would enable identification of areas of shared agreement, where perspectives are not shared, conflict is likely to occur.

The results of the study indicate that comparison of perspectives is a useful technique to reveal where agreement and disagreement exists. Additionally, the methodology employed here is able to identify the specific domains on which agreement can or cannot be reached.

CONTENTS

Summary

DIFFERENCES BETWEEN JUDGEMENTS OF STAKEHOLDERS IN SOCIAL DECISION MAKING

1 INTRODUCTION

The rapid development of risky and hazardous technologies in recent years has resulted in considerable concern being displayed by both the public as well as regulatory agencies affected by the development. The public's concern about these technologies often leads to conflict with industry and regulatory agencies.

Risky and hazardous technologies can encompass a number of processes that can present a certain level of risk to the population at large and is usually considered in terms of consequences of possible catastrophic effect in case of an accident or malfunction.

Previous work on decision making in social issues (Technical Report 87-3) has reported on the successful development of a methodology for identifying problem handling at different levels of knowledge representation among stakeholders in Hazardous Waste Disposal and the extent to which exploration of the decision problem is facilitated or restricted by setting constraints externally in terms of initial problem statement at a particular decision making level (Humphreys et al., 1987). The posited method of problem handling elicitation utilises content analysis as a means of determining domains of concerns to individuals and represents the characterisation of the problem, has been considered particularly suitable for identifying differences between stakeholders in the decision problem.

1.1 Problem structuring in social decision making.

A number of incidents in recent years has led to an increased level of fear and concern over catastrophies occurring in some industrial processes. The catastrophies have increased the level of apprehension in the public's mind over the risks involved in some technologies, resulting in a certain amount of alienation and conflict toward industry. This conflict can be harmful to the development and expansion of these industries, by the application of pressure on government and industry to limit and control development of technology. In recent years pressure groups have played a major role in bringing about policy changes. As a result of public concern, social policy planners are finding it increasingly more difficult to obtain the public's agreement to the development of hazardous and risky technologies. Thus the role of the public and need for their co-operation has become an important variable in Hazardous Waste Disposal. The need to recognise the issue of public acceptance of policies concerning risky and hazardous technology has been emphasised previously (Freudenberg & Rosa, 1984). However, in conflicting social decision situations, the parties concerned recognise that decisions relating to these have to be made and therefor a better understanding of each other's position are essential (Cats-Baril & Gustafson, 1986).

A major problem in obtaining concensus on societal policies is due to the conflicting interests and perspectives adopted by stakeholders in the decision making process. Studies which looked at problems of decision making over siting and policy (Kunreuther, 1982), highlighted a major theme: that areas of conflict arise due to the subjective views of stakeholders as well as their roles, goals and motivations within the process as stakeholders in risky technology bring different subjective views to the decision making table (von Winterfeldt, 1982).

In order to reduce conflict and ensure successful social policy development of hazardous or risky technologies by resolving differences and reaching concensus among stakeholders, it is important to identify where differences as well as agreement occur within the problem handling processes of all interested parties or problem owners. In many cases interested parties feel that *their* views are not recognised or accepted by the other stakeholders and therefore their interests are not properly represented.

In a previous study of intuitive handling of decision problems by stakeholders of a risky technology (Humphreys et al., 1987) we identified how problem structuring for the stakeholders is facilitated or impaired through setting constraints at each of the five levels of cognitive representation of the problem being handled (Humphreys et al. 1984). The methodology developed was based on identification of areas or domains of concern raised by the subjects, revealing the extent to which particular issues formed the basis of their problem definition and structuring, the extent to which they *explored* the issue. This exploration represents their subjective judgement of the decision problem or issue in hand, of how an individual "tests" the boundary of his/her "small world".

1.2. Exploring the boundary of the "small world" within which the problem is located.

In making subjetive judgements, material on which the judgement is based has to be retrieved from memory and then structured and explored in some way which allows a reasonably stable assessment of the material. In experimental settings of judgemental tasks, the experimenter's task instructions invite the subject to explore beyond what has been defined or given. This exploration may involve searching for ideas relevant in evaluating how the person feels about the consequences of offered options or may require searching previous experiences.

Humphreys and Berkeley (1984) consider this exploration as being carried out within the "small world" which defines the bounds of the material which the person is prepared to retrieve and attempt to structure in handling the judgement problem (Toda, 1976).

We can only infer the contents of a person's *Small world* from the outside, by looking at what they explore, and thus guessing its bounds or possible "holes" within by what they leave out or what they include. Exploration of familiar material that is conventional technology falls into the realms of what Sandler and Sandler (1978) termed: within a *background of safety*, which is usually built up during development through play, structured and guided exploration of ways of setting bounds or having bounds provided by parents or others for the individual's *worst case* phantasies, or worst case scenarios. This postulate may explain why the public sees familiar technology as safer than novel technology, why they consider coal mining as safer than nuclear power, even though its risk profile, expressed as a probability function over fatalities, is worse. Coal mining disasters are not only familiar but also they are conceptualised within a bounded world. There is uncertainty about *where* the next one will occur, and *who* will be affected by it, but the rescue measures and so forth explored tend to be familiar.

1.3 Analaysis of differences between stakeholders in problem representation.

Identifying stakeholders' small worlds enables the representation of their perspectives of the problem, which allows comparison of any existing differences in their conceptualisation of the problem. It is differences in problem representation among stakeholders that can lead to conflict over possible solutions of the problem. Successful resolution of conflict can only be achieved through a shared agreement not only about *what* the problem is but also *how* it can be resolved.

Results of the first study revealed the extent to which people were unable to handle and structure the problem of Hazardous Waste when either too constrained (level 2) or too free to explore (level 5). The findings revealed that problem handling was optimal at levels 3 and 4. At level 4, when presented with a scenario, people could explore the topic most widely: *across* levels. While at level 3, when the problem was constrained within a *frame*, the subjects were able to explore the topic in *depth* and did not venture outside the frame provided. The methodology is considered particularly useful to further expand the area of exploration of stakeholders' intuitive handling of decision problems and is particularly useful for identifying differing perspectives of the interested parties.

1.4 Resolving differences

Identifying and mapping differences in problem handling by stakeholders, especially in societal deision making have been a major focus of decision theorists in recent years. Several methods have been postulated which can usefully elicit the underlying cognitve structures utilised by stakeholders in their problem handling. Axelrod (1976) consider *cognitive maps*, in terms of a mathematical model of a belief system derived from from what a person states and not from what he thinks. A cognitive map is designed to capture the structure of the causal assertions of a person with respect to a particular policy domain and generate consequences that follow from this structure.

Identification of differences in problem handling and representation can also be elicited through *argumatics*. Toulmin's (1958) uses of arguments is based on the premise that a man who makes an assertion puts forward a *claim*. The claim is implicit in an assertion and is like a claim to a right of argument which could be produced in its support. Whatever the nature of the particular assertion may be, in each case the assertion can be challenged and demand that attention be drawn to the grounds (backing, data, facts, evidence etc.) on which the merits of the assertion are dependent. Central to Toulmin's theory is the use of *grounds, warrants* and *backing*, for the claim or conclusion whose merits are to be established and the facts that are being appealed to as a foundation for the claim or data. The next step in the process may be to seek the relationship to the conclusion of the data already produced. Thus Toulmin's approach to argumentation is to establish, after having made the claim, upon what grounds that claim is based and what warrants are used to legitimise the grounds also what backing is utilised to strengthen warrants, that is, not just what people are saying but what information they use and the route they utilise in getting there. This method for displaying cognitive maps can yield useful data in establishing the extent to which people explore their boundaries at level 5.

This method of problem representation has been utilised by Hogberg et al., (1984), who argued that the standard rational model of problem solving, that is to chose the best alternative, did not apply to problems in social policies. They also suggested that when problems are ill-structured or 'messy', it is more fruitful to look at the problem solving processes in terms of analysing argumentation, as the form of arguments and the content of the conclusions are interdependent. This means that interest groups or stakeholders with conflicting conclusions (common in public policy issues) use different forms of argumentation and that this blocks creative problem solving. Their methodology for analysing arguments in debates was applied to the nuclear energy debate (in Sweden). Through the use of their methodology they were able to identify systematic differences in the use of decision criteria, scientific logic and confidence in *established scientific knowledge* between opposing stakeholders in the debate. One of their major conclusions claimed that stakeholders with opposing interest will not *listen* to each other's arguments, and pointed future research toward identifying differences in problem conceptualisation.

Application of Hogberg's methodology to determine differences of problem handling between stakeholder groups in a social decision problem (hazardous waste disposal in the U.K.) has supported his findings that experts tend to use more facts and theories to support their argument in a public issue debate while lay people and pressure groups use more value judgements to support their arguments in a debate (Allan, 1987, Vari et al., 1986).

However, while this methodology is useful for identifying the *type* of argument utilised in the debate, it fails to identify as successfully the specific perspective utilised by different stakeholders or interested parties within such debates. An explanation of how stakeholders in, especially, social decision making situations *conceptualise* the problem, on what *kind* of issues they base their arguments and only displays how people *argue* and not on how they *view* the problem. In order to be able to argue the process it is necessary first to reach agreement on what is the problem. A prerequisite to a successful argumentation process must be agreement on what the argument is about. The methodology developed on this project and detailed in Techincal Report 87-3 proves more useful in identifying individual stakeholder's perspectives in handling the problem. The identification of stakeholder's perspectives is the first step towards identifying possible routes of communication, an essential factor in risky and controversial technologies and issues (Farago et al., 1987).

2 EXPERIMENTAL DESIGN

In the previous study on this project reported in technical report 87-1, we emphasised the need for reaching a shared agreement by reducing differences in the way problems are handled by stakeholders in societal decision making in order to minimise conflict amongst stakeholder groups and ensure the success of societal policies. The methodology developed was not only utilised for the elicitation of stakeholders' structuring of the problem but also for the analysis of results and was considered particularly useful for the development of facilitatory techniques for displaying the diffrences in the domains explored by particular stakeholder groups in social decision making situations.

To establish how different stakeholders viewed the issue of Hazardous Waste, it was considered useful to apply the problem strauctaring constraints at level 4 according to the 5 level framework for handling intuitive decision making described by Humphreys & Berkeley,(1983, 1985) and detailed in Techincal report 87-1 on this project. When constraints are set at level 4, a bounded problem scenario is supplied whereby stakeholders are encouraged to explore through problem structuring language, and identify the frames and domains they consider relevant in representing the decision problem identified within a pre-specified scenario: hazardous waste incinerators. As described in technical Report 87-1, setting problem structuring constraint at this level encourages exploration of the issue in *breadth*, and thus enables comparison of stakeholders' perspectives.

Central to the present study, like that reported in technical report 87-3, is the real life situation of the issues and the stakeholders. This seems to overcome the lack of applicability of previous research in this area which was usually carried out in laboratory or artificial settings (c.f. Berkeley and Humphreys 1982).

3 SUBJECTS

Four groups of stakeholders or people with specific interest in decision making on Hazardous Waste were selected. Each group comprised of 3 subjects each with similar roles in social decision making on Hazardous Waste. The roles played by members of each of the four groups were as follows:

1. Industry
2. Government
3. Lay people
4. Pressure group

Group 1: Industry

Industry was represented by employees of a Hazardous Waste Incinerator sited at Fawley, near Southampton. The subjects included owner managers as well as employed managers. Lower level employees were not permitted to participate.

Group 2 : Government

Government or regulatory agencies were represented by the Air Pollution Inspectorate from the Department of Environment, the Dept. of Environment as well as the Housing and Safety officer for Lyndhurst County Council, the Local Authority for Fawley.

Group 3 : Lay people

The lay people interviewed were local inhabitants within 2 - 3 miles of the plant at Fawley.

Group 4 : Pressure Group

Pressure group consisted of local inhabitants who were members of the local Residents Association committed to the protection of their environment as well as a local politician who supported the group in their endeavours.

4 PROCEDURES

All but one subject was interviewed individually and alone. All interviews were pre-arranged and subjects were told that the interviewer was conducting a study on Hazardous Waste for London University. The only objection to a private interview came from the management of the incinerator plant who insisted on being present during the interview of his Plant Engineer.

Interviewees in all four groups were provided with a scenario on Hazardous waste in the following form:

a Can you talk to me about Hazardous Waste Disposal by incineration?

b Do you consider incineration a safe method of disposal?

c Where do you think control should rest for Hazardous Waste Disposal?

The transcripts were analysed using text analysis to identify propositions and claims per stakeholder group according to our previous methodology (Technical Report 87-3). It was considered useful to expand on the previous 10 domains as it provided a more detailed analysis of domains of concern. Altogether 15 domains of concern were identified as a result of content analysis. These are as follows:

1	Regulation (how incineration methods should be controlled, safety ensured etc.)
2	Provision of information (whether information is available or should be)
3	Trust (trust or belief in expertise, technology and decision makers)
4	Acceptance/protest (for or against the concept of *hazardous* waste)
5	Long term prospects (or effects of waste disposal on people/environment and other future scenarios)
6	Effects on environment (immediate or future)
7	Disposal methods (reference to methods of disposal)
8	Siting (location of hazardous waste disposal facilities)
9	Effects on people (nuisance or detrimental to health)
10	Safety (issues of safety of method and plant system)
11	Policy issues (references to policy formulation or practices)
12	Economic issues(references to monetary considerations)

13 Interests/stakes (references to who may gain from the issue)

14 Fear (reference to apprehension or fear)

15 Global issues (consideration of the problem in a global context)

5 ANALYSIS AND DISCUSSION OF RESULTS.

The transcripts of each interview were coded into propositions and claims, in the manner discribed in Technical Report 87-1. A proposition is a statement about a problem without structure e.g. "People have fears." A claim is a conclusive statement containing structure e.g. "Monitoring shows that the operation does not have any effect on the neighbourhood". Propositions that lead to claims reveal that the problem/ particular issue is actually being structured and is considered more seriously.

5.1 Propositions and claims

The number of propositions offered (in the stranscripts) by each stakeholder group can be seen in Table 1, while the number of claims offered by each stakeholder groups can be seen in Table 2.

To see if there was an association between the stakeholder groups in the number of claims they advanced. A Chi-square test was applied which indicate that we should reject the hypothesis that there was no difference

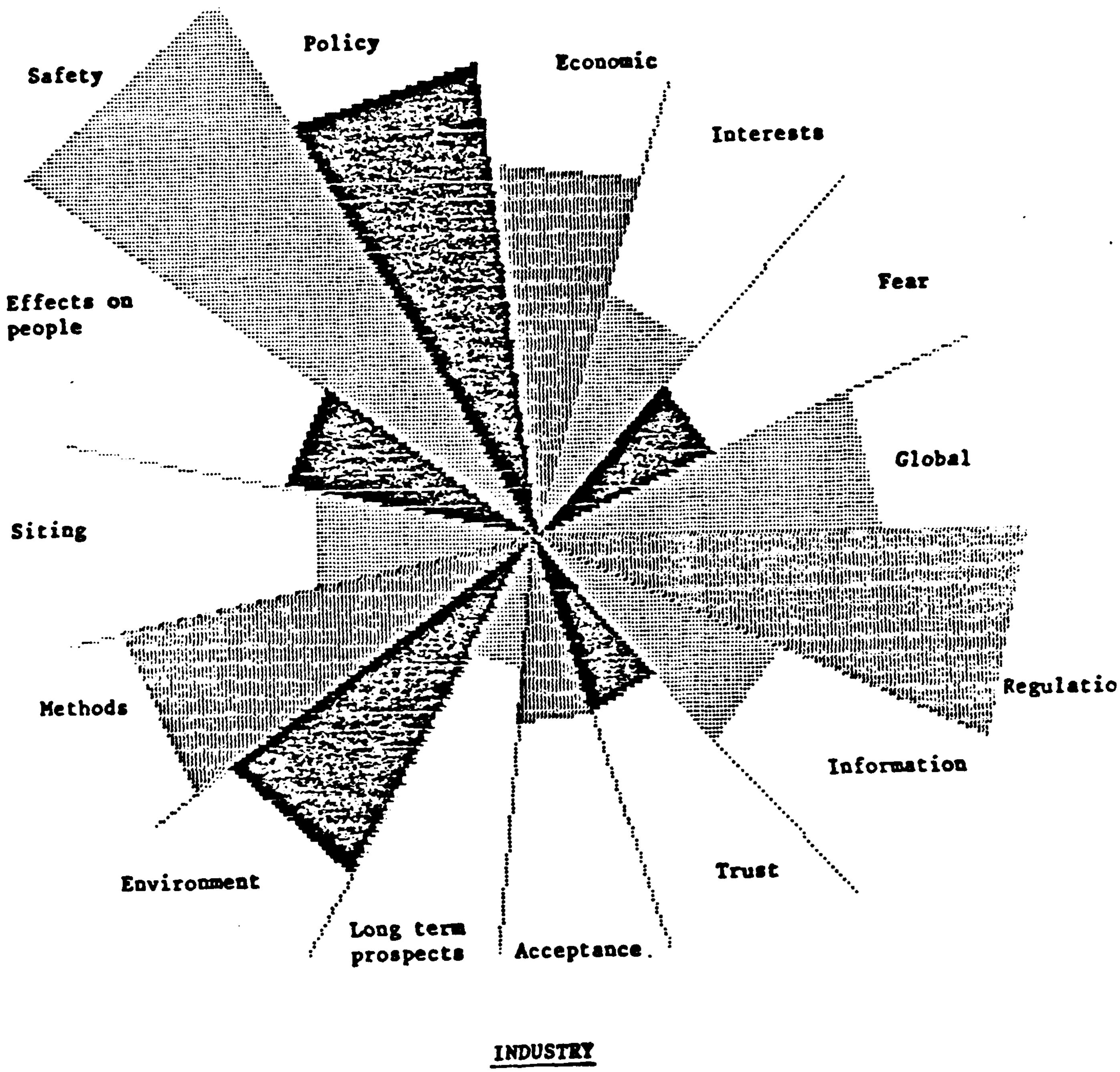


Figure 1: Number of propositions offered by Industry per domain

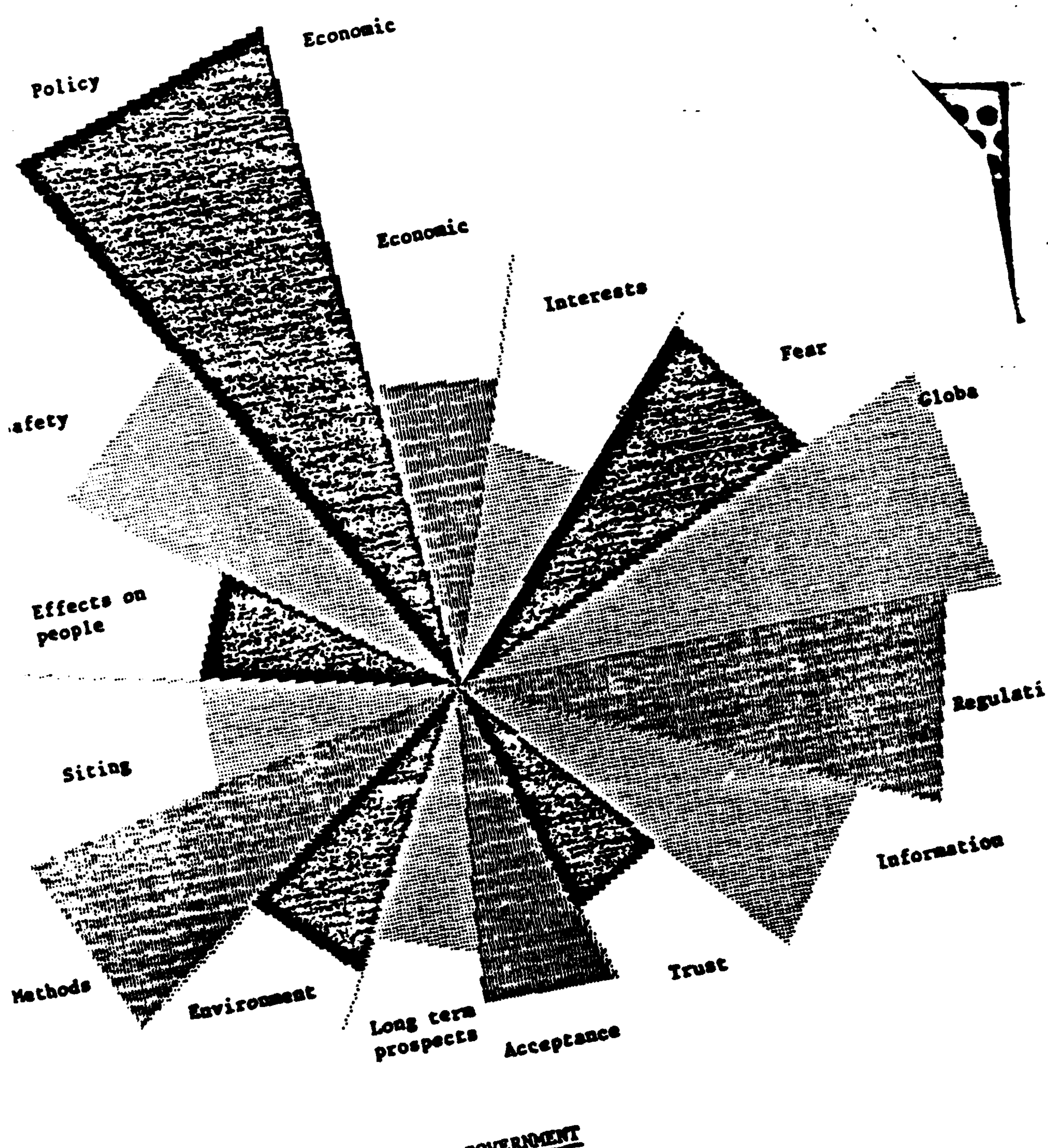


Figure 2: Number of propositions offered by Government per domain

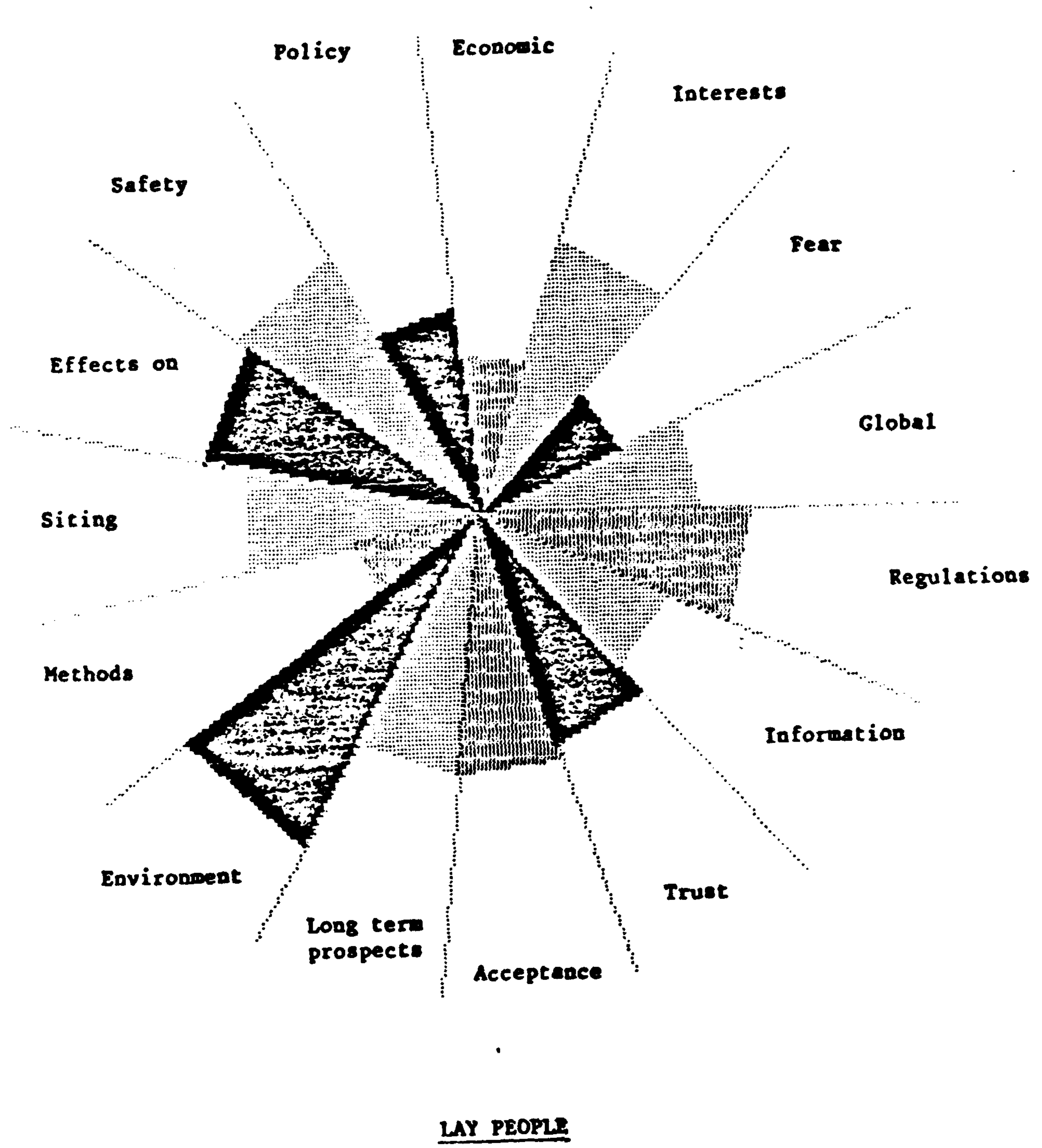


Figure 3: Number of propositions offered by Lay People per domain

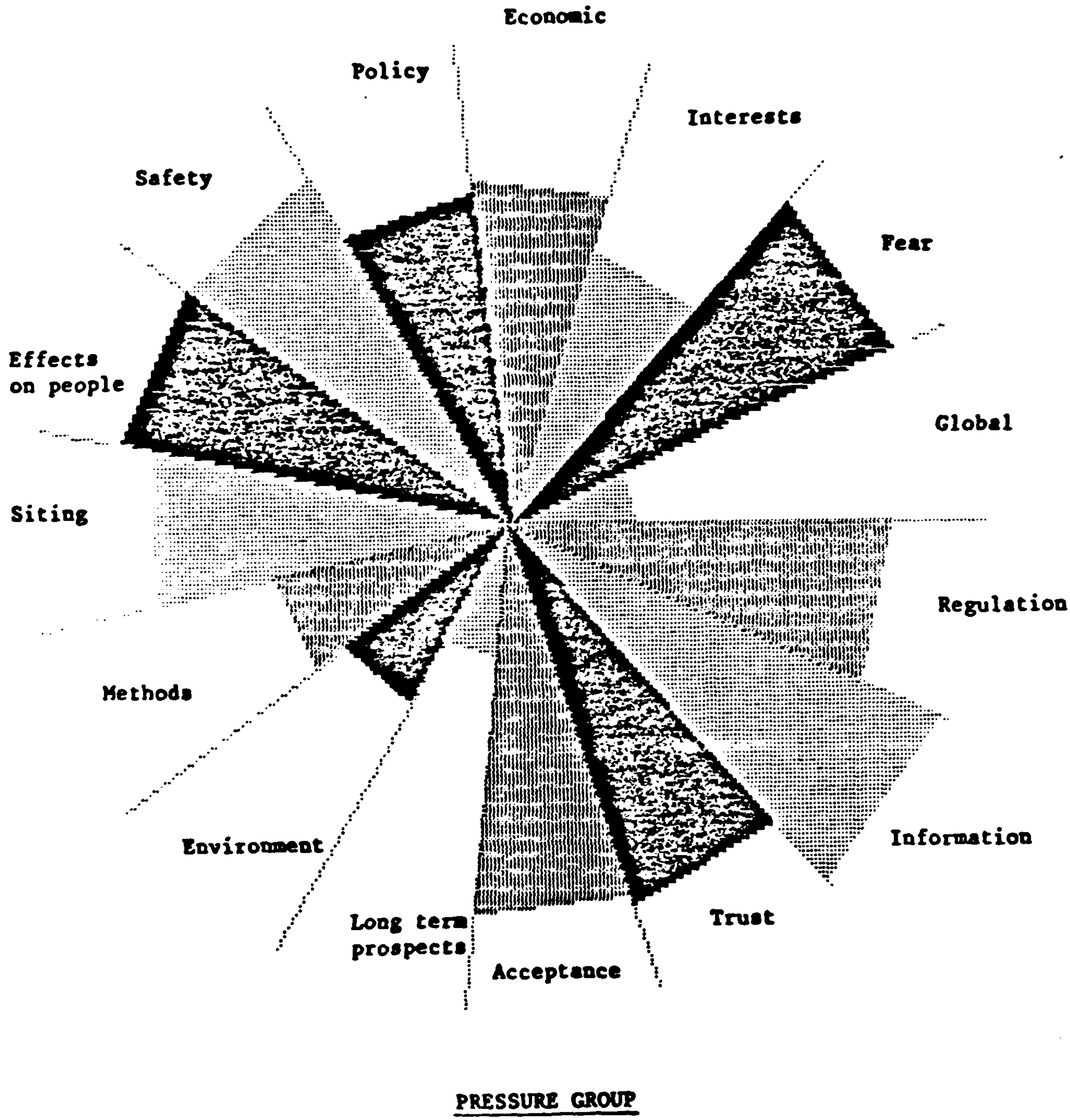


Figure 4: Number of propositions offered by Pressure Group per domain

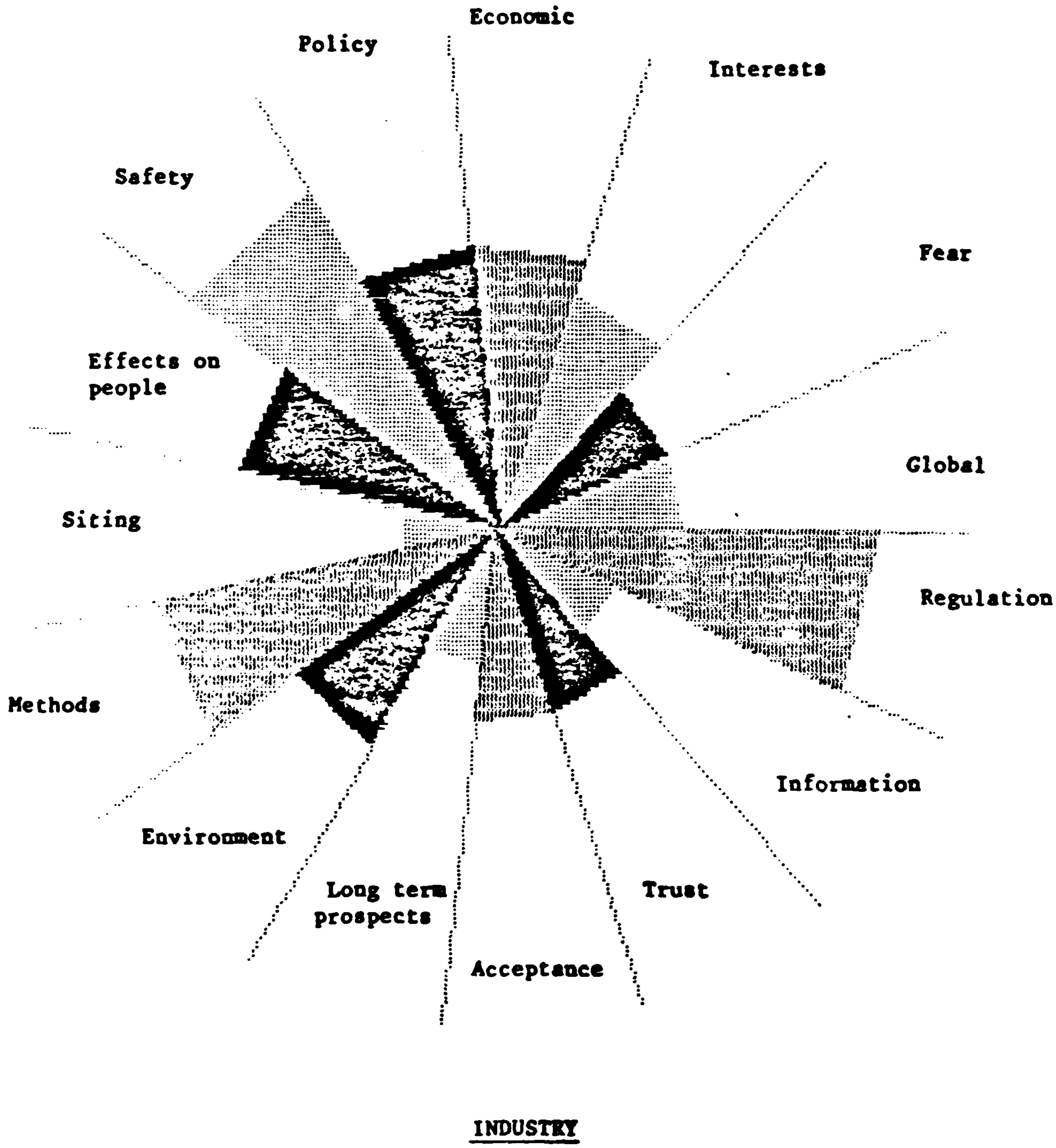


Figure 5: Number of claims made by Industry per domain

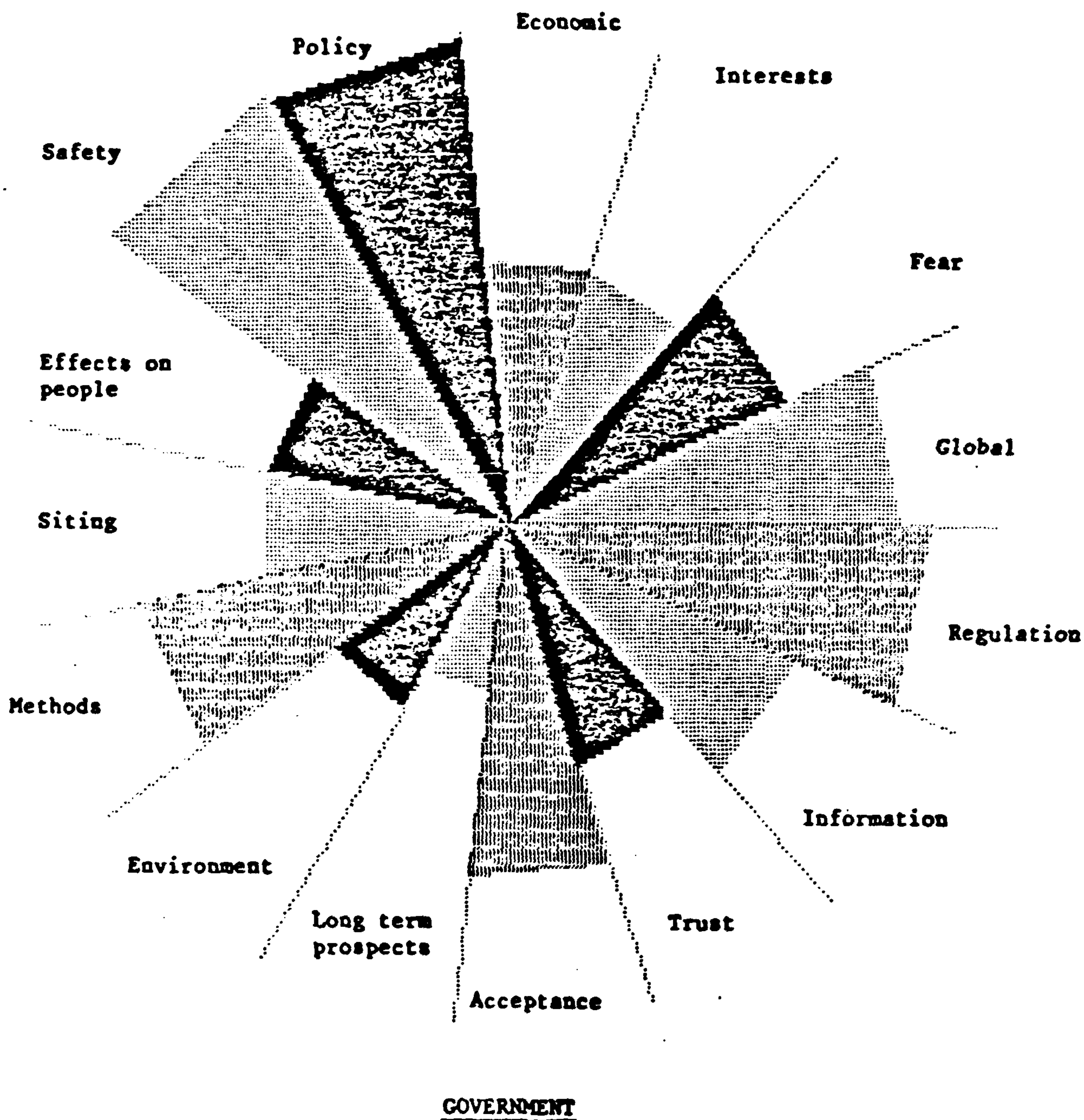
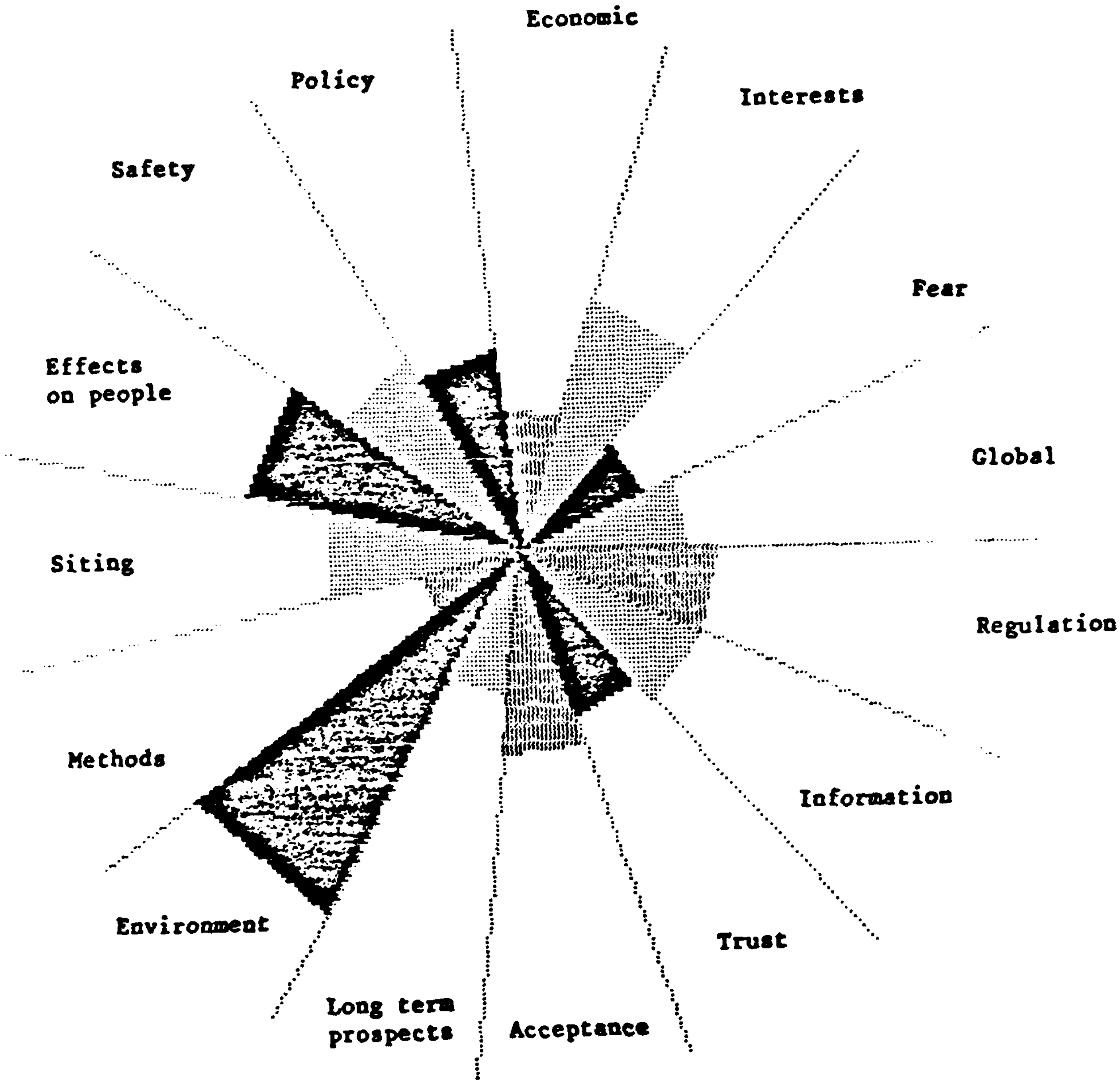
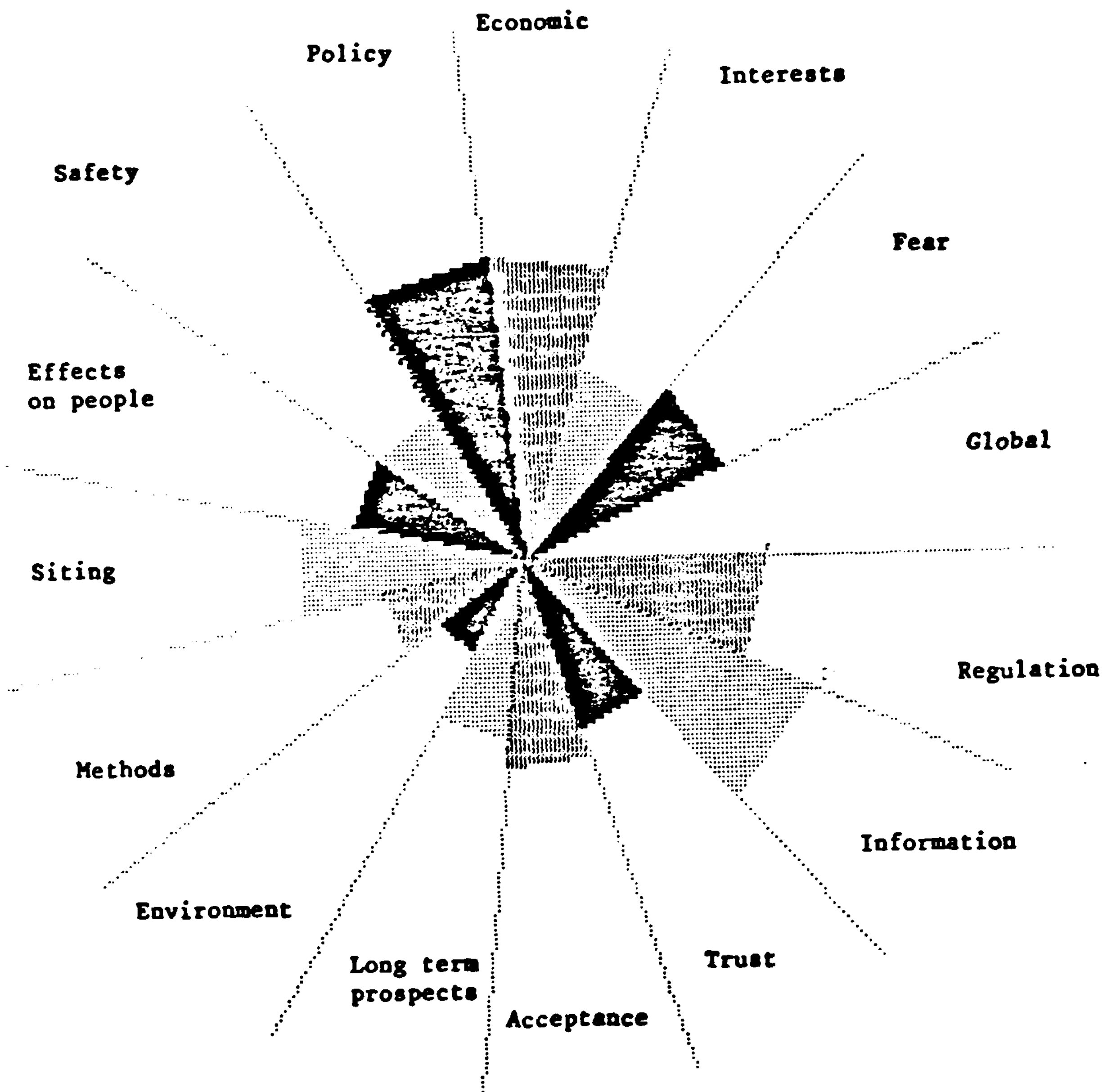


Figure 6: Number of claims made by Government per domain



LAY PEOPLE

Figure 7: Number of claims made by Lay People per domain



PRESSURE GROUP

Figure 8: Number of claims made by Pressure Group per domain

Table 1. Number of Propositions advanced by stakeholder groups in each domain of concern

PROPOSITIONS

DOMAIN	INDUSTRY	GOVERNMENT	LAY	PRES.GP.	TOTAL
1. REGULATION	30	36	9	18	93
2. PROV.INFO	9	25	5	27	66
3. TRUST	4	9	7	19	39
4. ACCEPT	4	17	8	18	47
5. LONG TERM	2	10	8	2	22
6. ENVIRONMENT	18	13	17	5	53
7. METHODS	22	32	2	7	63
8. SITING	6	10	7	16	39
9. PEOPLE	8	10	10	19	47
10.SAFETY	48	28	11	19	106
11.POLICY	28	69	5	13	115
12.ECONOMIC	17	14	3	14	48
13.INTERESTS	8	9	10	10	37
14.FEAR	5	26	3	22	56
15.GLOBAL	15	45	6	2	68
TOTAL	224	353	111	211	899

Table 2. Number of claims advanced by stakeholder groups in each domain of concern.

		CLAIMS			
DOMAIN	INDUSTRY	GOVERNMENT	LAY	PRESS.GP.	TOTAL
1. REGULATION	17	21	4	6	48
2. PROV. INFO	2	12	4	10	28
3. TRUST	4	7	3	3	17
4. ACCEPT	4	14	4	4	26
5. LONG TERM	2	3	2	3	10
6. ENVIRONMENT	7	5	17	1	30
7. METHODS	14	16	1	2	33
8. SITING	1	7	4	5	17
9. PEOPLE	8	7	8	3	26
10.SAFETY	17	28	5	3	53
11.POLICY	9	27	4	9	49
12.ECONOMIC	9	8	2	9	28
13.INTERESTS	7	8	7	4	26
14.FEAR	4	11	2	5	22
15.GLOBAL	4	18	3	-	25
TOTAL	109	192	70	67	438

between the groups in this respect at the 1% level. The exploration of domains of concern in terms of number of propositions and number of claims advanved by each stakeholder group within each domain is displayed in Figures 1 - 8, and summarised in Tables 1 & 2.

The greatest number of propositions offered was by the regulatory agencies (government) followed by industry. Lay people offered the least number of propositions. However most of these propositions did not lead to problem structuring, this is shown by the reduced number of claims made. The highest proportion of propositions that led to claims was offered by industry, and the lowest proportion of propositions that led to claims was offered by the pressure group. This suggests that industry was more prepared to begin to structure the whole problem of hazardous waste (in the way they saw it) than was the pressure group.

When we consider which domains are important for each we find that:

For Industry:

Safety and regulation are the most important domains of concern even for domains that they begin to structure. They also consider disposal methods, policy issues and the environment and to some extent economic issues.

For Government:

For this group most issues are of concern and regard the whole problem of hazardous waste in a more global perspective than any of the other groups. However, it is evident that their major area of concern is with policy issues.

For Lay People:

This group offered the least number of propositions and seemed to be least able to identify and define the problem adequetly. The major domain of concern was with the effects on the environment followed by safety, effects on people and issues of interests or stakes involved in hazardous waste. Their domain of least concern was with disposal methods, fear and economic issues.

For the Pressure Group:

This group's major domain of concern was with the provision of information and to a lesser extent fear. The other domains of concern were distributed evenly, showing the least concern with long term effects and global perspectives.

5.2 Differences across domains:

The following compares the extent to which the various groups advanced claims in each domain:

Regulation: Most concerned within this domain are government and industry lay people and pressure group are less concerned here.

Provision of information: The two groups who are concerned with this domain are government and pressure group. Industry or lay people do not show any great concern.

Trust: This domain is mainly the concern of the pressure group.

Acceptance: Both government and pressure group are concerned with this domain.

Long term prospects: Only government shows more concern in this area.

Effects on environment: This domain concerns industry, government and lay people equally but only to a lesser extent does it concern pressure group.

Disposal methods: Both government and industry show considerable concern.

Siting: This domain was mostly important pressure groups and government.

Effects on people: This domain elicited most concern from the pressure group and to some extent government and lay people were also concerned. Industry was least concerned in this domain.

Safety: While safety was the major concern to industry and some concern to government it was also considered important by both lay people and the pressure group.

Policy issues: Although industry showed considerable concern in this domain, it was a major source of concern to government, with very little ineterst shown by lay people.

Economic issues: This domain was considered equally to industry, govrernment and the pressure group it was of least concern to lay people.

Interests/stakes: Lay people and the pressure group considered this equally important while govrnment and industry did not regard it as a major issue.

Fear: This domain represented most concern to government and the pressure group, but industry and lay people considered this a minor issue.

Global view: This domain was considered particularly important by government and to a lesser extent by industry but lay people did not display particular concern with this issue and even less interest was shown by the pressure group.

5.3 Differences in perspectives adopted by the four groups of stakeholders

The differences in the way the various groups advanced *claims* in the various domains can be summarised by grouping those domains whose exploration follows from taking a particular general perspective of the problem.

We identified five general perspectives, as follows:

1 *Technical perspectives*. Taking this perspective implies concern with domains relating to issues that deal with technology and operational aspects relating to it. It comprises the following domains:

Regulation

Disposal method

Siting

Safety

2 *Economic perspective:* taking this perspective implies a concern with financial issues. This comprises of the following domain:

Economic

3 *Environmental/Health perspective:* taking this perspective implies a concern with effects of hazardous waste on the individual and his or her existence, quality of life in the future. It comprises the following domains:

Effects on people

Long terms effects

Global view

4 *Social policy perspective:* taking this perspective implies a concern with issues relating to policy surrounding the issue, the extent to which other parties are able to exert and exercise their power within the debate and its consequent effects. It comprises the following domains:

Interests/stakes

Provision of information

Policy issues

Acceptance/protest

5 *Individual perspective*: taking this perspective implies a concern for individual people's subjective feelings. It comprises the following domain:

Fear

Figure 9 compares the relative prominence of claims made by each group within each general perspective.

Areas of conflict are likely to occur within those domains where greatest differences exist in the degree of exploration made by members of the various groups. These are as follows:

Economic perspective: Three of the interest groups share this perspective, namely industry, government and pressure group, however lay people do show any concern within this perspective. Thus while industry, government and pressure group can reach a shared agreement within this perspective, lay people would not be able to and conflict is likely to occur for this group within this perspective.

Technical perspective: Industry and government share this perspective and thus would be able to reach a shared agreement, although pressure group and lay people also share this perspective and are able to agree they are likely to be in conflict with the other stakeholders.

Social/policy perspective: Government is most prominent within this perspective due to their role as regulatory agency, they have to take into account the effects of policies upon the other stakeholder groups. Industry, pressure group and lay people are not concerned with these issues and conflict may occur if government places too much emphasis on this perspective.

Environmental/health perspective: This perspective is prominent for government and lay people only and thus they share their concerns within this domain however conflict is likely with industry and pressure group as they do not consider this perspective as very important.

Individual perspective: Government is most prominent within this perspective, while industry, pressure group and lay people share agreement by their lack of concern within this perspective. Conflict is likely to occur between members of the three stakeholder groups who share agreement and members of the government agreement.

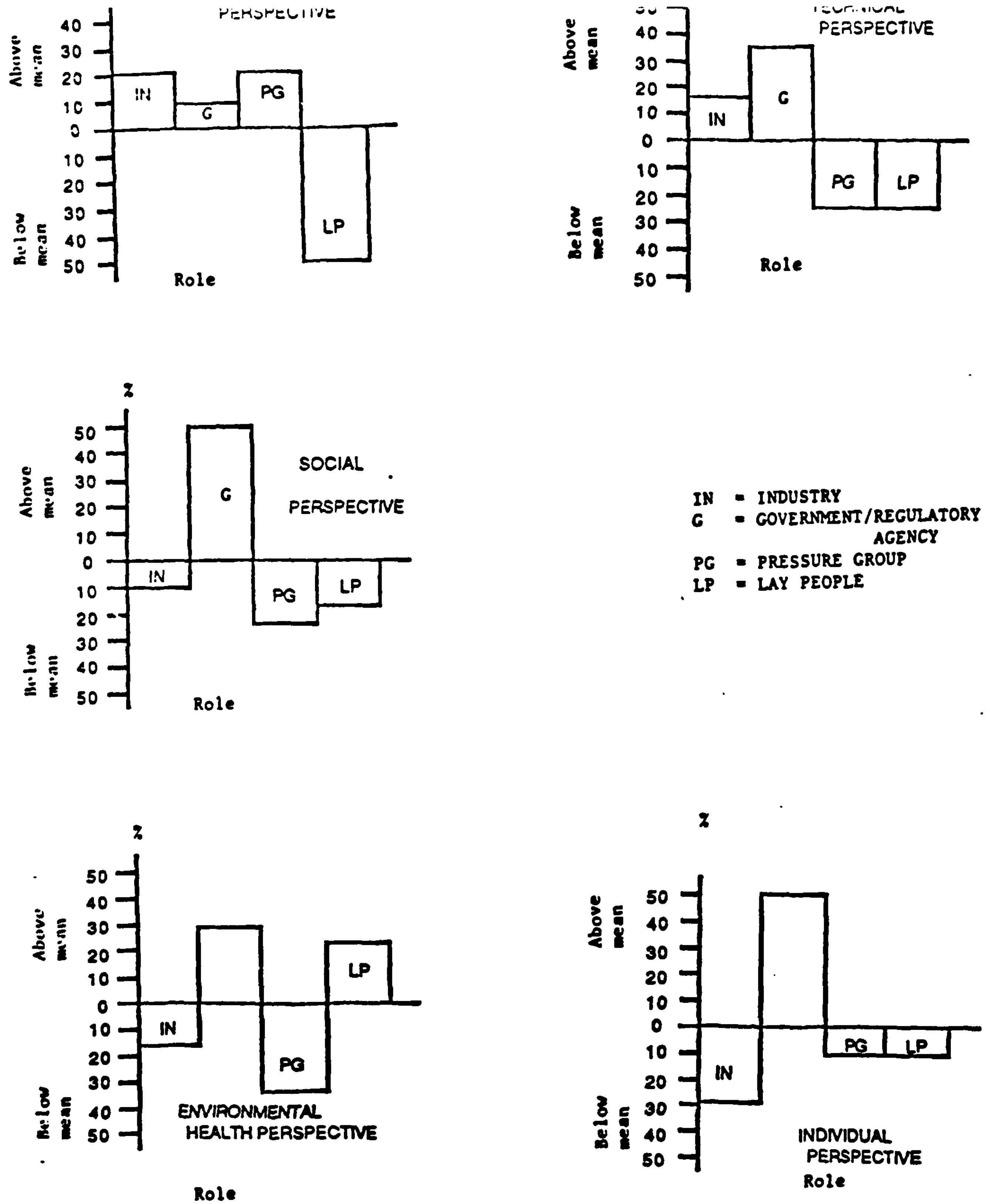


Figure 9 Relative Importance of Perspectives of Stakeholder Groups

6 CONCLUSION

The results identify the extent to which stakeholder groups can reach agreement on their decision problem, and highlight the extent to which these groups are unable to communicate with each other. The analysis reveals that their background of safety, and thus the boundaries of the small worlds that they are able to explore are not shared. In order to reach a shared understanding of the problem it would be necessary to extend stakeholders' background of safety to include domains beyond the existing boundaries so that all perspectives may be shared by each stakeholder. We discuss ways of doing this in section 2.1.1 of technical report 88-1.

The identification of the domains of concern explored by interested parties within the issue of hazardous waste, facilitated the comparison of perspectives adopted by members of stakeholder groups who would occupy different, and potentially opposing roles in social decision making on hazardous waste disposal.

The method of analysis we described in the first year of work on this project, and described in technical report 87-1 has here been shown to be useful in eliciting the perspectives of different interest groups within a decision problem. It is able to identify *where* differences in perspectives occur and thus enable resolution of such differences by aiding the particular stakeholder groups to extend their background of safety and encourage exploration to take place within domains not previously explored.

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