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Handling Decision Problems: A Structuring Language and Interactive Modules

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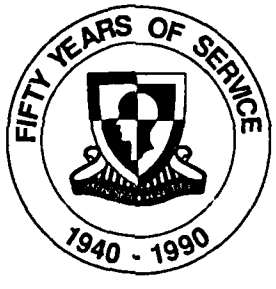

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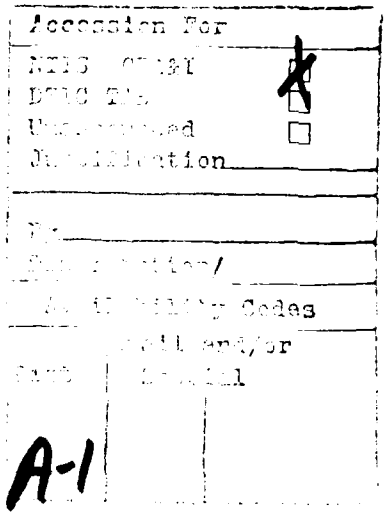

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This report describes the result of the second year's work on a 3-year project designed to identify and develop methods of effective support for higher-level decision making where the use of decision makers' own language in identifying and structuring problems is important. It examines the four classes of systems and tools for decision support that need to be provided within the general procedural schema for handling ill-structured decision problems to provide a comprehensive library of microcomputer-based tools for handling such problems at strategic and lower levels.

Analysis of results confirms the basic hypothesis--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.

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18. SUBJECT TERMS (Continued)

Organizational decision making
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19. ABSTRACT (Continued)

We also focused on identifying differences in perspectives of stakeholders in a risky technology, that of hazardous waste incineration in a real-life setting. We studied groups of stakeholders in industry and government (regulatory agency) as well as lay people and a pressure group.

SUMMARY

Successful application of computer-based tools and systems providing support for decision making have hitherto been limited to handling low-level, well-structured problems in which the decision maker has little discretion in formulating a policy for action. This report describes the results of the second year's work on a three year project designed to identify and develop methods for provision of effective support for higher level decision making where the use of decision makers' own language in identifying and structuring problems is of special importance.

The work plan for the project involves (1) the development of a framework for specifying, assessing, interfacing and transporting modules in a "decision problem structuring library", (2) analysis of a number of real-life high-level decision conferences, with emphasis on the ways in which problems were formulated and structured, and identification of ways where effective support could be provided by analyst and/or computer based systems, (3) identification and evaluation of methods for displaying and resolving differences in the way decision makers represent decision problems through a five level study of intuitive decision making by various stakeholder groups (in the field of hazardous waste management). A major characteristic of this research is that it is concerned not only with the descriptive approach to decision making which attempts to establish what people do do, but more importantly, with what people can do when appropriately supported.

During the second year's work on this project the following progress has been made:

1.1 Tasks described in section 7.1 of the proposal for the project.

Task 5: The evaluation of selected modules from the set reviewed in Technical Report 87-1 (Methods and tools for structuring and analysing decision problems) has been completed. Specifically, the following modules were selected for analysis from each of the four classes defined in section 2 of that report.

Class R1: **Systems and tools facilitating use of problem owners' problem expressing language.**

None (as there was a complete absence of tools in this category. Instead, a specification of desirable tool functions within this category has been developed. This is described in sections 2.1.2 and 2.1.3 of Technical Report 88-1.

Class R2: **Systems and tools aiding generation of conceptual models.**

- o Opcom (decision tree, modelling forward scenarios).
- o PG% (goal analysis, modelling backward scenarios).
- o Equity (pareto optimal analysis, provides negotiation support)

The evaluation showed PG% to be dominated by EQUITY. Hence while OPCOM and EQUITY are discussed within the context of building a problem structuring library in Technical Report 88-1, PG% is not.

Class R3: Systems and tools aiding exploration through conceptual models

- o Priorities (establishing work priorities).
- o Javelin (for financial modelling and business analysis)
- o Safeti (for risk analysis)

Javelin and Safeti were found to have useful characteristics and are described in Technical Report 88-1. Priorities was found to be a disappointment in practice, with no real capabilities for aiding exploration, and was not selected for further consideration.

Class R4: **Systems and tools which support preference structuring**

a) Tools based on multi-attribute utility theory.

- o HIVIEW (hierarchical decomposition for use by analyst)
- o SELSTRA (hierarchical decomposition for direct use by client)
- o MAUD (highly interactive direct decomposition for direct use by client)
- o POLICY-PC (uses a mixture of assumptions from MAUT and judgement theory

HIVIEW, SELSTRA and MAUD were found to have important support capabilities within this class and are described in Technical Report 88-1. Our evaluation of POLICY-PC showed it to be dominated by HIVIEW with no significant gains from the use of judgement theory, so it is not considered further here.

b) Rule-based tools employing semi-order methods.

- o ZAPROS (based on semi-order techniques)
- o DECMAK (finds ordering constraints based upon verbal rules)

Both these two were found to have useful support capabilities, in many ways complementary to those of the tools based on multiattribute utility theory. Here these tools are described in Technical Report 88-1, together with a discussion of ways of merging the capabilities of tools in subsets A and B.

Task 6: Development of the material to be presented in a technical report summarising the research findings from tasks 1 to 4.

This is presented in Technical Report 88-1, appended to this document (Technical Report 88-1 also comprises material from task 12 from section 7.2 of the proposal, as described below).

1.2 Tasks described in section 7.2 of the proposal

Task 6: Preparation of conference case studies.

Eight conference case studies, in which themes and issues are discussed in greater detail than is possible in the more summary analyses of decision

conference material also undertaken in this project, have been completed and which form the empirical basis for the research described in Technical Report 88-1.

Task 8: Preparation of revision version of Technical Report 87-3, taking into account results of Task 6.

This is presented as Technical Report 88-2, appended to this document. In fact 88-2 represents a considerable extension of the initial analysis presented in 87-1, rather than merely a revision.

Task 9: Analysis of further decision conferences.

As stated in our previous report we have considerably exceeded the amount of decision conference material analysed which we initially expect to have analysed this far. However, some detailed analyses will be continued in the forthcoming year.

Task 10: Interpretation of results.

Interpretation of results is given in Technical Report 88-2, appended to this summary.

Task 11: Problem structuring model building (from output of tasks 9 and 10).

Task 12: Prepare technical report on supporting problem structuring and report generation in decision conferencing.

We decided to merge the material for this report with the material from Task 6 described in section 7.1 of the proposal into Technical Report 88-1, appended to this summary. Technical Report 88-1 now gives a comprehensive view of support techniques for use in decision conferences and organisational and social decision making contexts.

1.3 Tasks described in section 7.3 of the proposal

Task 4: This has involved research into techniques which would be effective in displaying and communicating the differences between the way individuals or stakeholder groups handle a decision problem. In Technical Report 87-2 (Intuitive handling of decision problems: A five level empirical analysis), we described the importance of displaying how much different domains are explored in forming scenarios (Technical Report 87-2, section 7.2), and how claims, warrants and backing are used in participants' problem expressing language (Technical Report 87-2, section 7.3). We have successfully researched ways of making graphical displays of both these facets, and are now developing the functional specification for interactive computer-based tools, implementing the methods we have identified as most promising. The latter are described in Technical Report 88-1, sections 2.1.1 and 2.1.2.

Task 5: This has involved the development of material for a practical manual for modelling and resolving differences in judgment in handling complex decision problems (due to be delivered at the end of

next year's work). This has included ideas drawn from the research work described in Technical Reports 870-1 and 88-1, and will also describe the use of the techniques we are developing under task 4 above.

Task 6: This was the second empirical study on intuitive decision making scheduled for this project (the first was described in Technical Report 87-1). It differed from the first in that the subjects came from different stakeholder groups in the field of hazardous work, those affected through living near the disposal plant, and those in the mass media charged with reporting issues in this area). The results of this study are described in Technical Report 88-2, appended to this summary.

LIST OF KEYWORDS

Decision conferencing
Decision making levels
Decision support tools
Managerial group decision support
Managerial problem solving
Organisational decision making
Problem definition
Structuring decision problems

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SUMMARY OF PART I

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 (part of the first year technical report on this project). It examines in detail the four classes of systems and tools for decision support which need to be provided within our General Procedural Schema for handling ill-structured decision problems 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).

Within each of the four categories we have selected microcomputer-based support systems and tools from the entries in the catalogue given in technical report 87-1 which have a proven track record in use in decision making at the strategic level, and at lower levels. We describe their capabilities and limitations against the support goals identified for tools in each particular category within the account of the general procedural schema. The tools selected within each category are not evaluated in competition with each other. Rather, we have assembled a set ot tools which, taken together, indicate the state-of-the-art across the full range of support functions which could be offered by technology successfully incorporated in current tools.

This allows us to evaluate the capabilities of the tool set, taken as a whole, and also to consider the ease, or difficulty, of integrating information and methods across tools in the case where comprehensive support for an application may best be provided through the use of functions contained in more than one tool.

In fact, this is the most pessimistic part of our report. It shows that the tools we have selected all have 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, global functionality of the set, 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. This is because, 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 support functions provided 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.

We conclude that the next step should be to take a top-down view of what is required in building a decision problem structuring library, deriving first of all the set of support functions, and then describing how they may be clustered into "super-tools" which comprise both functions successfully implemented in existing tools and the required but currently missing functions. Such supertools should not be defined in a closed way. The aim should be to allow any individual library builder to integrate the tools and tool functions he wishes to use (regardless of the source from which they were acquired) into his own comprehensive library, offering *integrated* support facilities, tailored according to the applications needs of the library users.

SUMMARY OF PART II

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.

SUMMARY OF PART III

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.

Handling Decision Problems: A structuring language and interactive modules.
Second Year Annual Report

PART I

Building a decision problem structuring library: A review of some possibilities.

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Decision Analysis Unit Technical report 88-1

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SUMMARY

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This allows us to evaluate the capabilities of the tool set, taken as a whole, and also to consider the ease, or difficulty, of integrating information and methods across tools in the case where comprehensive support for an application may best be provided through the use of functions contained in more than one tool.

In fact, this is the most pessimistic part of our report. It shows that the tools we have selected all have 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, global functionality of the set, 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. This is because, 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.

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CONTENTS:

BUILDING A DECISION PROBLEM STRUCTURING LIBRARY: A REVIEW OF SOME POSSIBILITIES

1. PROVIDING SUPPORT WITHIN A GENERAL PROCEDURAL SCHEMA FOR THE PROCESS OF PROBLEM HANDLING AND DECISION MAKING.

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 (part of the first year technical report on this project). It examines in detail the four classes of systems and tools for decision support which need to be provided within our General Procedural Schema for handling ill-structured decision problems 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).

Here we re-visit the General Procedural Schema introduced in Technical Report 87-1, this time identifying (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 (Technical Report 87-1, volume 2), 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), as described in section 2, 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 (i) by a system synthesising the functionalities of several of the identified tools, or (ii) by a system whose functionality is derived from our research and consultancy experience, but for which no implemented tools yet exist.

2. FOUR CLASSES OF SUPPORT

The General Procedural Schema is shown in diagrammatic form in figure 1. It comprises seven stages (S1 through S7), described in detail in Technical Report 87-1. Progress through the schema is facilitated in practical applications by systems and tools located in four classes (R1 through R4 in figure 1), each providing a qualitatively different kind of support to the decision maker. In this section we review, for each of these classes in turn, ways in which such support may be provided.

2.1. Support class R1: Systems 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 stages S2 and S3 in the general procedural schema. User requirements here are for methods and systems 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. (At stage S1, 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 at this stage).

At stage 2, 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. This does not mean that one has to explore *the whole world* within which the decision is to be made, The small world is that which is sufficient to bound the exploration of the issues which are going to be expressed in articulating the decision maker's and other stakeholders' *desire* to make improvements.

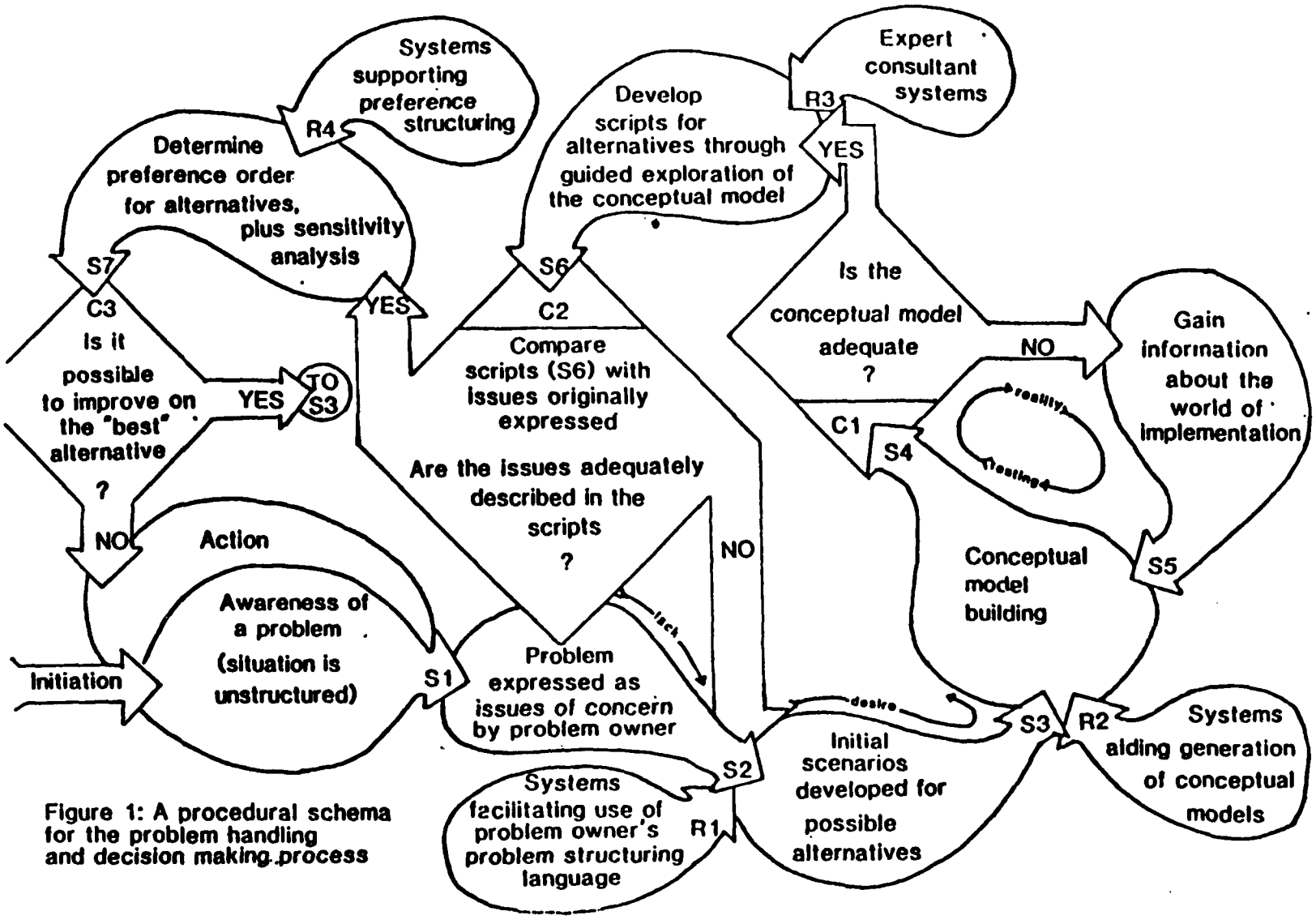

Figure 1: A procedural schema for the problem handling and decision making process

Following Checkland (1981), we presume that any decision problem representation which may be developed is always owned by somebody. We will refer to such persons as "problem-owners." In cases where the overall problem is owned by more than one individual, then it is important to ensure a consensus between the various problem owners concerning the boundary of the decision space. When such a consensus is not achieved, stages S2 to S7 have to be traversed separately for each problem owner's concerns.

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 methods, not previously incorporated into tools, may provide effective support at stages S2 and S3, respectively. The first, described in section 2.1.1, 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 2.1.2, deals with the presentation of the issues that various problem owners may wish to express within such shared domains through the inferences they advance.

2.1.1. 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 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 decison 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 decison 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 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.

Risk 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 – reminescent 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 negtive features, but just simply because it feels unsafe even to *consider* them.

Extending the background of safety

In Technical Report 88-3 (Humphreys, Oldfield & Allan 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, impressarios 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, 1987) 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 focusses 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 displays of the domains explored by different problem owners, constructed like those shown in figures 1-8 of Technical Report 88-3, can be very useful for providing the structured context which sets the

agenda for the exploration through small worlds which the psychodramatic techniques facilitate. In the next year's work on this project we will explore further the most effective ways of constucting and presenting such displays in supplying class R1 support.

2.1.2 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 2.1.1), we can continue to stage3 in the general procedural schema. The transition from stage S2 to S3 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 which 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 which 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 which 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 which characterise the set of objects or events to be considered and (ii) actions/events which 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 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 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 end 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 representd 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.

Hence, in general, inference diagrams can provide useful support within class R2, helping :

(a) to reveal the way in which problem owners express their awareness of the uncertainties which they would like to be investigated further;
(b) to demonstrate major differences in the approach to conceptual model building (in stage S4) which will be acceptable to particular stakeholders, and to display the divergences between them.

In subsequent work, we will explore the most effective way of displaying inference diagrams and thus derive the functional specification of a computer-based tool which can provide such support in an effective way.

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

The initial scenarios developed at stage S3 with the help of tools in support class R2 may not be very realistic, as these tools can only aid the expression and exploration of problem owners' subjective views on issues, without the opportunity to check on the completeness or realism of these views.

Hence, the initial scenarios may need to be shaped up and tested against the reality of the organisation or social context in which the decision is taken. This is why, in the general procedural schema, the goal analysis in stage S3 feeds into stage S4 where the conceptual model for representing the decision problem and exploring the effects of possible options is generated. This transition 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.

The first step in stage S4 is to assemble the statements of objectives and the scenarios which were generated in stage S3. These collectively represent what Checkland (1981) 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 requires 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 organisation. This, in turn, involves *reality testing* of the conceptual model by, for example, checking then with the personnel actually carrying out functions identified within the model (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).

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, here we will consider only modeling techniques which serve to structure, develop, contextualise, explore and test *future* scenarios. To this end, we have selected three tools from our catalogue. One, described in section 2.2.1 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 two, described in section 2.2.2, start from future goals and model backward scenarios through constructing the option which might best achieve those goals.

All three of these tools are based upon the fundamental assumption of decision theory, though developed in different ways. In section 2.2.3, we examine the types of uncertainty which can, and cannot, be handled in conceptual model buliding through the use of decision-theoretic techniques, and discuss the development of a more general conceptual model building system which can overcome some of the limitations of the decision theory based techniques.

2.2.1. 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 ocurrence) 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 technical report 87-1, 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" S4-S5 circuit shown 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.

2.2.2. 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 characterisation 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.

2.2.3. 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 modeled 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.

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

Although none of the tools in class R3 which are included in the catalogue in Technical Report 87-1 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 Office Frame of Reference (GOFOR) which offers many of these capabilities within one particular domain, i.e., conceptual model building relating to decisions on organisation and change in office contexts.

GOFOR has the general aim of guiding the investigation and model building process within practical, systems-based analysis of offices, office problems and office requirements. The development method for GOFOR starts 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. By way of summary, outlined below are some of the key features of GOFOR which facilitate its organic development.

GOFOR provides a consistent set of both formal and preformal representation means for organisational modeling. It does not recognise any rigid distinction between hard and soft modeling. Rather, the formal modeling capabilities of GOFOR represent an optional facility towards increased exactness of models which have been developed with pre-formal capabilities. At present, some aspects of GOFOR are expressed in pre-formal terms only (e.g., modeling levels of re-organisation in office management), but GOFOR allows for subsequent refinement when appropriate and proven formal modeling techniques subsequently become available.

GOFOR describes seven perspectives which are of particular importance in office 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 office personnel and analysts. GOFOR thus does not treat these perspectives as absolute but rather uses them to guide the initial organisation of material to be modeled. If a case is made for other perspectives to be considered for this purpose, these can be introduced without disturbing the basic structure of GOFOR.

GOFOR provides guidelines for using perspectives and modeling techniques which extend beyond the confines of any single interpretation of organisational investigation methodology. We have discovered that the capabilities of GOFOR can be extended to handle many aspects of the process of conceptual model building involving resolution of uncertainty of types (v), (vi) and (vii). Hence, during the third year of work on this project we will examine the possibility of developing GOFOR to provide a Generic Organisational frame of reference, capable of offering comprehensive support for conceptual model building within our general procedural schema.

2.3. Support class R3: Systems and tools aiding exploration through conceptual models.

Once the conceptual model has been judged adequate at the end of stage S4 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.

This comparison (C2 in Figure 1) may indicate that between S2 and S6 certain issues which were expressed 'got lost' through focussing on other issues when operationalising 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 stages S3 and S4. If extensive reality testing procedures were used, (stage S5) the final structure of the conceptual model may be rather different from that of the problem owner's initial objectives. In this case, the scripts can have a didactic role, helping problem owners to understand how their overall goals can best be translated into implementations of objectives which conform more closely to organisational or social realities.

Support can be provided for the process of developing these scripts for comparison through guided exploration of the conceptual model built in stage S4. 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 graphical 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 S2.

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 which 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 entirity, 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 we surveyed in this class (and described in the catalogue in technical report 87-1) offered 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 particuar 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.

2.3.1. 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.

2.3.2. 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 technical report 87-1 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.

2.3.3 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

sufficently 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 2.2.3).

In order to achieve such capabilites in future tools, we should keep the very useful concept of *view visualisers* in developing display and exploration techniques, but be able to attatch 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).

It is important to be able to explore user-defined substantive views, rather than just within pre-defined views, as in the case with SAFETI. Our next year's work on this project will investigate further the functional specifications for tools which could achieve such exploration in practice, and describe how they may be linked onto tools with comprehensive conceptual model building capabilities (c.f. section 2.2.3).

2.4. Support class R4: Systems and tools which aid preference structuring.

At stage S7, in the general procedural schema, the remaining task is to determine the appropriate preference structure within which the options described in S6 are to be assessed, so that their benefits and disadvantages on the criteria or attributes which comprise the structure can be traded off against each other in deciding on the best option overall (Edwards and Newman, 1982).

Systems and tools in this category aim to support the user by helping him or her 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.

Three subsets of option evaluation tools were identified in the catalogue described in Technical Report 87-1: tools based on multi-attribute theory; tools based on heuristic rules concerning tradeoffs to be made between scaled attributes; and rule-based tools employing semi-ordering methods. However, after evaluating the tools in these three subsets, we decided to include in the set of class R4 tools considered 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 sufficent 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 2.4.1.

The two semi-order based techniques described in section 2.4.2 (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 2.4.3., we discuss some possibilities for synthesising the advantages of the MAUT and semi-order based approaches into a single preference structuring tool.

2.4.1. 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 micro-computer based interactive system for use in developing a structure (defined in terms of key attributes) for characterising sets of alternatives described in particular domains (tasks to be performed, resources to be allocated, strategies to be selected, or whatever). No knowledge of decision theory, formal techniques or computing is required, and the system is so user-friendly that it can be operated without reference to the user manual.

In characterising, defining and assessing alternatives, MAUD converses with the user, employing and structuring his or her own descriptions. MAUD helps the user identify and explore the criteria which really matter in characterising alternatives and provides considerable facilities for editing material when the user (or MAUD) becomes dissatisfied with the way in which he or she has represented some aspect of the problem within the program or is attempting to represent the aspect currently being worked on. Examples of circumstances leading to editing are: spotting incoherence of ratings of alternatives on an attribute dimension owing to inappropriate specification of poles, failure to find an ideal point, and so on. Editing may involve restructuring the problem by changing the ratings or ideal points on attribute dimensions, renaming of poles, or deletion of alternatives or attribute dimensions, and replacement by others.

Alternatively, restructuring can be initiated by MAUD, in interaction with the user. MAUD automatically monitors the ratings on the attributes as they are made by the user, checking for *conditional utility independence* with all other attributes currently in the structure. (Capitalising on the fact that tests for statistical non-independence are stronger than those for violations of conditional utility independence, MAUD monitors the relevant statistical associations and only questions the decision maker about possible attribute independence

problem when its internal statistical testing indicates that there is a reasonable chance that utility independence might have been violated. In the case where a problem is so identified, 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 attributes to provide an adequate characterisation of alternatives in the context under consideration, and MAUD is satisfied with the coherence of the structure and its contents, MAUD can then investigate value-wise importance weights and relative scaling factors for all attribute dimensions in the structure.

At any time, at the user's request, MAUD produces a summary showing assessed preference values for alternatives (if relevant), the value-wise importances of the attribute dimensions, and the ratings of alternatives on them. The user may then wish to use the sensitivity analyses provided within MAUD, or carry out further restructuring, introducing new alternatives, removing old ones, or changing attributes dimensions, etc. The system is fully re-entrant, which means that restructuring, evaluation activities and sensitivity analyses can be carried out by the decision maker in any order until the final result has been achieved. Once a preference structure has been developed, it can be stored for future use by the user, or by others in assessing alternatives (new or old, in any mixture) within it.

2.4.2. 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 which, like MAUD, is intended to provide direct interactive assistance to a decision maker facing a multi-attribute decision problem. Unlike MAUD though, it is not based on multi-attribute 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 which checks the consistency of the option generation process and a programme which 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, like in ZAPROS, the knowledge base represents a policy which 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 committment 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 which 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 intially unstructured problems.

2.4.3 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 asessments which can be compared but not individually scaled.

- The tool insists that the decision maker performs artificial trade-offs 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 2.4.1 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 mult-criteria frame, with the attendant problems of insistence on numerical estimates and tradeoffs between criteria.

The tools we selected for discussion in section 2.4.2. 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 betwen 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 2.4.1 and 2.4.2. In our opinion, in order to provide comprehensive class R4 suport, this should combine rule based techiques 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.

3. Evaluation of the current capabilities of the problem structuring library and recommendations for future development.

In summary of our evaluation of the tools described in the four support classes in section 2, 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, our next activity in this area will be to take a top-down view of what is required in building a decision problem structuring library, deriving first of all the set of support functions, and then to describe how they may be clustered into "super-tools" which comprise both functions successfully implemented in existing tools (there should be no need to re-invent the wheel) and the required but currently missing functions.

Such supertools, however, should not be defined in a closed way. The aim should be to allow any individual library builder to integrate the tools and tool functions he wishes to use (regardless of the source from which they were acquired) into his own comprehensive library, offering *integrated* support facilities, tailored according to the applications needs of the library users.

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PART II

Analysis of Decision Conferences: Differences in problem handling by management stratum.

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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 of 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.

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.

Time / Type

Key Issue/Strategic

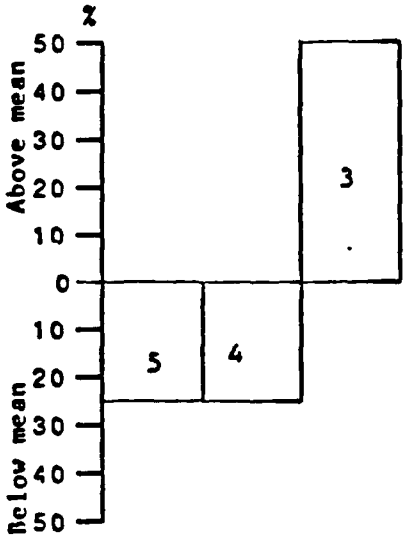


Fig. 1 Management Stratum (5,4 & 3)

Time / Type

Key Issue/Tactical

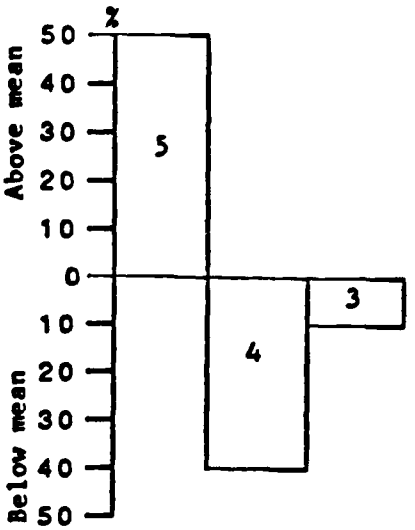


Fig. 2 Management Stratum (5,4 & 3)

Time / Type

Action List/Strategic

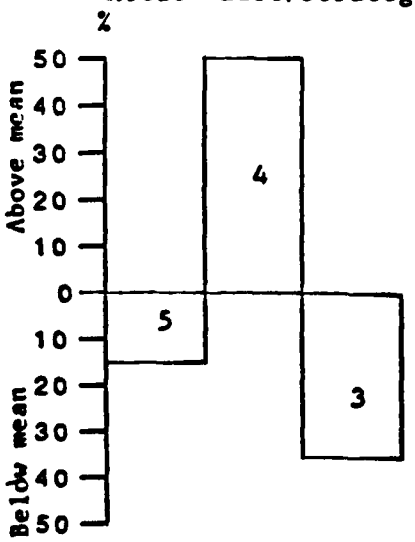


Fig. 3 Management Stratum (5,4 & 3)

Time / Type

Action List/Tactical

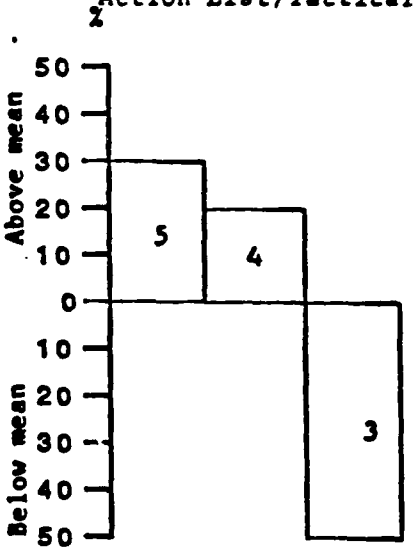


Fig. 4 Management Stratum (5,4 & 3)

Figs. 1 - 4 Relative Importance of Issues by Management Strata (Standardised Frequencies)

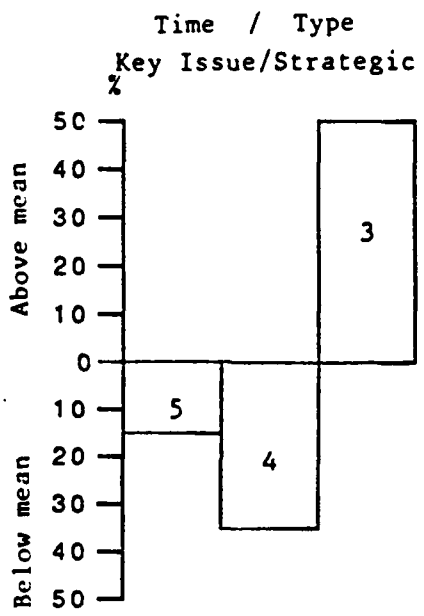


Fig. 5

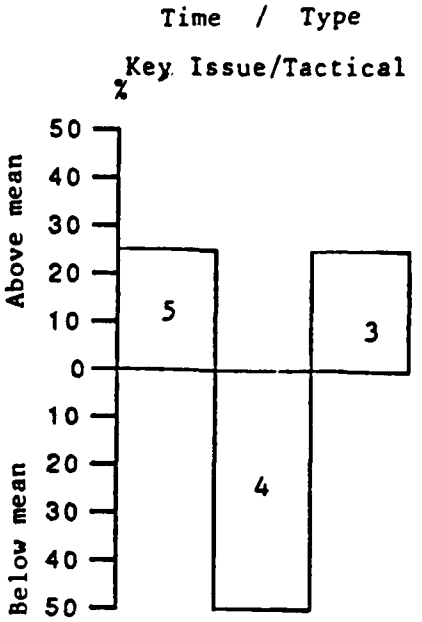


Fig. 6

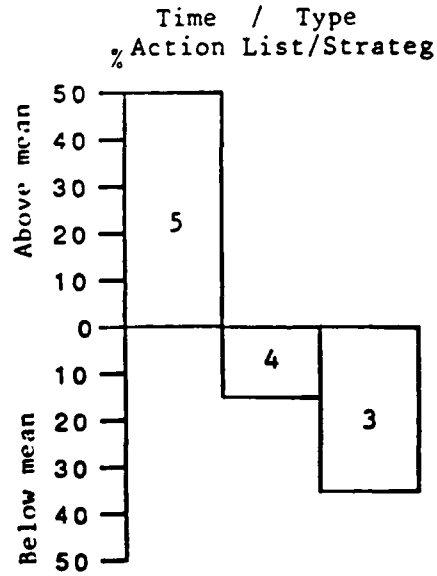


Fig. 7

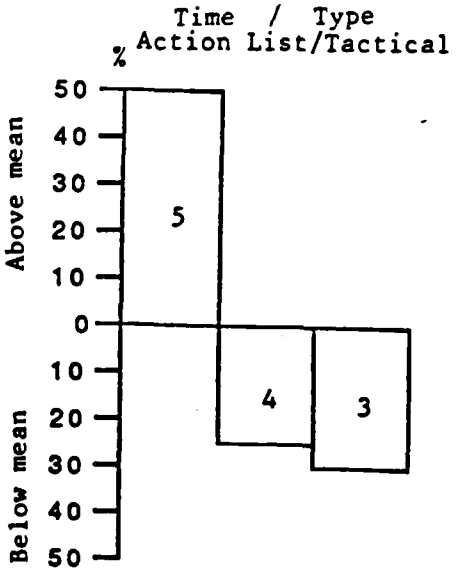


Fig. 8

Figs. 5 - 8 Relative Importance of Organisational Issues by Management Strata

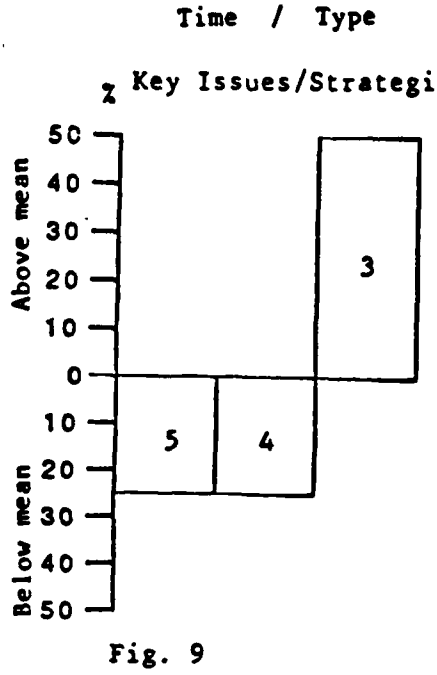


Fig. 9

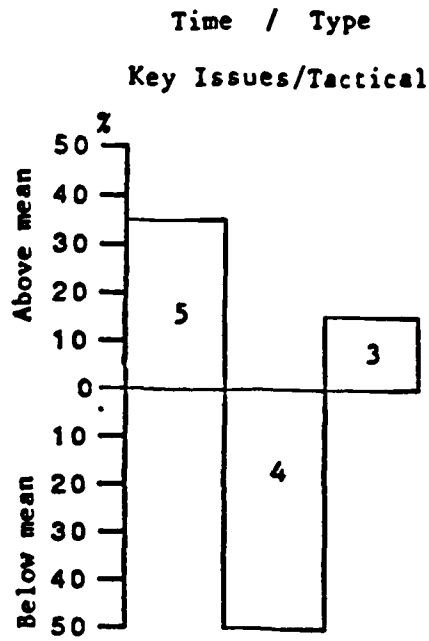


Fig. 10

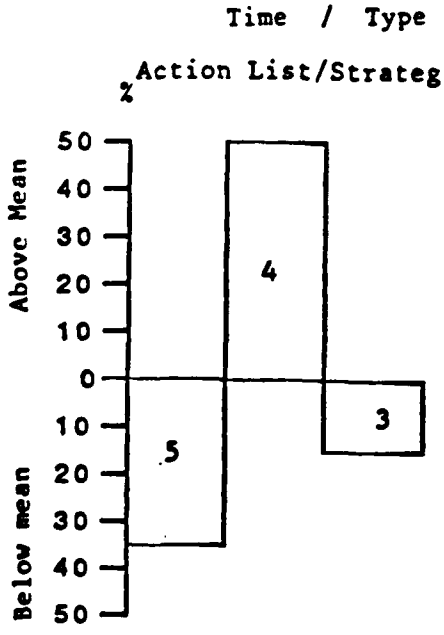


Fig. 11

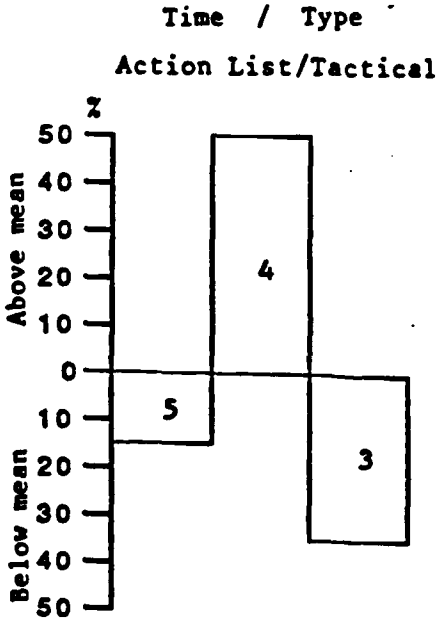


Fig. 12

Figs. 9 - 12 Relative Importance of Economic Issues by Management Strata

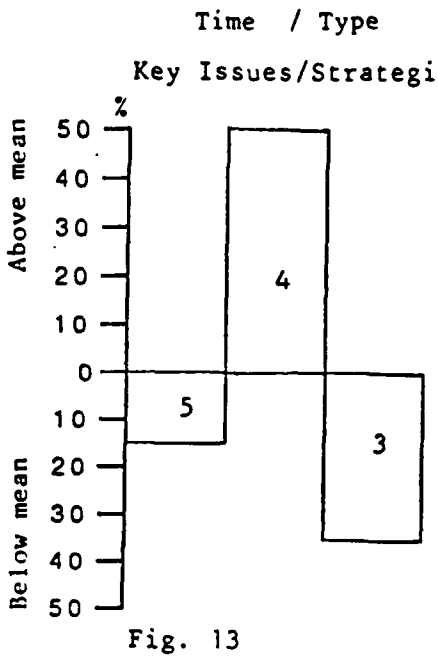


Fig. 13

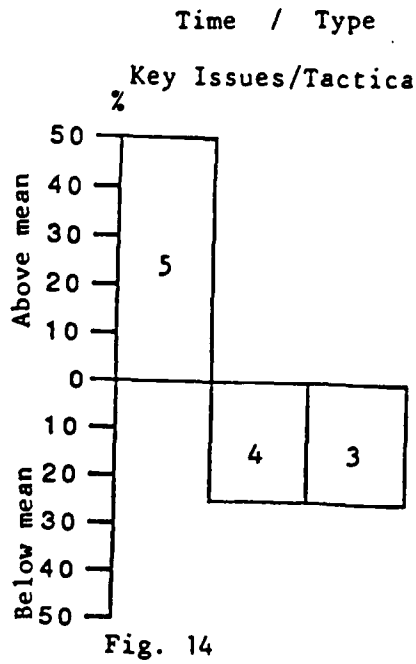


Fig. 14

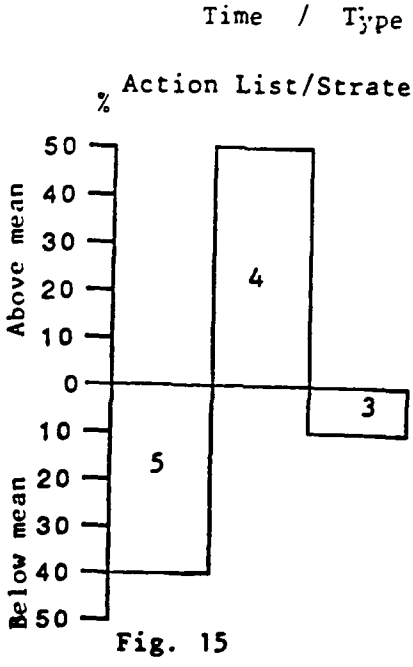


Fig. 15

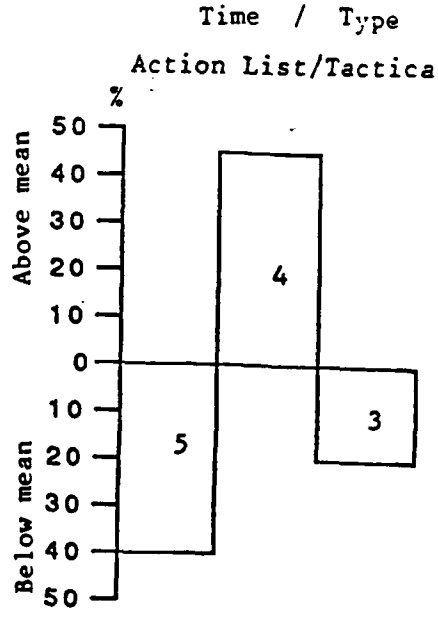


Fig. 16

Figs. 13 - 16 Relative importance of Product Related Issues by Management Strata

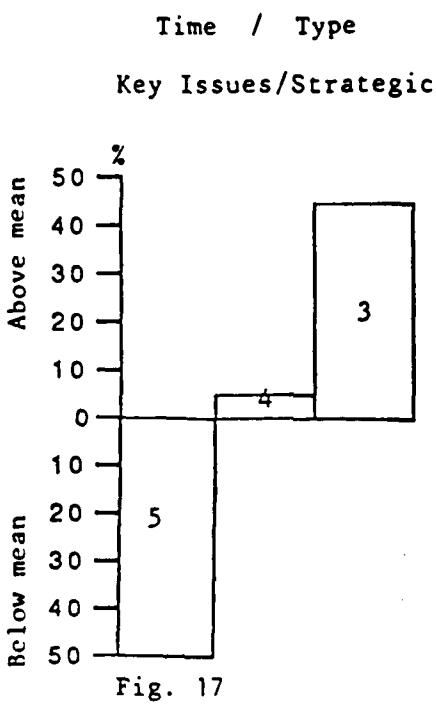


Fig. 17

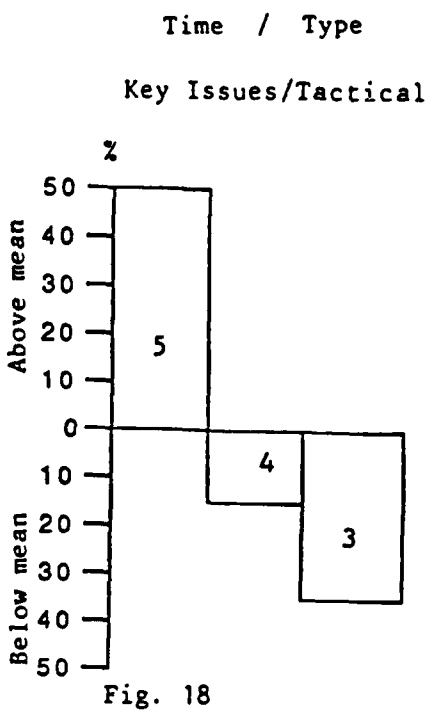


Fig. 18

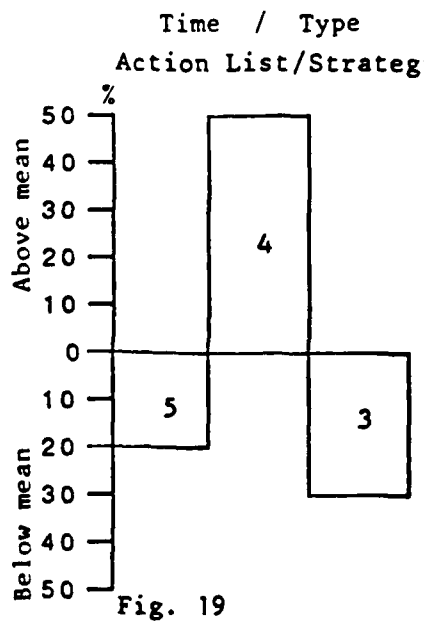


Fig. 19

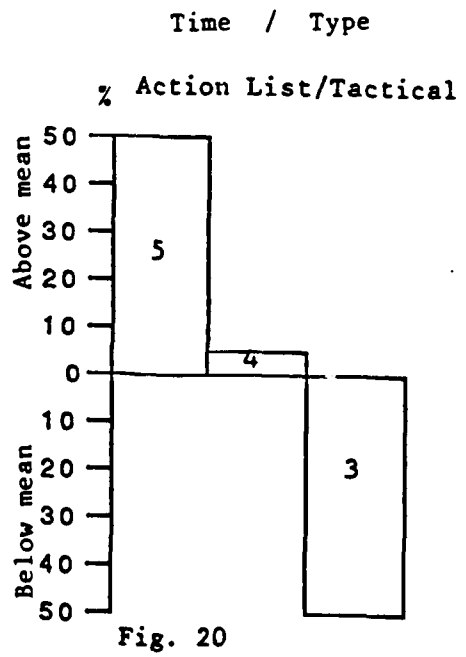


Fig. 20

Figs. 17 - 20 Relative Importance of Market Issues by management Strata

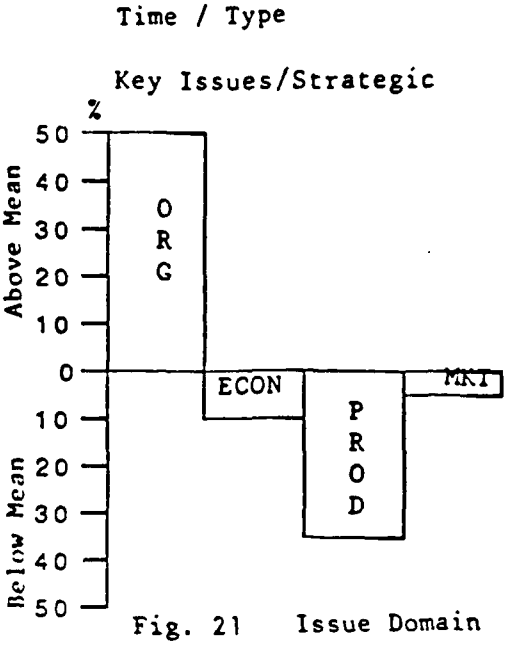


Fig. 21 Issue Domain

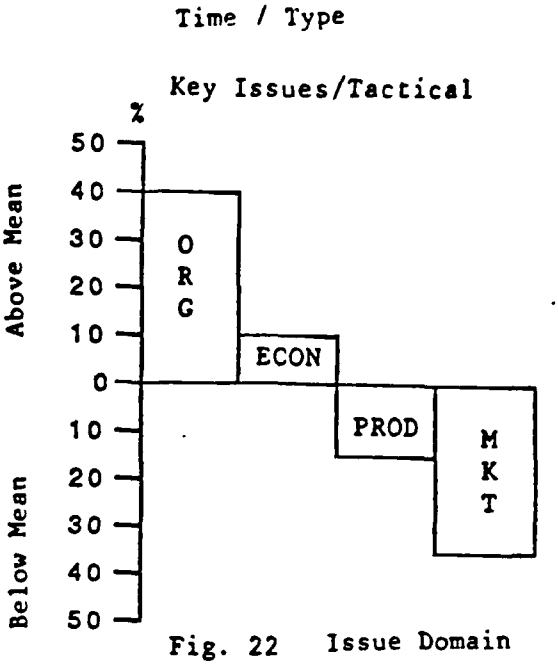


Fig. 22 Issue Domain

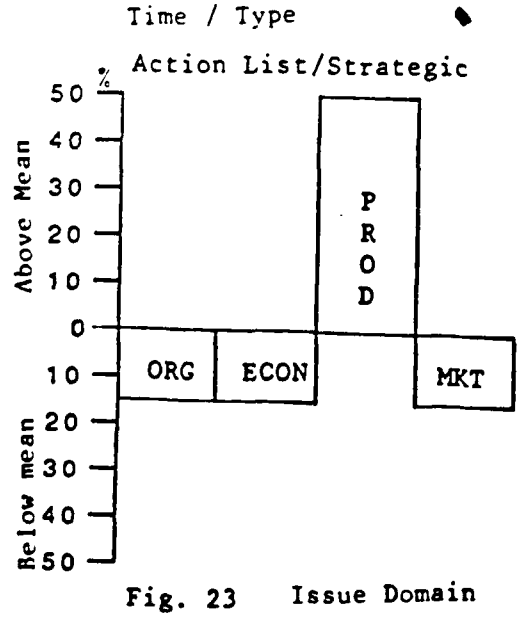


Fig. 23 Issue Domain

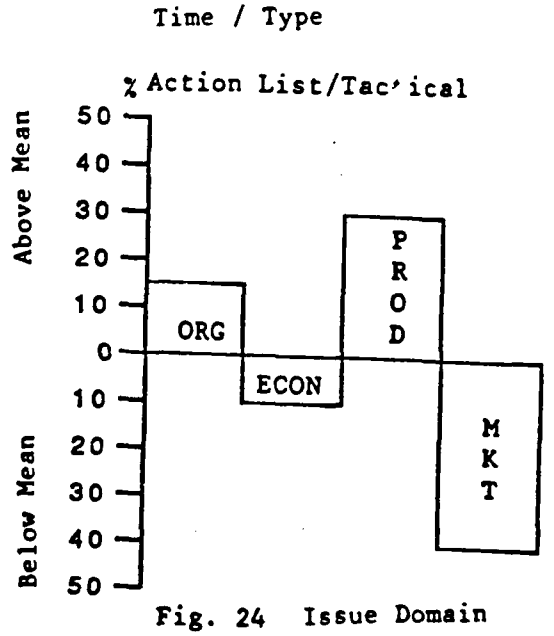


Fig. 24 Issue Domain

Figs. 21 - 24 Relative Importance of issues for Level 3 Managers

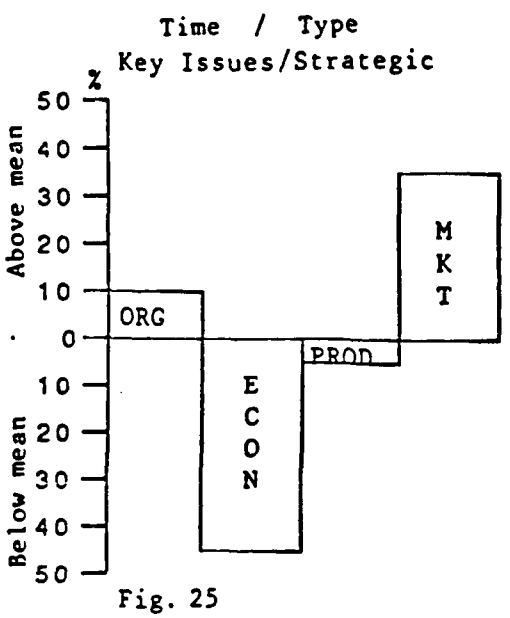


Fig. 25

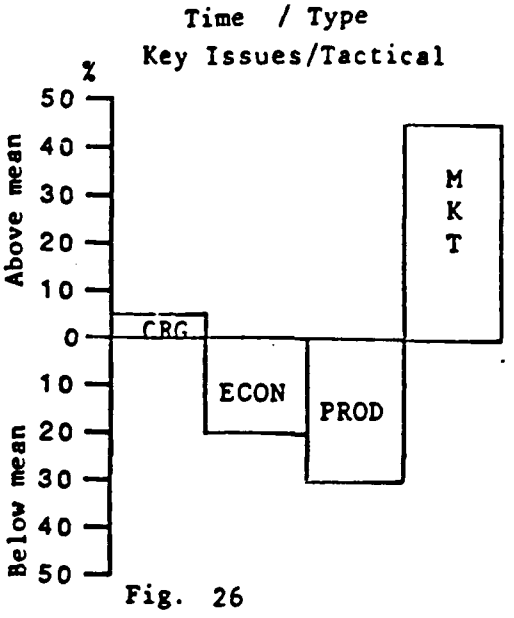


Fig. 26

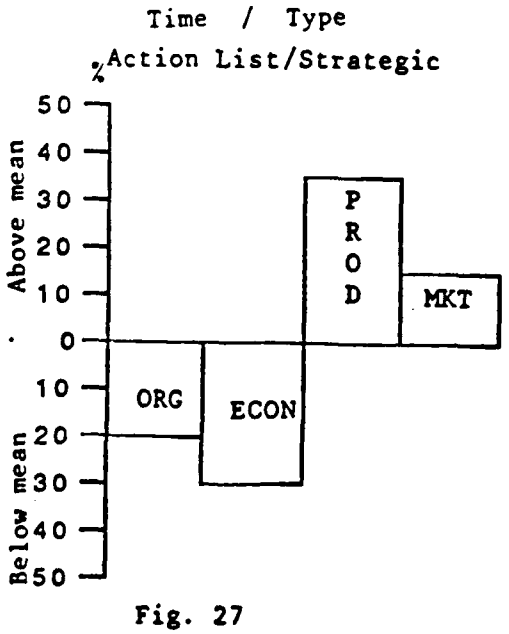


Fig. 27

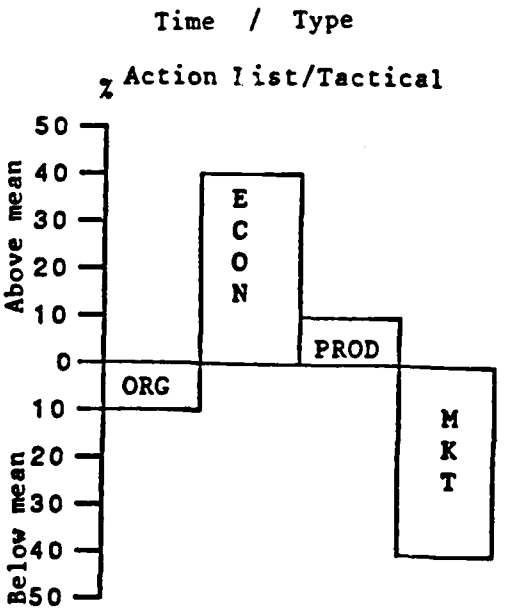


Fig. 28

Figs. 25 - 28 · **Relative Importance of Issues to Level 4 Managers**

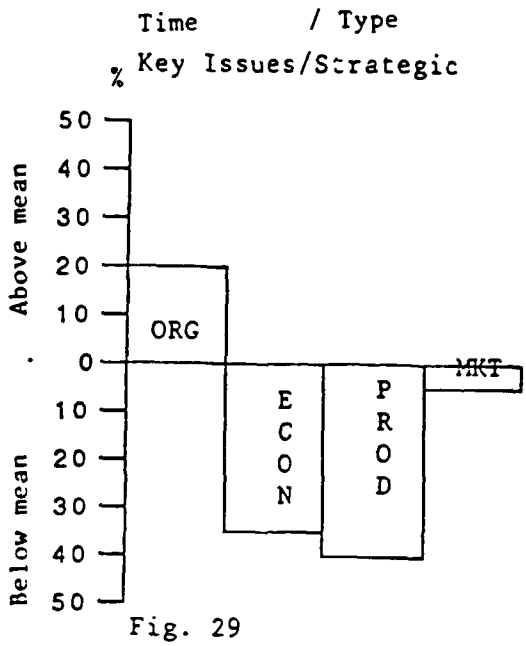


Fig. 29

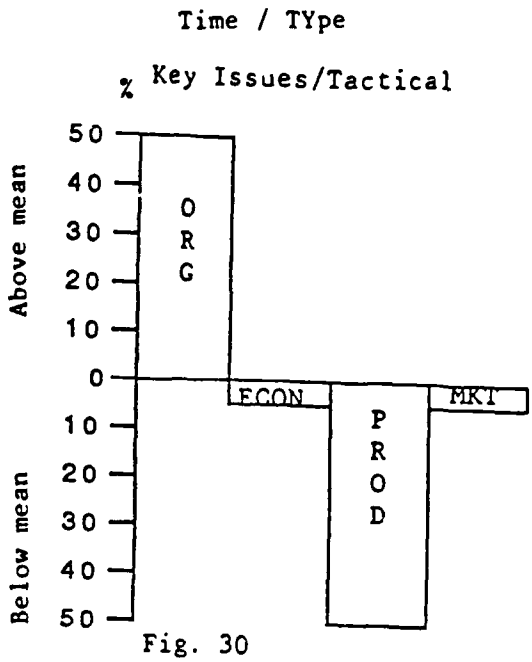


Fig. 30

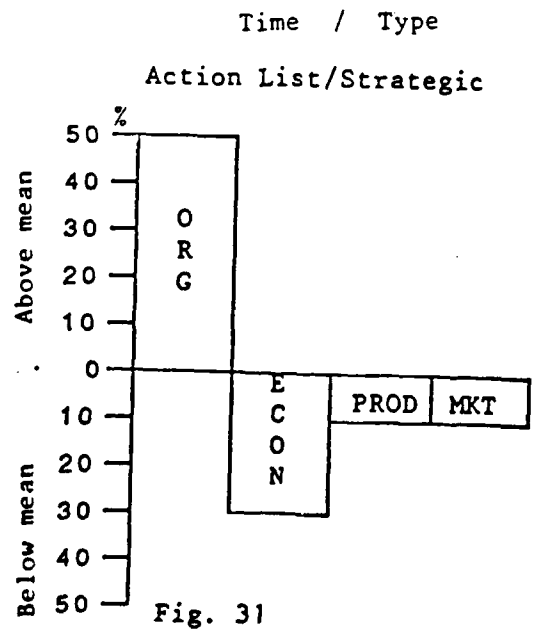


Fig. 31

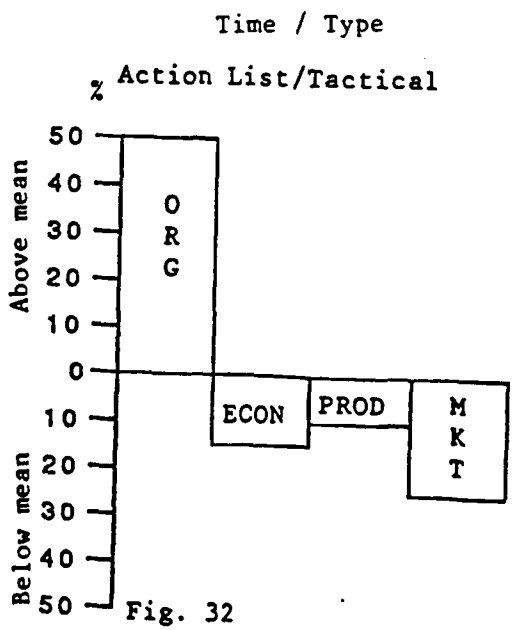


Fig. 32

Figs. 29 - 32 Relative Importance of Issues to Level 5 Managers

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.

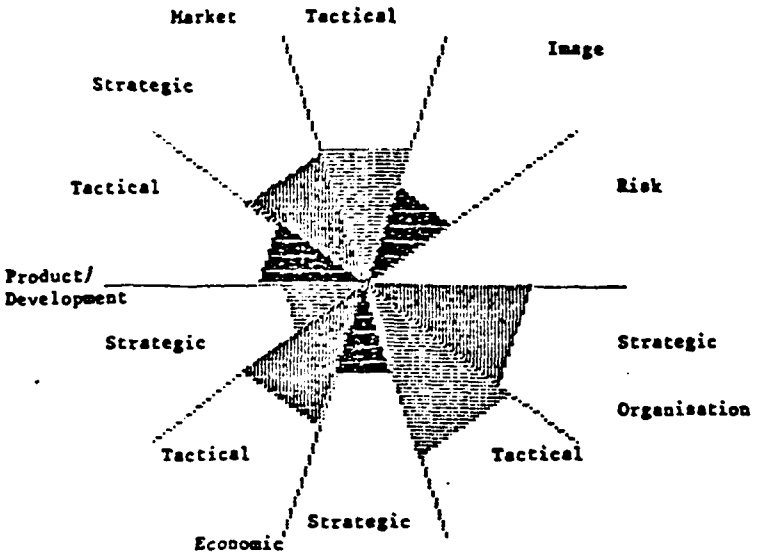
The frequencies were grouped according to the management level of conference participants (5, 4 or 3 according to Jaques' 1976 classification of levels). The chi-square statistic was used to test for differences in frequencies across management strata. Separate analyses were carried out for strategic (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

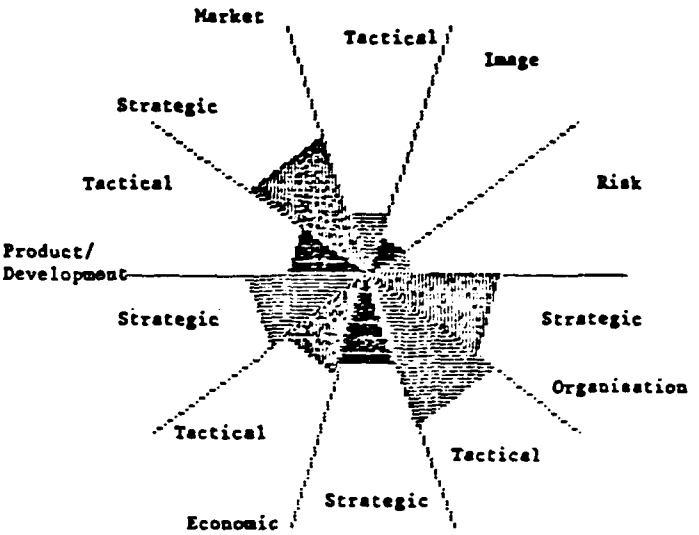
Managers at stratum 5 were most concerned (in relation to the other groups): with organisational issues that were mainly tactical in nature, both at the *key issues* and *action list* stage. For this group of managers, strategic issues raised were genrally in the *organisation* domain, particularly so at the *action list* stage.

The tactical issues that were raised concerned:

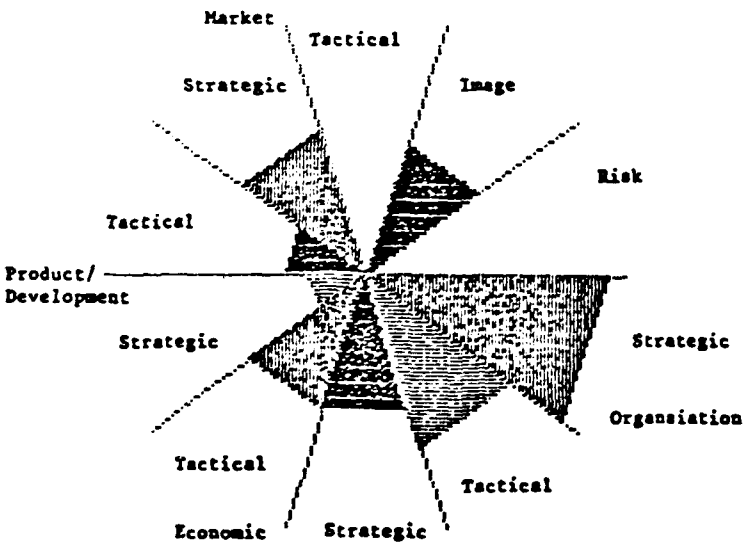
economic, product and market issues at the *key issues* stage
organisation and market issues at the *action list* stage.
(See Figs. 29-32, for details).



Stratum 5

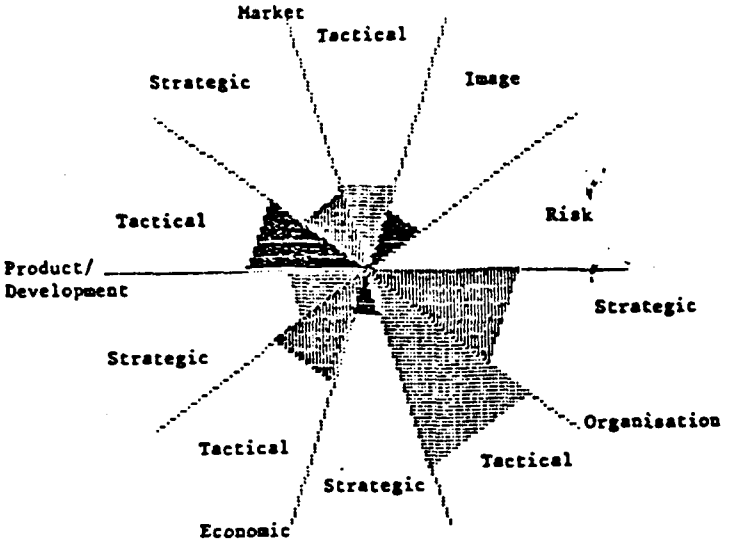


Stratum 4

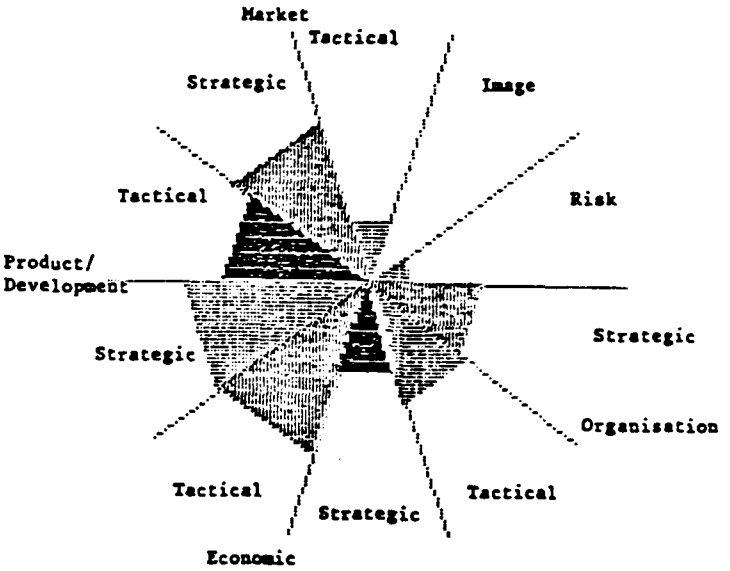


Stratum 3

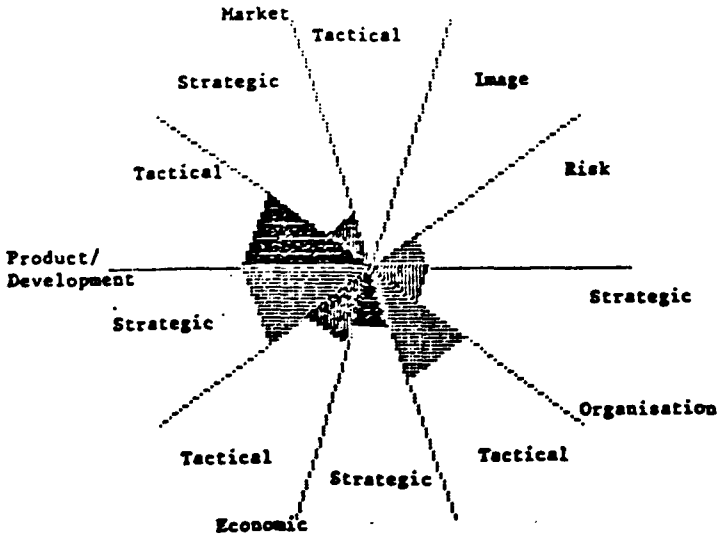
Figure:33 Proportion of issues raised in different domains per management strata



Stratum 5



Stratum 4



Stratum 3

Figure 34: Proportion of issues raised in different domains per management strata

Table 1: Mean frequencies of issues raised at "key issue" stage by managers at each stratum

Management Stratum	Domain: Organisation S	Organisation T	Economic S	Economic T	Product S	Product T	Market S	Market T	Image	Risk	Total S	Total 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

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.

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).

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.

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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PART III

Differences between judgements of stakeholders in social Decision Making

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Decision Analysis Unit Technical report 88-3

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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

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 straucturing 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

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

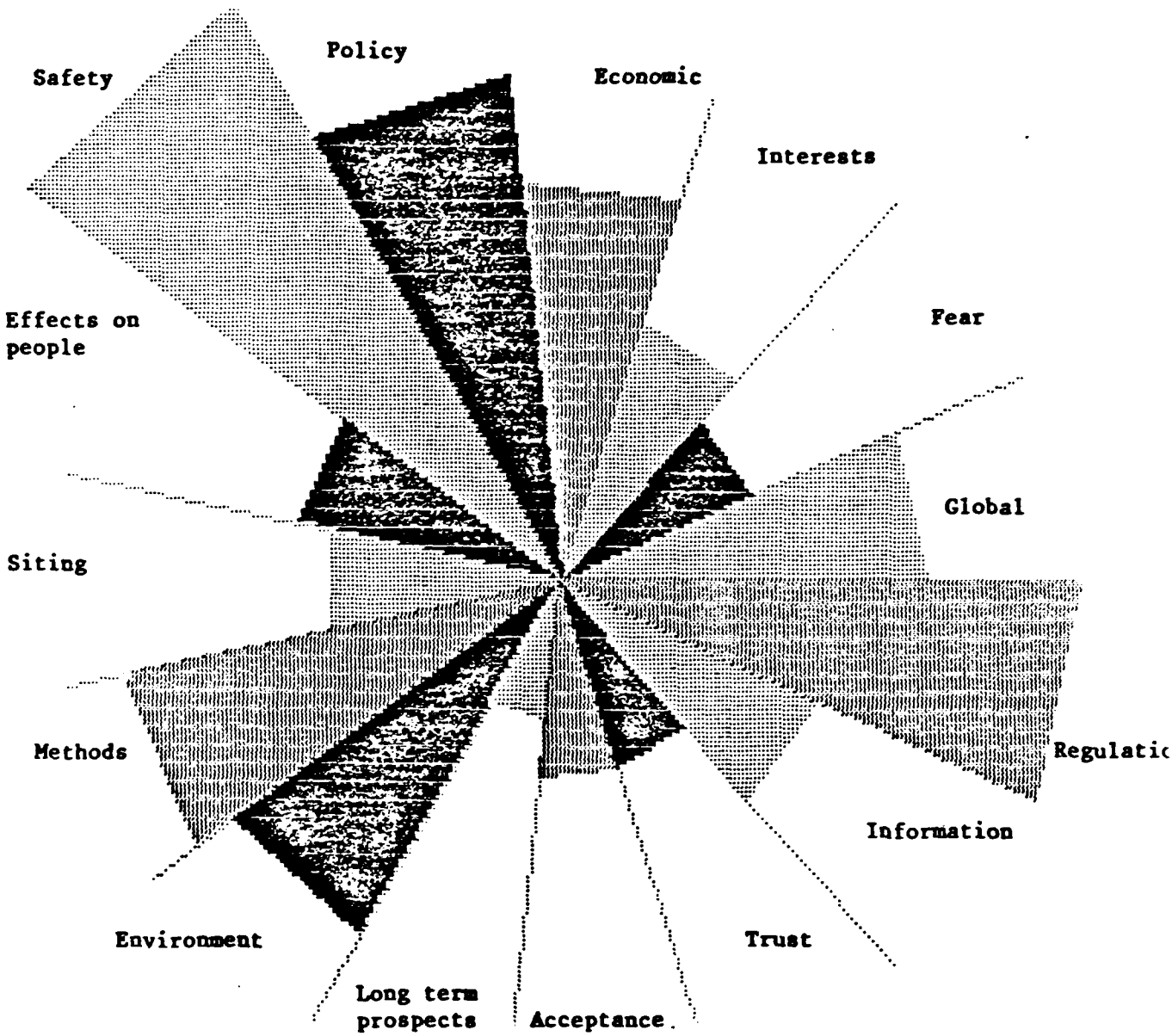
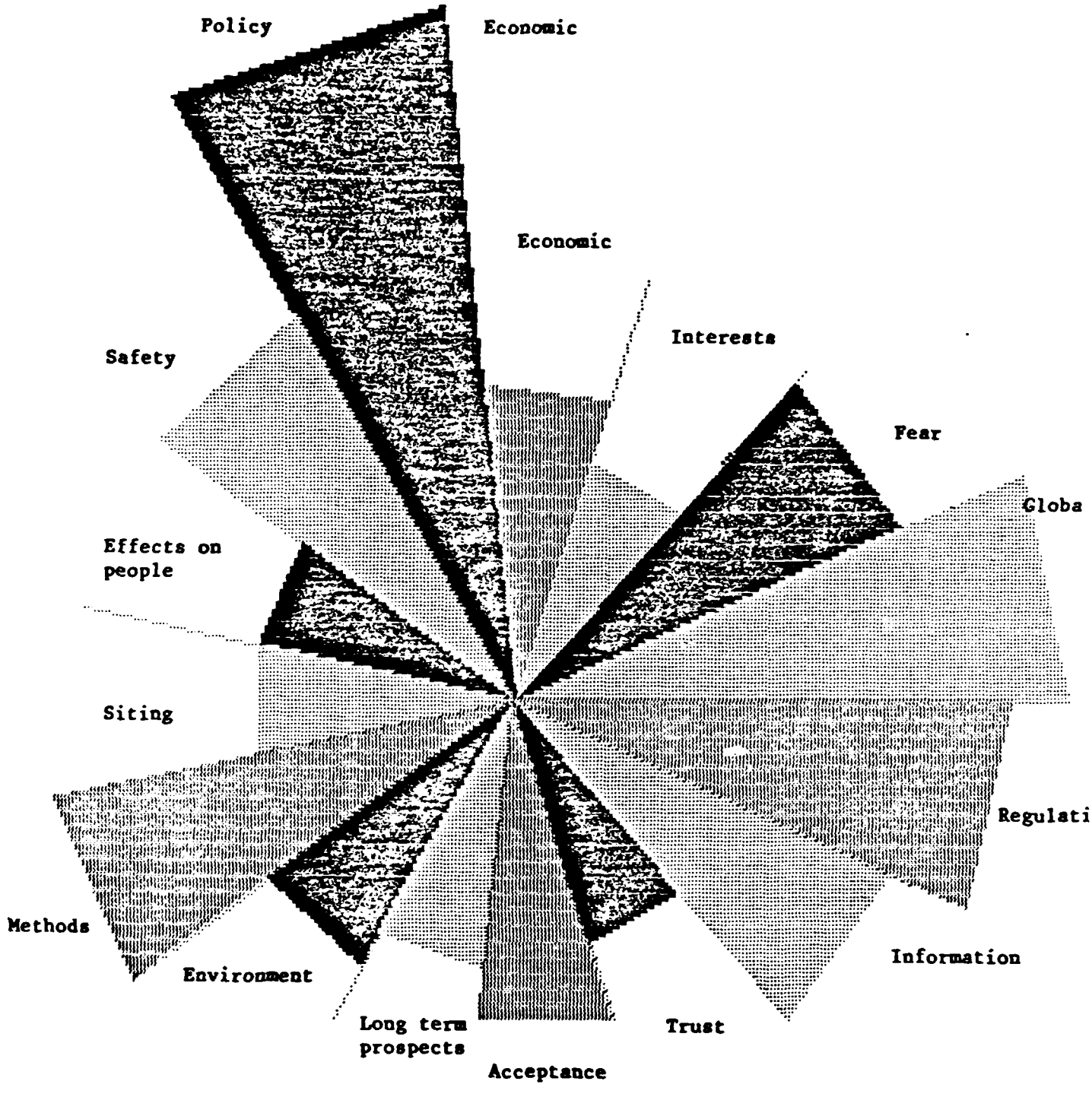


Figure 1: Number of propositions offered by Industry per domain



GOVERNMENT

Figure 2: Number of propositions offered by Government per domain

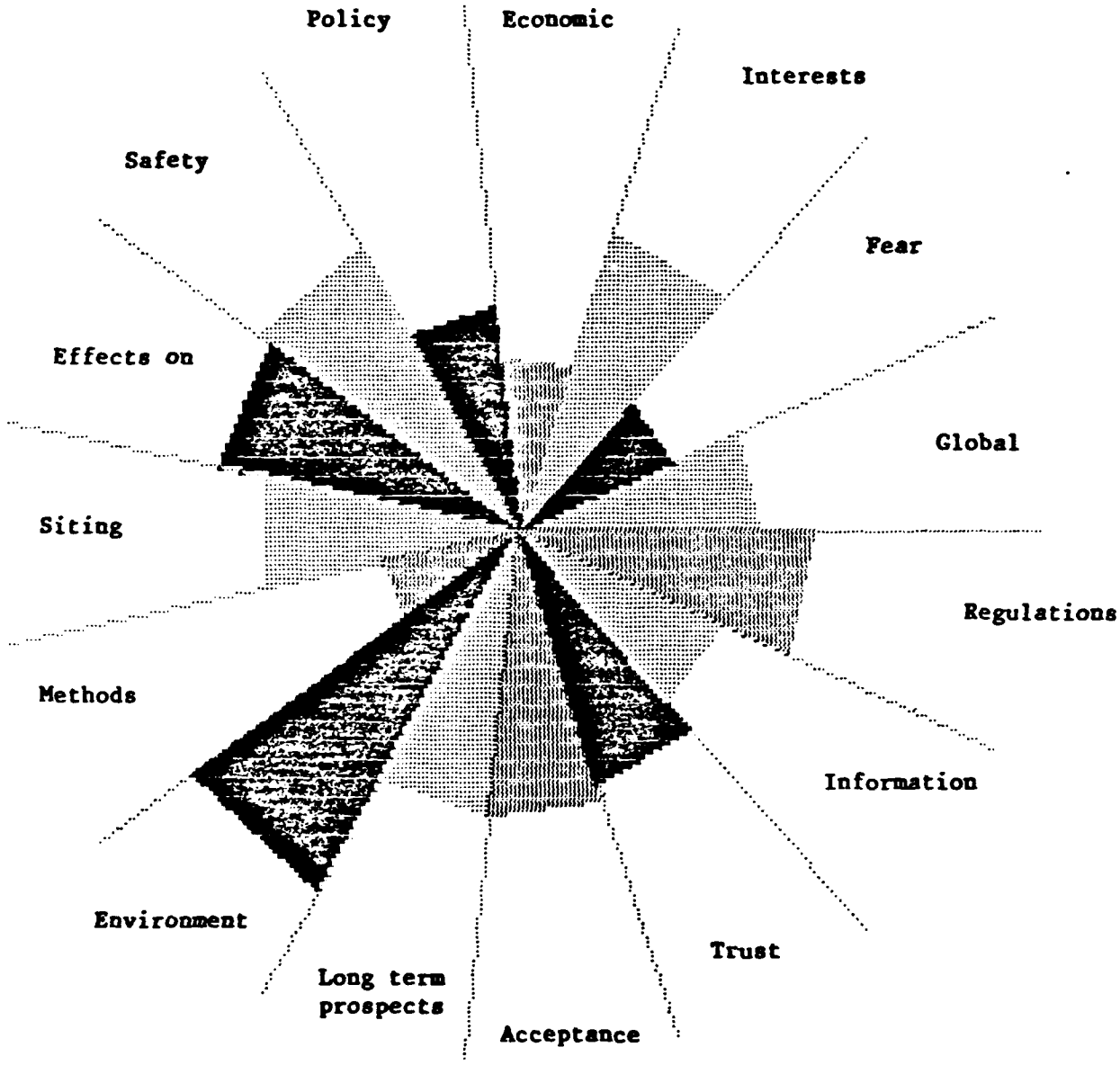


Figure 3: Number of propositions offered by Lay People per domain

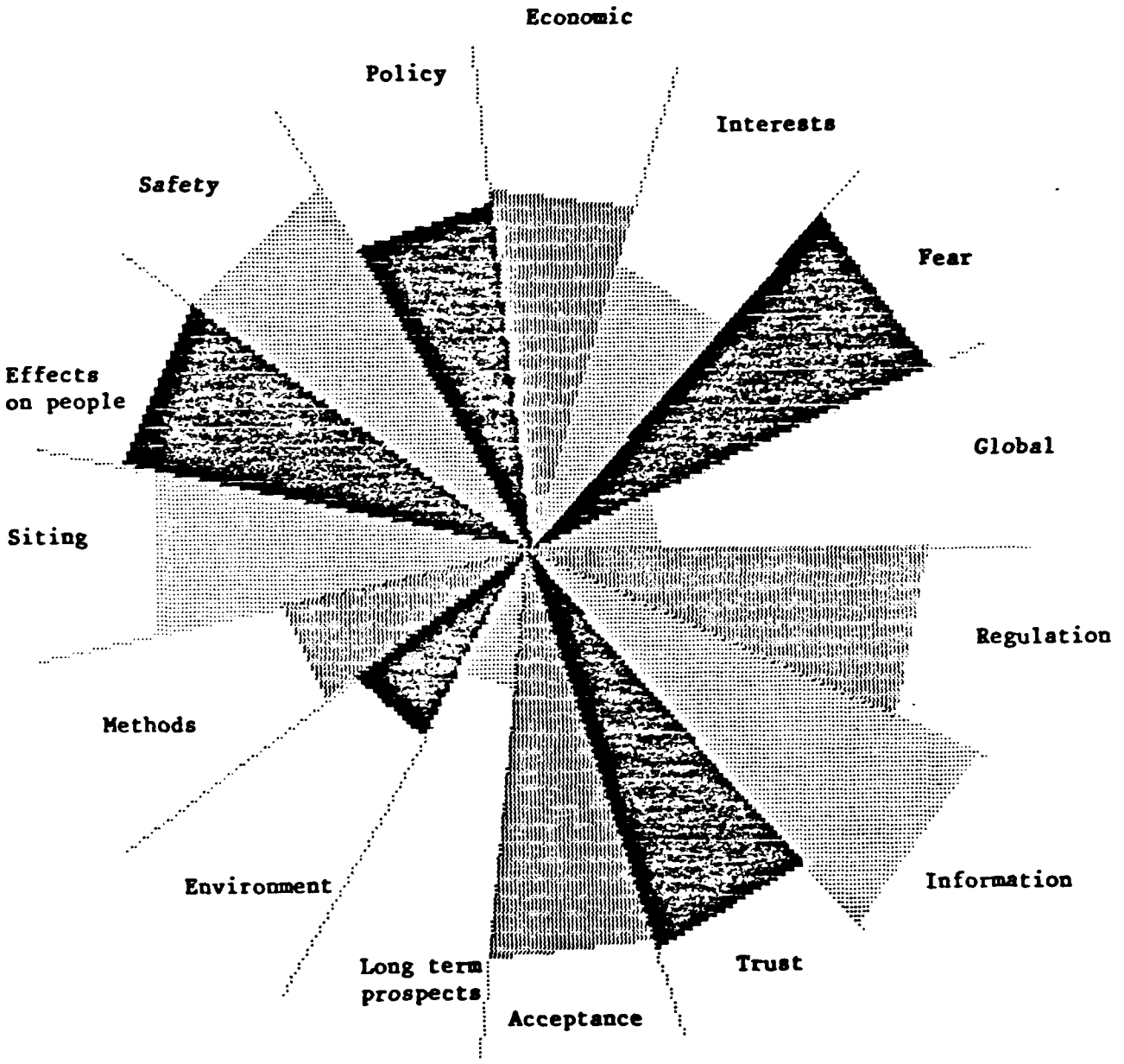


Figure 4: Number of propositions offered by Pressure Group per domain

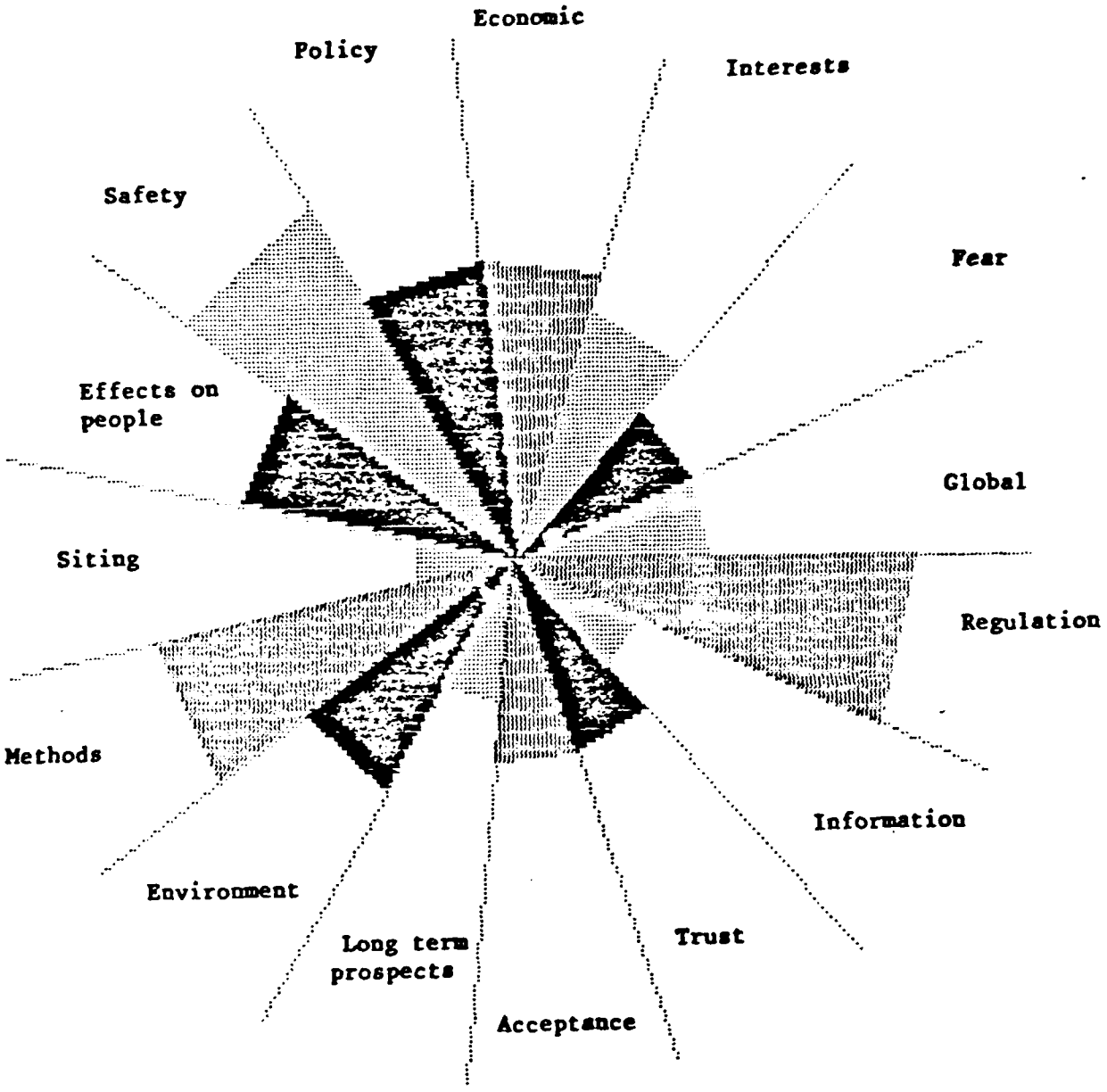


Figure 5: Number of claims made by Industry per domain

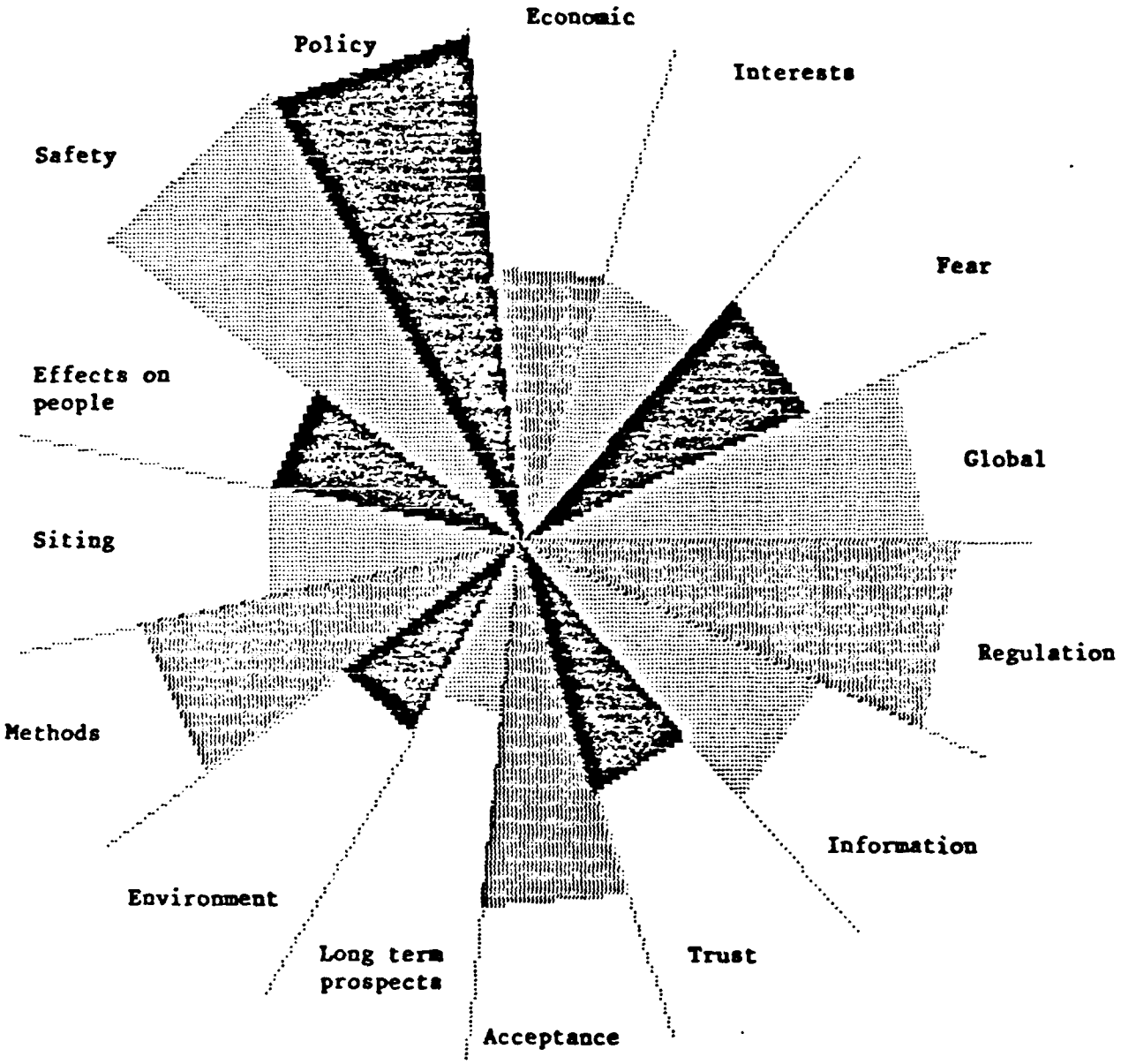


Figure 6: Number of claims made by Government per domain

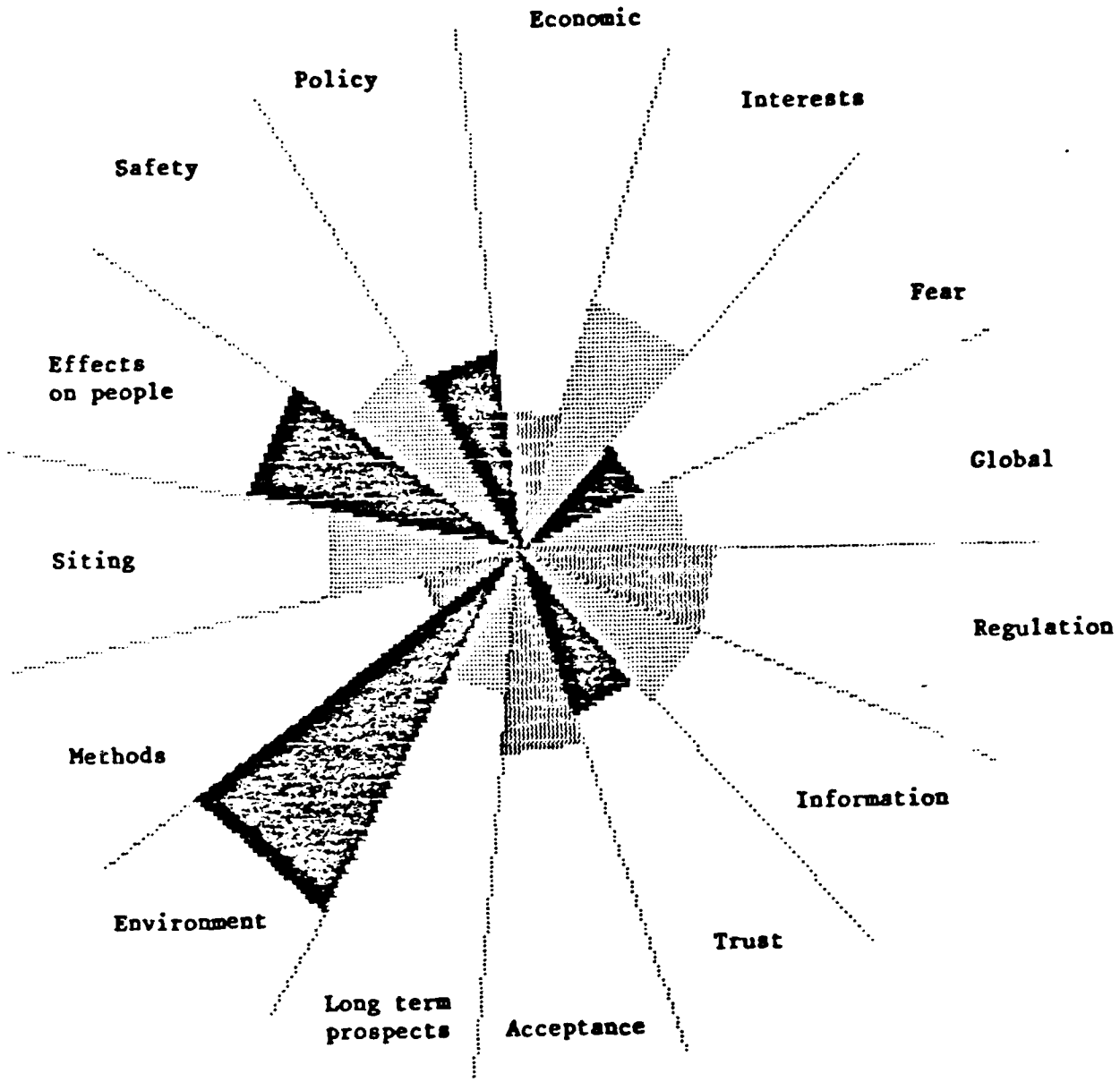


Figure 7: Number of claims made by Lay People per domain

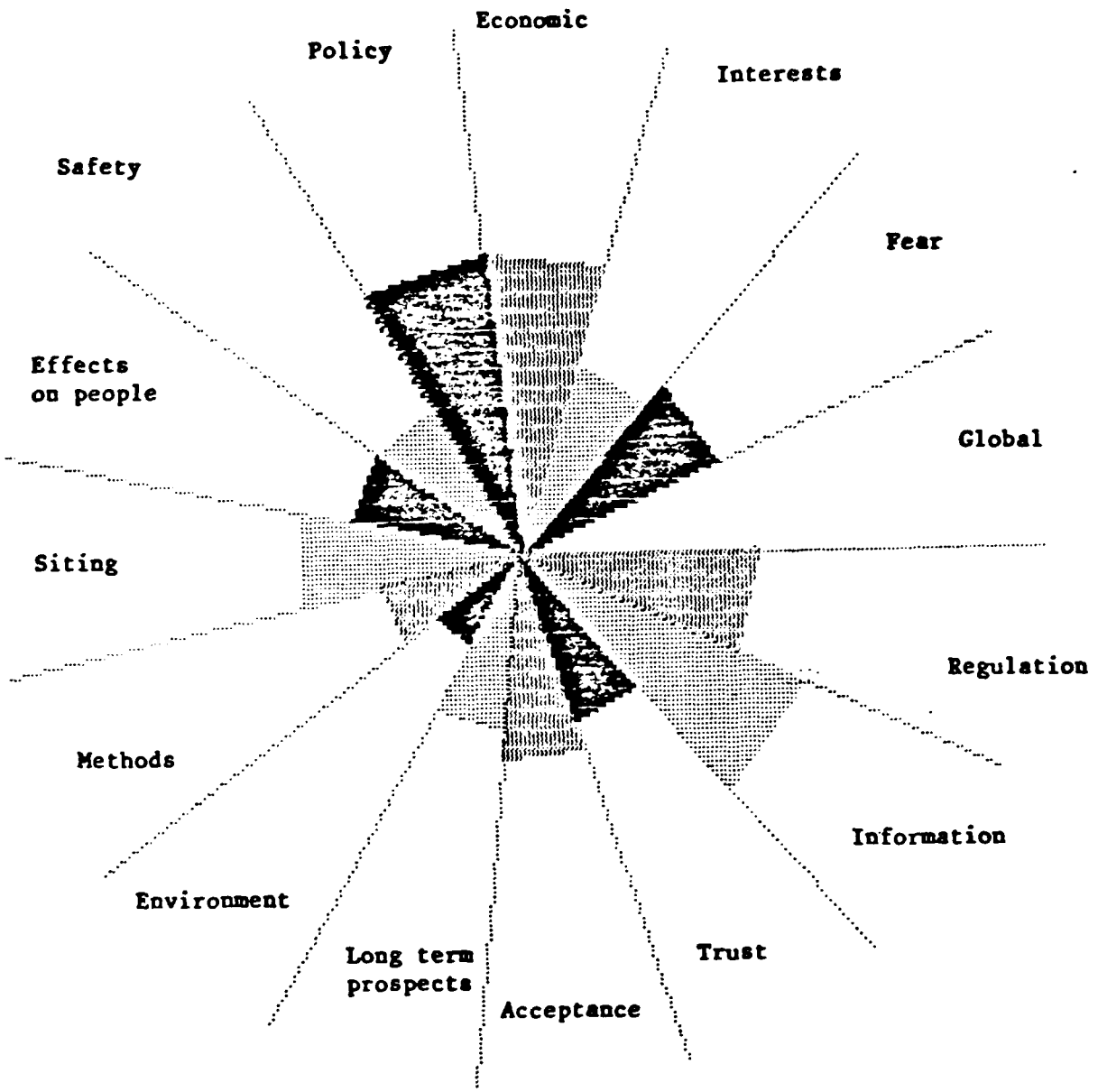


Figure 8: Number of claims made by Pressure Group per domain

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.

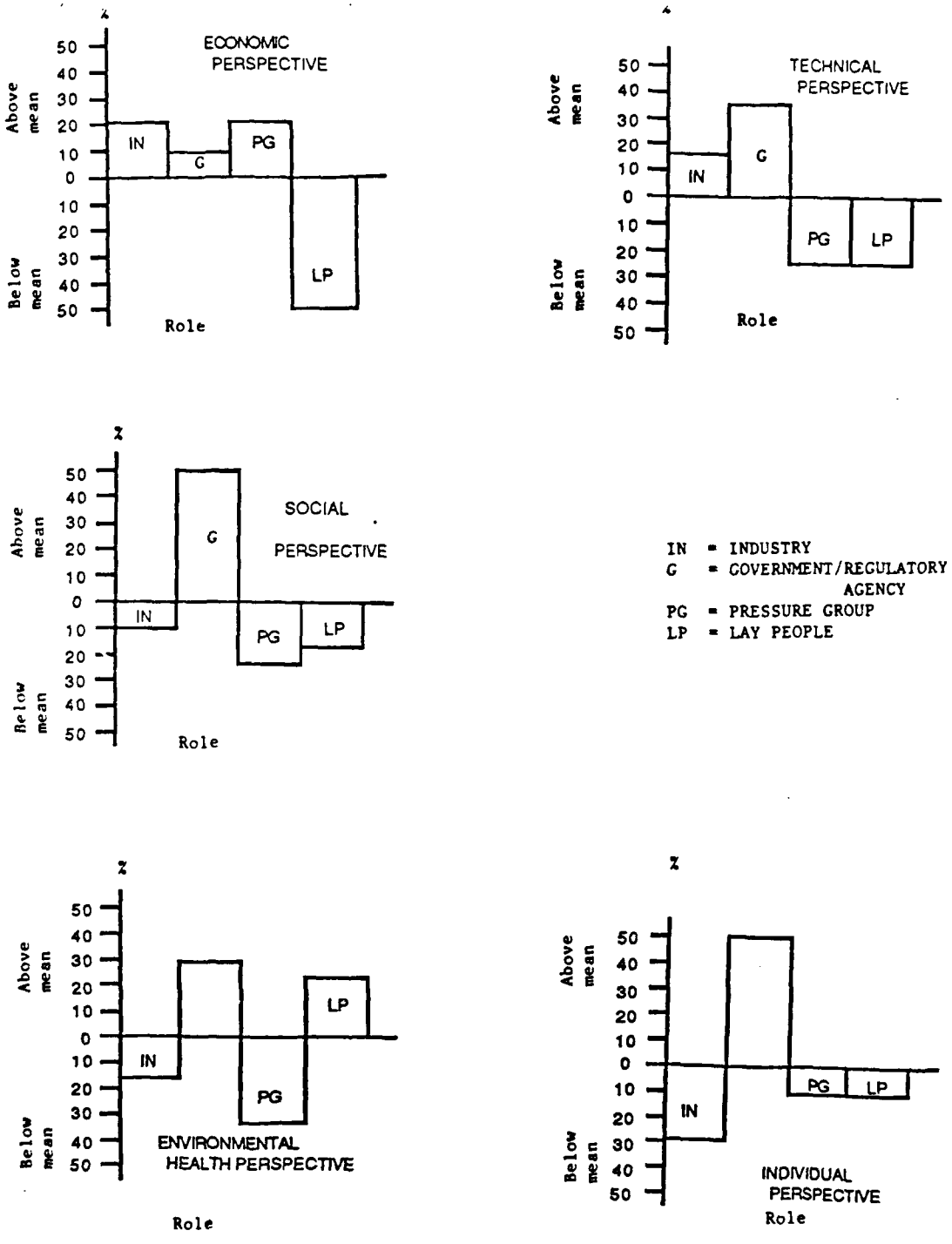


Figure 9 Relative Importance of Perspectives of Stakeholder Groups (Relative Prominence %)

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.

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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