



THE USE OF INTERACTIVE MODELS TO FORMULATE
MANAGERS' PROBLEMS AND TO IDENTIFY DECISION AIDS

A thesis submitted for the degree of Ph.D.

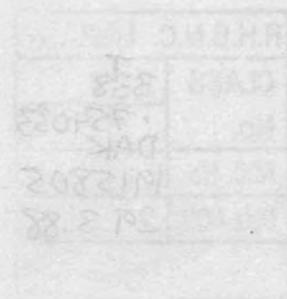
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ABSTRACT

This thesis describes a research inquiry into models which could be used in an interactive manner for formulating problems and exploring managers' needs for decision aids. It reviews a wide range of literature in Operational Research Methodology, Models and Games, and then argues the case that what managers want are models which could allow them to reflect on the way they manage process and not those which simulate that process.

A two phase practical study was carried out in association with two departments of a large organisation in which a group of managers were interested in the basic aims of the study and willing to cooperate. The aim was to research their managerial environment, seeking ways to improve management control of the processes which they do not directly involve themselves in, except by managing those who do.

In phase one, Bowen's Problem Formulation Methodology was used to structure and feed back the data obtained from managers. The Methodology proved to be a very effective tool to help both the Operational Researcher and the Problem Owners to communicate and identify potential problem areas and failures in communications and purposeful actions.

In phase two, a computer - based system was developed for the General Manager of one department to help him in the recording of and access to essential features of his current problems and communications about them. The system could be extended as a planning schedule and process control held in common by a management group, a decision support system for the department as a whole.

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To my wife Hana, and my children Nora and Sarah, go my deepest admiration.

Finally, I would like to acknowledge the financial support of the Iraqi Government during the course of this study.

“ Learning has to be an adventure, otherwise it’s stillborn. What you learn at a given moment ought to depend on things that come together by chance, and it ought to continue in that way from one conjunction to another, a learning by reshaping, a learning through pleasurable activity. ”

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CHAPTER 1

INTRODUCTION AND SUMMARY

The initial intention for the area of research described in this thesis was to examine a specific class of games, namely, 'learning games' as defined by Bowen (1978a). It was planned to set criteria for a 'good' or 'bad' game, and to find out their proper role in the process of research and training at top managerial level.

This demanded a coverage of a wide range of literature about games, learning processes for top managers and the problems and complexities of their tasks, and how one might provide them with an Operational Research (OR) type aid. The basic aim of the literature reviews was to develop ideas based on published research as guidelines for any possible further developments.

Chapter 2 is concerned with the process and practice of Operational Research. It argues the case that because OR analysts need to work closely to decision makers, they have to understand decision making activities in the systems under study. Moreover, analysts are expected to face 'ill - structured' rather than 'well - defined' problems. In the latter, a vast range of techniques is available to help the analyst in his problem solving activity. In the former, there is no way to obtain an 'optimal solution', and the OR analyst's role become that of 'helper' rather than as a 'technician'. In other words he will be engaged in a 'facilitative process' to enhance his clients' understanding of the 'messy'

problems they face.

The chapter reports three problem formulation methodologies developed by leading Operational Researchers and aimed at helping OR analysts to structure the unstructured real world problems. The first is developed by Eden and his colleagues, [see Eden, Jones, and Sims (1979)], and is supported by a computer package which helps in representing the problem owner's perception of his difficulties. The second is the Checkland methodology which is also a 'soft systems methodology' for 'inquiry' rather than 'optimization', [see Checkland (1981)]. It makes use of a 'root definition' concept of systems of concern. The third methodology which is described in the chapter is Bowen's problem formulation methodology, [see Bowen (1984)]. It is a qualitative modelling approach which I found effective in building conceptual models by making use of a notation specifically devised for this purpose.

Because it is very important to represent the real system under study in some type of model which can be manipulated, chapter 3 deals with the implementation of OR models. It examines different classes of models and points out that, although a large number of models is available for assisting managers in their decision making process, very few are implemented, hence an 'implementation problem'. The reasons for this problem are investigated in a number of studies which concluded that managers' participation in any model building process, will increase the likelihood for successful implementation. It is believed that what managers need are models which enable them to reflect on the way they manage process and not those which simulate that process.

These models may in fact be ones which lead to problem formulation rather than problem solving. They must enhance a manager's understanding of his problems by learning through the models.

It was initially thought that an Operational Research activity, namely gaming, discussed in chapter 4, would help in the top - level managers' appreciation of their tasks. The literature survey indicated that the type of games available are those which simulate a process such as 'inventory system'. They are useful for lower level management training, but not as vehicle for planning, communication, and control in an organisation, which are the prime concerns of top management. Hence, before proceeding to develop any type of game for real application, the chapter outlined the limitations of the available games. This conclusion, together with the experience gained and outlined in chapters 2 and 3, changed the emphasis of the original research programme. What is needed may or may not be a game in the traditional sense. It would be an inquiry into managers' problems, to learn what they are, their main features, and how to cope with difficulties. To carry out the research, a need arose for a real environment in which managers would be willing to 'gain' from the broad planned approach / experiment outlined in chapter 4. A positive response came from a local organisation which resulted in a successful experiment.

Before, during, and after the interaction, it became necessary to examine an area which has received much attention in recent years, that of decision support systems (DSS). Chapter 5 is concerned with DSS regarded as interactive computer - based systems aimed at supporting rather than replacing the man-

agement decision making process. It is generally held that DSS are needed to deal with ill - structured problems in order to improve the efficiency and effectiveness of organisations. They differ from other information processing systems such as Electronic Data Processing (EDP) systems and Management Information Systems (MIS). The chapter develops the argument that at the early stages of research and applications in DSS, there were difficulties in both hardware and software. Recently, however, major advances in computers, colour graphics and telecommunication networks makes it possible to develop manager operated DSS. It was also recognised that DSS suffer from almost the same 'implementation problem' already discussed in chapter 3. An 'Evolutionary Strategy' is seen as the best one to increase the likelihood of successful implementation.

Chapters 6 and 7 test and extend the ideas outlined in the preceding chapters in a real - life environment. Chapter 6 describes the development of the interaction with the client group. The study first concentrated on technological and organisational features of the systems involved, which proved to be an essential stage in the analyst learning process. It also prevented narrowing the scope of the study to a specific direction at an early stage (often an attempt to fit a mathematical model). A 'variety' of key managers were involved, which contributed to providing a rich picture of the complexities of their tasks and the extent of their ill - structured problems.

To structure the data obtained, and to represent it in a form which could easily be communicated to the managers in order to enhance their learning process and to explore further problems in their organisation, Bowen's problem

formulation methodology [see chapter 2] was chosen as a suitable device. The application proved to be a very successful process. It enabled the analyst to compare the wide range of experiences and perceptions of different managers in the same organisation; not surprisingly, they had not perceived their organisation and its environment in the same way. The process of building conceptual models was not an easy one, as it was difficult to decide what to include in any diagram in order to interpret how each key manager saw situations of his concern.

Nevertheless, very important outcomes of the interaction are pointed out. First, the changing nature of the problem perceived by the client. What was initially thought to be a major weakness in their information systems, changed to become an awareness of the lack of proper communication and control. The diagrams helped the managers to learn new things about their organisation. Further, an unexpected outcome was that, at some stage during the interaction, the 'student' experimenting for his thesis became accepted as a 'consultant', despite the fact that he was not employed by the organisation. The consultant and his client, were able then to decide which of the many problems identified, might be considered for further exploration.

This exploration was in the form of an experimental decision aid which came as a consequence of the joint learning process discussed in chapter 6 and as a second learning stage for management. This decision aid is outlined in chapter 7. The ideal was to provide a computerised communication facility which would help to integrate the scattered pieces of information throughout

the clients' department. However, a number of difficulties were obvious, such as the immensity of the job given the analyst's limited time, and the fact that not all managers were prepared to share their 'private' concerns with others at their level or above. Due to all this, it was agreed that a personal system should be developed for the General Manager's use only. The specific objective in mind was to give him a feel about how a likely DSS [not a traditional game] might help him and others in his organisation in their prime tasks of communication and control. The system will have an advantage of providing a learning environment.

The interaction process with the General Manager indicated his substantial support for the proposed system. Additional support for the ideas reported in this chapter and others came from literature which was not initially available and which is therefore reviewed in chapter 7.

Finally, chapter 8 provides conclusions of this research and lays down fundamentals for further research. In summary, this research emphasises that managers live in a world of 'ill - defined' problems [see chapter 2] for which neither 'traditional games' [see chapter 4] nor standard OR techniques can provide 'solutions'. A proper problem - formulation is a most essential stage, and needs a structured methodology to aid communication between analyst and client. Managers will learn through the conceptual models which can be built if rich data can be obtained.

CHAPTER 2

THE PROCESS AND PRACTICE OF OPERATIONAL RESEARCH

2.1 Introduction and Conclusion

In this chapter a sample of the literature on Operational Research (OR) process and practice is reviewed. The sample is chosen in relation to the importance for the research programme, namely the ideas found to be relevant at a later stage. The concepts of problem, problem - solving, problem - formulation, and the role of techniques in OR are examined. Because of the particular importance of the problem - formulation stage in the OR process, as it manifested itself in the research programme, three of the available problem - formulation methodologies are introduced here with the view that there is no obvious 'best'. The choice of a particular methodology to aid the analyst in a particular study will remain a subjective choice.

2.2 OR as a Scientific Discipline

The official definition of Operational Research (OR) as approved by the U.K. OR Society up to 1983 was:

"Operational Research is the application of the methods of science to complex problems arising in the direction and management of large systems of men, machines, materials and money in industry, business, government, and defence. The distinctive approach is to develop a scientific model of the system, incor-

porating measurement of factors such as chance and risk, with which to predict and compare the outcomes of alternative decisions, strategies or controls. The purpose is to help management determine its policy and actions scientifically."

The above definition has been widely debated and various OR practitioners have interpreted OR in different senses. Bowen (1975a), for example, argues that: "Operational Research is the process of giving aid to decision makers through measurement". He adds; "As more complicated systems are studied, less precise measurements, such as classification by sets and linguistic definition, become of increasing importance". Tomlinson (1974) thinks that: "OR will never be a comfortable profession with well - defined boundaries; if it ever becomes so, it will indeed have failed". Müller - Merbach (1986) suggests that OR is "... how to best design and operate man - machine systems ...".

The scientific nature of OR which appeared three times in the now discarded definition, is also emphasised by Eilon (1975) who saw OR as a 'scientific activity' because "... the elements of formulating a hypothesis, of prediction and of experimentation are clearly discernible in the OR process ...". Rivett (1975) in a feedback to Eilon's argument distinguished the 'laboratory scientists' who are "... fortunate in that laboratories are machines for uncoupling an experiment from its environment ..."; and 'OR scientists' who are "... affecting and affected by the decision structure they are studying...". Others, for example Dando et al (1977), argued that OR is a "... technology equivalent in many ways to the various branches of engineering ...".

Despite the above views about the scientific nature of OR, Hickling (1982) questions the 'scientific method' itself, which he sees as 'very difficult to use' by

being described as a 'linear process' by the sequence observation, interpretation, and theory.

Generally, it is outside the scope of this thesis to engage in the debate about the definition or the scientific nature of OR, but the wide range of perceptions of its role is relevant.

2.3 The Process of OR

The central characteristic of early Operational Research is that of 'problem - solving'. The OR analyst, faced by a 'well - defined' problem, had the task of building a model of that problem. The model, very often a mathematical one, was then solved in order to find an 'optimal' alternative out of a set of courses of action which are available to the 'decision - maker' whom the OR analyst is serving.

The above process of problem - solving is interpreted in different ways by OR practitioners. Tocher (1961), for example, distinguished the following eight phases: exploration of the problem, model building, model testing, model solution, check solution, sell solution, implementation, and monitor situation.

Bowen (1977) adopted a systems approach to the process of OR based on his broad interpretation of OR as a process of giving aid to decision - makers through measurement. Another systems interpretation came from Sagasti and Mitroff (1973) who argued that: "... the activity of OR is a system with several component subsystems ...". They added; " These subsystems are of a conceptual nature and correspond to some phase of the operations research

process". Scholz (1984) interpreted Operational Research and Management Science "... as a hierarchic system which consists of two complex layers to be labelled 'methodology' and 'technology'". Buzacott (1982) argues that "... any general consensus on the nature of the OR process seems to have disappeared"

He distinguishes three schools of thought on the practice of OR: Operations Research, Operational Research, and Systems Analysis.

Because of the wide range of experiences and interpretations of the OR process, Conway (1984) suggested an alternative model, 'the dynamic model', which he saw as "... a new paradigm for the process of OR, viewing it as a dynamic, on - going process of interaction between the Operational Research group, the organisation and the environment".

Generally, there is an on - going debate on the process and practice of OR. It is mainly stimulated by the activities of the U.K. Process of Operational Research Study Group which helps to generate new ideas to bridge the gap between academic and practical OR.

2.4 The Practice of OR

2.4.1 Decision Making

In many situations, OR practitioners need to work closely to decision makers in order to help them to resolve 'problematical situations' in their organisations. It is important for them to understand decision making activities in those organisations so that their advice can be seen as relevant to the decision makers' needs.

I shall discuss some views about decision and the decision making process. White (1975) differentiates between 'primary decisions' which are taken by the 'client' and the 'secondary decisions' which the 'OR analyst' takes on the sort of technique(s) he has to use to deal with certain problem situations. Ackoff (1977) argues that the concept of decision " ... contains five components and three types of parameters ". The components are: the decision maker, the available course of action, the possible outcomes of the courses of action, the environment and the constraints. The parameters are: the probabilities of choice, the efficiency of each available course of action, the relative value of each outcome.

Bowen (1975a) saw no difference between 'choice' and 'decision' although, he added, " ... when we choose, we have only 'decided to decide' : we can change our minds ". In a different place, Bowen (1981b) argues that " When a decision is made, it is as if there had been an assessment by those responsible for the decision, based on their values, on the weightings they would place on different criteria, and on their perceptions of what future events might occur and what consequences of possible actions might be ". As to the aid of numerical measurement in the above process, he adds; " It would be very satisfactory if numerical measurements could be made of the appropriate subjective variables involved ". Nevertheless he was sceptical of the practice; " Most procedures which aim to provide models of good decision - making propose ways of establishing such numbers and lay down normative rules for processing these".

It can be argued that the basic aim in carrying an OR study on behalf of the decision maker, is not to 'automate' the decision, but to 'aid' the decision maker.

2.4.2 The Role of Techniques in OR

Because OR was first started to deal with 'tactical problems' and used mathematical procedures to solve them, it was largely thought of as a branch or mathematics. Continuous efforts to clarify the process and practice of OR were made and the role of techniques as part of the whole OR process was examined by many OR professionals.

In 1961 Tocher summarised the reaction to mathematical programming by the witticism " ... I have a solution - now you find a problem to fit it ". Ackoff (1962) also recognised the need for OR to give more thought about problem - formulation. He drew attention to the fact that for OR to be successful activity , it must be " ... problem - oriented, not technique - oriented " . However, he added; " This is not to say that sophisticated mathematics cannot serve (OR) well. It can and does, but only if at least four conditions are satisfied:

1. if the problem is properly formulated;
2. if the appropriate techniques are applied;
3. if a proper measure of effectiveness is used; and
4. if the results are implemented " .

Ackoff urged then that research should be concentrating on " ... developing the ability to handle all kinds of relevant variables " in the problem situation rather than distorting the problem to fit a mathematical model in order to get

an 'optimal - solution'.

Because problems are not 'well - defined' and clearly formulated, an inevitable distortion will take place when they are modelled for solution purposes. Support for Ackoff's arguments came from Bowen (1970) who pointed out the risk in distorting problems; " There is a growing danger that problems will be modelled to fit techniques, which seem able to cope with a large and complex set of data, without realizing that some aspects of the problem are not being quantified at all ". In other places, Bowen provides further evidence in support of the above ideas, and the scope of mathematics in OR. Bowen (1972) pressed the need for a " ... developed mathematical language appropriate to the task of defining a large - scale complex of systems ". Bowen (1975a) argued that "Operational Research can never just be the sum of techniques, mathematical and non - mathematical, since it is essentially a collaborative, interactive and adaptive process ". Bowen (1975b) outlines the techniques available to the OR analyst and their potential weaknesses.

Through the process of modelling by the use of mathematical techniques, OR analysts are seeking an 'optimal solution' to the problem situation under study. Because a model is only an abstracted form of the problem situation, it implies that when it is solved; " The optimal solution of a model is not an optimal solution of a problem unless the model is a perfect representation of the problem ". See Ackoff (1977). Ackoff adds; " ... optimal solutions deteriorate because of changes in both the systems that employ them and their environments ". He wants OR to " ... engage in designing decision systems that learn and adapt well rather than in producing optimal solutions that do not ".

Additional support for the above ideas follows from Bonder (1979) who questions the relevance of mathematical techniques; he argues " The relevance of current mathematical development in OR is continually questioned and, of perhaps more significance, the techniques and methods are being developed by individuals who have more disciplinary allegiance to mathematics and economics than to operations research ".

More recently, the report of the commission on the future practice of OR (1986) suggests that: " The commission found little explicit use of those mathematical techniques which are most commonly associated with O.R. (for example, mathematical programming and queuing theory). These and the insights they offer, along with many other technical devices, help to constitute a tool - kit of methods from which the practitioner may draw as need dictates ".

To conclude, there is a strong evidence in the literature that many 'optimal solutions' to 'problem situations' have failed. It is likely that one major reason behind that failure is that problems were not thoroughly formulated: had they been so, it would have been either difficult or impossible to use mathematical optimising techniques.

Clearly, many OR researchers are carrying out their work in a way which broadly follows the views expressed above. However, whether the processes that are being used are yet adequate is far from certain.

The rest of this chapter is devoted to arguments related to the practice of OR and the importance of the problem formulation phase in it.

2.4.3 Principles of OR Practice

The wide spread views and experiences about the process and practice of operational research have led practitioners in the field to lay down principles for the practice of OR. These principles are mainly based on personal experience and practice in dealing with real world problem situations.

First, in a Presidential Address to the U.K. OR Society, Tomlinson (1974) proposed the following six principles for effective OR.

1. "The partnership principle"
2. "The catalytic principle"
3. "The interpenetration principle"
4. "The independence principle"
5. "The catholicity principle"
6. "The balance principle"

The above principles were implemented in the management of an in - house OR group, and found very effective.

Ackoff (1979a) and (1979b) has published two papers which provoked a critical debate in OR circles. He criticized the traditional 'problem - solving ' paradigm because it only helps to " ... compare alternative decisions or decision rules that are 'given' ". He sees the paradigm as only " ... a starting - point of OR's development, not as its end - point ". 'Problem solving' paradigm as seen by Ackoff consists of two parts: " **predicting the future and preparing for it** ". He adds; " Perfect prediction is only possible under two sets of conditions; first, when nothing changes.... second (when) the behaviour of that which we

predict occurs in accordance with deterministic causal laws, and that we know perfectly these laws and the structure of whatever it is that we are predicting..."

Because OR mainly took place in 'turbulent environments' in which 'perfect prediction' was impossible, Ackoff proposed an alternative paradigm for OR, **the paradigm of planning**. He based it on the following principles:

1. "The participative principle"
2. "The continuity principle"
3. "The holistic principle"

I found little difference between Ackoff's and Tomlinson's principles. They are both based on a long practical experience in researching and managing OR projects.

There are two main roles which the OR analyst may assume during the interaction with a potential client. Eden and Sims (1979) refer to these.

First, **the technician role**, "... in which, somebody else (other than the OR man), must be responsible for formulating the problem, for deciding which criteria of evaluation are significant ...". Second, **the help role**, in which the OR man's function "... is to assist or enable his client in working with his problem, using all appropriate abilities and techniques at his command". Eden (1982) saw the process which resulted from the second role as the **facilitative process**. Gault (1984) goes along with Eden by stressing the new framework of OR. He said: "A new OR framework is emerging. An important aspect of this new framework is an understanding that the operational researcher's role is to help others to solve their problems themselves. This is in contrast with the

more traditional view which emphasises solving the problem for the decision maker, and giving him this fact in the form of the 'optimal solution'".

Because of the sense of 'crisis' in the practice of OR, as some refer to it, [e.g. Checkland (1983)], the British OR Society established in June 1983, a 'Commission on the Future Practice of Operational Research', from whose findings I have quoted earlier with regard to techniques. Its purpose was:

- a. To describe the state of OR in practice
- b. To make recommendations to the OR Council about how the society might better support practitioners.

I am only concerned here with the commission findings about OR in practice. In fact, the commission found "... the nature of O.R. in practice more striking for its variety than for its uniformity ... ". The commission found significant amounts of OR in practice with one or more of the following aims:

- " to help structure 'messes' or messy problems";
- " to research into the facts of an uncertain topic";
- " to help understanding of a sphere of activity";
- " to design systems (usually of a non - routine nature)";
- " to facilitate change";
- " to help introduce new technologies and ideas (particularly at present in the information technology field)";
- " to provide an independent view of a contentious issue";
- " to provide technical solutions to technical problems".

The **important** benefits of OR, as the commission found, "... stem from **enhancing the client's understanding of his own problems** ". (My

emphasis) which is based on Eden and Sims (1979) and Gault (1984) arguments that an OR analyst has to assume a 'help role' rather than a 'technician role'.

I shall return to this point when I examine the 'problem formulation' stage in the OR process to find out what research has been done in problem formulation to help the OR analyst in his 'help' role. I shall link that to my research findings in the experiment carried out which is described in detail in chapters 6 and 7 of this thesis.

2.4.4 The Concepts of Problem and Problem Solving

The concepts of 'problem' and 'problem - solving' are widely debated in the literature. It can be argued that there is a shift from 'solving' the client's problem to 'helping' him to understand the 'problem - situation'.

First, I shall examine the concept 'problem'. Ackoff (1977) argues that "Problems are elements abstracted from messes, therefore, problems are to messes what atoms are to planets". He believes that managers are confronted with 'dynamic situations' which he calls **messes**. Bowen (1975a) supported Ackoff's argument and commented on messes by stressing that they are problems, "... which are not closed and are not solvable. They are manifestations of the need to choose in situations which can never be fully analysed nor even represented. The choice, when made and implemented, can never be identified as **good** or **bad** in any absolute sense, since the act of changing the situation changes the environment in which any such judgement has to be made".

Eden and Sims (1979) have talked about "... an objectively defined problem which is assumed to be self evident to all intelligent people, ...". However,

they expressed their belief that it is very rare to find a 'self evident' problem in real organisations. Ackoff (1981) returns to state clearly what he means by a problem. " By a **problem** we mean a situation that satisfies three conditions: first, a decision - making individual or group has alternative courses of action available; second, the choice made can have a significant effect; and third, the decision maker has some doubt as to which alternative should be selected " .

Checkland (1981), trying to outline clearly the logic behind his research programme and his 'soft - systems methodology' argued, " ... it was not possible to take for granted the concept of 'a problem' and the activity of trying to solve it " . He refers to: **Structured problems**, " ... which can be explicitly stated in a language which implies that a theory concerning their solution is available ... " . **Unstructured problems**, " ... which are manifest in a feeling of unease but which cannot be explicitly stated without this appearing to oversimplify the situation ... " . Checkland prefers to deal with 'problem situations' rather than 'problems'.

Stainton (1984a) saw no unique way of looking at problems; he argues that " Problems may be viewed from many different angles and in many different ways. The order in which facts are collected, the attitudes of the people involved in the problem, the climate in which the problem finds itself to be, all play their parts in determining what the problem is perceived to be and how it is tackled " .

In a private communication with Professor Bowen, he commented on 'well - defined' and 'ill - defined' problems. He thought that: A well - defined problem may be stated because one is comfortable with it, even though it is

not the problem that should be tackled. But assuming that there has been an effort made to formulate the problem, it would be well - defined if:

- a. all controllable variables, and all uncontrollable ones that effect the system being modified (or created) or are affected by it, are measurable in absolute or statistical (probability terms);
- b. all relationships are describable and are understood;
- c. the necessary data can be collected.

Generally, it looks as if what could be a 'problem' for some researcher, might be a 'solution' to another one. The literature evidence suggests that the OR analyst should not start immediately a 'solution' process without a proper identification of the causes of the likely problem(s): and knowing what the problem really is may be all the client needs. What will follow is a broad discussion of the concept of '**problem - solving**'.

Because Ackoff (1977) preferred to talk about 'messes' rather than 'problems', and he thinks there is no optimal solution to the mess, he argues that: " ... the sum of the optimal solutions to each component problem considered separately is not an optimal solution to the mess. This follows from the fact that the behaviour of the mess depends more on how the solutions to its component problems **interact** than on how they act independently of each other " . Ackoff (1981) identifies three kinds of things that can be done about problems - they can be resolved, solved or dissolved.

Mitchell and Tomlinson (1979) argued in the same sense " ... to talk of solving problems is usually to talk of the impossible. The solution usually generates other problems, the better solutions being those which put off significant

new problems longest. Nor can one often talk about defining a problem. Rather one defines some activity which one hopes will contribute to solving a problem ” .

Since Stainton (1979) thinks that problems may be viewed from different angles, he talked about **slippery solutions** . He argued “ Solutions are slippery and must change with time. It is much harder to convince management of the single, final solution; better to design a solution with which they interface and with which they feel a part. Solutions are as much about conviction to act as they are about saying what should be done ”. Fripp (1982a) referred to the concept of ‘problem - solving style’ which in his words: “ ... is introduced as a means of understanding the emphasis placed upon different aspects of the O.R. process ”. Fripp concludes that; “ (There are) major differences in problem - solving style between fellows of Operational Research and line managers, ...”.

A final comment comes from Müller - Merbach (1986): “ ... the problem is not solved in numbers! it is solved not earlier than when the manager’s decision is carried out ”.

2.5 Problem Formulation

2.5.1 Introduction

As shown in the arguments outlined in the preceding sections, ‘problem formulation’ or as some call it ‘problem structuring’ or ‘problem definition’, is a very important stage in the OR process. The need for proper research to develop methodologies to assist the analyst in his task is not new. However,

the work to meet that need had not started until the early 1970's.

For example, Ackoff (1962) called for research to be carried out in order to 'solve' one of the 'unsolved problems' in 'problem solving' namely; " How should we (OR researchers) go about determining what a sponsor's problem really is? ".

Bowen on a number of occasions has drawn attention to this issue and encouraged research to devise methods which can help the analyst to structure and explore what the client's problem(s) is. His own research will be discussed later. First, Bowen (1970) named three levels at which Operational Research may structure problems and describe them logically;

" At the lowest level such structuring may provide models which enable decisions to be reached; at the intermediate levels it provides models which enable useful advice to be given to decision - makers; at the highest level it can perhaps help by casting light on what the problems are ". Bowen (1972) identifies three requirements for problem - formulation:

- (i) an understanding of the decision - making system that will use advice based on ordered processing of data;
- (ii) an understanding of the decision sets that are relevant; and
- (iii) the establishing of agreed assumptions that will limit and partially define the multi - dimensional space within which paths from the current state to a desired future state can be mapped ".

Bowen has gradually developed his ideas about problem formulation. However, it was not until 1984 that a full picture become apparent and this will be discussed later in this chapter.

Eden (1982) used the term 'problem construction' to refer to the process which enables "... the client or each member of a team to elaborate and think about the context - the explanations for their predicament, why the situation matters to them, the beliefs they have about key people ". Eden argues that it is a "... process of gradually making explicit personal views of the nature of the issue, it is the collection of subjective knowledge and experience of the sort that means the organisation employs a person to manage rather than a microcomputer ".

Checkland (1981) has developed a 'soft - systems methodology' which he claims is applicable to 'ill - structured' problems. He believes that it is "... a methodology for inquiring and learning, rather than optimising" (my emphasis). For more details about Checkland methodology, see also Checkland (1983, 1985). The Checkland methodology and that of Eden will both be discussed later.

Others [see Pidd and Woolley (1980) and Woolley and Pidd (1981)] have carried out what they call a 'pilot study' in problem structuring. They first define problem structuring as: "... the process of arriving at a sufficient understanding of a particular problem so as to proceed to some sort of formal modelling ". They saw the process of problem structuring as very important because it involves such fundamental questions as:

- What is the real problem?
- How does the OR analyst know that he is working on the right problem?
- How does the analyst decide what to do about the problem?
- How does the analyst decide to set limits to the area of investigation in

a project?

They conclude their research by viewing the process of problem structuring " ... as a process of exploration as the analyst strives to comprehend the full complexity of the issue and consider carefully how to manage this complexity"

Hence, they propose the **Exploration Approach** for problem structuring which is characterised by four fundamental aspects: Informality, Hierarchy, Continuance, and Inclusiveness. Their main conclusion is that, by following the Exploration Approach the analyst will **learn** about the problem by 'exploration'.

The need for problem formulation is also emphasised by Stainton (1984b) who argued that " Operational research in the text books is different to that which is applied in practice. The text book versions deal with the mechanics of solution whilst in practice, the first necessity is to define and formulate "

2.5.2 Problem Formulation Methodologies

A comprehensive coverage of problem formulation methodologies is very difficult because of the limited documentation of how people actually do OR. It is also difficult to provide a thorough comparison between those methodologies which are documented. It is largely accepted that if the analyst feels that by using one methodology he, and his clients, can get to a close understanding of the 'problem situation' under study, that methodology is a good one for a particular study.

Checkland (1981) differentiated between methodology and method. What in fact he aimed to get out of his research programme was a " ... methodology

which is a set of **principles of method** which in any particular situation have to be reduced to a method uniquely suitable to that particular situation ". Scholz (1984) used 'method' and 'methodology' as in Chekland's sense; he saw method as the actual tool for solving a problem, whereas methodology deals on a meta level, with the nature and creation of concepts suitable for the development and implementation of the methods. Scholz went on to argue that a methodology " ... tells us, why and how and which specific methods should be developed as well as why and how and where these methods should be implemented " .

The commission on the Future Practice of OR defines 'methodology' in their report (1986) as " (Methodology) includes, but is more than, the set of methods used. Methodology decides the ends and means of O.R. work, as well as including the means, that is methods ... " .

In the following sections I shall outline briefly three problem formulation methodologies. These have been chosen because of clear documentation, and evidence provided from practical exercises that they are proved useful in aiding analyst and client in formulating an ill - defined problem.

2.5.2.1 Eden's Methodology

Eden and his colleagues have developed and tested successfully a problem formulation methodology to deal with ill - structured policy issues. It is well documented in Eden, Jones and Sims (1979, 1983). Due to the fact that, in most OR projects, there will be an on - going interaction process between the OR analyst and the 'problem - owners', the analyst's main purpose is to 'explore' his client's perception about the difficulties of his tasks and the problems in his

organisation.

In order to help the above exploration process, Eden and his colleagues have developed a computer program (COPE) which is now implemented on a microcomputer and can be transferred to the client's organisation in order to facilitate the process of data collection and analysis. The program facilitates explanation of a 'cognitive map' which represents the client's perceived causes and consequences of the problem. A detailed inquiry, using the program, might be necessary to 'resolve' certain issues in the 'problem situation'.

Although Eden's methodology is now well established, he did not claim that it is a comprehensive approach to structure problems. In fact he did stress the fact that, "... any means of discovering and representing a policy - maker's world will inevitably capture some parts of it, distort others, while yet other parts will be entirely missed".

2.5.2.2 Checkland's Methodology

As stated before, Checkland's methodology is developed to deal with ill - structured problems. It is a 'soft systems methodology' for 'inquiry' rather than 'optimization'. Checkland argued that the 'hard' is a special case of the 'soft' systems thinking. He stressed that "... it is extremely unlikely that the real - world problem situation will map neatly into the well - structured situations with which the algorithms deal".

Checkland's methodology consists of two types of activities: 'real - world' and 'systems - thinking' activities. Central to the later, is the establishment of 'root definitions' of systems relevant to the inquiry for which then conceptual

models will be built to enhance the understanding of both analyst and client of the problem situation. At this stage, Checkland is willing to accept 'hard' systems techniques if this helps to explore the problem situation.

Although the Checkland methodology is widely experienced and used in real - world problem situations, people do find difficulties in producing appropriate conceptual diagrams because there are no obvious rules for this process. See Bowen (1984) for more details about possible shortcomings of the Checkland Methodology.

2.5.2.3 Bowen's Methodology

Bowen's methodology is a qualitative modelling approach which is developed for problem formulation. In developing his methodology, Bowen has made use of earlier ideas and research in conflict analysis which are reported in Bowen and Smith (1976).

Central to the methodology is the notation [see figure 6.1] and the rules for its use which help in building conceptual models. Bowen (1981a) provides a clear specifications for these rules. He argues that " ... the elements that make up a system or a sub - system will be those and only those which are relevant to the inquiry, and similarly for the direct or indirect relations between them ". Bowen goes on to point out that " The environment of a system will consist of all relevant elements that can affect the system's state ... the environment will be defined as including the system itself ". Conflict as seen by Bowen " ... implies that there are some differences (in aim, policy, understanding, etc.) between two systems that interfere with one or the

other, or both, in their attaining future states preferred by them ". Purposeful action should start from a person (shown as a circle) and communication should end at a person.

Bowen (1981a) stated the following conditions to be satisfied in a potential experimental environment in which the methodology can be applied:

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

The first experimental test of the methodology in practice is reported in Bowen (1983) which is a summary of the larger document Bowen (1984). Bowen concluded his experiment by arguing that " By itself this experiment is not enough: it is also, inevitably, incomplete ". What Bowen wanted, was in fact further studies which would help to " ... 'prove' the usefulness of the methodology ... ". Nevertheless, the following are the potential advantages in using the notation as suggested by Bowen (1984):

1. " As a basis for a language to describe and develop problems, the notation has the advantage of logical simplicity and visual neatness and compactness ";
2. " It enables both physical and conceptual systems to be described in the same sort of way ... ";
3. " It can compress a lot of data into a small space, it provides a diagram to guide thought and communication, and particularly to offer, partially, a

common language for the latter ”;

4. “ It does not accept overlapping systems: **either** systems must be broken down and given new sub - systems labels **or** systems must be drawn as at a particular time or stage to identify changing states or shifting roles ”.

Chapter 6 of this thesis will describe one of the ‘further studies ’ recommended by Bowen. This in fact was the first industrial application of the methodology which was proved useful for the notation and the methodology as a whole.

2.5.3 The Choice

The choice of the methodology was conditioned by the eventual practical task undertaken to support the research aims. An operational researcher chooses a particular methodology because he feels that he can handle it efficiently in that situation. It is probable that those who had developed a methodology would almost certainly use their own. For me the choice was based on both subjective and objective reasons. It is possible that all the three methodologies introduced above may have worked successfully for the purpose of the problem formulation experiment outlined in chapter 6.

An advantage in using Eden’s methodology is that it enables the problem owner(s) to understand their problems in terms of their cognitive style. What I wanted was to examine how managers learn and how they perceive situations, and this is an issue which is fully compatible with what the cognitive maps can offer. However, using Eden’s methodology needs a deep understanding of verbal construction which is very difficult for one who does not speak English as

a first language. It is also true that, although there are differences, Eden offers a learning process which can also be provided by using Bowen's methodology.

Although Checkland's methodology has been tested in practical studies [see Checkland (1981)], Bowen (1984) has pointed out certain possible shortcomings of the methodology. He argued that Checkland " ... uses, on occasion, set theoretic diagrams and influence arrows in a manner similar to (Bowen's), although (Checkland) has not developed his ideas and so they lack consistency, discipline and definition ". Bowen also stated two 'reservations' on the concept of 'root definition'. He argued " ... it is not clear what guides and stimulates their formulation, nor whether they have to be acceptable in principle to the owners of the systems, or whether they can be simply models used by the analyst for his purpose, at least initially ". In fact both Bowen's and Eden's methodologies inherently introduce 'root definition'.

The Checkland methodology is intended for a total OR intervention by a consultant invited in for a specific purpose by a firm, whereas I was doing something rather different. My intention was to look into certain areas which I wanted to research.

Based on the above arguments, and on the fact that there are inevitable difficulties in borrowing others' methodologies to be applied in a real environment where both research findings and client satisfaction are of great importance, I did not feel that learning to use and adapt these methodologies for my purpose would be a satisfactory choice. The time scale that was required to understand and apply Bowen's methodology, especially when the author had a direct contact with its developer, was relatively less (possibly very much less) than that

necessary to know and apply either Eden's or Checkland's methodologies. The purposes of the Bowen methodology as defined by Bowen (1984) are consistent with the task in hand. It was designed to look mainly at the problem formulation area and to aid the analyst and his client to communicate purposefully in order to formulate the client's problem.

For all the above reasons I decided to choose the Bowen problem formulation methodology and I have applied it in chapter 6. I was aware that this would be the first time that the methodology would be used in direct interaction and as aid to decision-making. Once again what is required here are aspects in an industrial environment. However, there was no obvious reason to believe that it would not work in ways similar to that outlined in Bowen's experimental work. Hence, there was an added opportunity to test the methodology in the way that Bowen had originally intended.

3.2 The Concept of Model in OR

In operational research, as well as in many other disciplines, the concept of 'model' is widely used. Ackoff and Sasin (1967) defined a model as a 'representation of reality'; i.e. an abstraction of things thought to be important in a real life situation. They stress the need for simplicity in models: "If they were as complex and difficult to control as reality, there would be no advantage

CHAPTER 3

IMPLEMENTATION OF OPERATIONAL RESEARCH MODELS

3.1 Introduction and Conclusion

In this chapter I discuss a wide range of model classifications and uses. Models are developed for various purposes, such as research, experimentation and as aid to decision - making. Once again what is included here are aspects of implementation which are important for guiding the actual implementation process met in this research.

Experience shows that many operational research models have 'failed' to be implemented by their potential users; hence, an 'implementation problem' is recognised. Despite the importance of this problem, the literature review shows that very little attention has been paid to research in this area.

It is felt that what managers need are models which allow them to reflect on the way they manage process and not those which simulate that process.

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in their use".

The simplicity in models does not mean that reality should be distorted in order to get a manageable mathematical model. Any predictions through the use of a distorted model will, of course, mislead the potential model user. Apart from predictions, the model may be used to enhance the client's understanding of his problem by learning through the model.

The model building process is both an 'art' and a 'science'. It definitely needs a closer user involvement especially when dealing with 'messy' problematic situations. See chapter 2 for a definition of messy problems. It is also subjected to certain types of errors; Bowen (1978b) has pointed out the following three types of error which can be committed by analysts in using the models that they build:

- (1) The irrelevancies and inadequacies of models which have not been developed for the particular problem in hand may be insufficiently studied, identified and corrected, and their consequences overlooked in the analysis.
- (2) The capability of the model for determining outcomes which are not of interest, or for providing precision which is not required, may be used because it is there.
- (3) The model may be perceived as equivalent to reality, rather than as representing reality in some uncertain way.

Among the various issues that the model builder have to concentrate on in building and improving his model, are 'verification' and 'validation'. **Verification** is to test the model output against results of another known cases.

Bowen (1978b) argued that " ... as models become more elaborate, such verification becomes very difficult ". **Validation** is to test the agreement between the model and the actual system behavior. But as Bowen (1978b) pointed out, " Validation of models is not possible in an absolute sense. Models are, in one sense, valid only in so far as they are accepted by the primary decision - maker and their solutions found useful by him in coming to a final decision ". Bowen went on to argue that " ... there is no theory of validation, and no objective way of measuring the value of analysis ".

Because of the wide interpretations of the concept 'model', several attempts have been made to classify models. In the next section, various classification schemes will be examined.

3.3 Classification of Models

In this section, three proposed classification schemes will be discussed. It is important to note that these classifications are not intended to aid the analyst in building a model for some stated problem situation. They are also not urging the solving of a specific class of problems by a specific class of models. The schemes are guides to assist thinking about the possibilities and nature of different types of model.

Ackoff and Sasieni (1968) identified three types of models that are commonly used in OR as well as in most of science: **iconic**, **analogue**, and **symbolic**. They define an iconic model as the one in which " ... the relevant properties of the real thing are represented by the properties themselves, usually

with a change of scale ". Examples of this type of model are 'model' airplanes, ships, and automobiles. In an analogue model, "... one set of properties (is used) to represent another set of properties ". For example, a hydraulic system can be used as an analogue of electrical, traffic, and economic systems. Finally symbolic models use letters, numbers, and other types of symbols to represent variables and the relationships between them. "... (They) take the form of mathematical relationships (usually equations or 'inequalities') that reflect the structure of that which they represent ". The emphasis by Ackoff and Sasieni is on the symbolic models because "... they usually yield more accurate results under manipulation than do either iconic or analogue models ". But Ackoff and Sasieni also refer to another type of model, namely the **conceptual model**. Such models often are "... diagrams that record our conception of what variables are relevant and how they are related ". According to the above classification, the OR type models come under symbolic and conceptual schemes.

Laing (1981) proposed a classification which is based on a broad understanding of the concept 'model'. Table (1) shows the seven types of the proposed models. Table (2) shows the subclassification of models also proposed by Laing (1981). He argues that his classification method tends to "... prevent a narrow approach to problem - solving ". Nevertheless, he believes that "... classification and model building approaches tend to be a matter of personal choice ".

Wilson (1985) has examined three classification systems of models in OR and found that not all case studies from the Journal of the Operational Research

Table 1. Types of Models

	<u>Type of Model</u>	<u>Comment</u>	<u>Example</u>
PP	Pure Physical	Real full scale models	'Reconstruction of the crime', using real people and objects.
PG	Physical Geometric	Geometrically scaled model retaining the general physical characteristics of the full-scale version.	A model building designed to study strength of the structure
IG	Interpretive geometric	Model geometrically scaled but with different physical characteristics to the original	A scaled model human dummy, the design of which entails the use of mathematics.
IA	Interpretive Analogue	Model is unlikely to resemble physically the original but to give an analogous effect	A shape designed to indicate an effect, such as ball bearings of weights and sizes designed to simulate the movement of a human body under shock waves.
CA	Computational Analogue	These models are concerned with mathematical simulation and use very simple mathematics.	The probability of ships waiting for unloading, as in a computer simulation model.
CM	Computational Mathematical	Mathematical estimation based on observation and mathematics which are not especially complicated	The determination of the coefficients of an equation for a market share by analysis of observations.
PM	Pure Mathematical	Mathematical models using pure mathematics and the minimal assumptions.	The Newtonian laws of physics.

Table 2. Explanation of Terms

	<u>Special category</u>	<u>Comment</u>	<u>Example</u>
A	Adaptive	Adapts to latest data.	Forecasting.
B	Behavioural	Explains behaviour patterns	Interactions of groups under stress.
D	Deterministic	Chance does not affect model.	Newtonian laws of motion.
E	Economic	Indicates influence of economic factors.	Prediction of effects of change.
S	Stochastic	Model makes allowances for chance events.	Probability of critical build up in reactors.

Taken from Laing (1981)

Society can be fitted into the classification types. The classifications are based on the Ackoff and Sasieni (1968) view that "... in solving a problem, what is required is an examination of the structure and content of the problem, and once that has been performed, a model can be built of the system in which the problem is embedded. The problem may then be grasped and solved once its structure has been established". Following are the three proposed

classifications.

1. Ackoff and Rivett (AR) in which seven types of problem are isolated in terms of form and content. These are queuing problems, inventory problems, allocation problems, scheduling and routeing, replacement and maintenance, search problems, and competition.

2. Ackoff and Sasieni (AS). This approach classifies problems according to the difficulty of formulating the structure.

3. Rivett (R). This approach classifies problems according to the presence or absence of an element of feedback by which the variables affect the condition of the system.

Wilson concludes by arguing that all three classification schemes did not give information about " ... what went on at the sharp end of the analyst - client interface ... ".

3.4 Implementation of OR Models

When an OR inquiry is carried out to explore 'problematic situations' in operational systems, there might be a need to go beyond the problem formulation stage. In this case, the OR analyst has to develop types of model for a number of purposes other than those of analytical 'solutions' (e.g. to enhance the client's understanding of certain aspects of the problem by **learning** through the model).

Experience shows that many OR models have not been implemented by potential users; hence, it was felt that there exists an 'implementation problem'

in OR. However, in the early days of OR development, very little attention was paid to implementation because of the assumptions that research efforts should be concentrating on developing technically sophisticated techniques and that these would be easily accepted by problem owners. In more recent years, however, research has been directed to investigate the problem and various ideas are reported in the literature to enlighten the causes for the 'failure' of OR models to meet managers' expectations. As with problem formulation this problem is not new. However ways of dealing with it are only slowly emerging.

Ackoff (1962) called for attention to be paid to the implementation of OR investigations especially when the object of the OR study is to improve the operations of systems. He argued that, "... the decision maker may be very strongly influenced by the availability of a detailed plan for implementation in determining whether or not to accept and act on the research findings". Ackoff's argument came in the early days of OR where it was mainly concerned with 'tactical' well - defined problems. As we will see later, the implementation problem gets difficult when the OR analyst deals with 'ill - defined' problems. See chapter 2 for definition of well - and - ill defined problems.

Little (1970) has argued that " The big problem with management science models is that managers particularly never use them ". Although he added; " There have been a few applications, of course, but the practice is a pallid picture of the promise. Much of the difficulty lies in implementation and an especially critical aspect of this is the meeting between manager and model ". Little went on to identify the following reasons for the failure of models to meet managers' expectations:

1. good models are hard to find;
2. good parameterization is even harder;
3. managers do not understand the models;
4. most models are incomplete .

Little warned OR analysts not to add further 'complications' to their models when managers do not understand them. What a manager needs, as Little has found, is a model which is "... an extension of his ability to think about and analyze his operation ". He called this model a 'decision calculus'. In fact, Little's argument was a call to think about and research the causes of the failure of models to get user satisfaction.

White (1975) made the following four points about the implementation of OR analysis.

1. The likelihood of implementation will depend on how the project was carried out.
2. The ability to persuade people to implement is very important.
3. The resources needed to implement a solution should be considered as early on in the study as is feasible.
4. The participation of the researcher in the implementation is advisable because only he really understands when the model is valid and when changes should take place because of changing conditions.

White's treatment of the OR process and the need to pay attention to problem formulation may help the analyst's research findings to be implemented.

Closely related to the ideas of Little (1970) and others, Bandyopadhyay (1975) stressed the existence of 'implementation problem' in OR models. He

summarized his understanding of the reasons for rejecting models in actual practice as follows:

1. " Certain consequence variables missed in the modelling stages (including testing stages) may be considered later as significant ... "
2. " The model, though workable in theory, does not clearly prescribe the changes needed in practice to implement the model ... "
3. " The model does not reflect the change that has taken place in the environment since its validation ... "
4. " A model may be rejected because either the mechanism or the measure or both are not adequately understood by the decision - maker "
5. " Further behaviour may be dependent on future random events and the model can describe these only probabilistically "

The above ideas, and other research work, may have influenced some researchers to find out what type of models the decision makers want out of a client - analyst interaction. Simon et al (1976) identified the following types of models employed by managers: (1) 'decision - making' model, (2) 'information supplying' model, (3) 'need to know' model, (4) 'rationale' model, (5) 'reputation' model. However, the fact remains that before developing any type of model, a thorough identification of the manager's needs has to be made.

Michel and Permut (1976) have carried out a survey of the articles reported in the Operational Research Quarterly over the period 1965 - 1974. They stated the following reasons why there has been relatively little impact of the OR literature on its practice:

1. The literature does not reflect organisational needs.

2. Organisations distrust the use of OR models.

3. The assumptions made by operational researchers are not reflective of the actual environment.

4. The models described in the literature are too complex and costly to be implemented within an organisation.

They conclude that only 30% of the models reported were actually implemented during the above period.

Hildebrandt (1977) has also observed the implementation gap between the theory and practice of OR. He considered the implementation problem as a **fundamental one** since " Decision making can only be improved through OR/MS if the methods and models are used in organisations ". He went on to argue that the implementation problem is a **continuing one** because " ... future advances in OR/MS methods must be accompanied by new and useful applications ". Hildebrandt (1980) provides supporting evidence for his earlier ideas by arguing that " Our ability to provide managers and user organisations with systems they will find useful and will adopt has not kept pace with our growing technical capacity ". Although what Hildebrandt says could refer to the implementation of OR models in the simple sense, his main concern is with those models which govern and guide the behaviour of analyst and client through the OR process.

Mintzberg (1979) pointed out the managers' 'resistance' to OR models and analysis. He stated the following 'pitfalls of implementation'.

1. Managers resist analysis because they do not understand it (or the people who do it).

2. Managers resist analysis because they haven't been sold on it.
3. Analytical solutions are resisted because they lack the support or participation of top management.
4. Resistance to analysis can be explained by managerial attitude and organisational climate.
5. Politics in organisations blocks or distorts the use of analysis.

The above five 'pitfalls' are equally important, and analysts have to seek ways to make sure that their research findings are not considered redundant by top management. Supporting evidence for the above ideas came from Quade and Tomlinson (1981) who argued that "... there are numerous papers pointing out where implementation has failed, but many fewer that tell what to do during the study before the decision is taken to make failure less likely".

Although the 'implementation problem' is now well recognised, very few research studies have been reported which tackle the issue of resolving it. Of some importance is the study carried out by Fripp and Stainton (1981) which is documented in detail in Fripp (1982b). A research game was used to study the implementation problem of OR models. Their recommendation of the type of model(s) the manager needs was that, the analyst may "... give the manager a relatively crude model of his problem developed in such a way that it is easy to understand and use; to let him refine it where he feels necessary, and discard it when he understands the problem well enough. As this procedure continues the manager is essentially involved in a **learning process**, with the OR model being used to provide new information, new 'experience' and to answer a range of questions". (my emphasis)

Later, based on this research work Fripp (1985) stresses the 'implementation problem' and points out the need to research the 'effectiveness' of models (i.e. to study the 'effects' of their 'usage' on managers' decision making process). Fripp concludes that " ... models can be effective in improving the quality of decisions. (They) can have a valuable learning effect for users particularly (in) understanding the problem (they are) facing ... ”.

3.5 Discussion

To sum up the discussion on implementation and what models managers need, I make the following points.

1. The implementation of an OR model will depend on whether it deals with a 'well' or 'ill - defined' problem. In well - defined problems, a conventional model can be easily offered and sold. The manager might well be persuaded to use it. However, with ill - defined problems the model may not go further than to help the manager to learn about the problem rather than solve it [see Quade (1981)]. It is this learning process with which the research in this thesis is concerned.

2. The decision maker may 'ignore' the 'advice' given to him by an OR analyst especially if the advice is of 'a too definitive nature' and if the decision maker " ... perceives new constraints, obtains new information and, consequently decides to act on new assumptions. " [see Bowen (1975a)]. This implies the time dimension in modelling and implementation of models.

3. The model may 'solve' a particular problem encountered by the decision

maker, but may not be implemented. One likely reason for this may be that the manager does not understand the model or see it as containing enough of his world. It is not advisable in this case to build a new complicated version of the original model.

4. A high degree of managers' participation in model building is very important for later model implementation, [see chapter 6 of this thesis]. Although OR models reported in the literature are considered theoretically sound and represent processes logically, they often failed to be implemented. They are either technically wrong or something of the managers' world is missing. It is the latter issue which leads to the hypothesis stated in the following point.

5. It seems that although managers have to understand the technical processes which they are managing, the decisions they take include so much else. In handling the organisation that uses these technical processes, they are faced by a management task which is very complex. Hence, what managers need are models which allow them to reflect on the way they manage process and **not** those which simulate that process. This reflection should not only affect the way they take decisions but also enhance their learning. These points are taken as a basis for the practical study which is discussed in chapters 6 and 7 of this thesis.

CHAPTER 4

GAMES AND GAMING

4.1 Introduction and Conclusion

This chapter will discuss gaming technique as an Operational Research activity which involves real decision makers interacting with a model environment. Gaming and game theory are seen as two different, albeit related, activities.

Games are classified, according to their purpose, in different categories, viz., teaching, research, learning and fun. Based on Bowen's definition, the concept of a learning game was examined in detail.

The available games were seen as useful in learning about a process, e.g. an inventory system, but not in controlling that process (which is the prime job of management). The literature review shows that learning games in the traditional form do not seem to have developed for application at top managerial level.

4.2 Games and Gaming

A game is a model which is developed for some purpose. More specifically, it is defined by Klein (1984) as: " a model of the real world in which the passing of time is of particular importance, and in which the behaviour of one or more human participant is of primary importance " .

Because of the nature of the decision process in complex systems, decision

aids are becoming of increasing importance. Earlier, it was largely thought that optimization models are the ultimate tools in the sense that they help the decision maker in making a choice. However, issues such as, problem formulation and identification of the required data or information for decision are activities which need other than optimization models. Hence, as Bowen (1978a) argues:

“ A game may be a means of obtaining some idea of the decision problems involved in operating within a complicated system. It may be used to give confirmation, in the mind of a customer, of the sort of results obtained from less overt, and less realistic, computer simulations or mathematical models ”. Bowen sees both computer simulations and analytical models as useful techniques in decision making research.

Gaming is the activity of using games. More specifically as Shubik (1975a) argues:

“ Gaming entails the use of a scenario, game, simulation, or model to provide a background or environment in which a set of individuals usually referred to as players will act. The environment is almost invariably a simulation or model of a real environment ”.

Participants in a game are guided by rules which provide them with choices, for each of which there will be a likely outcome. Generally, the participant is uncertain about the model's reaction to his choices. More difficult is the situation when he is also uncertain about other participants' choices.

Game theory and gaming are frequently confused. They are in fact “ ... two extremely different yet highly related disciplines ” [Shubik (1972)].

In other two very useful references, Shubik [(1975a), (1975b)] has provided an outline of the use of game theory concepts in gaming. He defines game theory as a;

“ ... part of a growing body of theory concerning decision making. In particular, game theory provides the language for the description of (a) conscious, goal - oriented decision - making processes involving more than one individual. It has provided the tools for analysis of certain relatively subtle concepts, such as the state of information, the meaning of choice, move, strategy, and payoff ”. Shubik went on to argue that “ In general, game theoretic reasoning and analysis are of considerable use in constructing, discussing, and analyzing gaming exercises ”.

A good classical reference for game theory is Von Neumann and Morgenstern (1972). Current developments in game theory includes Metagame theory [see Howard (1971)] and Hypergame theory [see Bennett (1980)].

Despite Shubik's remarks above, game theoretic approaches were not found relevant to the particular type of games which will be discussed in section (4.4) of this chapter.

4.3 Classification of Games

Three classification schemes will be outlined. First, Eilon (1963) has classified management games according to:

Design characteristics:

a- total enterprise or functional,

b- interacting or non - interacting,

c- computer or non - computer.

Purpose:

a- Training:

(1) as a part of a general management training programme,

(2) to 'sell' new techniques or procedures.

b- Research: in order to study

(3) the behaviour of systems,

(4) decision - making process of individuals,

(5) interaction of individuals in a team.

However, as Bowen (1978a) argued, the above classification can be regarded as a 'specialized classification'. Bowen in fact has classified games according to their purpose to: teaching, research, learning and fun. The classification was intended to " .. help to identify and use characteristics on which useful descriptions of games can be based ". Bowen went on to argue; " ... classification enables a number of very useful distinctions to be made without the need for absolute measurement, or with a minimum of such measurement ".

A teaching game in Bowen's sense is " ... a model of some part of the real world, within which a student can be guided to see why his behaviour might be 'right' or 'wrong' ". As an example of the above category, Dando and Brown (1981) have developed an industrial relations teaching game. The purpose of a research game is " ... to obtain measures which describe the decision - process and the relationships between situations, choices and consequences ". 'Repli-

cation' and 'control' are two main characteristics of a research game. As an example of a research game, see Sharp and Dando (1977), Cooper (1979) and Moynihan (1987a,1987b). See also Bowen (1986) for further discussion about research games. Bowen's learning category will be discussed later.

Shubik (1972) has stated the following reasons for classifying games:

1. To call attention to the important prevalidation problems of specification, i.e., stating purpose and devising criteria by which to judge the attainment of one's goals;

2. To indicate the possibility that in spite of the diversity there may be a common core of knowledge and professional skills of importance to all games; and

3. To suggest that all specialists stand to benefit from an understanding of the diversity of gaming because frequently different types of gaming overlap and errors or important phenomena that may be completely ignored by one specialist may be obvious to another who sees the same from a somewhat different viewpoint.

Shubik classified games according to their purpose to the following categories: teaching, experimentation, entertainment, therapy and diagnosis, operations and training. It is important to note that the above classification has something in common with Bowen's broader approach. First, both experimentation and operations will come under Bowen's research category. second, Shubik's teaching and training categories are related to Bowen's teaching and learning games.

Klein (1984) has added a third dimension to Bowen's classification. The new dimension is "... the level of constructional abstraction at which the game as a whole is understood ". Klein divided this into two categories:

1. " Low, in which the meaning and content of the game are taken literally and more abstract conclusions are not drawn ".

2. " High, in which the meaning and content of the game are abstracted in order to draw conclusions ". For further developments of Klein's work, see Klein (1986).

A category which has some aspects of both learning and research games is what is labelled in the literature as 'operational games'. These, are still models of real - world situations which are designed to aid participants to make decisions and observe their consequences. Shubik (1972) has stated the following purposes of using operational gaming:

1. Cross - checking and extra validation of other methods,
2. Extraorganisational communication,
3. Exploration, testing, and planning,
4. Group opinion formulation and 'Delphi',
5. Forecasting,
6. Advocacy.

Recently, Ståhl (1983) has edited a very good book about operational gaming. It contains experiences from both West and East. However, the concept of operational gaming as defined in the book would leave out many potential learning processes stemming from research gaming developments in the United

Kingdom. The definition insists on interaction between human players in a defined situation within which the decision problem resides: such games are seen as too complex and specific to be developed for more general learning purposes.

4.4 Learning Games

Bowen (1978a) defines a learning game as a model "... in which players are not controlled, but play freely to extract something for themselves. Their behaviour will be known, to some extent, by themselves, but it will not be the purpose of the game to make this behaviour explicit for the information of any one else". Bowen considers a game such as HOT SEAT developed by Hartley et al (1979) as a learning game. Further, Bowen (1982) suggests the following two actions that could improve the chances of a learning game being correctly used.

" Firstly, the game designers should prepare a clear statement of the nature of the game, what it can and cannot do. They should emphasise that its main purpose is to provide models of the world in which the players have to act. From the game, players should be able to learn something of the nature and complexity of their allotted tasks in future real situations".

Bowen went on to argue that, " Secondly, such a statement should be available to the players from the outset, and should guide the directing staff in all their communication with the players".

Based on Bowen's definition of a learning game, it can be argued that any models used in the learning process are games. The important question,

however, is:

What sort of models can be made available to managers which will help them to learn and retain control of a process which they do not directly involve themselves in, except by managing those who do?

It is stressed throughout the literature on games that because of the advanced information handling techniques, organisational changes, technological progress and other factors, managers need to engage in a continuous learning process. What is available in the literature, to aid the above learning / training process, is what are largely called 'management games' or 'business games'. The amount of material is vast, and only a small part of what has been surveyed is mentioned here as having particular relevance to the argument. Examples of these games are available in [Mellor and Tocher (1963), McFarlane et al (1970), The Scottish Management Game, Creese and Gentle (1974), Yefimov and Komarov (1982)].

Generally, a management game is a model of a process, such as an inventory system, which provides an environment in which participants make decisions. Several claims have been made about what participants may learn from these games, e.g., motivation, skills, knowledge, self awareness, attitudes, and understanding. [See Fletcher (1971)] for details. Bowen (1978a) argues that:

" Management games are learning games and may relate to research games in two ways. Firstly, they may have some teaching function; secondly, there must be a learning process in the development of research games which might need support from a learning game " .

Inevitably, the game will provide the participants with a useful environment to learn from its experience. However, that learning will be enhanced, as Jackson (1958) argues; "... by a fast moving time scale, by detailed reports on results quickly presented once decisions are made, and also to some extent by greater freedom to experiment for the sake of information than is usually available in the real life ". Learning from the experience will also depend on: What the person is looking for, the detailed 'shape' of the experience, the nature of the person, opportunities to practice, similarities of that experience to other experiences, the intrinsic pleasantness / unpleasantness of the experience. [See Bredemeier and Greenblat (1981)].

4.4.1 Limitations of the Available Games

It is well understood that organisational policy is the primary responsibility of top management in the organisation. In shaping this policy managers will encounter different problems and need to learn about different issues. Can the available models (games) help in that learning process?

Shubik (1975b) questioned the level of that learning provided by the game, he argued: " Did (the participants) learn the right things? Was the method more effective than any other feasible and no more costly alternative? ". Evans and Sculli (1984) went along with Shubik and argued, in their attempt to evaluate business games on a scale related to managerial talent, that " Results suggest that games may not be as useful in developing managerial talent as they are in teaching basic business principles and quantitative decision

making techniques". Supportive evidence for these ideas came from Klein (1984) who stresses the fact that "... a game (may) inadequately represents or models reality (his emphasis), and he warned that this is a serious weakness in using the game, because participants "... will probably learn or taught the wrong lessons ...".

For a quite different, albeit related category of games, Ståhl (1983) addressed the question: " Why has operational gaming not been used more extensively? ". He stated the following three reasons:

1. " Some top managers regard gaming as a nonserious activity and balk at the very ideas of letting gaming influence their decisions ".
2. " Top managers think that there is nothing new that they could learn from a gaming exercise ".
3. " Top managers regard games as too simple and hence too unrealistic to depict complex reality well ".

As a final comment and supporting evidence to these ideas, I would like to quote Field (1985) who has stated the following reasons for abandoning games:

1. " Management games did not accomodate the process of decision too well ".
2. " Many games are cumbersome to handle ".
3. " Management games are incomplete in their structure ".
4. " One had to be careful in choosing a game to ensure that it would teach the required lessons ".

So, despite the claimed advantages in using classical learning games, the warning is clear, and it includes the fact that management and control of the process is quite different from understanding the process.

4.5 The Way Forward

The original research programme was in fact started solely to set clear criteria for 'good' learning games. However, according to the argument developed above, and based on what managers really need [see chapter 3] some change of emphasis was required.

A statement was drafted to define what needed to be examined in the next stage. The ideas generated needed to be looked at in a real environment. The statement was therefore a research proposal in very general terms and a request for help so that the necessary inquiries and experiments could be adequately carried out.

4.5.1 The Statement

The statement that follows was sent to local industrial organisations.

Operational Research (OR) has gained a high reputation in dealing with industrial problems and in providing an aid to management decision making. Games, which are part of a comprehensive body of OR techniques, have been established and played for different purposes; one of them is for 'learning' where participants in a learning game (such as business games) can extract something for themselves.

Several claims have been made about the effectiveness of learning games such as the following:

- They enable decision makers to practice their skills and to observe consequences of their decisions without having to effect the real world.
- Participants may learn from the game what they might learn from experience in the real world in which there are several constraints.
- They capture interest.
- They have the ability to focus attention.
- Participants can learn different skills such as communication, strategy selection, and resource allocation.

Despite the above claims, it is not yet clear what is in learning games which validate these. It seems that we must look at the concept of a game more broadly, as some sort of interactive modelling. Hence we are addressing the problem of the 'use of models as learning "games" in which we hope to investigate several issues such as:

- What are the criteria for a 'good' learning "game"?
- What is the proper role of models in the learning process?
- What parts or part of the decision process can be exercised by a learning "game"?
- Can a learning "game" provide an environment in which the participant can be trained to become a good decision maker in his own business, or in some other business?
- Can we generalise the results obtained from running a learning "game"

devised for a particular organisation to another one?

We are looking for a cooperative management who are willing to 'gain' from such a study in return for providing us with a framework for our enquiries.

4.5.2 The Response

The main purpose of the contacts was to find an environment in which managers are challenged with 'unstructured problems'. Clearly, they will need a structured process which may result in developing model(s), to enable them to reflect on their expertise to understand these problems. The models might then be implemented not only for learning, but also as decision aids for managers, or as a training aid for others in the organisation.

The only positive response came from British Airways (BA) Heathrow. Initial discussions with the Operational Research and Business Support Manager resulted in the following understanding:

1. In BA, they have experience with traditional business games.
2. The Operations Department Training Group have introduced computerised allocation models to train BA's staff on resource allocation problems.
3. They are interested in aspects of Information Technology related to their business.
4. The OR manager mentioned specifically that he is looking for a "Process which will result in model(s) such that a manager can see (through, say a computer terminal) the whole decision making process in parts of his organisation".

Two departments of BA [Motor Transport / Ground Support Equipment (MT/GSE)] and [Information Management (IM)] were named to need a process in the sense of the fourth point above. The main reason for the need was the perception of 'conflict' between the two departments on the implementation of computer models developed by IM for MT/GSE.

In this discussion, and the discussions which followed with the named departments, it became apparent that a specific type of model, namely a Decision Support System (DSS), was in their mind as a possible consequence of my intervention. Although I accepted that this could be so, the primary purpose would be to look at the learning process and learning models that could assist the managers concerned to appreciate their tasks more fully. Whether these would also constitute a DSS or only the basis for DSS could not be stated at this stage. It was stressed that by enhancing their learning would enable problems to be perceived more reasonably. But, there was still a need for some process to help them to formulate their problems.

Because of the OR manager's perception of the problems of the departments he mentioned and their links with DSS , it was necessary to examine the area of DSS both before and during the interaction with the departments. The next chapter deals with some of the principles of DSS which turned out to be relevant in the research that follows. The main research is described in chapters 6 and 7.

CHAPTER 5

DECISION SUPPORT SYSTEMS

5.1 Introduction and Conclusion

This chapter will discuss Decision Support Systems (DSS) as interactive computer - based systems aimed at supporting rather than replacing the management decision - making process. More literature exists than can possibly be read, assimilated and reviewed in the time available. What is quoted is a selective collection of ideas of recent date, chosen because they seem to be experientially - based, generic rather than specific in nature, and related directly or indirectly to the **learning process** of managers (both in the development and use of decision support). The fact that DSS are interactive processes implies a game of some sort in the general sense dealt with in chapter 4.

DSS are developed to deal with ill - structured problems and to improve the efficiency and effectiveness of organisations. They are seen as complementary to but different from other Information Systems such as Electronic Data Processing Systems (EDP) and Management Information Systems (MIS).

Various definitions of DSS are discussed which are based on both practical and academic experiences, and a 'definitional problem' is recognised. Interactiveness and flexibility are seen as the two key issues in the development of a DSS.

The DSS as a 'model', was found to face the common problem in all models,

the 'implementation problem'. Various reasons for this are outlined and an 'Evolutionary Strategy' is seen as the 'best' one to increase the likelihood of successful implementation.

5.2 Information Processing

A widely accepted view is that information processing is not always an end in itself. Rather it is a means to decisions. [Bonczek et al (1981)]. Bonczek et al view decisions as the 'finished products' of a human - machine information processing system in which information is only a 'raw material'.

In fact, all computer systems are implemented in organisations to help people to store, retrieve, update,...etc. data and information. Note that, despite the label, it is data processing that is generally being carried out, although it is hoped (or even planned) that the data become information for decision.

There are three widely confused terms concerning the use of computers in organisations. Based on a 'connotational view', the roles of Electronic Data Processing Systems (EDP), Management Information Systems (MIS), and Decision Support Systems (DSS), are distinguished by Sprague and Carlson (1982).

EDP has the following characteristics:

- " a focus on data, storage, processing, and flows at the operational level" ;
- " efficient transaction processing " ;
- " scheduled and optimised computer runs " ;
- " integrated files for related jobs " ;and
- " summary reports for management".

MIS has the following characteristics:

- “ an information focus, aimed at middle managers ”;
- “ structured information flows ”;
- “ integration of EDP jobs by business function (production MIS, marketing MIS, personal MIS, etc.)” ; and
- “ inquiry and report generation (usually with a data base)”.

DSS has the following characteristics:

- “ decision focused, aimed at top managers and executive decision makers ”;
- “ aimed at flexibility, adaptability, and quick response ”;
- “ user initiated and controlled ”;
- “ support for the personal decision - making styles of individual managers ”.

Recent advances in computer technology have resulted in a ‘problem’ of how to integrate information processing systems in organisations so that their outputs are ‘good’ decisions. Kami (1978), quoted in Bonczek et al (1981), has pointed out two possible directions to treat the above problem:

1. advances in computer technology (e.g. memory size and processing speeds); and
2. the methodologies of information - processing systems, which include
 - a. methodology for implementing mechanical information processing; and
 - b. methodology for integrating the mechanical information processing with the human elements in a human machine system.

The view is that technological advances are ‘revolutionary’ whereas method-

ological advances are 'evolutionary'. The following section will provide a thorough discussion of DSS.

5.3 Decision Support Systems (DSS)

5.3.1 General Background for DSS

Decision Support Systems (DSS) first emerged in the 1970's [Alter (1980), Bonczek et al (1981)] as a new, practical approach for applying computers and information to the decision problems faced by management. DSS is one of the most interdisciplinary fields within information systems research. [See Jarke (1986)].

As a discipline, DSS is largely engaged in research to:

1. identify design criteria for tools that can help improve the effectiveness of decision - makers;
2. develop techniques and approaches for evolving a DSS as the user, with the designer, learns through system development and system use;
3. observe the use and impact of a DSS in order to define better strategies for decision support; and
4. assess the opportunities and constraints for Decision Support in available and emerging management and information processing technologies. [Alter (1980)].

Alter states the following important questions that need special attention in the Decision Support discipline.

1. **The system:** What does the system do?

What is its technical configuration?

2.The problem: What problems does the DSS address?

How does it help the user?

3.The user: Who uses the system and in what manner?

4.The implementation: How was the system conceived, developed, and installed? What problems arose in the implementation, and were these problems addressed?

5.The impact: What impact has the system had?

How was the impact measured?

6.The evaluation: Why is or is not the system a success?

Keen (1981) argues that " ... most DSS evolve. There is no final system; an initial version is built and new facilities are added in response to the user's experience and learning ". Keen went on to stress that " The decision to build a DSS seems to be based on value, rather than cost. The system represents an investment for future effectiveness ".

At the early stages of research and applications in DSS, there were difficulties in both hardware and software. Recently, however, advances in micro-computers, colour graphics and telecommunication networks have become increasingly effective and available, as Keen (1986) has pointed out that " .. technology is not the bottleneck anymore " for DSS. What is now needed, as Keen argues, is to "... provide more active modes of support ... by focussing on supporting decisions that **really matter** in organisation ". (my emphasis - this implies some concentration on adequate problem - formulation).

The next section will examine various definitions of DSS which are based

on both practical and academic experiences.

5.3.2 Characteristics of DSS

Since the start of the movement of DSS, there exist various definitions of this new activity. An examination of these definitions will reveal that they agree that the system must be designed to aid rather than replace the functions of the decision - maker.

Some researchers in the field see DSS as an interactive system designed to be used by managers. Others concentrate on the support issue rather than on the technical characteristics of the system. Phillips (1984) usefully summarised by Bowen (1985), argues that a DSS is "... any system that helps the manager to **form preferences**, make judgements and **take decisions**". There are "... three main components to decision technology: **people**, mainly the problem owners who provide essential expertise; **information technology** that stores data, processes it into information and provides analysis; and **preference technology** that helps to clarify value judgements". Further, it is stated that " At the top managerial level, a decision - support system must include;

- those (including the top manager) who have information and preferences relevant to the problem, for which they have some responsibility;

- computer systems that aid modelling and analysis, and

- 'facilitators' who provide the framework in which preference judgements are encouraged and expressed, where possible in quantitative form, against a structure which represents the agreed, formulated problem".

Dickson (1980) reflected on the difficulties that arose when an international group attempted to define a DSS as part of their discussion on various issues in the DSS area. He pointed out that a major breakthrough occurred when it was recognised that " ... a process exists that leads to the production of a specific Decision Support System. Much confusion is caused when the title DSS is applied both to the process and to the resulting product ". It was then agreed that the process of Decision Support Engineering (DSE) has as its primary product a Decision Support System (DSS). DSE draws upon a number of disciplines such as Operational Research and Computer Science and others. Its product, the DSS, is a tool offering a dynamic, adaptive, and interactive process involving the decision maker.

In general we should expect a DSS to have one or more of the following characteristics [see Sprague and Watson (1975, 1976), Alter (1980), Keen (1980), Keen (1981), Sprague and Carlson (1982), Alavi and Henderson (1981), Keen (1986), Sprague (1986), Zmud (1986), Fick and Sprague (1980)].

1. The DSS is designed specifically to support decision making. It often addresses "what - if?" questions in a non - routine process which involves frequent and ad hoc analysis and fast access to data and models. The level of 'support' to managers is seen as an important issue in both research and practice, e.g., Keen distinguished the following levels of support

- passive support,
- traditional DSS support,
- normative support, or
- external decision support.[Keen (1986)]

2. The DSS must possess an interactive query facility with a query language that is easy to learn. The language enables the user to state the problem that he wants the system to advise him on.

3. The DSS is to be flexible and adaptable so that it meets the needs of many types of managers who work in different areas in the organisation. Flexibility is important because the environment, the tasks and user of DSS are subject to frequent changes: It may be

-flexibility to solve,

-flexibility to modify,

-flexibility to adapt,

-flexibility to evolve. [Sprague and Carlson (1982)]

Although 'flexibility' and 'adaptivity' are used interchangeably, some writers [see for example Methlie (1980)] points out that the DSS should be adaptive in the sense that it fits the user's requirement and that it should also 'stimulate (users') learning' .(his emphasis)

4. The DSS should utilise modern information processing and management science techniques.

5. A DSS may deal with a variety of problem areas or perhaps only one.

6. An important issue which differentiates DSS from other related information systems is the explicit linkage between DSS and some specific decision process.

5.3.3 The Definitional Problem of DSS

More recently, two researchers have argued the case of the absence of an established definition of a DSS. First, Stabell (1986) argued that "... trying to define what is unique about DSS technology is not a very useful exercise The key characteristics of DSS are linked to the context where such systems are to be used, to why and how the systems are developed and how the systems are intended to be used ...".

Secondly, Keen (1986) has proposed the following directions to 'solve' the the definitional problem:

1. to recognise the difference between definitions for understanding and definitions for action;
2. to accept that there can be no definition of decision support system, only of decision support because the technology that DSS draws on constantly changes, and there is no independent or idiosyncratic technical base for it;
3. to establish a version for DSS research which builds on what has been learnt about developing systems but that emphasizes what to develop and why.

There is as yet no agreed 'theory' of DSS, and some writers [see Sprague and Carlson (1982)] have preferred to talk about a 'framework' for DSS. In the light of their proposed framework, three levels of technology were identified, Specific DSS, DSS generator and DSS tools.

5.3.4 Implementation of DSS

As with many decision aids (e.g., models, systems, ...), DSS will encounter implementation problems, [see Methlie (1980), Alter (1980), Alavi and Henderson (1981)], and for a general discussion on implementation, see chapter 3 of this thesis.

Here I refer to two statements about the implementation of DSS. First, Alter (1980) called for an 'implementation risk analysis' which will identify an 'ideal implementation situation' and observe any deviations between the existing circumstances and the ideal situation. These deviations are called 'risk factors' and they decrease the chance for successful implementation. Alter identifies the following risk factors.

1. Nonexistent or unwilling users
2. Multiple users or implementers
3. Disappearing users, implementers, or maintainers
4. The ability to specify purpose or usage pattern in advance
5. The ability to predict and cushion impact on all parties
6. Lack or loss of support
7. Lack of prior experience with similar systems
8. Technical problems and cost - effectiveness issues

The second study was carried out by Alavi and Henderson (1981) to investigate alternative strategies for implementing DSS. They identified two strategies: **Evolutionary** and **Traditional**. The evolutionary approach is the one which " ... utilises judgement modelling as a means to create a felt need, to

provide insight into the decision process and the implied weighting of decision variables, and to establish a learning based, participatory implementation strategy". The traditional approach, in contrast, is characterised by "... a problem solving orientation wherein the DSS is portrayed as providing a valuable 'product' that can be theoretically justified".

Alavi and Henderson's study suggests that the Evolutionary Strategy is a more effective one than the Traditional Strategy. They also offer two guidelines for DSS designers.

1. The DSS designer **should** consider the nature of the learning activity which is being supported by the DSS.
2. The DSS designer **must** consider the sequence in which the learning process is carried out.

In addition to the above two studies, and for a quite different albeit related category of systems, namely Expert Systems (ES), Bell (1985) has stated the following reasons behind the failure of ES especially at the first stage of their development.

" The expert is not available "

" The expert is unable to communicate his ideas "

" The expert is unwilling to communicate his ideas "

" There is no expert "

The above reasons apply equally if we think of a DSS client rather than an ES. I have encountered the first three in the course of my research but not the fourth.

It can be argued that for a successful implementation of a DSS, both the

consultant analyst and the user(s) should fully cooperate in both the building and the maintaining of the DSS system. This issue was one of the central ones which affected the process of developing the DSS outlined in chapter 7.

5.3.5 Discussion

1. Although 'interactiveness' was seen as a very important feature of a Decision Support System, some writers [see Alter (1980)] preferred the use of the term 'responsiveness'.

Responsiveness is seen as a combination of:

- a. **Power** - the degree to which the system (including its human elements) can answer the most important questions.
- b. **Accessibility** - the degree in which the system can provide answers in a timely and consistent manner.
- c. **Flexibility** - the degree to which the system can adapt to changing needs and situations.

2. DSS can be developed for individual or group users. Issues such as communication and control in organisation will become of great importance within any group DSS. Support should, ideally, be provided at all levels in the organisation in order to assist integration between the levels. DSS should also support all phases of the decision making process.

3. The experiment and the analysis reported in chapters 6 and 7 are consistent with and support the ideas outlined in these chapters. It was found that in real organisations, managers are engaged in creating 'decision situations' and

are dealing with ill - structured problems. Hence, providing them with 'flexible' and 'adaptable' DSS is an important task which needs a thorough analysis prior to the development phase. The analysis should aim at understanding the management task environment in order to develop a 'better' model of support.

4. The definitional problem in DSS may be caused because the words DSS have certain 'intuitive validity' in that any system that support a decision is a DSS. Another cause of the problem is that people from different backgrounds view DSS quite differently.

5. Based on the ideas outlined in this chapter, it can be argued that a DSS is not a 'technical solution' to a 'technical problem'. It is not primarily developed to collect and manipulate data and information although it might sometimes do some of this. Rather, it is a device which aims to support the decision process and its success will depend on the principles of its development and the manner of its use.

A good DSS provides a learning process and its flexibility should enable this learning to be made effective by modifying the DSS. The analyst as a facilitator may be required to help with the process that leads to definition of the changes required.

CHAPTER 6

THE BA EXPERIMENT

6.1 Introduction and Summary

This chapter describes the first stage of development of the interaction in the real environment briefly introduced in section 4.5.2. The total interaction took place between February 1985 and July 1986, including the studies reported in chapter 7. The chapter reports the first use of the Bowen problem formulation methodology [see Bowen (1984)] in an industrial environment with managers facing 'unstructured problems'.

A key feature of the methodology is the development of conceptual models by using a notation specifically devised for this purpose. In this chapter conceptual models are developed as part of the inquiry and proved very efficient as a means for communication between the analyst and the client group. They enable the analyst to structure and reduce data into information to facilitate the feedback process to the 'problem owners'. This contributed to changing the 'nature' of what the clients originally thought to be the problem: further the analyst who is a student was treated as a 'consultant'. The successful interaction has also resulted in deciding on one of the many problems identified to be explored in detail [chapter 7].

6.2 The Environment

This is centred around two departments of British Airways (BA) Heathrow as shown in diagram 1.

6.2.1 MT/GSE Department

This department is responsible for all scheduled maintenance and emergency repairs of about 3000 vehicles and ground support equipment of Ground Operations London (GOL). MT/GSE employs a large number of qualified people in different aspects of technical and organisational functions. Workshops are distributed, in general, close to the users' areas, and controlled by Senior Maintenance Engineers (S.M.E.) in order to provide efficient service. Each workshop has the responsibility to manage its resources in order to meet a particular schedule planned by the Maintenance Control department. They draw spares from central and forward stores.

MT/GSE is a user of two computer systems, **STOCK** and **SERVE**, which were developed by the Information Department (IM).

6.2.2 Information Management Department (IM)

This department is responsible for the structure and type of software and hardware of all computerised information systems developed for MT/GSE and other departments in BA. These systems are supposed to be reliable and to meet user's requirements. IM's computer support group is responsible for providing users with efficient training in the operation of computer systems. Their ideal

is that every user will be able to contact a named representative in case any problems arise.

6.3 Computer Systems Implemented by MT/GSE

6.3.1 SERVE

This system is designed by IM for MT/GSE to enable their operators to:

- a- report vehicles unserviceable (U/S);
- b- monitor the progress of the vehicle through the workshops until released;
- c- check the availability and serviceability of vehicles;
- d- plan normal service checks;
- e- show the number of vehicles of a particular category required within a

particular control section for each day of the month;

f- show the seasonal peak number of vehicles required for each type of vehicle, for each user;

g- inspect the current number of vehicles and equipment held and automatically update records. See SERVE (1985).

It is mentioned later that MT/GSE had no difficulty in operating this system, and this may well be because they participated in its development.

6.3.2 STOCK

This system was initially developed for BA's Aircraft Engineering department to carry out all the required accounting and control operations for about

600000 engineering stock items. BA's policy required that all stocks of items brought, stored and used within the airline should be controlled by a common computerised stock control system **STOCK**. See Johnson (1981). Despite the fact that both the stock and type of service provided by MT/GSE to the rest of BA are different from that of A/C Engineering department, MT/GSE was asked in April 1983 to implement the original **STOCK** system, without certain improvements available to A/C department. In MT/GSE, **STOCK** is implemented in the stores department to control about 60000 spare parts. The other user is the supplies department which is responsible for ordering the spare parts from some 400 suppliers. It is easy to imagine that, no matter how sophisticated is the **STOCK** system, any errors in the input of data concerning spare parts, will create serious problems to the supplies department.

6.4 Background to the Problem

In the middle of 1984, a new MT/GSE General Manager was appointed. He introduced a considerable reorganisation of the department and started to examine various problem areas. He was told by his staff that MT/GSE were given the **STOCK** system which is designed for another user within BA, and there was a lack of back - up support provided by IM, which caused problems in the availability of spare parts to support the maintenance process. He also understood that IM were not prepared to tailor **STOCK** to MT/GSE's needs.

The General Manager had no option but to set up in August, 1984 a Special Stores Working Group (SSWG) to investigate the MT/GSE stores and

the STOCK system. The SSWG were given six months to identify better:

- a- computer systems;
- b- supplies interface;
- c- stores organisation and methods.

The SSWG consisted of four Airline Engineers and was headed by the Manager of stores and special projects. After six months of study and analysis both inside and outside MT/GSE, the SSWG published a report in February, 1985. Their main recommendations were:

- a- MT/GSE could implement a stand - alone stock control system. The cost as estimated by an IBM consultant would be about £25000 (for both software and hardware);
- b- IM and MT/GSE have to cooperate to tailor the current STOCK system to meet MT/GSE needs.

Some action had already been taken by IM in a report published in October 1984. Their recommendations were:

- a- IM should commit resources to tailor STOCK to meet MT/GSE needs;
- b- MT/GSE should take actions to improve data quality into STOCK.

The above two studies were completed prior to my intervention which was facilitated by the Operational Research and Business Support Manager in BA [see diagram 1] who helped in the first formal discussion with IM management. IM then arranged my introduction to the MT/GSE management. Both managements agreed to the broad research programme [see section 4.5.1] and

as a first step relevant documents about STOCK and SERVE systems were obtained.

6.5 The Analyst Intervention

The initial discussions and the documents acquired, especially the SSWG report, indicated that there were contradictory views about the reasons behind the 'failure' of MT/GSE's version of the STOCK system to meet their needs. At this stage, one may define the client's 'problem' as 'the need to develop a new computer - based stock control system'. To examine learning processes in such a context might have been an impossible task for the experiment required. It had taken a group in IM department nearly five years to develop and implement the current system in BA; however, the definition of the problem as a stock control deficiency was not yet justified. There was a need to talk to 'various' managers who had a role in developing the current system and who are using it. I therefore started a very important stage of inquiry to seek possible explanations for the following:

1- Who uses the computer systems to get what results? (this was to understand the nature of delays and how they are treated in the STOCK system).

2- How does information for management come to managers (a) from the computer models; (b) from others as a consequence of information from the computer models ?

3- Do managers expect advance warning that some one is not satisfied by MT/GSE or IM services?

4- What control do management exercise over the operations they are responsible for, and how?

5- How did MT/GSE management become aware of the need for the SSWG study?

6- How do management plan to stop things going wrong? or put them right quickly?

7- What data is required by whom to identify; (a) any recurrence of the identified shortcomings; (b) some overall picture of interactions that might lead, unless improved, to as yet unidentified shortcomings.

Because there were various proposed changes (still to be properly discussed between IM and MT/GSE) in the current STOCK system as a result of the internal study, I also decided to find out:

- 1- Whose responsibility is it to make these changes?
- 2- What authority (if other than their own) do they need?
- 3- Are there any things needed as a consequence of answers to the above?

This framework for the inquiry served later to identify other 'problems' further to what was initially thought to be a problem. It also prevented narrowing the scope of the inquiry to a specific direction at an early stage.

6.5.1 The First Round

Because of the wide range of experiences and contradictory views as to why the STOCK system was not functioning properly, the need arose for a process which would help in structuring and reducing data into information for both

communication and further exploration of the managers' needs for decision aids. In other words, I realised that my clients were facing 'unstructured problems' [see chapter 2] for which a structured methodology should be applied.

At this stage of the inquiry, 'various' people had stated their views quite openly and clearly and the interviews were tape - recorded, but, for confidentiality reasons, the data acquired cannot be reported here in detail. The following members of MT/GSE department have participated in this stage.

The stores and special projects manager [see diagrams 3 and 3 first revise];

The senior stores supervisor [see diagrams 4 and 4 first revise];

The stores staff union representative [see diagram 5];

The maintenance control manager [see diagram 6];

The MT/GSE systems developments engineer [see diagrams 7 and 7 first revise];

Two senior maintenance engineers [see diagrams 8, 9 and 9 first revise];

The vehicles and equipment manager [see diagrams 10 and 10 first revise];

The operations manager [see diagrams 11 and 11 first revise];

Others outside MT/GSE also participated:

The accountant in the finance department, responsible for MT/GSE affairs [see diagrams 12 and 12 first revise];

The supplies department manager and his spares / maintenance support buyer [see diagram 13];

The IM manager and his senior analyst programmer [see diagram 14].

The initial process of building the diagrams was difficult as it was necessary to reduce data into information coded in each diagram for feedback to their 'owners' and to the members of the management group as a whole. What they regard as information could not be fully clear at this stage. I had to introduce two additions to the notation; namely, the delay and lack of communication and purposeful action. The intention was not to extend the notation beyond general and simple terms. See Bowen (1984).

Although those who were involved provided me with a rich picture about possible problem areas, they wanted to know the direction of my research and the possible 'solutions' to their problems. At the same time I wanted to present my analysis of the data I had. The MT/GSE management group agreed to a meeting, and it was attended by: Professor K. Bowen, the Deputy General Manager, the Stores Manager, the Vehicles and Equipment Manager and the Maintenance Control Manager.

A brief introduction to the Bowen problem - formulation methodology and its diagrammatic notation [see figure 6.1] and the problem of problem formulation [see diagram 2] were the first two issues which were used to draw the management's attention to the difficulty in defining their current problems. The discussion, which was aided by diagrams 3 through 13 was very encouraging. With reference to the STOCK system I pointed out to them that there will be actions by people on their computers which may be quite good and definite, and there are many others which are distorted. The output from the computer

will be in some cases understood, and in other cases not understood. In the latter, it is not necessarily that the computer system is bad, but operators may not act correctly or purposefully, which might be a result of bad training.

The management group soon realised that my inquiry was totally different from a traditional OR investigation which might well have concentrated, say, on providing another version of the STOCK system. Despite the apparent simplicity of the diagrams and the fact that they only contain issues said to me earlier by individuals, they seemed to be aware of some of these for the first time. Throughout the presentation, members of the group asked very serious questions about the analysis and the methodology. More important is that they were engaged in discussions about possible 'problems' which were not yet identified by the analyst. The status of communication between the MT OPS manager and the MT/GSE general manager [see diagram 11] was seen as a very important matter which needed special attention. They also indicated that they did not face any problems with the SERVE system for which they had participated in the early stages of design, an issue which is explored in detail in chapter 2 of this thesis: management participation in building any models is one of the key factors for successful implementation. It was also indicated that the communication between IM and MT/GSE had improved considerably over the period of my interaction with them: the present discussion was not the first influence.

Because of their considerable interest in the first analysis the management group agreed that I should continue the inquiry. They asked specifically if I could possibly find out how their customers, for example the terminals, felt

about MT/GSE service. Their initial perception of the problem had changed considerably.

A similar presentation was arranged for the IM department with the presence of the Senior Operational Research and Business Support Manager [who had arranged my introduction to the organisation, see diagram 1]. Perhaps the most important result of this presentation was this Manager's interest in the findings. He said that he had learnt a lot about the organisation and the problems of the two departments and expressed his support for my research. He also discussed the possibility for extending this work to examine potential problem areas in other departments in BA. The possibility of developing a computer graphics software to process the notation used with the Bowen problem formulation methodology was also discussed provisionally.

6.5.2 The Second Round

This was intended to extend the diagrams through further sessions in order to get insight into:

- the critical channels of information;
- breaks in the links of communication;
- can managers identify their information needs?;
- the nature of delays MT/GSE is creating to other departments;

There were also two very important additional interviews with

- two Senior Managers in one of the customer Groups [see diagram 15];

and

- the MT/GSE Maintenance Manager [see diagram 16]

The MT/GSE General Manager was invited to a formal presentation, which was attended by Professor K. Bowen, the stores and special projects manager, the vehicles and equipment manager, the supplies manager, a principal analyst programmer in IM and the MT/GSE accountant [a link with the finance department].

Those attending were taken through chosen diagrams. They reacted very seriously to the information contained in each diagram and they were engaged in important discussions about possible problem areas which were not clear to the General Manager or his group before.

Following are quotations from reactions to the diagrams presented in the this presentation.

Diagram 3 First Revise: The stores and special projects manager indicated that MT/GSE did not had a hand in developing STOCK and they did not understand its main functions when it was first implemented. The stores and special projects two roles were not clearly identified.

Diagram 4 First Revise: The MT/GSE General Manager agreed to the need for a training group within MT/GSE to train the staff in the use of the computer systems.

Diagram 11 First Revise: The main issue which dominated the discussion was the status of communication between the MT/GSE General Manager and the MT OPS Manager. It became clear later [see diagram 17] that there is a distorted communication between the two managers.

Diagram 14: The MT/GSE General Manager claimed that he did not understand what IM are doing. The IM representative replied that IM do not

understand how MT/GSE classify maintenance priorities to

(a) V.O.R. Vehicle Of the Road, which is awaiting one specific spare part to be operational; and

(b) V.I.P. Vehicle In Progress under routine maintenance in the workshops.

Diagram 15: The General Manager was surprised at the T1 management's perception of no clear communication with him. Their intention to communicate directly to the workshops was stressed.

Diagram 16: Although the diagram suggests that the Maintenance Manager is at a centre of communication and he is satisfied with all his information channels, the General Manager wanted to know the status of communication with both IM and MT OPS departments.

The General Manager was impressed by the information provided by the diagrams and by their value as a basis for focussing discussion. He said " **I have learnt something new** ". I immediately requested a one hour interview with him to get his perception of the problem areas in his organisation. He responded by offering me two hours and cancelled some of his other important commitments to give me an opportunity to get his views.

The interview took place one week later. The General Manager talked about very important issues related to how he managed and controlled his organisation. To interpret the data obtained into diagrammatic form took a considerable time because of the extent and detail of his stated concerns. Some of the more important issues are listed below.

1. One of the special projects manager's responsibilities is to aid the mutual understanding of problems and difficulties between MT/GSE and their

customers.

2. The main area which needs better cooperation with MT/GSE customers is that of long term planning.

3. The General Manager does not trust the terminals planners because they have different and conflicting ideas.

4. Because of his many commitments, the General Manager finds it very difficult to fit every thing into his limited time. He also feels that the load on his managers is high.

5. The General Manager would like to see MT/GSE as an organisation selling its service to the rest of the airline (independently or as a part of BA).

I have interpreted the data obtained from the General Manager into Diagram 17 which is a model of the perceived situations of his concern, specifically the status of communication and purposeful actions and the potential problem areas in his department. This, and the experience gained from the other diagrams, led to a point where I had to make a decision as to where all this was leading, and what was their problem?. I needed to be clear about this before any feedback of diagram 17 to the General Manager.

6.5.3 Where to Go from Here?

It would be very useful at this stage to be able to give clear measures as to what success I had in stimulating the management group learning process and understanding their problems. There were in fact strong indications that these had taken place because:

a- the General Manager has devoted a considerable time to participate in

the experiment.

b- the members of the management group have also contributed by providing a great deal of data, as used in building the conceptual models; and

c- communication between IM and MT/GSE had already improved to the extent that STOCK was no longer a serious issue.

The inquiry revealed the following 'family' of possible problem areas:

1. total data on occasions that MT/GSE customers have not been well served;
2. failures of communication of data and appreciation of purpose;
3. main requirements of MT/GSE for appreciation of shortcomings in the processes within MT/GSE;
4. effect of top management decisions on 'load' on MT/GSE departments;
5. communication from outside MT/GSE to inside MT/GSE;
6. training functions in STOCK procedures.

All the above problem areas are issues which the General Manager and his deputy have to concentrate on in order to 'resolve' them. However, there was something that could be done in a form of a general DSS that could encapsulate all the above problems in general terms. In the discussion with the General Manager which was guided by diagram 17, I proposed the idea of a system which would help the General Manager and members of his group to communicate and record key aspects of importance to their organisation, either individually or as a group. The details of the system are described in chapter 7.

6.6 Conclusions

1. The research described in this chapter has indicated that the Bowen problem - formulation methodology is effective for its stated purposes [see chapter 2]. The methodology involves the 'problem owner(s)' in the process of analysis to formulate their problem. This provides a rich picture about other possible problem areas.

2. The models developed using the notation which is devised by Bowen and extended here, are concerned with organisational matters, with information flow and purposeful actions. They enhanced the managers' understanding of major weaknesses in important links of communications and helped to identify where certain actions have to be taken. These models have received substantial support from all members of the client group.

3. The diagrammatic models helped also to change the nature of what was initially thought to be a problem. The 'failure' of the STOCK system became awareness of the lack of proper communication and control.

4. My application of the Bowen problem formulation methodology necessitated the introduction of two very important symbols. These are the delay and the lack of both communication and purposeful actions. See figure 6.1. The rules for using these two new symbols are exactly the same ones which govern the use of both good communication and purposeful actions.

5. The 'learning' model (or game) turned out to be the OR process as it was practised by me. The OR process as a game has been discussed by Bowen (1978).

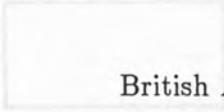
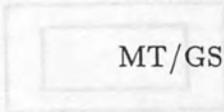
6. The management learning process was enhanced and the methodology acted as a framework for this learning: it related to the actual needs of management to reflect on their activities in a way that any conventional game could not. Importantly, it was dealing with current and changing activities as they arose.

7. The process of collecting data and building diagrams was difficult. I encountered the first three issues proposed by Bell (1985) [see section 5.3.4] during the course of the experiment reported in this chapter. However, the use of a structured method, namely Bowen's problem formulation methodology has enabled me to overcome major difficulties in the process of structuring and feedback of data.

8. As a result of the interaction, the status of communication between MT/GSE and IM has improved considerably. Computer systems will be tailored to meet MT/GSE needs.

9. A proposal for a Decision Support System was accepted and is explained in detail in chapter 7.

ABBREVIATIONS

BA		British Airways
IM		Information Management Department
MT/GSE		Motor Transport / Ground Support Department
MT OPS		MT/GSE Operations Department
V. and E.		MT/GSE Vehicles and Equipment Department
Supplies		BA Supplies Department with special responsibility to MT/GSE
MT/GSE Customers		Terminals 1, 2, 3 and 4
		Cargo Terminal
		Aircraft Engineering
		MT/GSE Operations
STOCK		Computer-Based Stock Control System
SERVE		Serviceability of Vehicles and Equipment Computer-Based System
MEM/FOCUS/FIND		Computer-Based Information Systems



No communication



No purposeful action



General interaction or influence



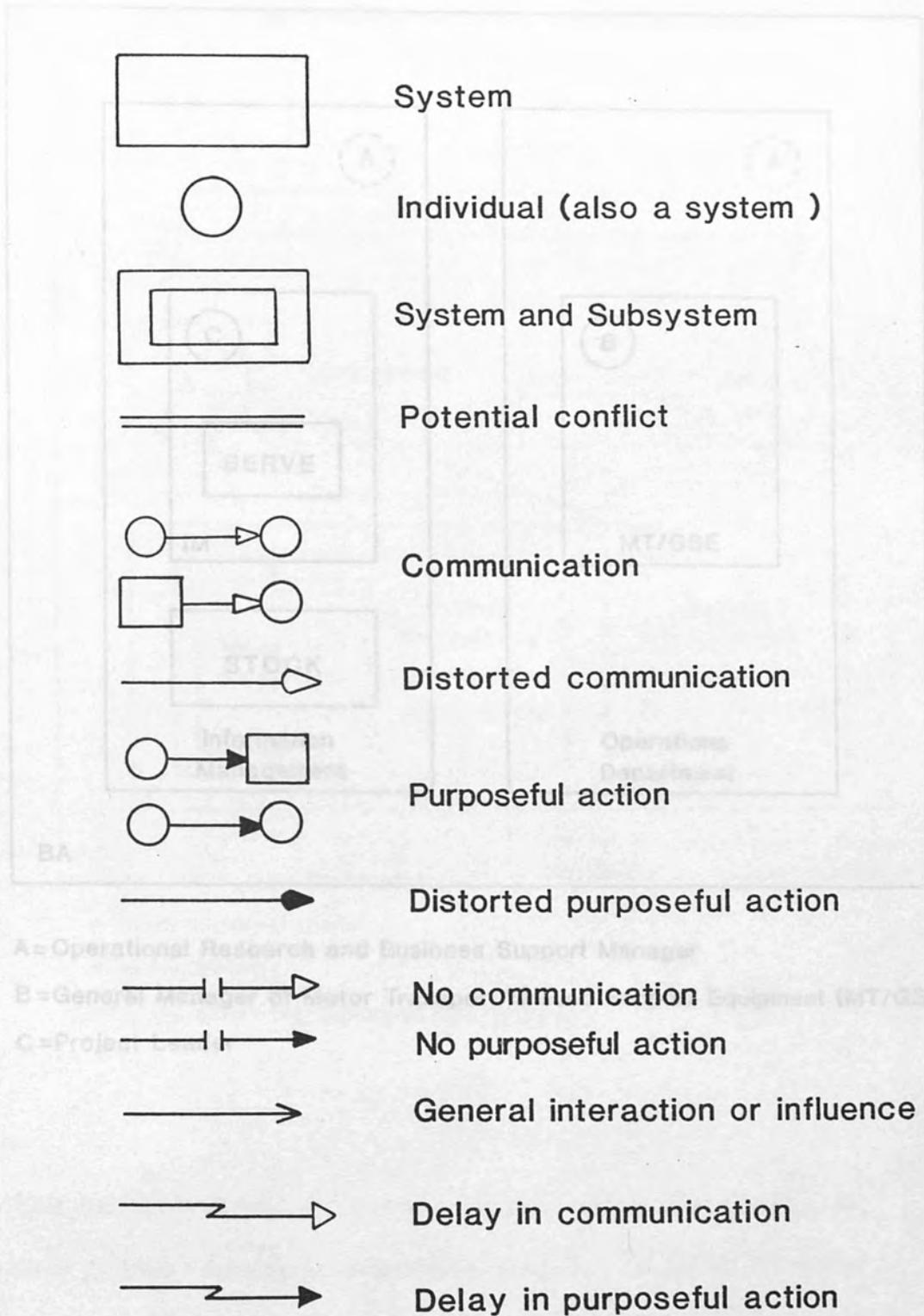
Delay in communication



Delay in purposeful action

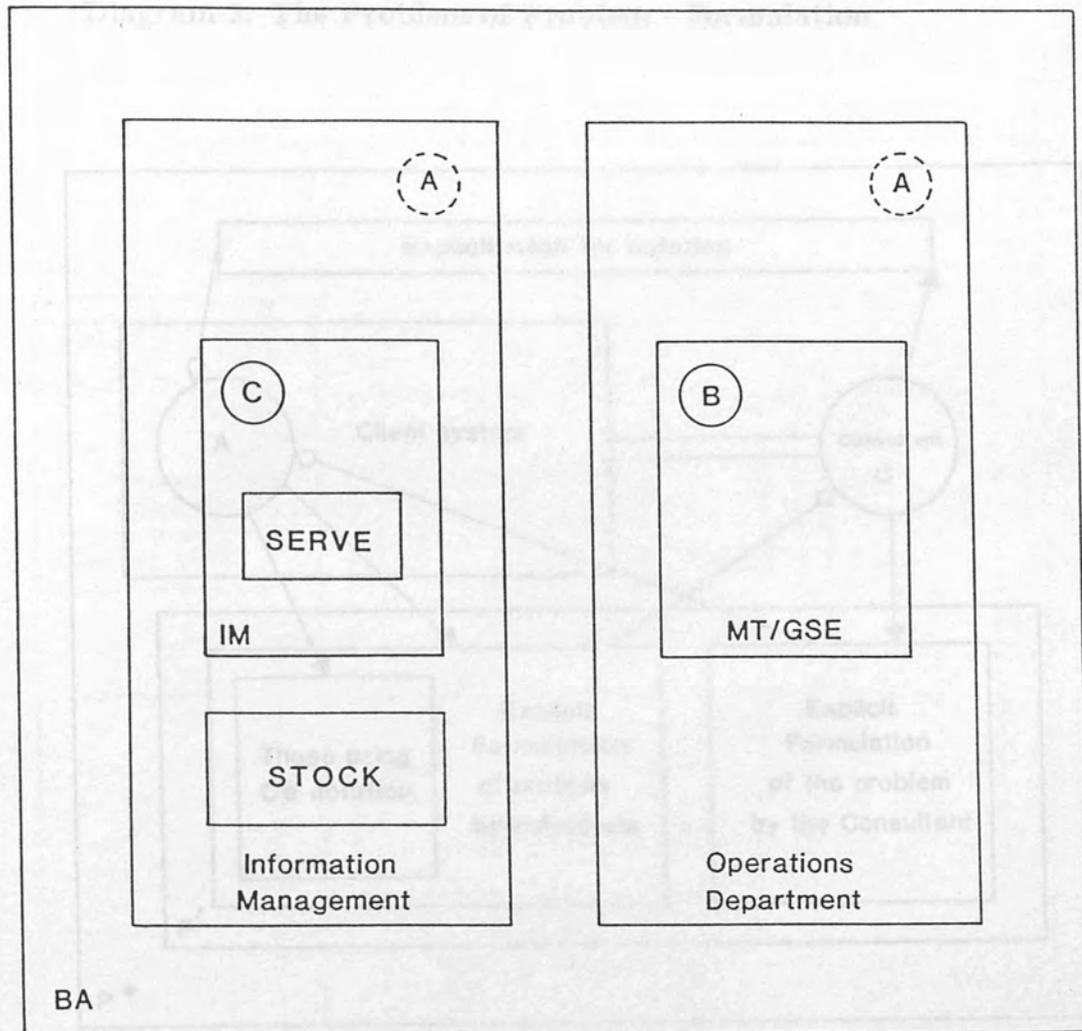
Arrows are used to emphasise interactions

Figure 7.1. Notation



Arrows are used to emphasise interactions

Diagram 1. The Environment



A=Operational Research and Business Support Manager

B=General Manager of Motor Transport/Ground Support Equipment (MT/GSE)

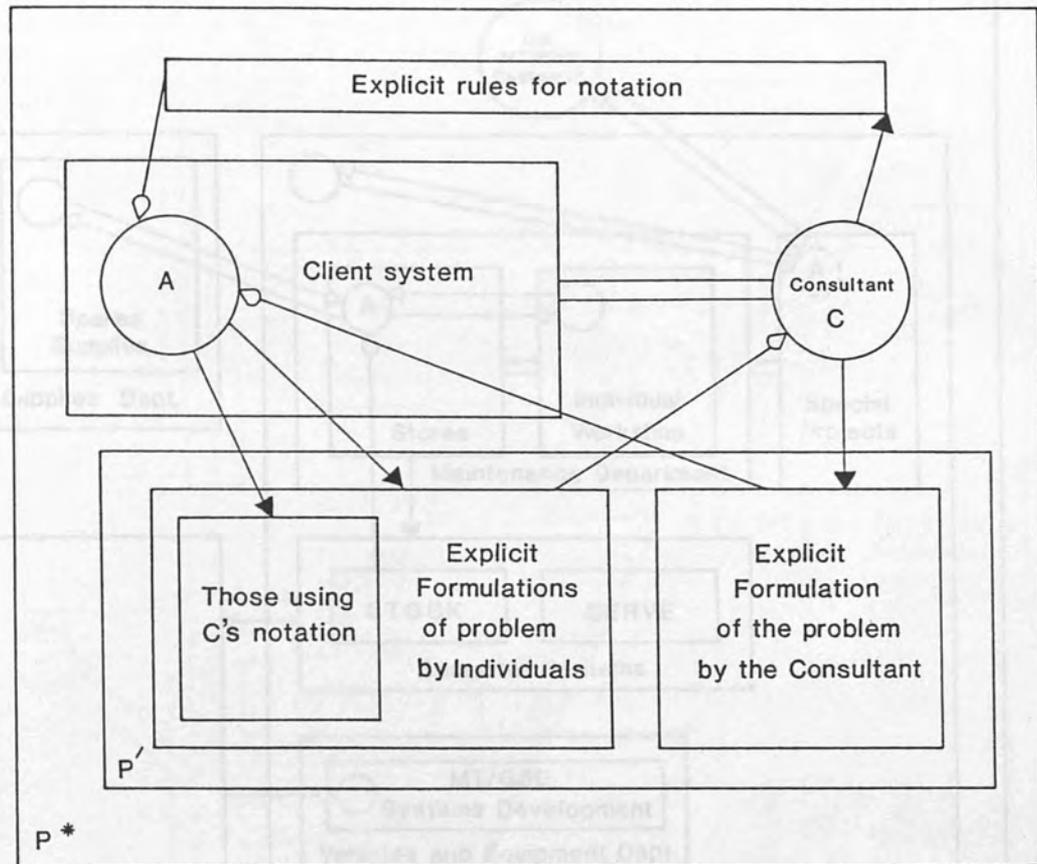
C=Project Leader

Note:

This diagram is derived from the process of conducting the process of problem-formulation with a consultant (see Powell [1981a]).

The logic behind the diagram will be discussed in more detail in chapter 7.

Diagram 2. The Problem of Problem - Formulation



A is any individual client

P* is my problem

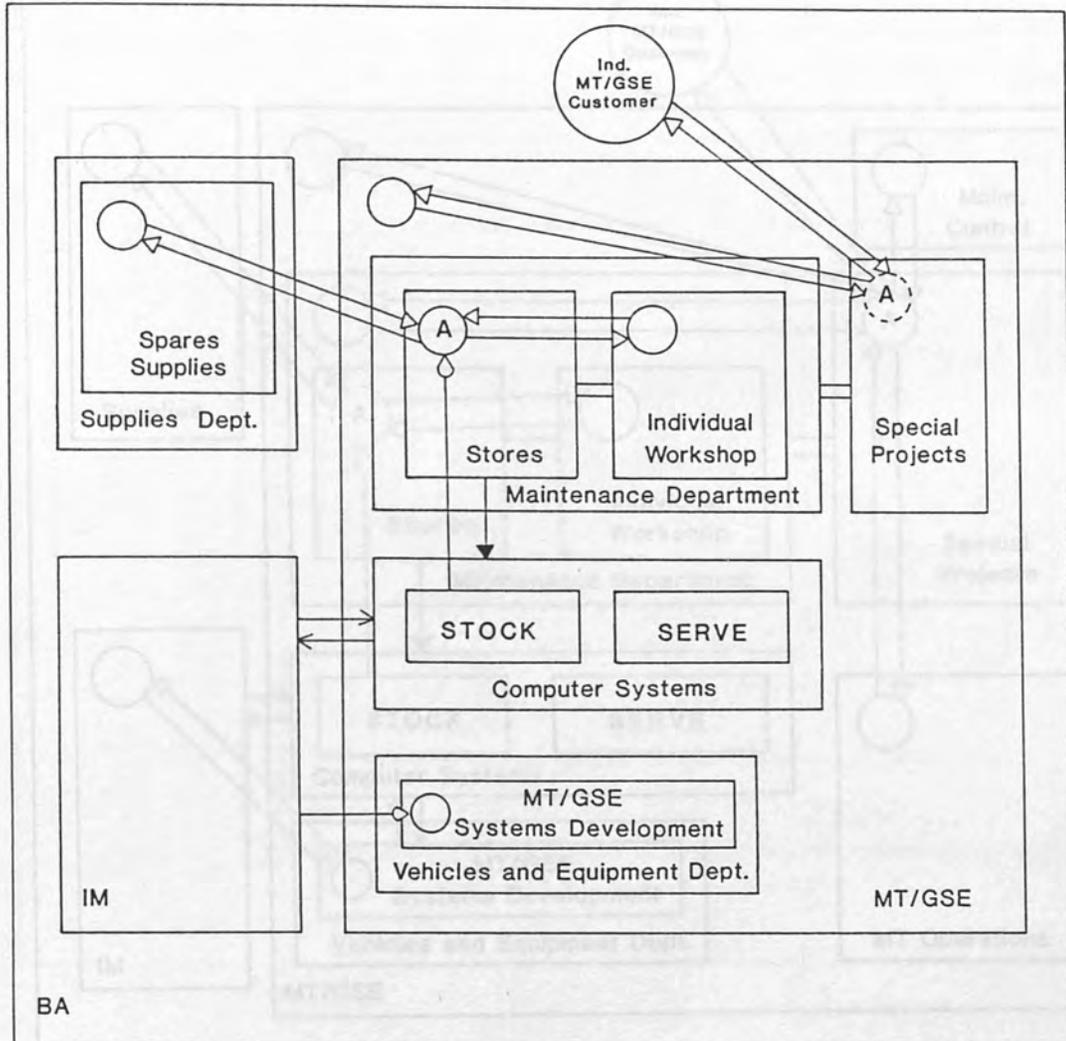
P' is the developing picture of their problem

Note:

This diagram is devised to "... encapsulate the essence of conducting the process of problem - formulation with a client group ". [See Bowen (1981a)].

The logic behind the diagram was followed in the process of inquiry conducted in chapter 7.

Diagram 3. The Stores and Special Projects

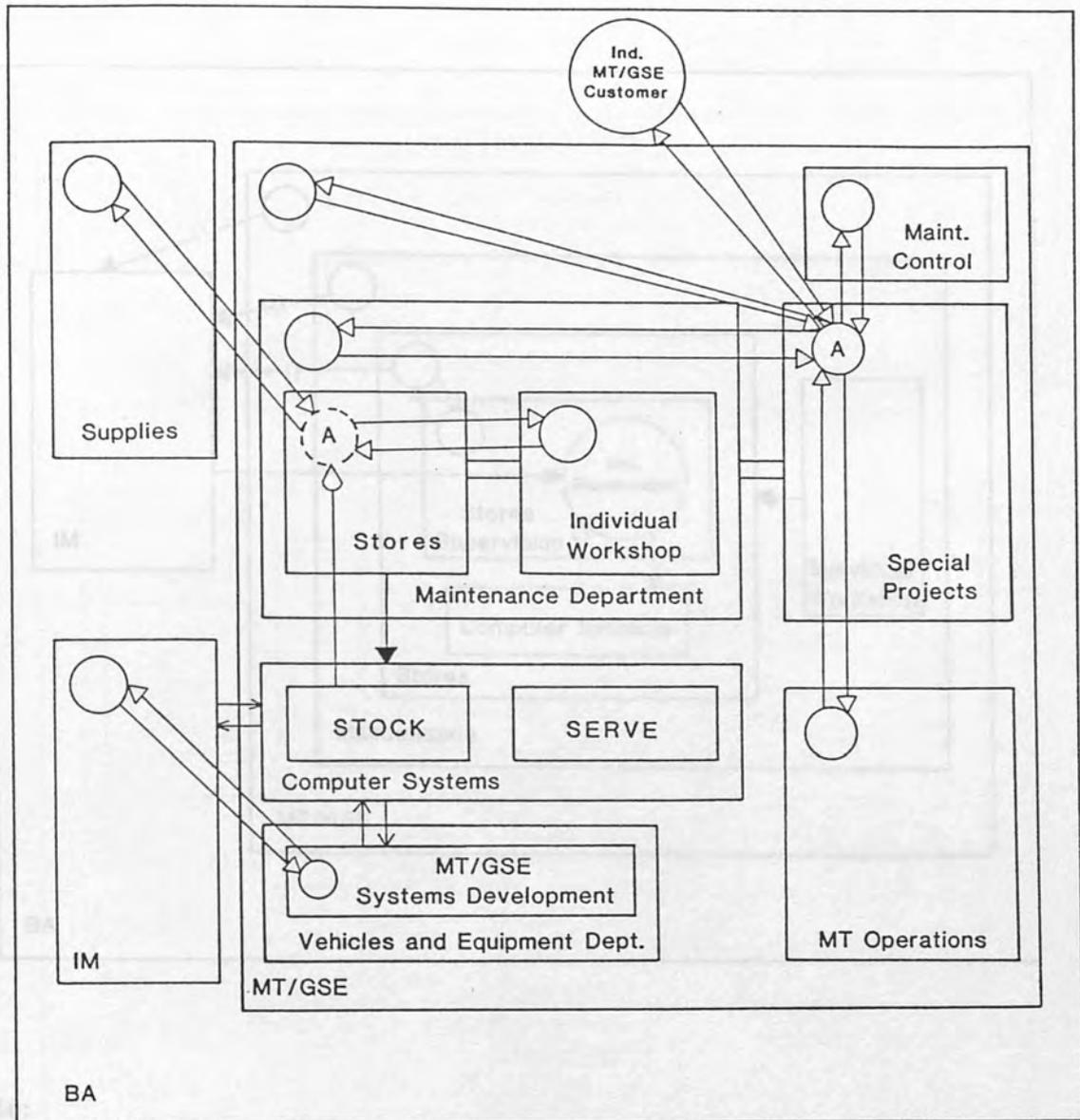


A=Stores and Special Projects Manager

Note:

This diagram is my interpretation of data obtained from the stores and special projects manager. The diagram indicated that the manager does not see any clear communication between MT/GSE and IM departments. His special projects role is not defined.

Diagram 3. First Revise

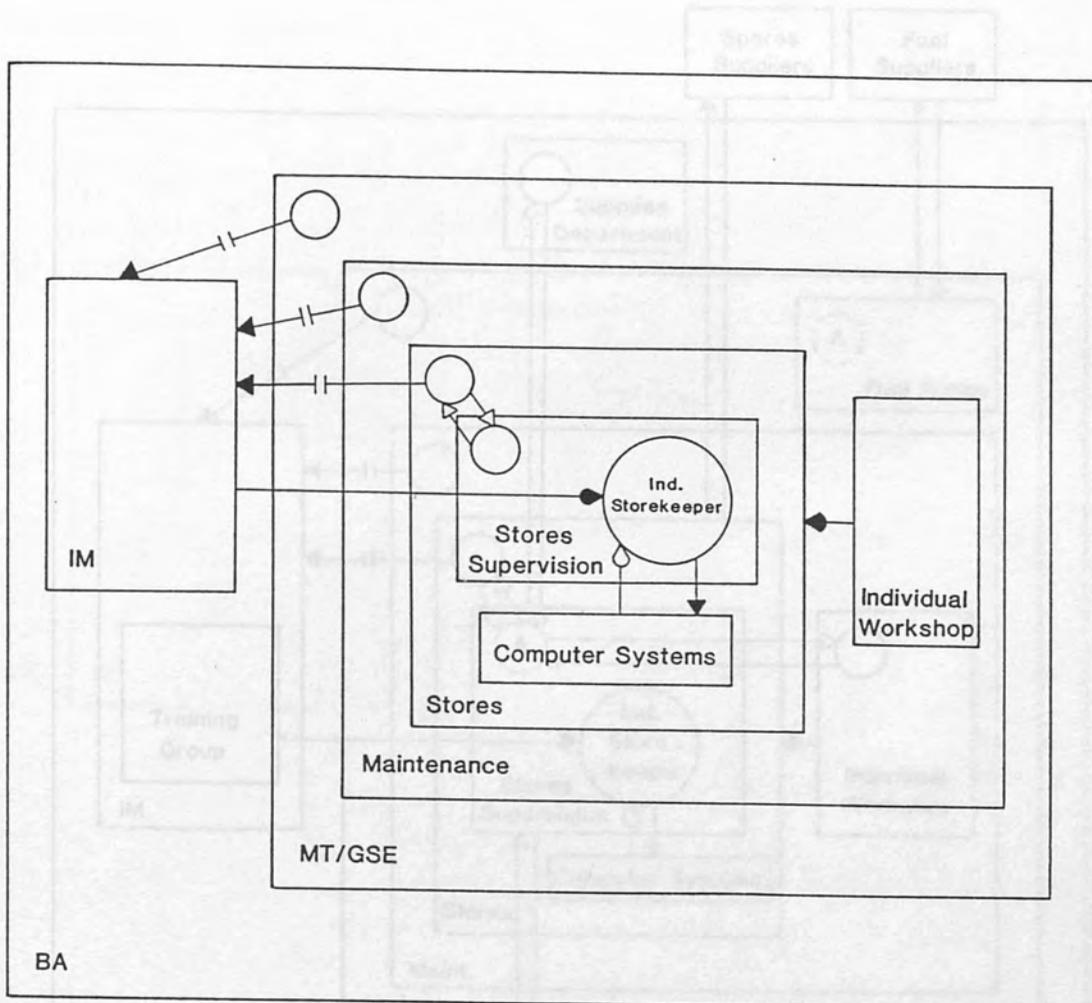


A= Stores and Special Projects Manager

Notes:

1. The manager considers MT OPS as an MT/GSE customer.
2. He believes that the stores are 98% efficient.
3. He is after the MT/GSE stock disposal programme.

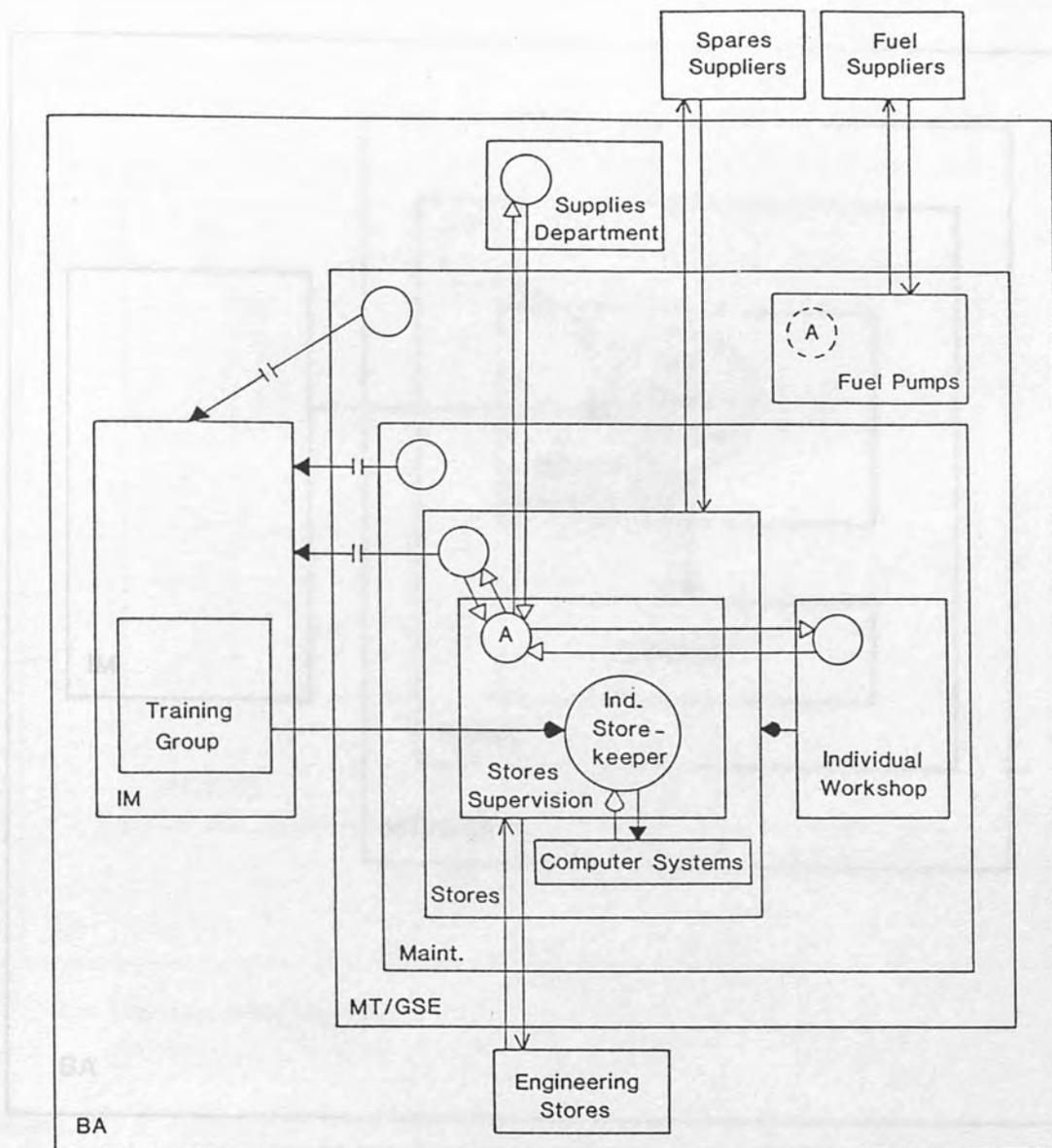
Diagram 4. The Stores Supervision



Note:

The senior stores supervisor believes that MT/GSE can run an in - house training course in computer systems provided that the IM department will update them on any enhancements of the current computer models.

Diagram 4. First Revise

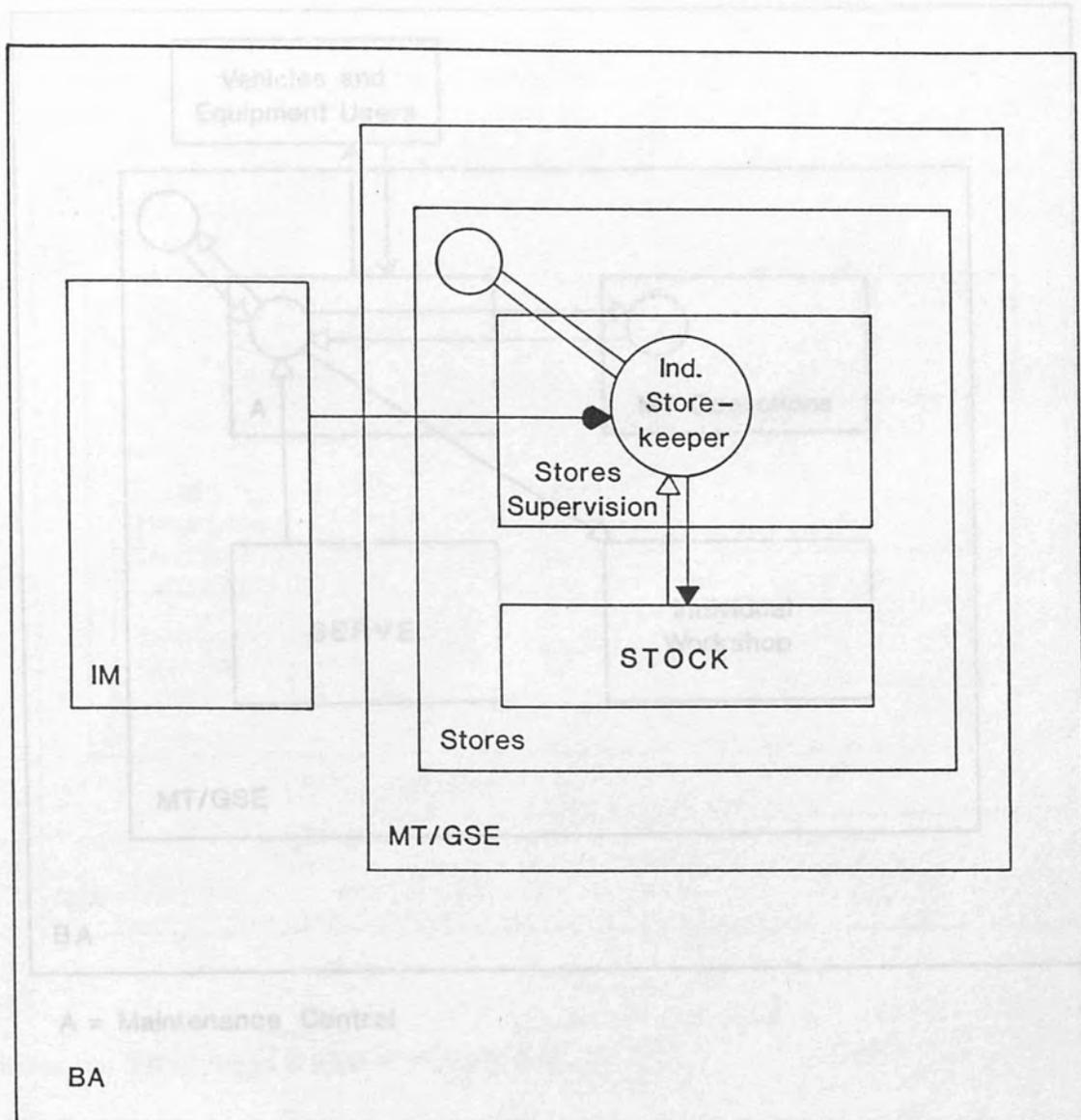


A=Senior Stores Supervisor

Note:

The stores and special projects manager should have one role only because, as it is clear from the diagram, his deputy [the senior stores supervisor] is responsible for many functions in the department.

Diagram 5. The Union Representative



Notes:

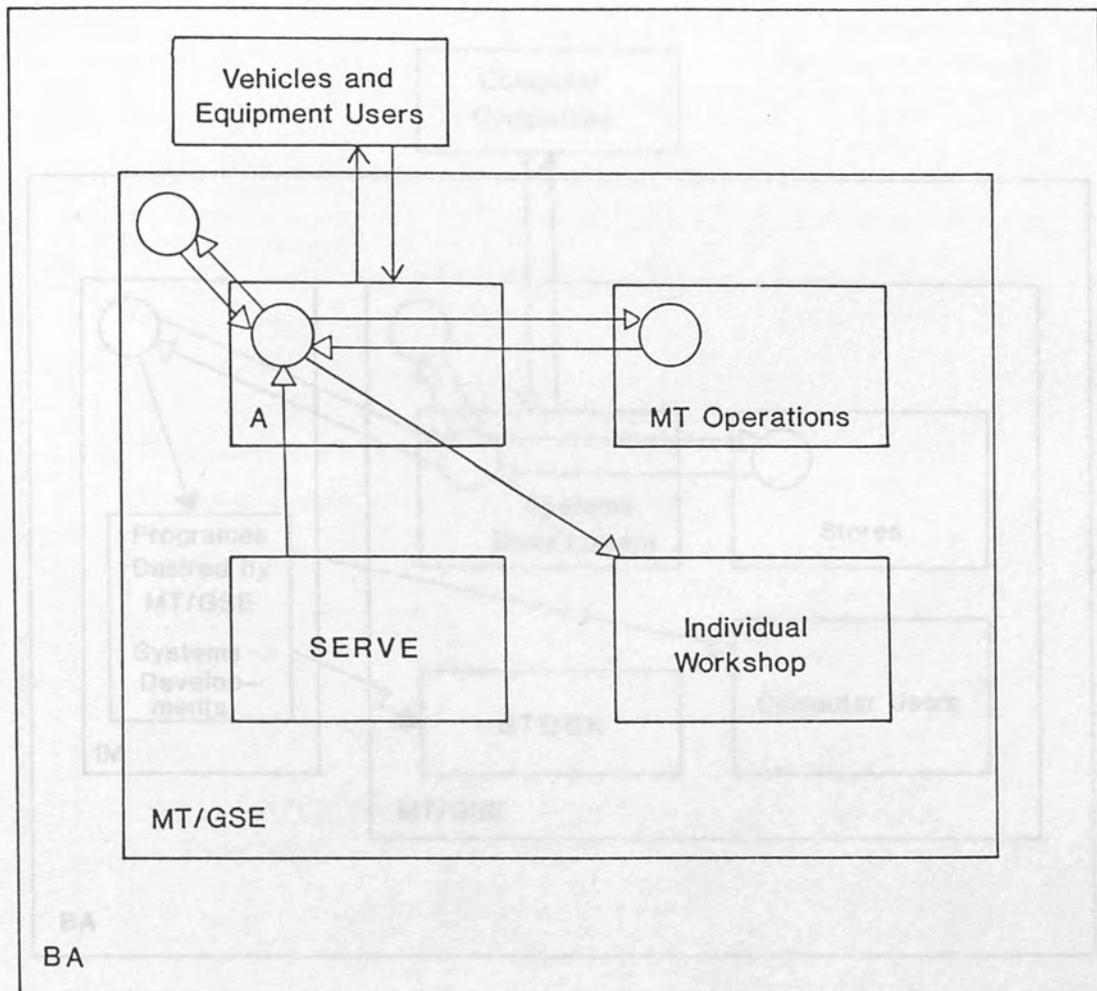
Notes: Maintenance control activities include: workshop booking, maintenance

1. Management do not recognise stores as a main service to the workshops.

They are only concerned with the workshops output.

2. Aircraft Engineering stores have more facilities than the MT/GSE stores.

Diagram 6. The Maintenance Control Department



A = Maintenance Control

Notes on Diagrams 7 and 7 First Revised

Notes: MT/GSE will no longer need a stand-alone computer-based work

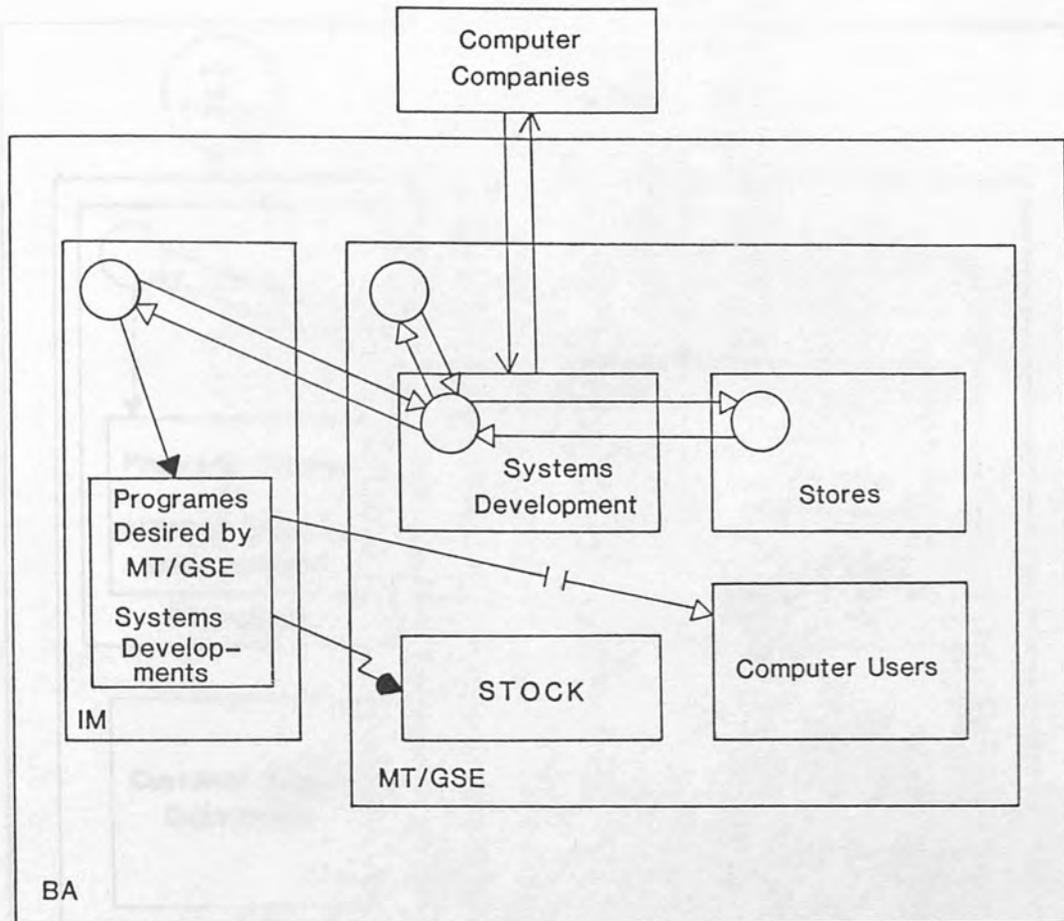
1. Maintenance control activities include; workshop loading, maintenance scheduling, individual vehicle costing, and administration.

2. The maintenance priorities are not clear.

3. FIND is a software package which helps to find out aircraft schedules.

4. FOCUS is a software package which helps to produce meaningful reports.

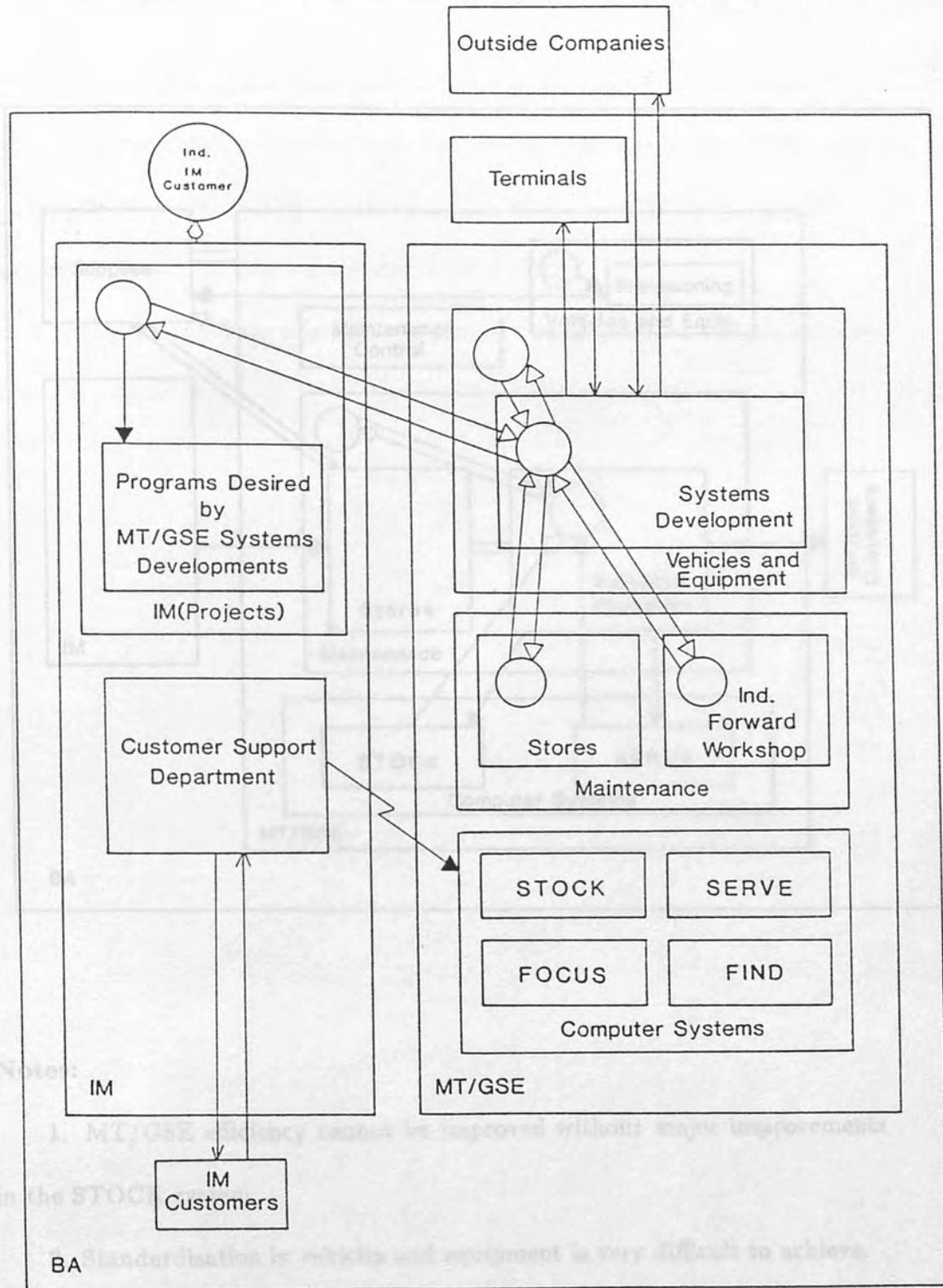
Diagram 7. MT/GSE Systems Developments



Notes on Diagrams 7 and 7 First Revise:

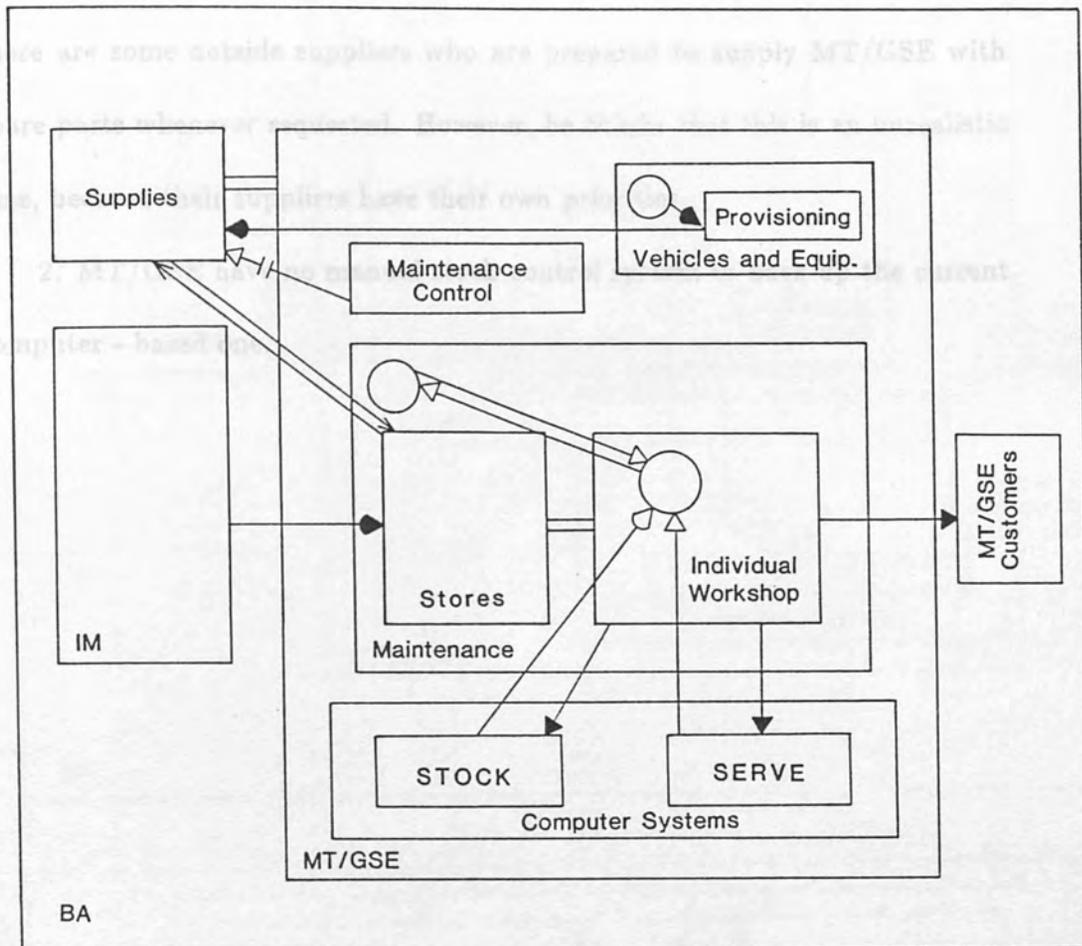
1. MT/GSE will no longer need a stand - alone computer - based stock control system as IM started to modify the current STOCK system.
2. Customer support department is a progress chaser rather than a problem solver.
3. FIND is a software package which helps to find out aircraft schedules.
4. FOCUS is a software package which helps to produce meaningful reports.

Diagram 7. First Revise



Note: See diagram 7 for comments.

Diagram 8. Senior Maintenance Engineer Building 470



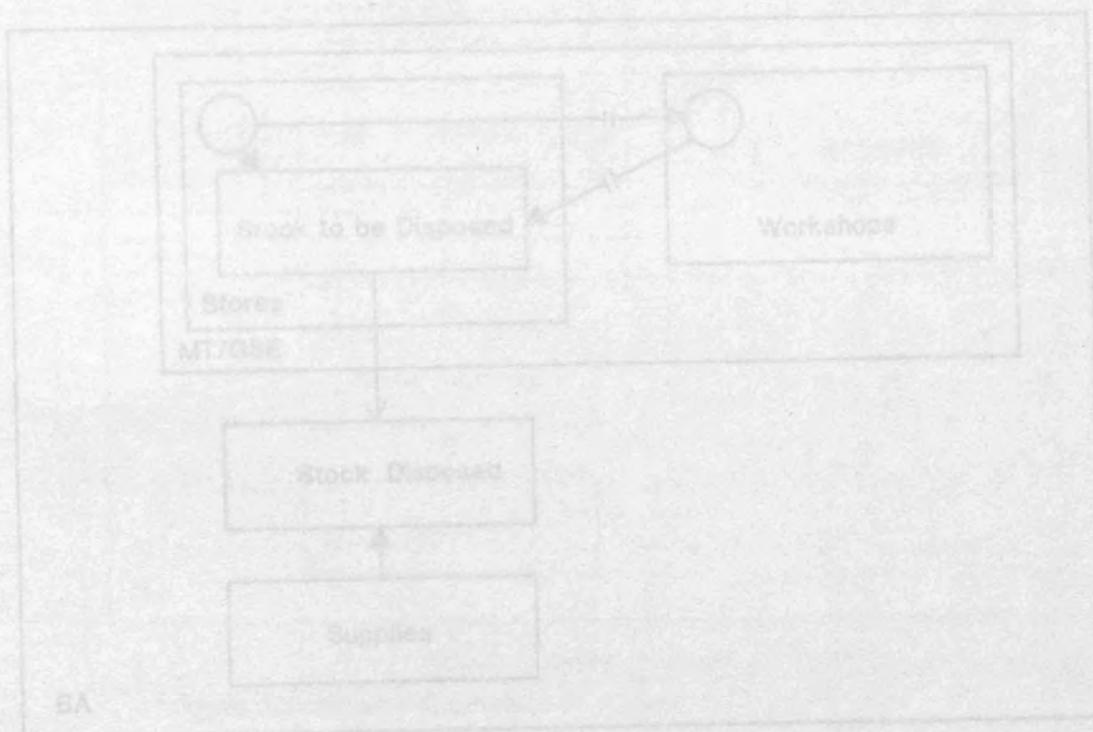
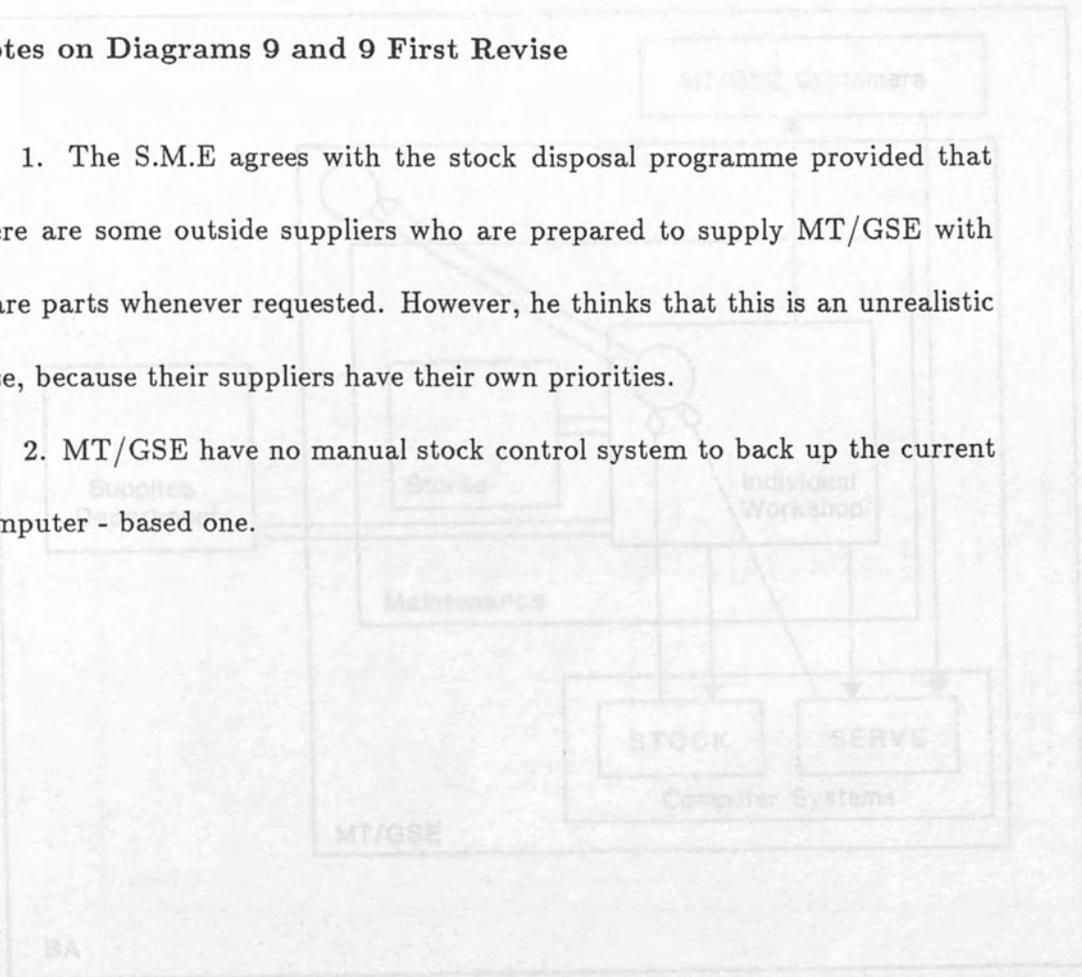
Notes:

1. MT/GSE efficiency cannot be improved without major improvements in the STOCK system.
2. Standardisation in vehicles and equipment is very difficult to achieve.

Notes on Diagrams 9 and 9 First Revise

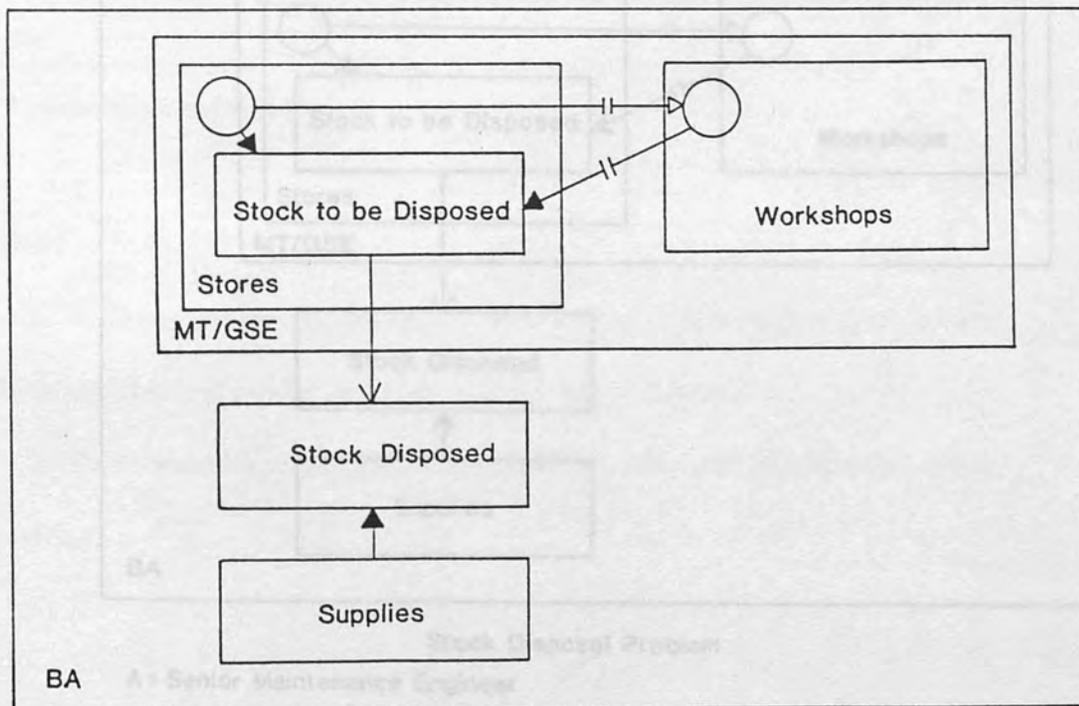
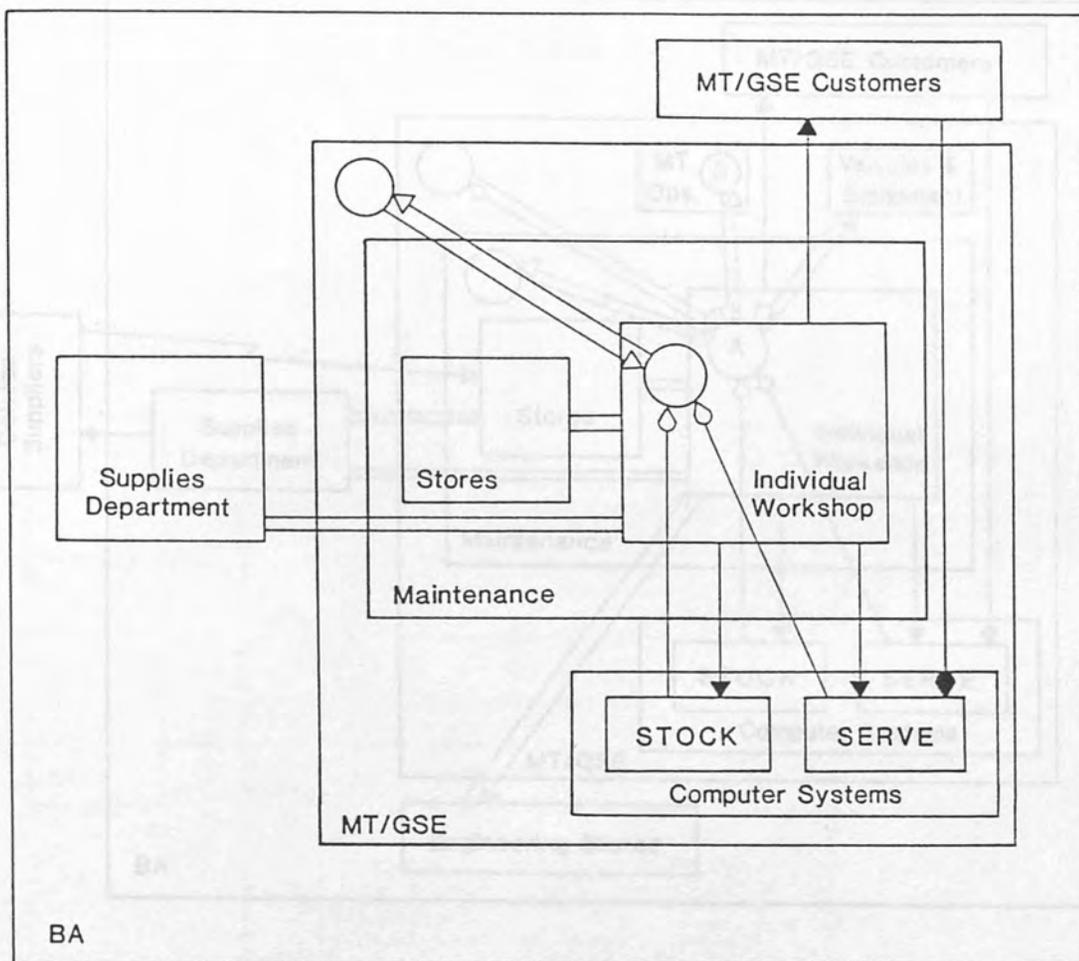
1. The S.M.E agrees with the stock disposal programme provided that there are some outside suppliers who are prepared to supply MT/GSE with spare parts whenever requested. However, he thinks that this is an unrealistic case, because their suppliers have their own priorities.

2. MT/GSE have no manual stock control system to back up the current computer - based one.



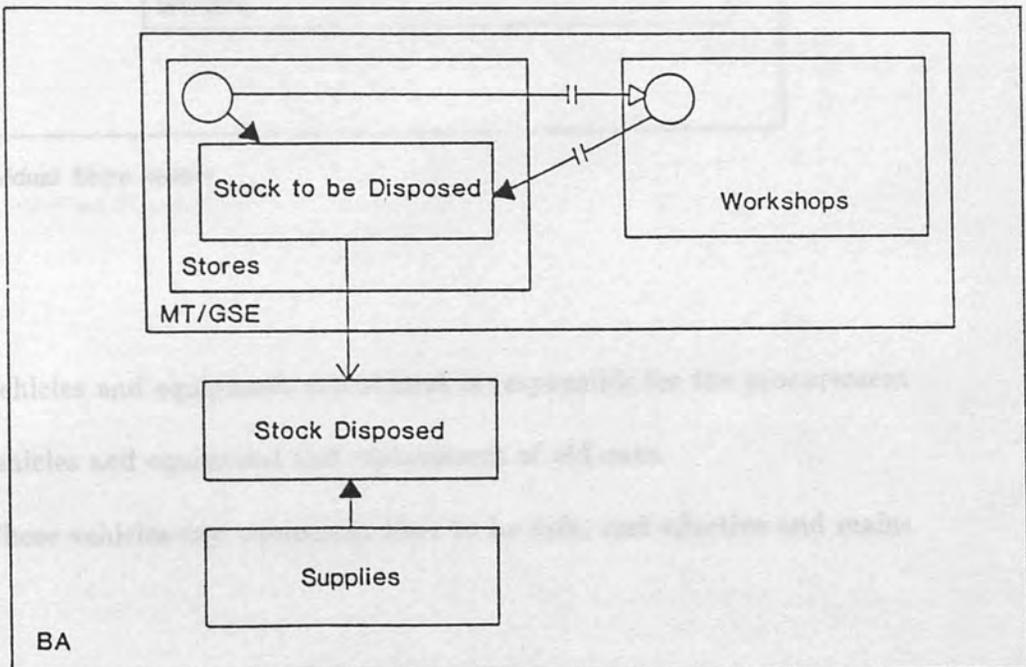
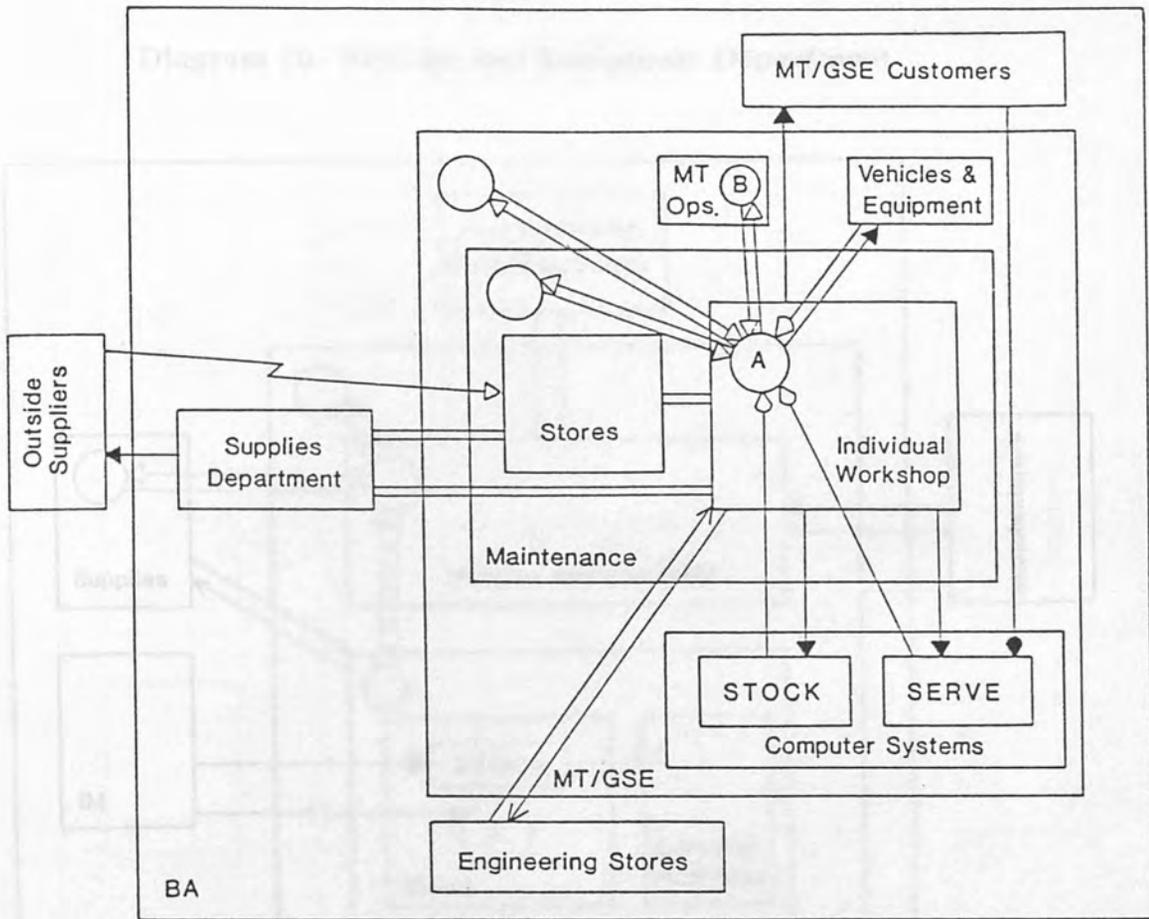
Stock Disposal Problem

Diagram 9. Senior Maintenance Engineer, Building 470 Extension



Stock Disposal Problem

Diagram 9. First Revise

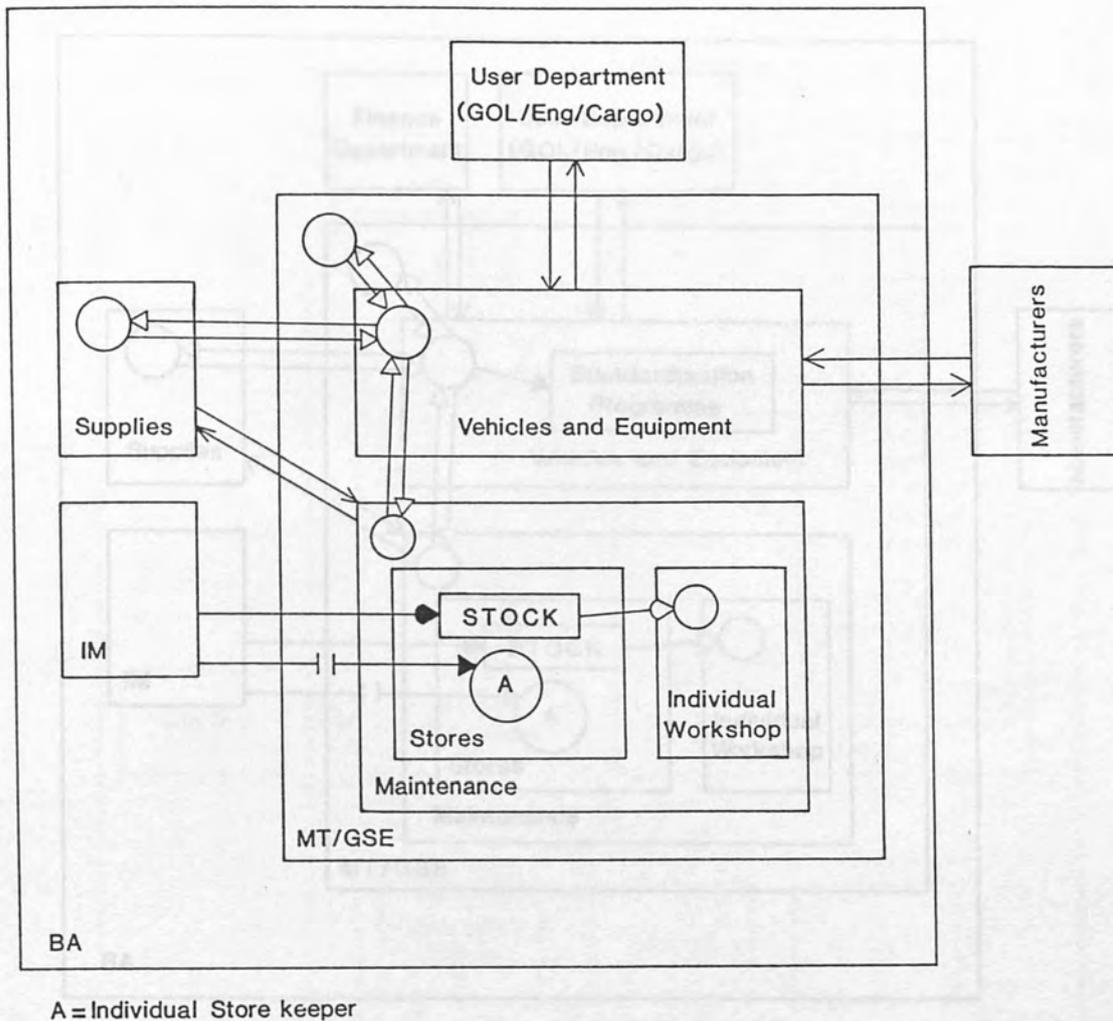


Stock Disposal Problem

A = Senior Maintenance Engineer

B = Individual Operations Superintendent

Diagram 10. Vehicles and Equipment Department

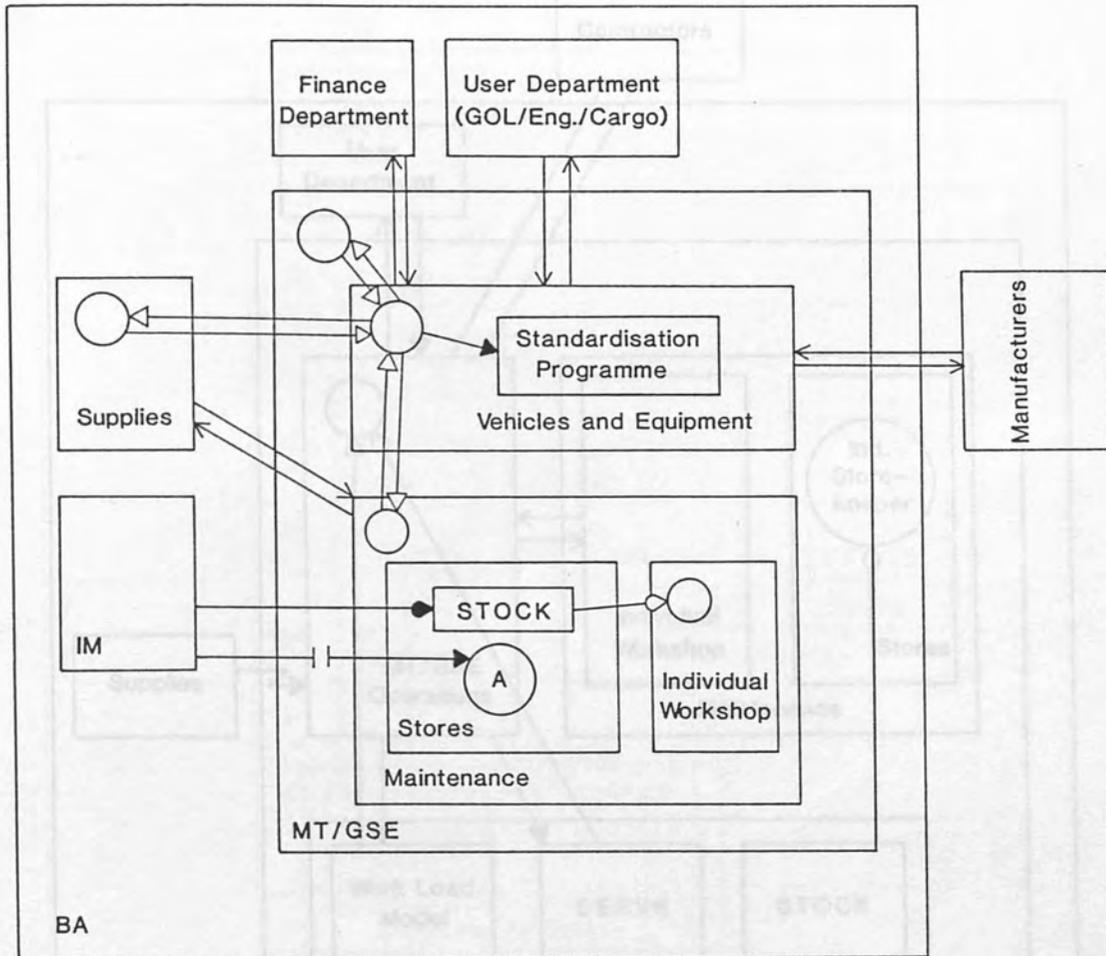


Notes:

1. Vehicles and equipment department is responsible for the procurement of new vehicles and equipment and replacement of old ones.
2. These vehicles and equipment have to be safe, cost effective and maintainable.

3. The stores are not efficient to meet the maintenance requirements.

Diagram 10. First Revise

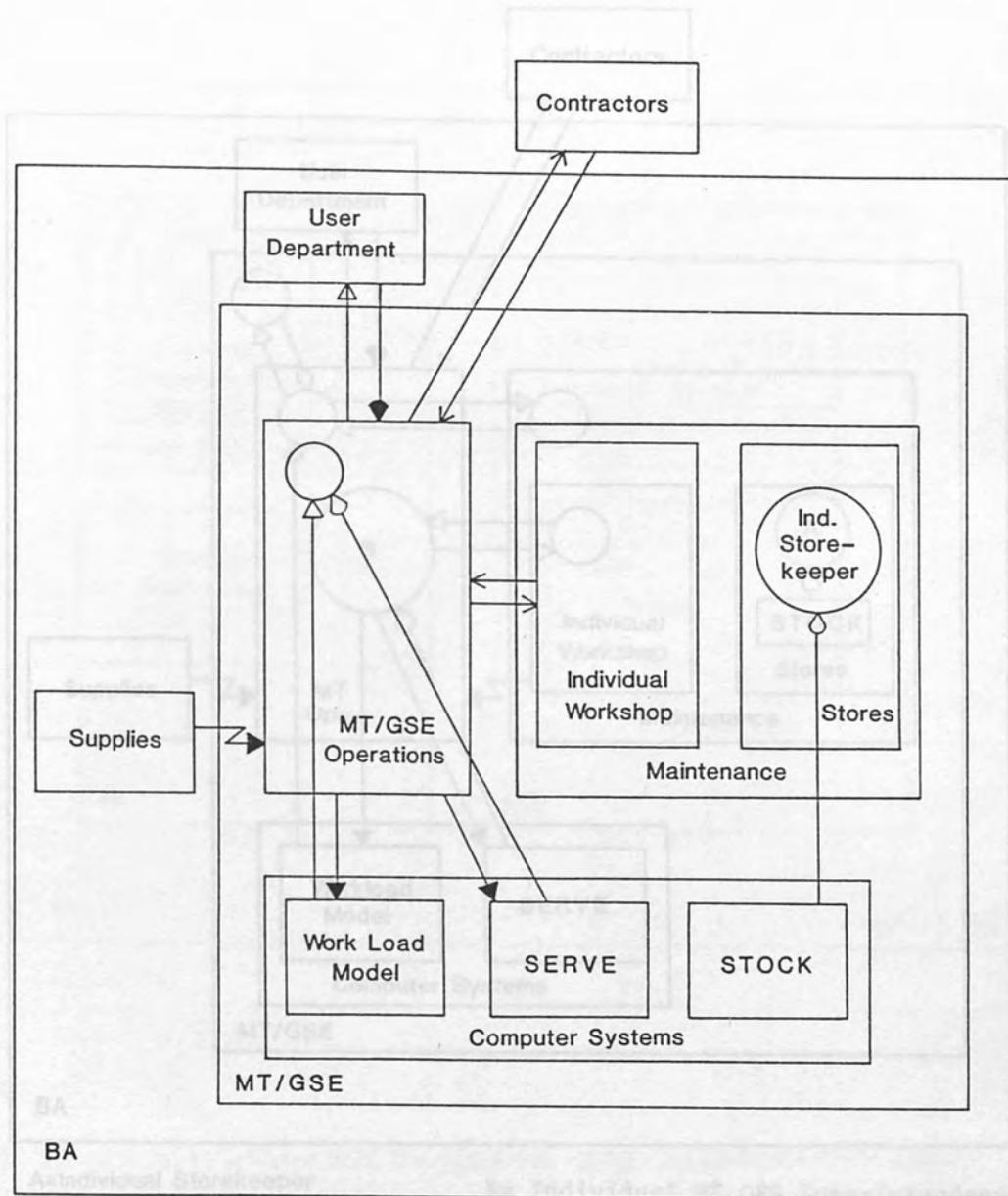


A = Individual Storekeeper

Notes:

1. The computer input requirements are too complicated for MT/GSE staff to understand.
2. Vehicles and equipment department is not responsible for any stores problems.
3. The stores are not efficient to meet the maintenance requirements.

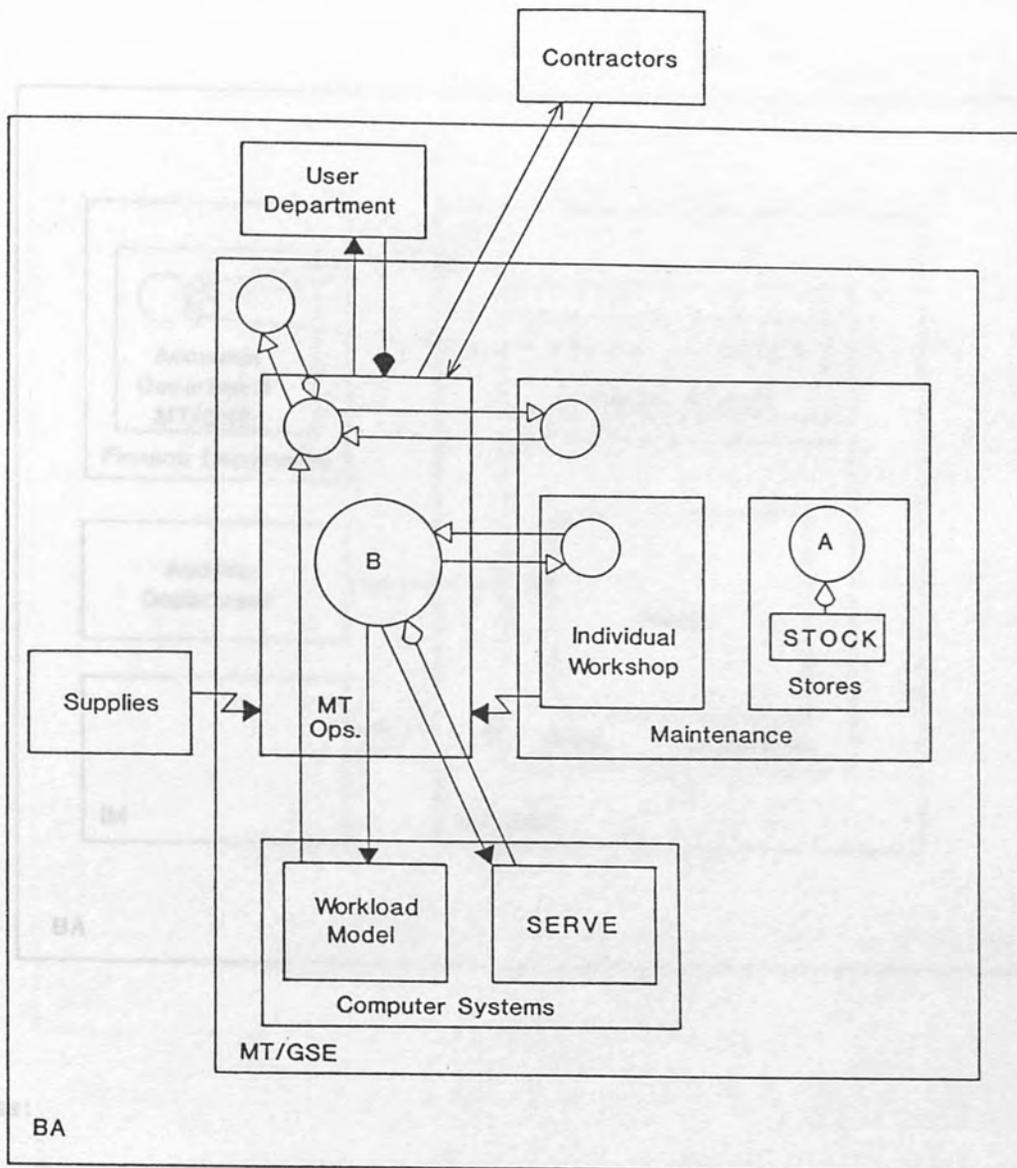
Diagram 11. MT/GSE Operations Department



Note :

The MT OPS department objective is to provide an efficient motor transport for BA's user department and for other airlines with whom BA has a handling agreement.

Diagram 11. First Revise



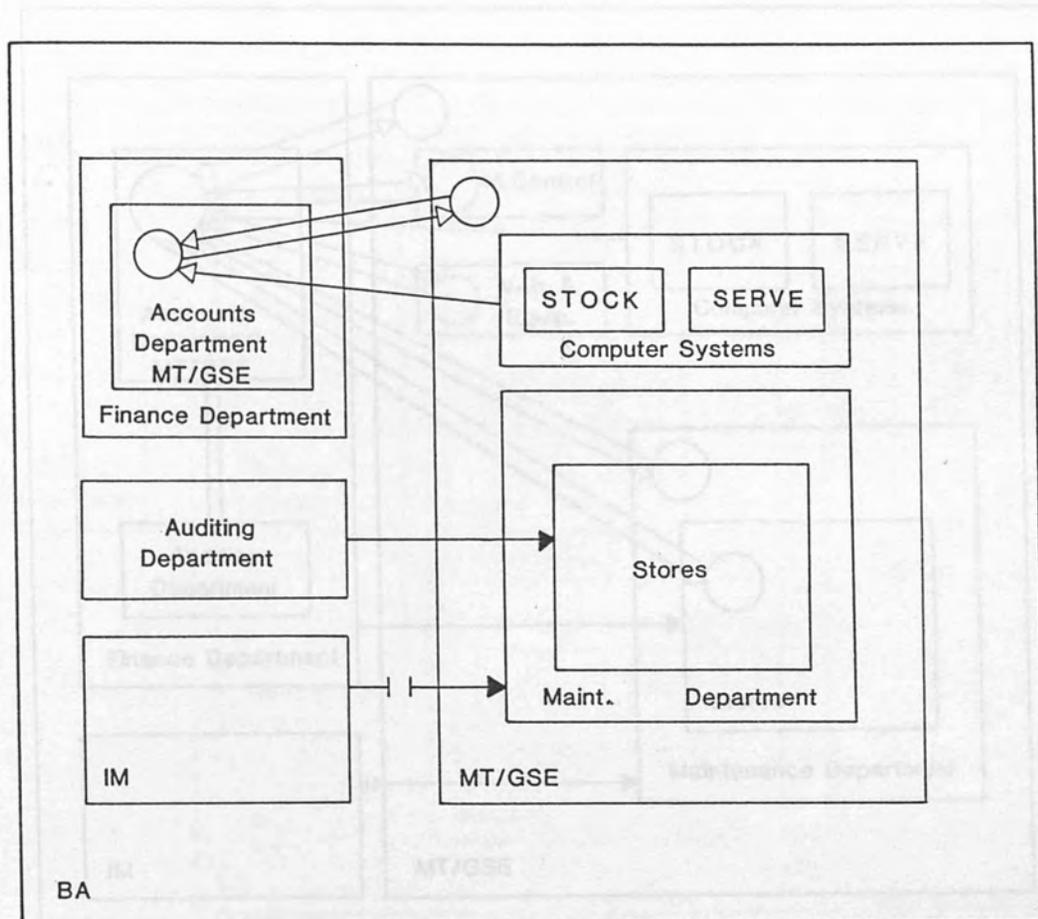
A=Individual Storekeeper

B= Individual MT OPS Superintendent

Note :

The MT OPS manager does not understand what the special projects role means [see diagrams 3 and 3 first revise].

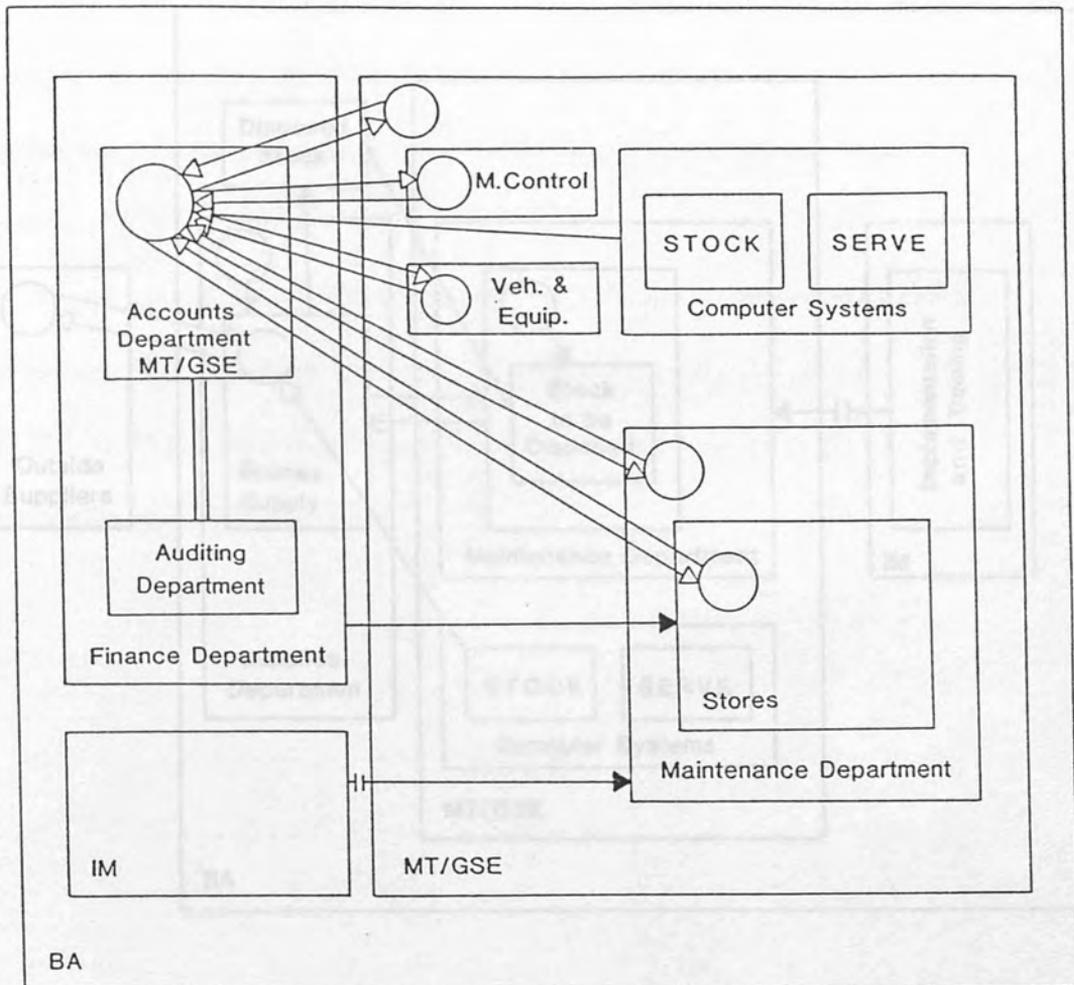
Diagram 12. The MT/GSE Accountant



Notes:

1. There is no guarantee that the proposed stand - alone computer - based stock control system will be efficient.
2. There is a very good response from IM department in case of any proposed modification in the STOCK system.

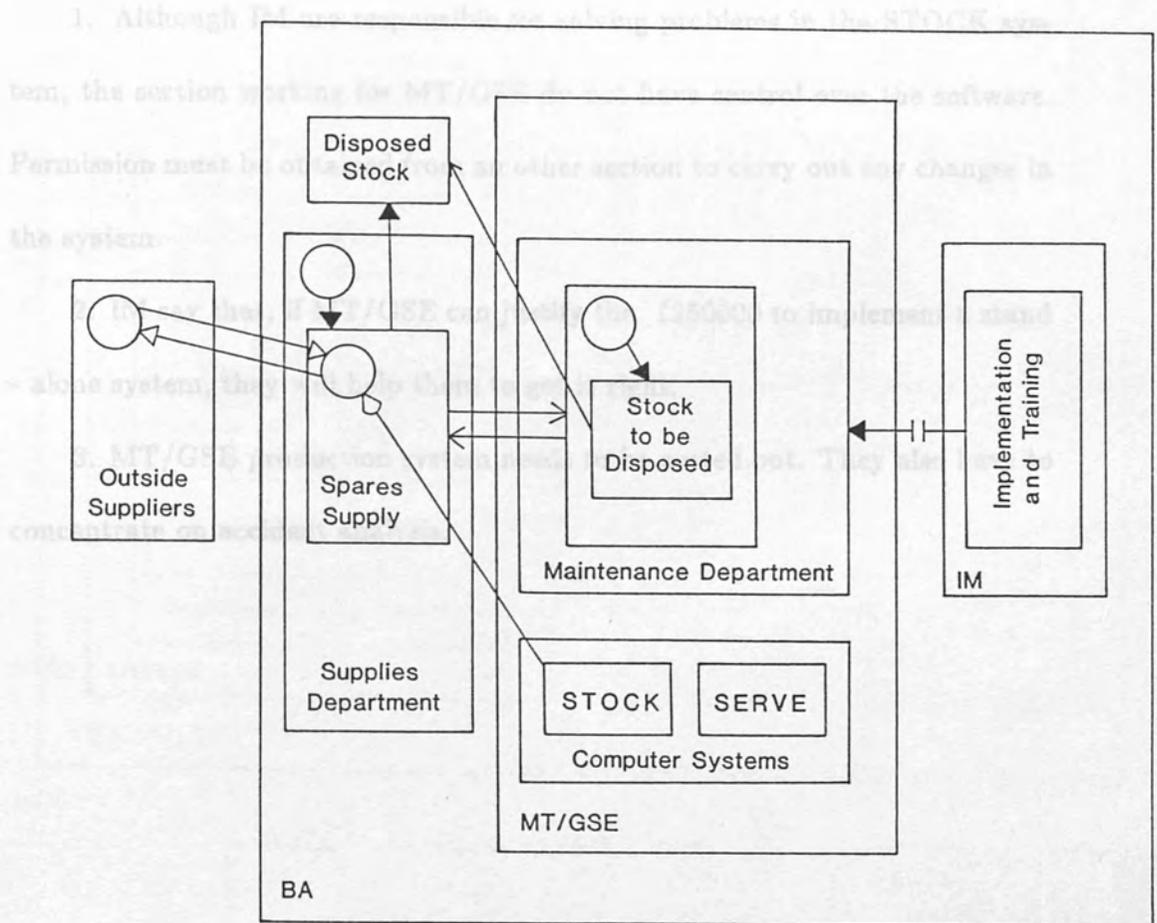
Diagram 12. First Revise



Notes:

1. The department interventions on most parts of the BSG report.
1. The current STOCK system is efficient but the problem is the distorted data in the system.
2. IM should allocate resources to train MT/GSE staff in the operations of computer systems.

Notes on Diagram **Diagram 13. The Supplies Department**



Notes:

1. The department have reservations on most parts of the SSWG report.
2. MT/GSE staff do not understand many stock control terms.

Notes on Diagram 14

1. Although IM are responsible for solving problems in the STOCK system, the section working for MT/GSE do not have control over the software. Permission must be obtained from an other section to carry out any changes in the system.

2. IM say that, if MT/GSE can justify the £250000 to implement a stand - alone system, they will help them to get it right.

3. MT/GSE production system needs to be sorted out. They also have to concentrate on accident analysis.

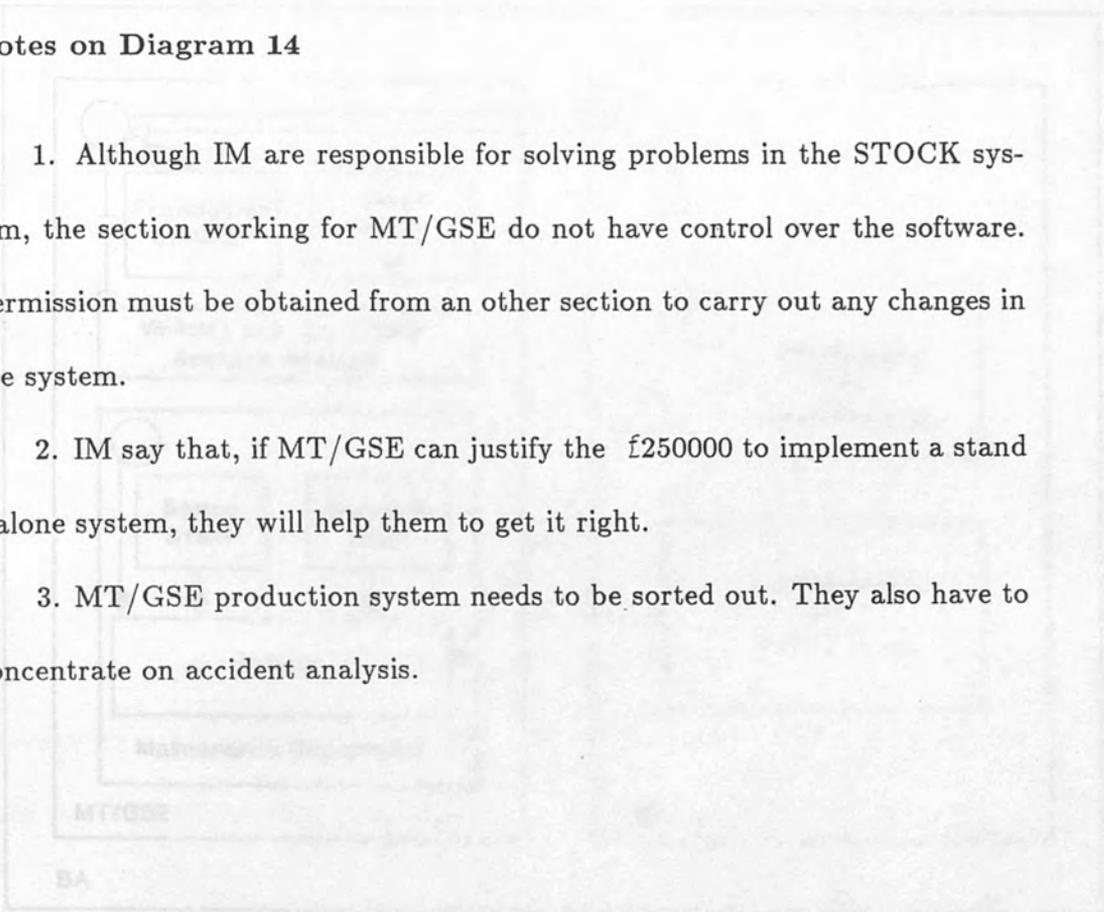
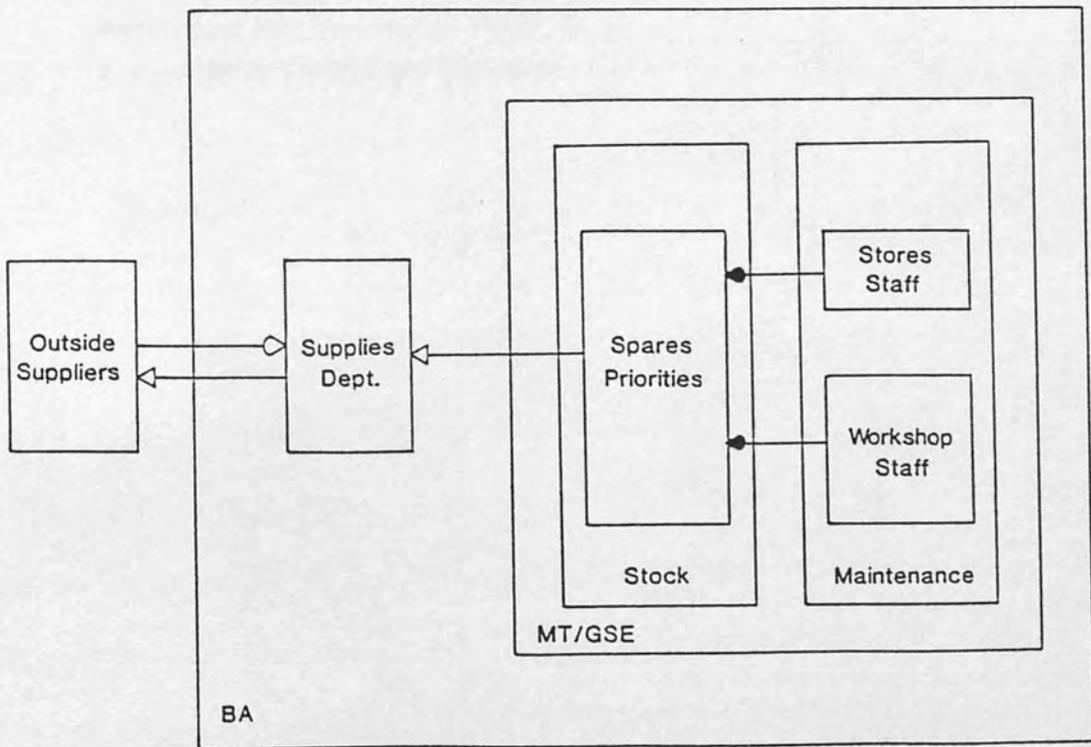
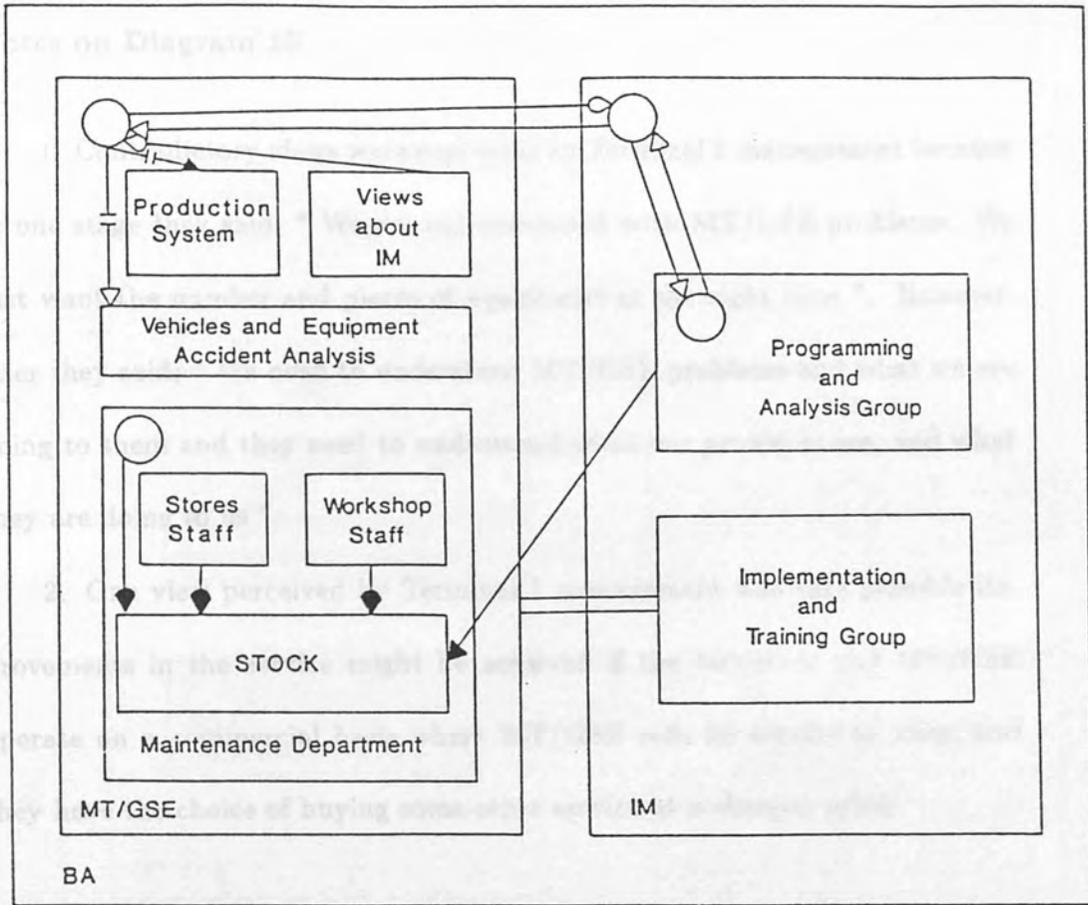


Diagram 14. The IM Department

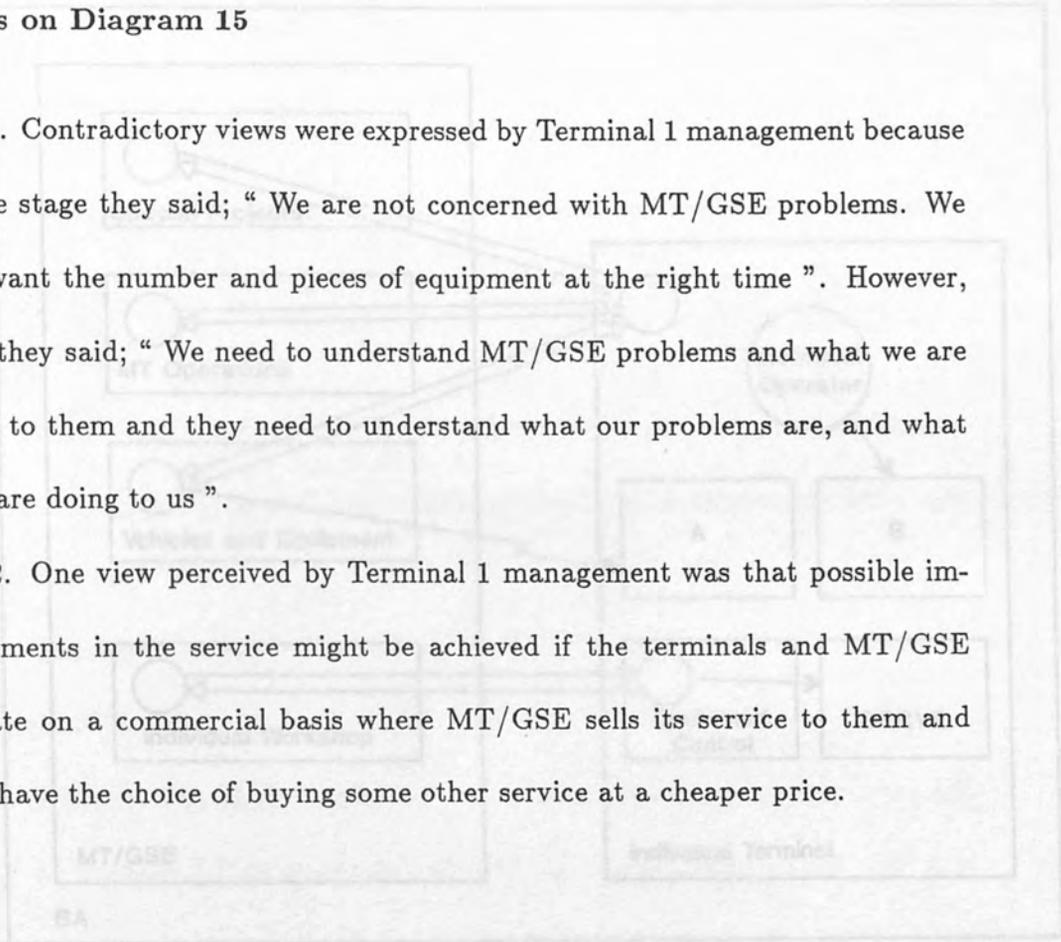


Spares Priorities problem

Notes on Diagram 15

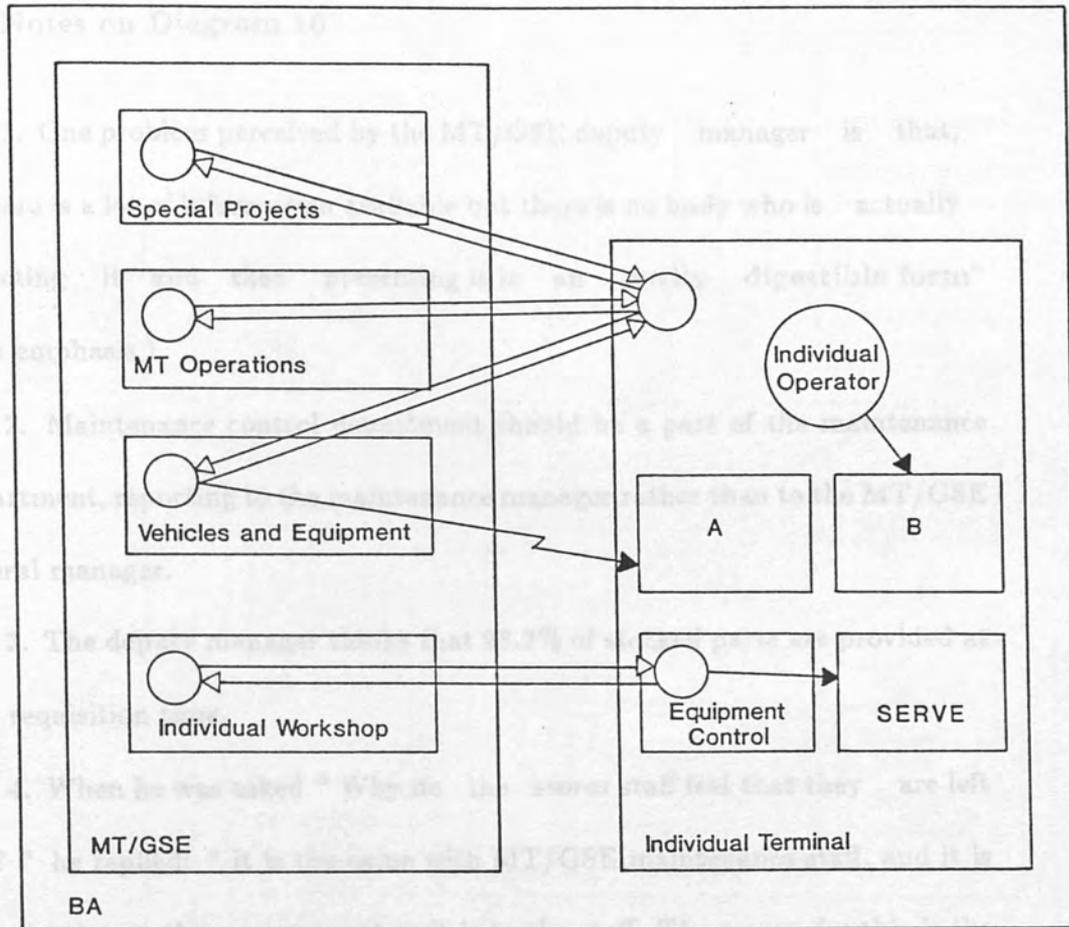
1. Contradictory views were expressed by Terminal 1 management because at one stage they said; “ We are not concerned with MT/GSE problems. We just want the number and pieces of equipment at the right time ”. However, later they said; “ We need to understand MT/GSE problems and what we are doing to them and they need to understand what our problems are, and what they are doing to us ”.

2. One view perceived by Terminal 1 management was that possible improvements in the service might be achieved if the terminals and MT/GSE operate on a commercial basis where MT/GSE sells its service to them and they have the choice of buying some other service at a cheaper price.



A=Proposed New Vehicles and Equipment
B=Operational Vehicles and Equipment

Diagram 15. An MT/GSE Customer (Terminal 1).



A=Proposed New Vehicles and Equipment

B=Operational Vehicles and Equipment

Notes on Diagram 16

1. One problem perceived by the MT/GSE deputy manager is that; " There is a lot of information available but there is no body who is actually collecting it and then presenting it in an easily digestible form" (my emphasis).

2. Maintenance control department should be a part of the maintenance department, reporting to the maintenance manager rather than to the MT/GSE general manager.

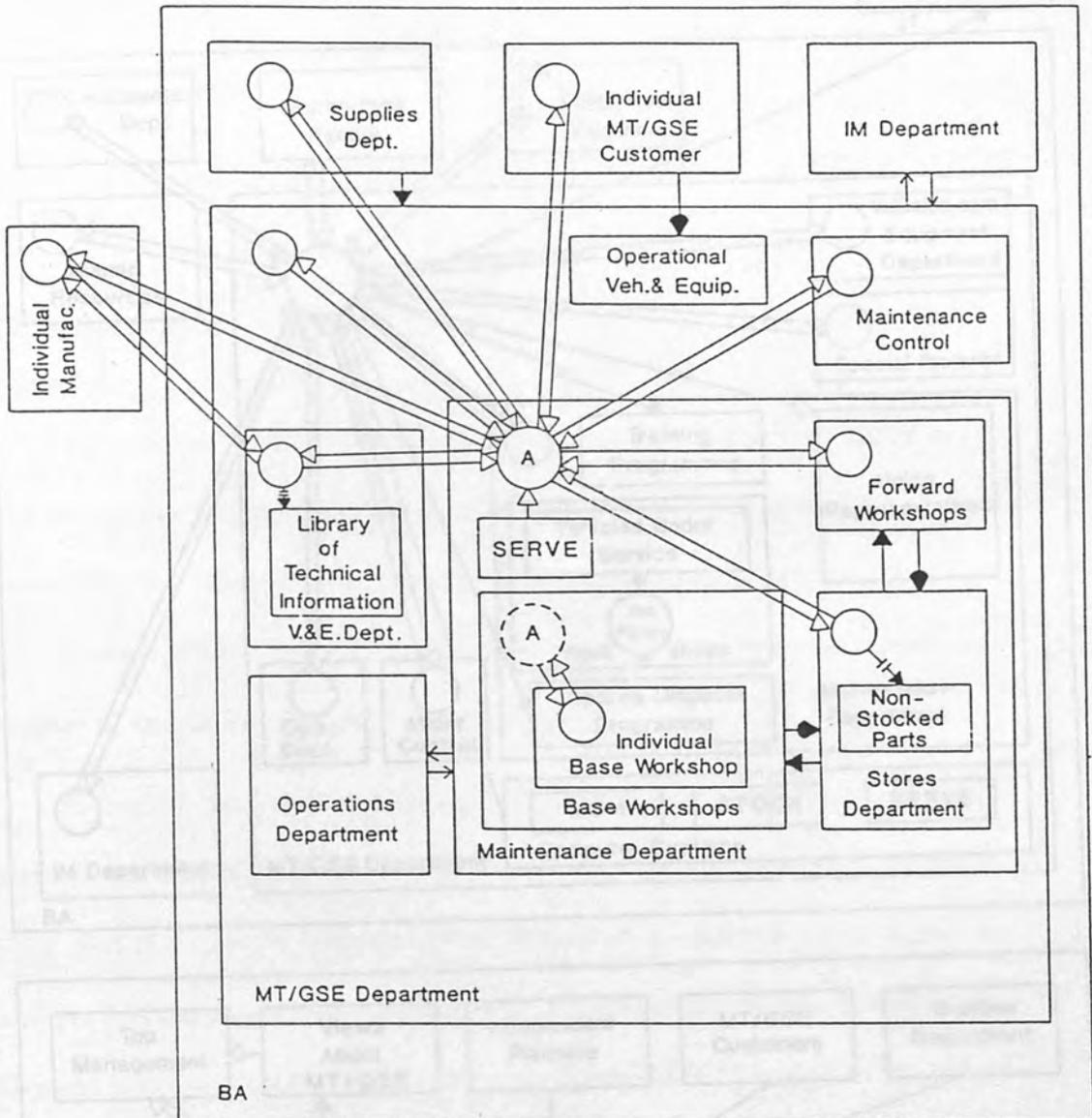
3. The deputy manager thinks that 98.2% of stocked parts are provided at first requisition time.

4. When he was asked " Why do the stores staff feel that they are left out? " he replied: " It is the same with MT/GSE maintenance staff, and it is a frustration to the management as it is to the staff. The reason for this is the wrong perception that the type of service provided by MT/GSE to BA is not as important [to the top level management] as that provided by the Aircraft Engineering department " .

5. The deputy manager believes that; " MT/GSE has to understand more fully their own needs and problems before criticizing any other BA department (such as IM) for creating problems for MT/GSE " .

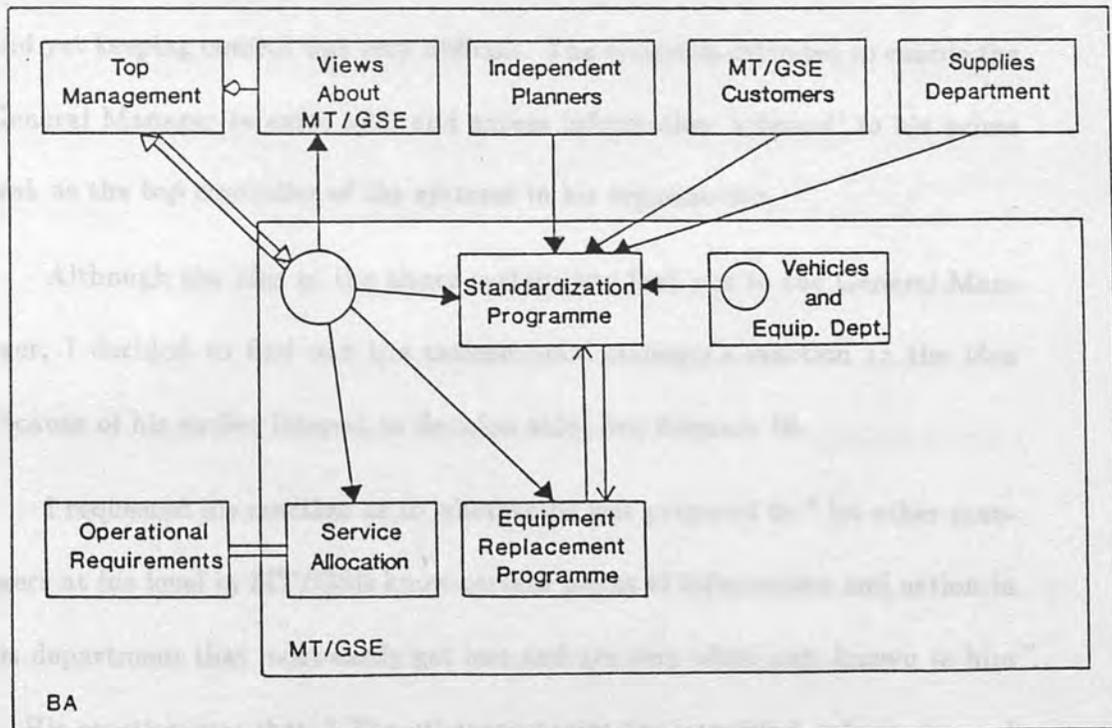
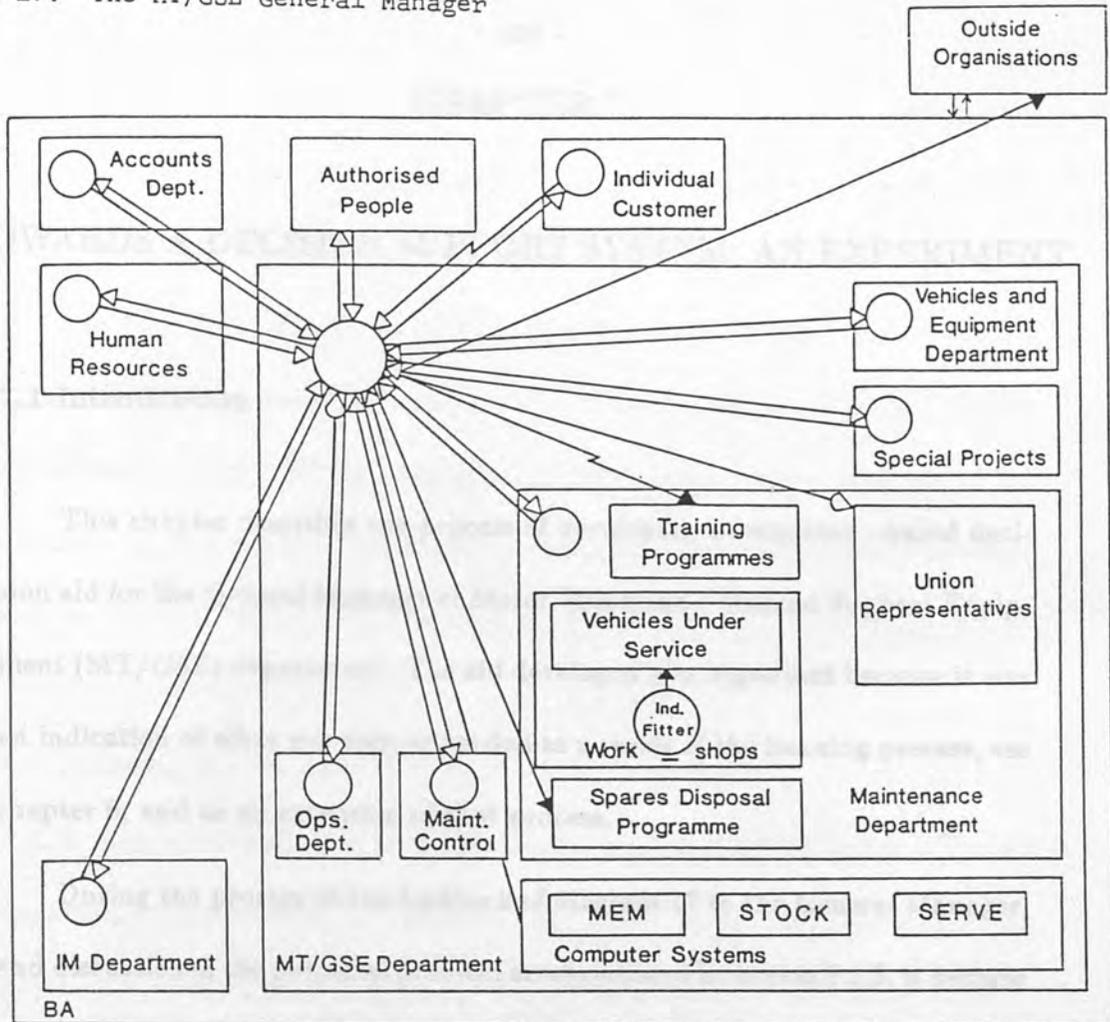
6. The deputy manager is looking for; " tools, methodology or computer systems which will help to perform his managerial tasks efficiently and communicate with other managers easily " . He adds; " I want something cheap and effective, something that we are all trained to use " .

Diagram 16. The MT/GSE Maintenance Manager



A = The Maintenance Manager (MT/GSE Deputy General Manager)

Diagram 17. The MT/GSE General Manager



Perceived problems in MT/GSE

CHAPTER 7

TOWARDS A DECISION SUPPORT SYSTEM: AN EXPERIMENT

7.1 Introduction

This chapter describes the process of developing a computer - based decision aid for the General Manager of Motor Transport / Ground Support Equipment (MT/GSE) department. The aid developed was important because it was an indication of what was seen as needed as a result of the learning process, see chapter 6, and as an extension of that process.

During the process of the feedback of diagram 17 to the General Manager, and discussion of the potential problem areas outlined in section 6.5.3, it became clear that the General Manager found himself at a centre of communication, and yet keeping control was very difficult. The system is intended to enable the General Manager to save, add, and access information 'relevant' to his prime task as the top controller of the systems in his organisation.

Although the idea of the above system was first put to the General Manager, I decided to find out the maintenance manager's reaction to the idea because of his earlier interest in decision aids. See diagram 16.

I requested his reaction as to whether he was prepared to "let other managers at his level in MT/GSE know certain pieces of information and action in his department that most easily get lost and are very often only known to him".

His reaction was that "The other managers are interested only in the end

product of (his) department, not in its problems ". He was also unwilling to record information for inclusion in a computer system because he was busy with so many tasks to perform and there would be no time to update the system.

I realised then that he was unsure about the likely consequences of such a system, and what I was beginning to see as the overall needs of MT/GSE, despite his evident concern with the complexity of his managerial task. Because of his ambivalence, and because I believed that the General Manager would cooperate, despite his considerable load, I decided to develop the outline of a system which would be a personal aid to him.

Following are the basic characteristics of the system.

1. This would be to provide, primarily, for the General Manager of MT/GSE department, an interactive, adaptive computer - based information system which will enable him to record and access vital pieces of information about various activities inside and outside his organisation. The aim is not to replace any of the existing systems, but to develop one which will integrate with these systems in order to help the General Manager to communicate and control efficiently.

2. The idea was that the General Manager himself would develop and update the system, but would undoubtedly need an analyst's support and advice. This would ensure a **learning process** for him about the system and the organisational matters implemented into it.

3. The decision for a personal aid was based on the problems of obtaining data, and the need for a strong venture across the department as a whole. If the system is implemented successfully it could be developed as an overall

departmental tool with certain privacy arrangements.

In choosing software and hardware, the intention was to find a system on which the above proposal could be carried out. The crucial reason for using accessible packaged software was to speed up the process of interaction in order to make use of the General Manager's enthusiasm for the proposal.

The logical search was to start at the BA's end. A brief inquiry revealed that the only possible system that can be used is the WANG OFFICE, which offers mail and messaging, time management, directory services and office file manager facilities. This system was implemented on the mainframe computer, but was not to be available to MT/GSE until the middle of 1987. It could not therefore be used to test the proposal.

The search continued at the college and ended successfully with the choice of the SUPERFILE system [see Southdata (1985)] which was implemented on the RM Nimbus microcomputer. SUPERFILE is a database system which enables the user to store, add and access data quickly and efficiently. The user can easily make his own FORMS on the screen and enter, alter store and retrieve his information. It is available on both stand-alone and networked Nimbus computers. An IBM microcomputer version of the SUPERFILE system is also available which can be acquired and implemented on the IBM microcomputer already installed in MT/GSE department.

During the process of running the experiment which will be described in the following sections of this chapter, I became aware of some recent studies reported in the literature which examined the process of building a decision aid and the philosophy behind it. See section 7.3. No important discrepancy

was found with the ideas which led to developing the system described in this chapter.

7.2 Running The Experiment

My broad understanding of the General Manager's information needs which was based on the data interpreted in diagram 17, enabled me to produce two fictitious examples which are shown in figures 7.1 and 7.2. These were presented to the General Manager in a formal discussion. As anticipated, he expressed his interest and support, and agreed on a first real sample of his data to be examined and abstracted for the purpose of implementation on the computer. His willingness to give me access to his data was yet another indication to me that I was tackling issues which were of great importance to him. This is another subjective measure of the success of the problem - formulation stage already described in chapter 6.

The process of data reduction was very difficult because of the way the documents contained information 'irrelevant' to the General Manager. However, I was guided by the following principles in abstracting the data into, what would be, a meaningful information:

1. flexibility;
2. reasonable completeness;
3. personal nature;
4. simplicity.

The intended end product of the process, guided by the above principles,

would be that the General Manager would have minimum information which will tell him;

1. what has been happening about a given issue X?
2. what network of communication is operating on X?
3. what key documents are available on X?
4. what departmental shortcomings are still unresolved and what live issues might they affect?

In order to update the General Manager on the progress achieved and the principles followed in data reduction, I forwarded discussion notes [see annex to chapter 7] to him which gave him a summary of my involvement in his organisation. I also sent examples of information formats [see figures 7.3 and 7.4 which were abstracted from the General Manager's real data]. The General Manager recognised this as an excellent example of the type of information he needed in summarised form. He asked me to apply the same principles on further six channels of his information.

Further support for the above ideas was expressed by the Information Management (IM) Manager after a demonstration about the system, and he assured me of any help I required.

Having completed the forms of the further six information channels, I sent them to the MT/GSE General Manager and wrote to him " Enclosed are abstracts (thought to be information) which might be useful for understanding situations in and outside MT/GSE ". I added; " The decision to implement the computer system I used, or any other accessible software to update and

extend the information sample used for experimentation, will depend entirely on whether you find the above information useful or otherwise ”.

The General Manager acknowledged my efforts (see letter following the discussion notes at annex) and asked me to discuss some of the implementation difficulties with his computer systems advisor. The latter has agreed on an implementation programme.

NEXT INTERACTION - 2nd of April 1977

Figure 7.1 Example of Problem Paper

DATE	21 March 1977
SUBJECT	Planning of the system
OBJECTIVE	To determine the requirements for the system
RESPONSIBILITY	Systems Development Department
NOTES	The system is to be developed in the following stages: 1. Requirements analysis 2. System design 3. Programming 4. Testing and commissioning
NEXT INTERACTION	April 1977

Figure 7.2 Example of Implementation Paper

DEPARTMENT	Operations Department
PROBLEM AREAS	1. Delays in transportation
PEOPLE INVOLVED	2. Bad communication with the workshops
NOTES	3. Reorganisation of work schedules
WHO IS INVOLVED	Operations manager and his supervisors
ACTIONS	1. To speed up the maintenance process in the workshops 1. To contact the supplies department
NEXT INTERACTION	End of April 1986

Figure 7.1 Example of Problems Format

SUBJECT	MT/GSE workshop training course
DATE	15 march 1986
OBJECTIVE	
SUBJECT	Systems Steering Group
RESPONSIBILITY	
OBJECTIVE	To investigate X's computer systems
PEOPLE INVOLVED	
RESPONSIBILITY	X's computer systems advisor / Y department
DATE	
NOTES	The following issues will be investigated
NOTES	1. Accident reporting system
	2. Stock control system
	3. Workshop scheduling
NEXT INTERACTION	August 1986

Figure 7.2 Example of Communication Format

Figure 7.3 Training Information

ISSUE MT/GSE communication meeting

DATE 17 July 1985

PEOPLE INVOLVED MT/GSE Gen. Man. and Maintenance Man.

NOTES

1. Management is to set a T4 special working group
2. Management is to set an exhibition of T4 equipment
3. Staff were to be provided with a list of intended procurement of vehicles
4. MT/GSE is to be involved in outside work

NEXT INTERACTION 15 December 1986

Figure 7.3 Communication Information

SUBJECT MT/GSE supervisors training course

OBJECTIVE Designed to train MT/GSE supervisors

RESPONSIBILITY MT/GSE and BA training department

PEOPLE INVOLVED MT/GSE engineers and MT OPS supervisors

DATE April 1986 to May 1987

NOTES

The course will cover:

1. MT/GSE role within BA
2. Control of the airline
3. Experience from outside companies
4. BA panel machinery
5. Dealing with BA customers
6. Instructional techniques
7. Discussion and feedback

Figure 7.4 Training Information

7.3 Discussion and Conclusion

I had now reached a satisfactory situation where a learning process had been achieved and a decision aid, which will be a further learning process, accepted in principle.

The success of this research I had so far only been able to judge by client satisfaction and my own feel that things had gone very well. It also seemed that I had gone through a process which was very general in nature and could be repeated elsewhere. The principles I followed are clear. However, I had become aware in the course of this last phase of my work that some new studies had been reported in the literature. Earlier papers had only offered general ideas about information and decision aids. For instance Radford (1974) has pointed out "There is, as yet, no generally accepted theory regarding the use of information in organisations". Certain issues have to be considered in the development and implementation of any Management Information Systems (MIS). Questions such as:

- what kind of information is needed by what kind of people?
- how should information be produced and presented in an easily digestible form?

have to be answered as part of the process of building MIS.

The above points are widely debated in the literature and various ideas are reported concerning the building of 'successful' systems. (Most of these are now generally thought of as DSS). Ackoff (1967) developed certain concepts related to the development and implementation of MIS. His arguments were proved

valid some twenty years later. For example, Ackoff's emphasis that managers suffer from " ... over abundance of irrelevant information ", is taken as a basis for Targett's (1985) 'data reduction' principle. Ackoff's rejection of the view that managers do not need to understand the MIS is taken care of by Targett's 'evolutionary approach' in MIS design.

Targett (1985) has pointed out that traditional research in MIS has concentrated on issues such as the design of software, the choice of hardware and the behavioural factors related to both the organisation and users. His experience in the design of one successful (as he claimed) MIS for a bank, led him to emphasize new directions for research and development of MIS. He recommended the following issues for successful computer - based MIS.

1. " Analysis of the decision - taking system " in order to find out information requirements at different levels in the organisation.
2. " An evolutionary approach " in which users have the chance to 'confirm' or 'deny' the information produced by the system. This process will ensure users' learning about the system and about their information needs (his emphasis).
3. " Data reduction ": this emphasizes Ackoff's (1967) argument that managers very often receive 'irrelevant information'.
4. " Data presentation " to improve the MIS user's recognition of the information.
5. The use of " techniques of management science " in order to transform data into information.

Without then having knowledge of Targett's work, the process which led

to the direction emphasized in chapter 6 is consistent with Targett's arguments outlined in points one through four above. The General Manager, for example, has participated in the most critical decisions such as the identification of the information he wants to be implemented in the system. Data was reduced by considering flexibility, reasonable completeness, personal nature and simplicity. As far as my earlier stages of inquiry were concerned the General Manager has acknowledged that he has learnt a great deal about his organisation. It should also be borne in mind that the early stages of the inquiry [see chapter 6] ensured that management as a whole had been involved in an examination of what their problems actually were. It would have been easy to have spent time unnecessarily trying to replace one of the central computer systems, that governed stock control, on which concern was originally centered, instead of moving towards a DSS.

Another support for the process outlined in chapters 6 and 7 came from Espejo and Watt (1986). In their paper, they argued for a new understanding of the concept of 'Information Management (IM)'. By IM, they mean "... how skillfully and efficiently the individual manager or groups of managers use the information sources or resources available to them ... (to) convert information into effective action". Espejo and Watt have devised and tested three strategies. " **Strategy One - Adjustment to the Organisation structure**". They view organisation structure as a collection of 'filters' and 'amplifiers'. Through the former, information is reduced and channelled to the manager. The amplifiers are used to convey the manager's 'intended actions' to different units in his organisation. Espejo and Watt's experience shows that 'adjustments' to both

'filters and amplifiers' will result in more effective information management. It is relevant to say here that as a result of my intervention in BA's MT/GSE and IM departments, certain organisational adjustments have already taken place. One of the reasons behind these adjustments is to improve the organisation effectiveness.

" **Strategy Two - The Design of Organisational Conversations** ". This strategy is designed to " ... increase the chance of meaningful commitments, to increase the chances of coordinated action and to increase the chances to learn from the inevitable breakdowns ". The ideas behind the experimental system outlined in this chapter and its purpose coincide with the philosophy of Strategy Two. Such a system will enable the MT/GSE management group to obtain and update information about issues such as; what problems exist in department X?, what issues do any manager need to understand and take action in department X?, etc. This will certainly increase communication and commitment, and hence, will reduce the chances of 'breakdowns'.

" **Strategy Three - Manager - to - tasks Fit** ". This strategy is based on the philosophy that the manager, using his 'mental model' of situations of his concern, has a limited ability to 'attenuate' data and 'amplify' actions. Any process which may lead to the design of a model(s) to aid the manager, should take into account making 'explicit' the manager's perception of situations under his control. What was reported in chapter 6 is a successful stage in the above sense which led to the logical need for the system developed and outlined in chapter 7. The use of Bowen's problem formulation methodology proved to be a successful process which is acknowledged by the clients since it made them

aware of the complexities of their tasks.

Other ideas about MIS, also consistent with my development, are discussed by Checkland and Griffin (1970), who adopted a systemic view in developing MIS. Their main emphasis is not the technical aspects of the MIS, but the 'problem - oriented' issues. Huber (1982) has discussed problems such as 'modification' and 'delay' that affect the communication of information.

It must be emphasized that the MIS as a model designed to aid the manager's understanding of situations of his concern and to reduce uncertainty about events, suffers from the well defined 'implementation gap' of all models. See chapter 3 for further details. In particular Argyris (1977) has pointed out the following reasons for the implementation gap:

1. " MIS were not well understood by line management ". This is in fact in total agreement with Ackoff's (1967) assertion. It is one of the reasons, I believe, for the initial perception of MT/GSE management group that their STOCK system was not functioning properly.

2. " Top line management was not involved in persuading and selling the use of MIS to the users in the organisation ". This was true for the MT/GSE system and was overcome by the proposal outlined in chapter 7.

3. " MIS specialists and line managers did not understand each other's job requirements, perspectives, and pressures ". This again is true in my study. See diagram 17, especially the distorted communication between MT/GSE and IM.

The following points summarise the work described in this chapter.

1. The successful application of Bowen's problem formulation methodology

and the diagrams documented in chapter 6, has led to the recognition that the MT/GSE General Manager can better manage and control his department if he has better organised and 'relevant' information (specified by him) from both inside and outside his organisation. Many of his decisions are influenced by the quality of this information channelled through each link shown in diagram 17.

2. A computer - based information system was developed for the General Manager with his full support and participation. It helped him to record and access essential features of current problems and communications about these. The experience gained from the process of the system's development will be very useful in developing any DSS for the department as a whole. However, the different information needs by different managers in the department have to be considered in any such development.

3. The ideas behind the development of the system and the inquiry outlined in both chapter 6 and 7 are consistent with recent research work which is reviewed above.

4. Once again the model provided is a learning 'game' in the broadest sense, to be used as part of an on - going process.

ANNEX TO CHAPTER 7

Discussion Notes: prepared as an internal departmental note and used as a hand - out for discussion at a formal MT/GSE meeting.

1. This is neither a progress report nor a final recommendations of the finding of my research on the sort of processes and systems MT/GSE has to implement. The report's main aim is to generate a discussion in my forthcoming interaction with the MT/GSE General Manager.

2. During the course of my analysis to MT/GSE 'problems' and needs, I was influenced by:

a- the ideas of Professor K.Bowen whose problem formulation methodology I used;

b- my interactions in MT/GSE and IM;

c- ideas reported in the literature about Decision Support Systems (DSS) and Management Information Systems (MIS).

However, the following is by no means a comprehensive coverage of the literature or what I have heard from the key people I met.

3. Because of the direction my research has taken, particularly after the interaction with MT/GSE management group and because of various limitations (e.g. time and technical), it is important to stress the fact that my current purpose is not to develop a DSS nor a MIS, but hopefully (with management cooperation) to test the following hypothesis:

Given

a- managers;

b- computer systems;
c- operational environment (e.g. MT/GSE),
how can one integrate these effectively into an information processing system whose outputs are:

- a- 'better' management and control which hopefully leads to;
- b- 'better' decisions which hopefully leads to;
- c- the operational environment operating efficiently and effectively, e.g.; 'better' service standards provided by MT/GSE to the rest of the airline.

4. Although there are various ideas about 'what DSS are?' [see chapter 5] they generally are one of the following:

- a- systems designed to facilitate decision processes;
- b- systems that support rather than automate the decision making process;
- c- systems that can respond quickly to the changing needs of decision makers;
- d- systems that provide useful information at the top managerial level.

[See Alter (1980) and Bonczek, Holsapple and Whinston (1981)].

The question;

- whether MT/GSE management group needs a DSS?;
- in what areas?; and
- what software / hardware is required?

is not the subject of this report. It is certainly an issue which needs further technical and conceptual research.

5. Recent research in this area concentrates on the issue of " How skillfully and efficiently the individual manager or groups of managers use the information

sources and resources available to them. ... to convert information into effective action ". See Espejo and Watt (1986) who have suggested the following three strategies:

1. " Adjustments to the organisational structure ";
2. " The design of organisational conversations ";
3. " Manager - to - task fit ".

Their research also concentrates on:

- the matching of the manager's limited information processing capabilities (input needs attenuation);
- manager's information output needs amplification.

Another researcher [see Targett (1985)] proposed the following issues which appear to be crucial to the success of the MIS particularly in the design, development and implementation phases:

1. " Analysis of the decision - taking system ";
 2. " An evolutionary approach ";
 3. " Data reduction ";
 4. " Data presentation ";
 5. " Techniques of management science ".
6. Consistent with the logic provided in the above five points, a sample of the MT/GSE General Manager's information input has been taken and includes courses / training and the task force 1985 data. The data has been reduced into what is thought to be information necessary for the General Manager and fed into the computer in a way that can be amended easily. I was guided by

the following principles in transforming the data into information:

1. flexibility;
2. reasonable completeness;
3. personal nature;
4. simplicity.

The important step now is getting minimal information requirements that would be useful for the General Manager to be implemented into the computer and updated by the General Manager. This will help to identify the relevance (or otherwise) of the proposed system and the information for the General Manager and perhaps his view of the relevance to the management group as a whole.

Computer/System Manager
attached letter.

I think now, to get the
need to have a
difficulties. I
you like to

Yours sincerely



JOHN GIBBONS
Manager NE/555

C.C.

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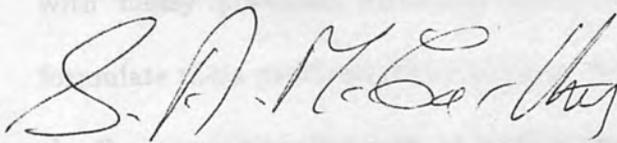
29 July 1986

Dear Sabah

Thank you very much for your discussion notes which I found very interesting and a good summary of your work. I have passed the comments to Brian Maskell, who is our Computer/Systems expert and his comments are on the attached letter.

I think now, to get things working practically, you will need to have a meeting with Brian to discuss some of the difficulties. I have copied this letter to him. Would you like to ring him direct on 562 7761.

Yours sincerely



MG JOHN GIBBONS
Manager MT/GSE

C.C. Brian Maskell



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CHAPTER 8

CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

Because the research described in the preceding chapters of this thesis could not be sensibly reported except as a whole, it has not yet been possible to bring out a published paper. However, one paper, appendix A, which is submitted for publication in the European Journal of Operational Research, was presented at the Eighth European Conference on Operational Research (EURO VIII), Lisbon, Portugal, September, 1986. This paper summarises some of the material in this thesis, and some of the conclusions of this research: this had to be drafted quickly and was done by Professor Bowen as a second author working from my records and working notes. However, for completeness, I shall restate these findings and outline important implications for further research.

1. As stated in this thesis [see chapter 2], OR analysts may need to deal with 'messy' problems, which are heavily influenced by qualitative factors. To formulate these problems, there is a need for structured methodologies, such as the Bowen problem formulation methodology [see chapters 2 and 6].

2. The research carried out in this thesis has indicated that the Bowen problem formulation methodology, is effective for its stated purposes. In my work, I applied it in a different environment from that in which it was originally tested, and it was the first consultant - client application of the methodology.

The use of the methodology has an important prerequisite: knowledge of

the significant features of the systems and subsystems relevant to the study. This includes both technological and organisational aspects that influence the effectiveness of a particular system. This prevents narrowing the scope of the inquiry to a specific direction at an early stage in order to search for a 'quick' solution (possibly by fitting a mathematical model to the wrong problem).

I developed, using the methodology, models which represent managers' perceptions of their task difficulties and the problems of their concern. These models were revised and put into a more useful form in the course of communication with their 'owners'. The diagrammatic models enhanced the manager's understanding and appreciation of major weaknesses in important links of communications, and they helped to identify where certain actions had to be taken. That these models have received substantial support from all members of the client group is a measure of the success of the intervention and the effectiveness of the methodology. Further, the discipline of the methodology, and its structural properties, enabled a 'student' experimenting for the purpose of his thesis to become quickly accepted as a 'consultant'.

As a side issue, I added two elements (the delay and lack of communication and purposeful action) to the symbols used. Because of the importance of the notation being simple and generally relevant, I discussed these additions with Professor Bowen. I did not add them until I had convinced him that their inclusion met the conditions he had laid down in Bowen (1983).

3. It can be said with confidence that the evidence provided by the experience of chapters 6 and 7 supported the proposition, stemming from chapters 2, 3,

4, and 5, that what managers need are models which enable them to reflect on the way they manage process and not those which simulate that process.

4. The models developed in chapter 6 which are consistent with the logic of point 3 above, helped to change the initial feel of management that their main problem was a major weakness in their computer information systems. They became aware of the lack of communication and control, which are central to the process of management.

5. There is no need for a gaming process in the traditional form if a satisfactory learning process can be achieved as part of a process of intervention. In the intervention reported in chapter 6 of this thesis, the first 'learning' model (or game) turned out to be the OR process as used by me. The OR process as a game has been discussed by Bowen (1978), but the use of the process as a learning 'game' has not been clearly emphasised before.

6. The results of this study support the argument developed in chapter 3, that the problem owners' participation in the process of building any models as part of an inquiry into 'problem - situations', will increase the likelihood of successful implementation. Models should be simple, flexible, and reasonably complete. (It was apparent during the interactions that the information not explicit in the models, but shared by the 'owners' and in part by the analyst, were satisfactory although 'incomplete' to an outsider).

7. Point 6 above is supported by the experience of chapter 7 in which, as a result of the management learning process and participation, a decision aid

was provided for the top - manager of the part of the organisation I served. This system should help him to integrate scattered pieces of information about various activities inside and outside his department. In other words, it will act as a 'diagnostic facility' which will help him to discern where things are going wrong or starting to go wrong, and what actions might be taken to get them right.

8. This decision aid (MIS or DSS) is a second type of learning process in two stages. First, its development requires the manager involved to reflect on the detail of the information he needs in filling the data store and in updating etc. Second, it can be used to play through the information in the course of the days work as a memory aid. And third, it can accept the learning gained by modifications to the system, which can be done by the manager or, if he wishes, with the aid of an analyst.

9. The processes that I have gone through successfully in an industrial management environment are based on principles taken from a wide range of subject areas, and it has proved possible to merge these coherently in the context of seeking ways to provide 'good' learning models.

10. Based on the above conclusions many recommendations for further research can be identified.

a. Effort is needed to develop a computer graphics software to enable the diagrammatic notation used in Bowen's problem formulation methodology to be easily processed. The task of providing adequate diagrams is time - consuming

and the ability to try out possible descriptions of people's perceptions quickly, or to modify diagrams quickly is important.

b. Mathematical developments could be introduced to enable questions to be more easily posed about the diagrams produced e.g. whether the rules have been properly applied, whether interactions not shown should be investigated and soon. Ideas could be borrowed from areas such as set theory, graph theory and others. However, this issue is beyond the scope of this thesis.

c. It could be very useful to examine the possibility for developing certain models of the STOCK system as devices for lower levels of management and for key operatives. These would be learning games of the type mentioned in chapter 4, by the BA Operational Research and Business Support Manager.

d. It would be valuable to use the Bowen problem formulation methodology to inquire into problems of communication and control in other selected areas (e.g. in British Airways), irrespective of there being a perceived problem.

e. Finally, and more specifically, further developments of the decision aid outlined in chapter 7 are required to examine its potential advantages for implementation as a device for communication and control for a management group (such as Motor Transport / Ground Support Equipment (MT/GSE) department of BA).

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APPENDIX A

Material Submitted for Publication

APPENDIX A

Material Submitted for Publication

A paper presented at the 1974 Annual Meeting of the American Chemical Society (PURE VIII), Boston, Massachusetts, September 23-28, 1974.

Abstract

This paper stems from a research inquiry into models which could be used in an interactive manner for exploring managers' needs. During the early stages which concentrated on the learning process, the concept arose that what managers want are models which allow them to reflect on the way they manage process and not those which simulate that process. In a small part of a large organisation, a study was made of the perceptions of a hierarchy of managers, and other key individuals, of their roles, their essential communication channels and the processes of decision-making, planning and feedback process used. This proved to be the first stage of a learning process for the managers and also, of course, for the researchers. The second stage was the development of a computer-based system for the recording of and access to essential features of complex problems and communications about these; it was to be a planning schedule and process control held in common by a management group. The account given is of work in progress towards a management aid, or decision support system, of this kind.

EXPLORING MANAGERS' NEEDS FOR DECISION AIDS

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and

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Keywords:

Management

Learning

Model

Process

Decision

Full Address:

A paper presented to the Eighth European Conference on Operational Research (EURO VIII), Lisbon, Portugal, September 16-19, 1986.

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Abstract

This paper stems from a research enquiry into models which could be used in an interactive manner for exploring managers' needs. During the early stages which concentrated on the learning process, the concept arose that what managers want are models which allow them to reflect on the way they manage process and not those which simulate that process. In a small part of a large organisation, a study was made of the perceptions of a hierarchy of managers, and other key individuals, of their roles, their essential communication channels and the problems they faced. Because of the structuring and feedback process used, this proved to be the first stage of a learning process for the managers and also, of course, for the researchers. The second stage was to provide a computer-based system for the recording of and access to essential features of current problems and communications about these: it was to be a planning schedule and process control held in common by a management group. The account given is of work in progress towards a management aid, or decision support system- of this type.

Keywords:
Management
Learning

Models

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1. Introduction

This paper describes some aspects of a current PhD study by the first author. It has been drafted from his material by the second author who is supervising the study. It concentrates on practical research carried out in a large organisation and is an inquiry on behalf of managers, and with managers, seeking ways to improve management control. For convenience, the paper uses "we": in practice it has been an interaction between managers and the first author, with the second author intervening at important 'political' stages in the total process.

The study started with the intention to examine learning 'games' and to seek criteria for judging these. At an early stage, it was realised that any models used in the learning process were games as defined in [1]: a further shift occurred when, after a survey of the literature on 'learning' and 'management' games, it became apparent that while there was a great deal that referred to the process in an organisation, there was very little that related to the control of that process by senior management. The question then became "what is the learning process of managers that enables them to adapt and retain control of a process which they do not directly involve themselves in, except by managing those who do?"

Such a question could not be studied in theory. Ideas could only be tested and developed in a real environment. We were fortunate in finding hosts who were interested in the basic aims of the study and willing to cooperate, trading the time of managers (a precious resource) for our research of their managerial environment.

We gratefully acknowledge their role in the research we now describe.

2. The Environment

Two departments of the organisation were primarily concerned, although we were given considerable freedom to talk to key people elsewhere.

Department X, our main client group, was responsible for all scheduled maintenance and emergency repairs of some 3000 vehicles and related equipment of varied, and sometimes highly specialised, types. Their aim was to ensure high availability of vehicles as required by the customers who were part of the overall organisation.

Two computer systems were available to them to handle stock control and vehicle and equipment serviceability and availability. These were developed by Department Y, who were responsible for all computerised information systems used by the organisation.

The situation, when we came in, was that management's primary concern was with the suitability and performance of the computer systems. Our initial enquiry was to some extent conditioned by this concern, but, as we told them, our research interest would take us

into wider reaches of their management process. The sort of issues we had in mind included seeking answers to the following questions:

who uses the computer models and with what results, satisfactory or adverse?

how and from what sources does information come to managers?

do they expect advance warning of customer dissatisfaction?

what control is management able to exercise over the operational process and how?

how did management become aware of the need for an internal study (recently put in hand) of computer systems performance?

how do management plan to stop things going wrong (prevention or rapid cure)? e.g. by learning from earlier shortcomings and by better understanding of interactions that could lead to shortcomings.

3. Methodology

We had already decided to use a problem formulation methodology [2], and its diagrammatic notation, that had not yet been tested in such an industrial setting, and to concentrate initially on the broad structure of internal and external communications and data flow. This concentration was recommended as a result of experimental work [3] carried out with a university teaching group as clients: the value of such initial study had also been partially supported by the results of a demonstration given to a group of methodology researchers with one of their number as a client (his problem was concern with his own process of consultancy using a different methodology).

It was very evident, from documents provided initially (to give us a feel for the activities of the departments and the roles of the hierarchy of management), that there were contradictory views as to why the stock control system was not functioning properly; we planned to get independent perceptions about this and about wider issues from a number of those involved. In the end, as our relationship with our clients blossomed, we were able to seek views from relatively junior members of Department X and from customers, as well as those of many senior people in both departments, including all managers.

Because we needed to build a number of diagrams of perceived system structures and inter- and intra-system interactions (communications, data-flows, etc) for later discussions with management as a whole, we asked if all interviews could be tape-recorded, and used freely (inside the departments) apart from any statements specifically said to be "for our ears only". This was readily agreed: the group as a whole prided themselves on the openness with which they conducted affairs, and we found as we progressed that such openness was indeed very real.

4. The First Round

Interviews took place with the following people, members of Department X unless otherwise stated:

The Stores Manager (who had a second managerial role as the main interface with customers when problems arose);

his Senior Stores supervisor;

a storekeeper;

a manager in Department Y, with specific responsibility for computer systems support to Department X, and his senior analyst/programmer;

two Workshop Senior Maintenance Engineers;

the Vehicles and Equipment (V & E Manager);

the Operations Manager;

a Systems Development Engineer (a link-man between Departments X and Y, working under the V & E Manager);

the Accountant in the Finance Department, responsible for Department X affairs; and

the Maintenance Control Manager.

the Spares/Maintenance Support Buyer (Supplies Department).

We had not up to this point, interviewed the General Manager or his deputy (also Maintenance Manager), nor had we met any of the customers, although the view was expressed that the Operations Manager, was, in effect, a customer.

However, because interest was growing, questions, which were difficult to answer simply, were being asked about what we were doing. Also we needed some discussion on the relevance of our analysis. A first formal group meeting was held, those present being the authors, the Deputy General Manager, the Stores Manager, the V & E Manager and the Maintenance Control Manager.

Diagrams representing the expressed views of the thirteen interviewees, some having been revised by feed-back sessions with them, were presented. A brief preamble explained the notation, in part a coding system for qualitative data - some of them had already seen a paper giving fuller details. Examples of the diagrams, which relate to interviews referred to later, are shown in Figures 1 to 3 as illustrating the sort of data being presented. The notation is shown in Figure 4.

Some interesting aspects of discussion, largely between themselves, were:

the ease with which they used the diagrams to aid discussion;

the seriousness with which they took individual differences of perception, as reflecting partial or particular views based on responsibilities and expertise;

the difficulties faced by some staff in knowing exactly to whom they should respond;

the somewhat anomalous position of the Operations Manager;

the nature of their links with Department Y (it was noted that steps were being taken to improve communication - see below)

the disagreements with the views of one of the Senior Maintenance Engineers, while accepting that his having such views had to be recognised.

Additionally, there was discussion on the different categories of communication (formal reporting; informal; semi-formal in meetings). Things of interest to them were emerging, and they agreed that we should continue and extend our enquiries.

We then went through a similar process with the manager in Department Y. A senior adviser to the organisation as a whole (through whom we were introduced to the two departments) also attended this session. It was at this stage that we came to realise that the stock control issue was no longer a central one, and that, by just being there asking questions (nothing to do with our methodology), we had influenced communication between the two departments (in exactly what way we cannot be sure, and perhaps it would eventually have improved anyhow). The most encouraging outcome of this meeting for us was the senior adviser's interest. He said that he had learnt a lot about the organisation and problems of the two departments in a very short space of time; indeed, he had learnt things that he felt he should have known before. The diagrammatic notation and the process of its use impressed him as a tool that could have much wider use in the organisation. He thought that a computerised method of using it could be of great value.

5. The Second Round

And so we went on to have further sessions with all participants, revising and extending the diagrams; there were additional interviews with

the Maintenance Manager (Deputy to the General Manager); and

two Senior Managers in one of the Customer Groups.

the Supplies Department Manager.

This culminated in a formal presentation using chosen diagrams to the General Manager of Department X. This meeting was also attended by two of his senior managers, and by his key links with Department Y, with Supplies and with Finance. Without going into detail, the General Manager was impressed by what he heard and by the way in which the discussion was focussed by the diagrams. One phrase he used was "I have learnt something new".

We requested that he now be interviewed and asked for an hour of his time. He offered us two hours and cancelled some other appointments to give us an early opportunity to question him.

We were now moving towards a point when we had to make a decision as to where all this was leading. It was certainly exciting everyone (especially ourselves) but where was it taking us? And what was the problem?

6. Where to go from here?

One direction would have been to reinterview, to establish in some detail what went on in all the communications and other interactions. What was certain was that, when we were ready to discuss our analysis of the General Manager's picture with him, he would properly expect to have a clear exposition of what we now intended. We had accepted, mainly as a result of comment by the Deputy General Manager, that the diagrams themselves would not be suitable as a central feature of management aid, although at one time we had had this in mind. What seemed to be wanted was some record, possibly one held in common by all managers, and in their language, that would enable them to access the various important bits of information that stemmed from both formal and informal communication.

We tried to persuade the Deputy to keep a diary for a few weeks and note his key bits: he had indicated that with his wide spread of links (in his role as Maintenance Manager), it was not easy to maintain control everywhere. However, he felt that he had insufficient spare time to do this. Despite the fact that he had just spent a relaxed two hours discussing our ideas, we realised that a formal on-going commitment was not a welcome 'extra' for a busy man, and such concentration (even for a limited period) could be both worrying, even threatening.

So we decided to put the general idea of a decision support system, as described above, to the General Manager, one that the first author would structure using, in the first place, key files that the Manager would specify. The aim would be simplicity and flexibility: the principle would be that eventually he would construct his own required formats for data and be solely responsible (he or his secretary) for updating and adapting as time passed and emphases changed.

7. Serving the General Manager

The interview and feed-back sessions with the General Manager proved to be most constructive. He rapidly centred his thinking, when faced with his most complex communication network, on his inability, despite good intentions, of getting around to everyone. He was also very conscious of the difficulties of getting a clear resume of key issues and actions

to be taken, particularly when in a hurry, which was a normal state of affairs.

In short, he was enthusiastic when we proposed our as yet untested ideas. He asked us to go ahead and assured us of his cooperation.

Our own constraints were a further pressure towards something simple. The first author had only a limited time to get to a definitive stage, since his main task was the completion of his doctoral thesis. We therefore warned the General Manager that we certainly could not contemplate any development of an overall departmental tool (which would also have to incorporate privacy arrangements) and it was agreed that we would aim merely at establishing the feasibility and acceptability (to the General Manager) of a personal management aid, but one which could be developed for wider use among department managers in due course.

8. Software, Hardware, and the Chosen Formats

Issues of compatibility of the computer system to be adopted with existing and future systems in the organisation, and the need for a lot of the work to be done at the College, were thoroughly investigated.

The final choice was the SUPERFILE system implemented on the RM NIMBUS microcomputer. An IBM microcomputer version of the SUPERFILE system is also available: it can be implemented on the IBM system which the organisation uses. The actual formats produced are of course very specific to the General Manager's manifold responsibilities and these and the sort of data they would contain are confidential. The type of format is given in the fictitious examples of Figures 5 and 6.

The problems of introducing the system have been discussed with Department Y and with the General Manager's computer systems adviser. An implementation programme has been provisionally agreed.

9. Summary of Major Research Points

1. The Bowen problem-formulation methodology proved to be effective for its purposes:
 - (a) exploration of managers' problems;
 - (b) provision of a focus for communication between analyst and managers;
 - (c) provision of an effective tool for recording the essential features of interviews (primarily communication and organisational perceptions); and
 - (d) stimulating discussion between members of the overall client group.
2. The discipline of the methodology and its structural properties enabled a relatively unpractised researcher to attain rapidly, in the eyes of management, the status of an acceptable consultant. The original arrangement was that they were helping a student with a

research programme, but this perception of the first author's role lasted no longer than the period up to the first formal presentation

3. The "learning" model (or game) turned out to be the OR process as it was practised by us. The OR process as a game has been discussed by Bowen [1], but the use of the process as a learning process has not been so evident before.

4. The initial feel of management that their computer systems were the central feature of their problem soon disappeared. They came to focus on the process of management, as we had predicted.

5. A model of the process centring on their stock control and vehicle serviceability and availability might well be useful as a learning device for more junior staff. Part of the management process is concerned with such training programmes.

6. The move towards a simple and manager-operated information system seems to be something that was a 'seen' need, but it had never been pressed - perhaps because it seemed trivial? What we have done, and how we have done it, seems to be in good accord with work by Targett [7] and by Espejo and Watt [4], and, although not so directly, in accord with Espejo's cybernetic approach [6]. Our ideas, however, were independently developed. We have also studied work by Checkland and Griffin, Ackoff, Radford, Hubber, Argyris and many others, without observing any essential incompatibility.

7. We observe that, in this case and probably very many others, managers do not have a planned process for reflecting on their own management and control, whereas they have many experts who study the more mechanical processes and lower level control processes in their departments. Similar findings come from recent research by Moynihan [6] in military and business areas and from current research by him in a transportation environment (not yet reported).

8. Finally, we note that there are many methodologies, apart from the one we have used, which would probably be equally, albeit differently, effective in the early inquiry stage. The important thing is the ultimate provision of a tool which puts managers into the driving seat without the need for constant analyst intervention, and we believe that we are en route to achieving this. We would like, eventually, however, to see the problem-formulation process available on computer, so that it can also be used by, rather than for, clients.

9. The second author has adopted (as yet in pencil and paper form), the concepts of the simple format approach as a management aid for his academic and research activities. He finds himself, even at the present primitive stage much more efficient and in control. He intends to extend this usage and become a micro-computer owner.

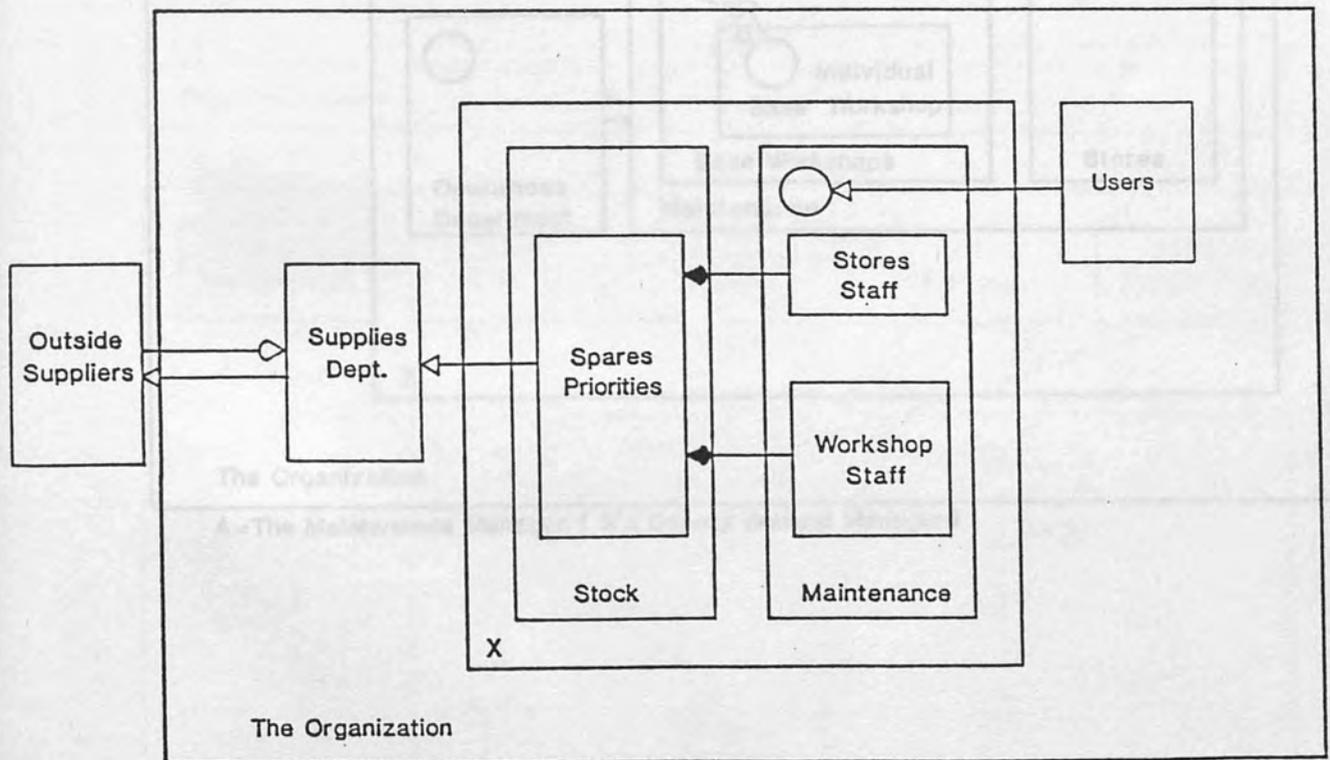
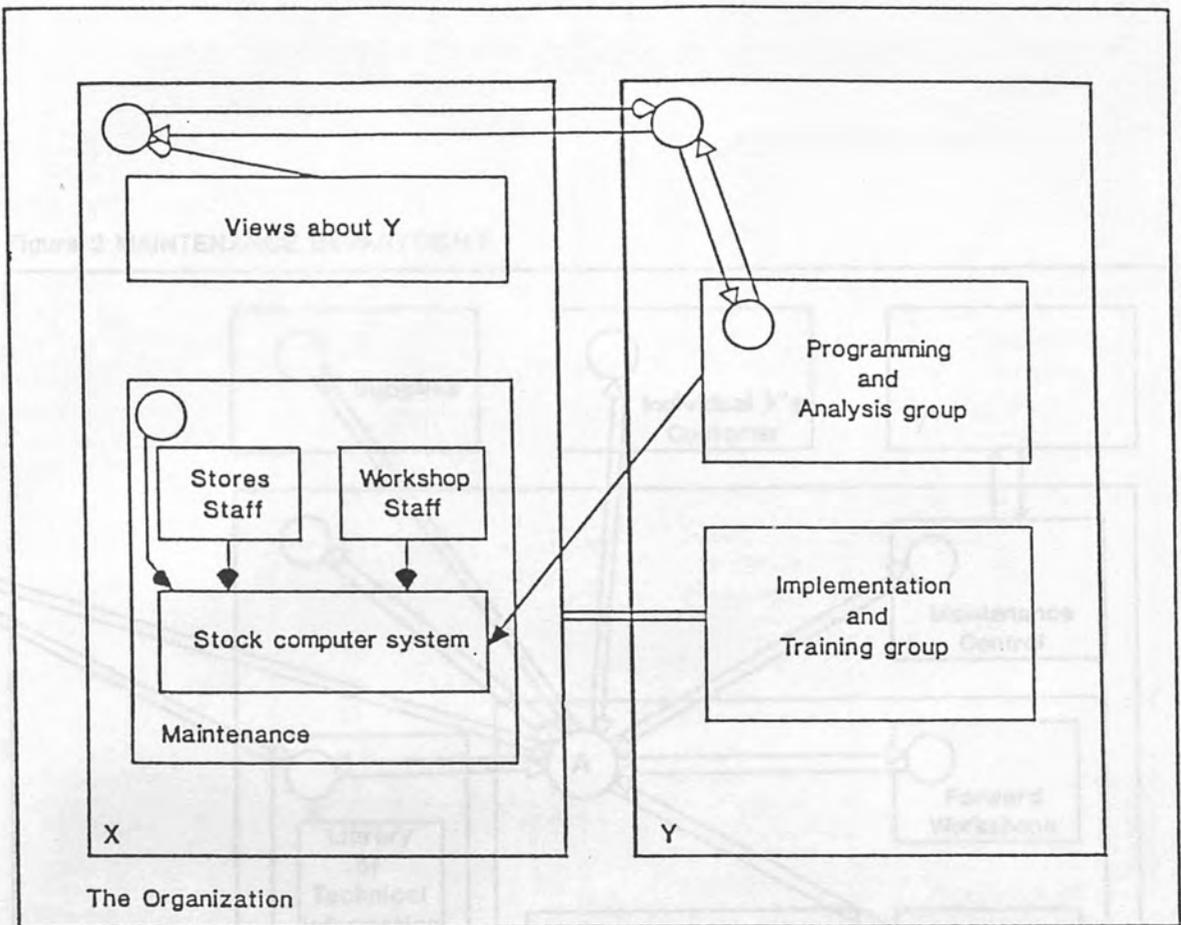
DEPARTMENT	Operations Department
PROBLEM AREAS	<ol style="list-style-type: none"> 1. Delays in transportation 2. Bad communication with the workshops 3. Reorganisation of work schedules
WHO IS INVOLVED	Operations manager and his supervisors
ACTIONS	<ol style="list-style-type: none"> 1. To speed up the maintenance process in the workshops. 2. To contact supplies department.
NEXT INTERACTION	End of April 1986

Figure 5. Example of Problems Format

DATE	15 March 1986
SUBJECT	Systems Steering Group
OBJECTIVE	To investigate X's computer systems
RESPONSIBILITY	X's computer systems advisor/Y department
NOTES	<p>The following issues will be investigated</p> <ol style="list-style-type: none"> 1. Accident reporting system 2. Stock control system 3. Workshop scheduling
NEXT INTERACTION	August 1986

Figure 6. Example of Communication Format

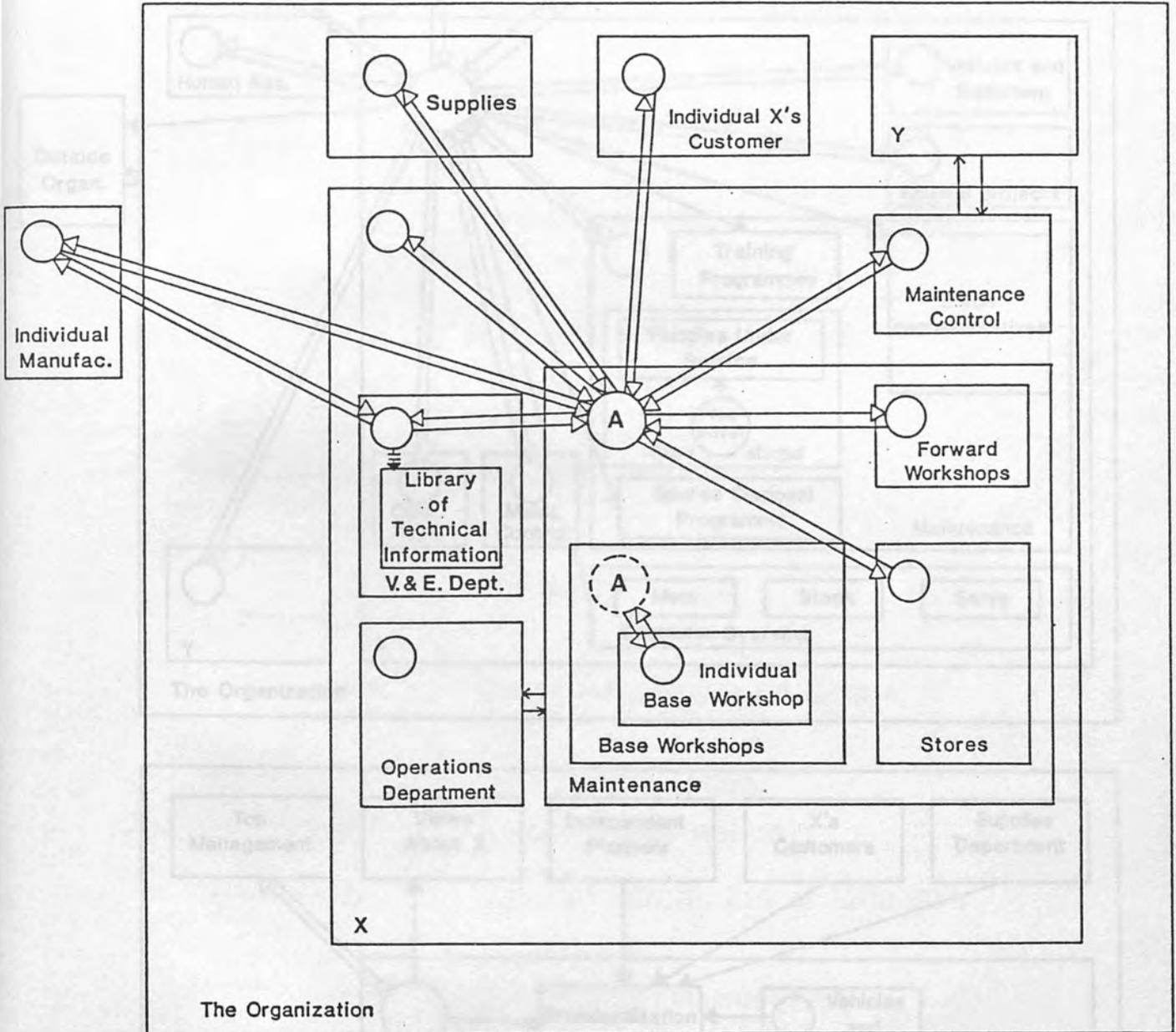
Figure.1 Y DEPARTMENT



Spares priorities problem

Figure 2 MAINTENANCE DEPARTMENT

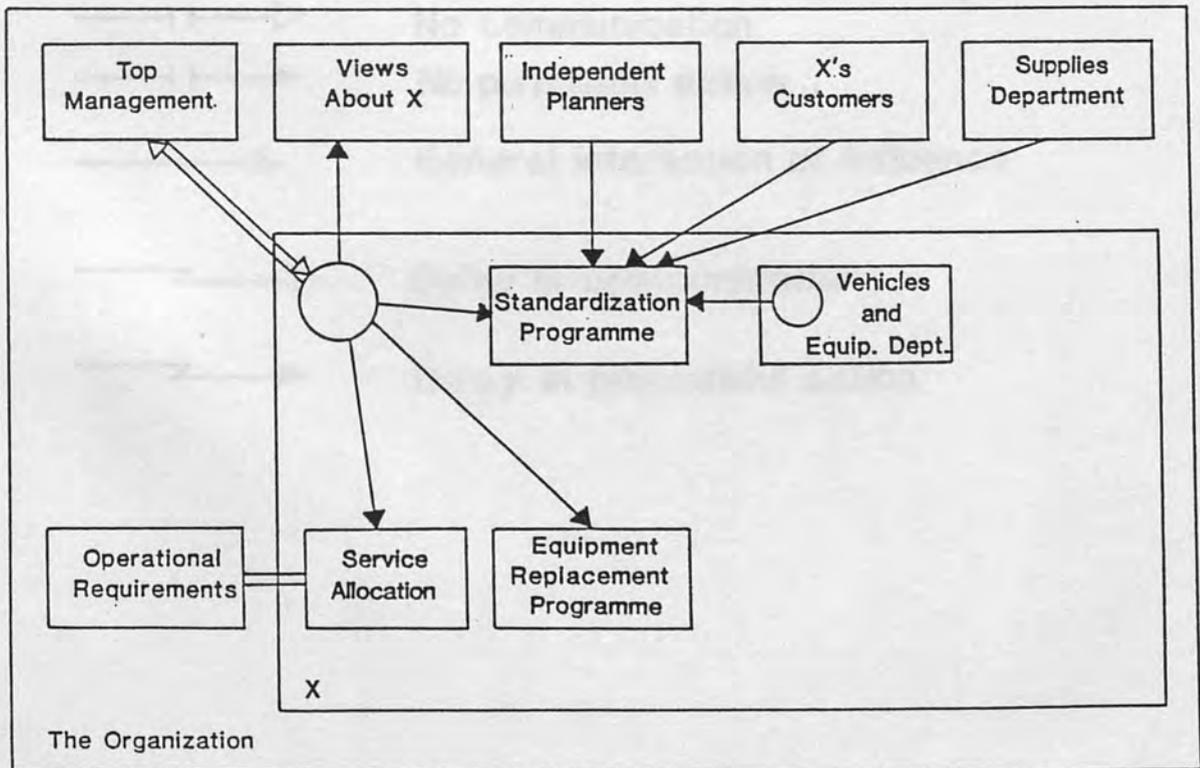
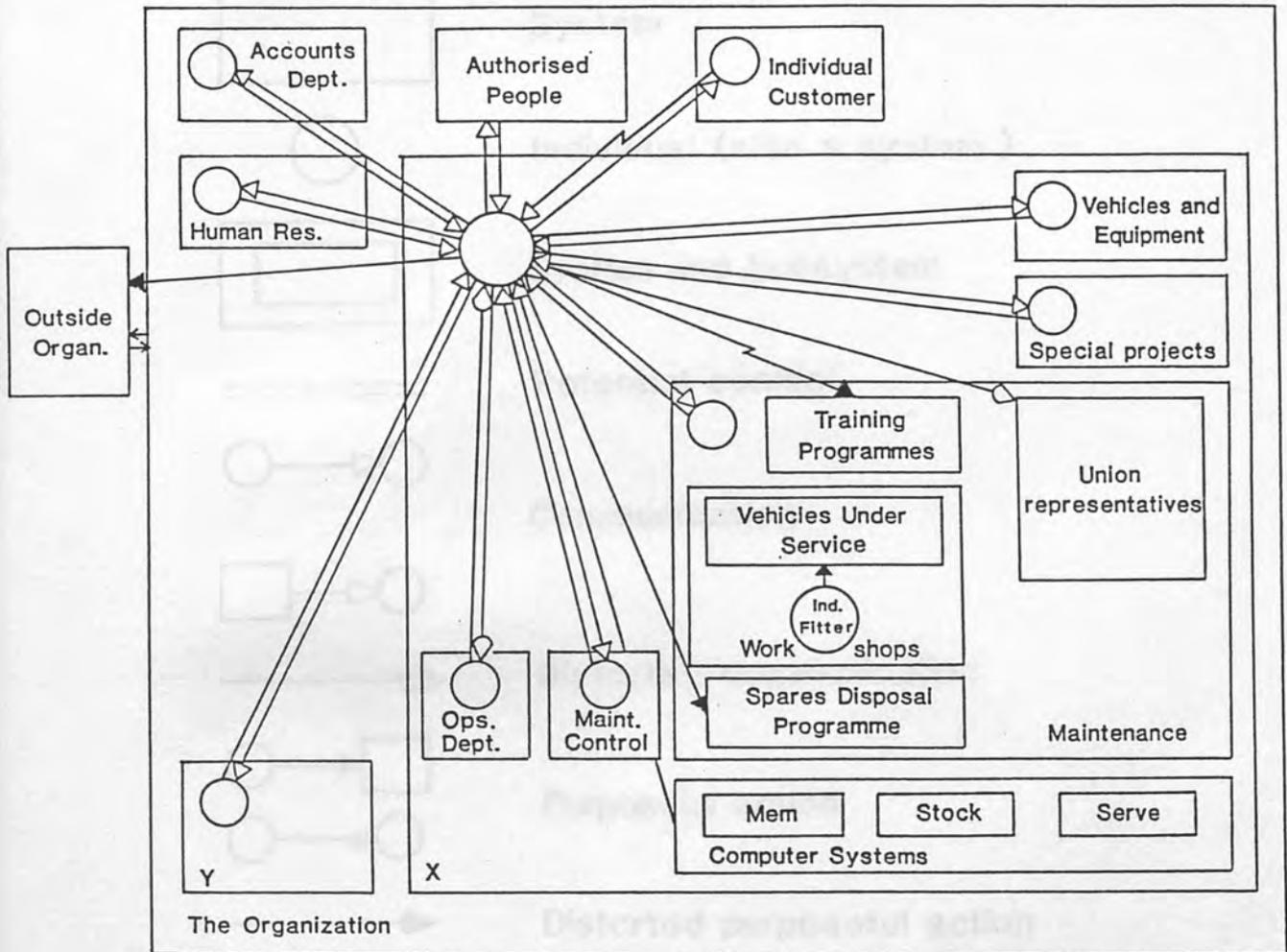
Figure 2 MAINTENANCE DEPARTMENT



The Organization

A=The Maintenance Manager (X's Deputy General Manager)

Figure 3. X DEPARTMENT



Perceived problems in X

Figure 4 NOTATION

