2

# NAVAL POSTGRADUATE SCHOOL
## Monterey, California



# THESIS

A COMPARATIVE STUDY OF GDSS USE:
EMPIRICAL EVIDENCE AND MODEL DESIGN

by

Amy L. Hughes
and
Daniel H. Webb

September 1987

Thesis Advisor: Tung X. Bui

Approved for public release; distribution is unlimited.

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

A186308

# REPORT DOCUMENTATION PAGE

| | |
|---|---|
| 1a REPORT SECURITY CLASSIFICATION<br>Unclassified | 1b RESTRICTIVE MARKINGS |
| 2a SECURITY CLASSIFICATION AUTHORITY | 3 DISTRIBUTION/AVAILABILITY OF REPORT<br>Approved for public release; distribution is unlimited. |
| 2b DECLASSIFICATION/DOWNGRADING SCHEDULE | |
| 4 PERFORMING ORGANIZATION REPORT NUMBER(S) | 5 MONITORING ORGANIZATION REPORT NUMBER(S) |
| 6a NAME OF PERFORMING ORGANIZATION<br>Naval Postgraduate School<br>6b OFFICE SYMBOL (If applicable)<br>Code 54 | 7a NAME OF MONITORING ORGANIZATION<br>Naval Postgraduate School |
| 6c ADDRESS (City, State, and ZIP Code)<br>Monterey, California 93943-5000 | 7b ADDRESS (City, State, and ZIP Code)<br>Monterey, California 93943-5000 |
| 8a NAME OF FUNDING/SPONSORING ORGANIZATION<br>8b OFFICE SYMBOL (If applicable) | 9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER |
| 8c ADDRESS (City, State, and ZIP Code) | 10 SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO |

11 TITLE (Include Security Classification)
A COMPARATIVE STUDY OF GDSS USE: EMPIRICAL EVIDENCE AND MODEL DESIGN (u)

12 PERSONAL AUTHOR(S)
Hughes, Amy L. and Webb, Daniel H.

| 13a TYPE OF REPORT | 13b TIME COVERED | 14 DATE OF REPORT (Year, Month, Day) | 15 PAGE COUNT |
|---|---|---|---|
| Master's Thesis | FROM ____ TO ____ | 1987 September | 109 |

16 SUPPLEMENTARY NOTATION

| 17 COSATI CODES | | | 18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) |
|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | Group Decision Support System (GDSS); Decision Support System (DSS); Management Information System (MIS) |

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


Although the technology is in its infancy, Group Decision Support Systems (GDSS) have attracted attention as a possible means of improving the effectiveness and efficiency of the ever-increasing number of group decisions that are made in modern organizations. We have conducted an empirical study in which groups of three were tested in two different settings. One setting involved unaided face-to-face problem solving and the other involved GDSS-aided face-to-face problem solving. Our study expanded the research of Fijol and Woodbury and thus, we replicated the conditions of their experiment. In support of a major premise of our model, we found that the case used was too simple to be efficiently solved using a GDSS. Further research is necessary to define precisely which characteristics and settings are best used to support each problem type and to make GDSS a useful management tool.

Research has suggested that a wide range of options may be included in a GDSS and that there are several possible settings for its use. Not all settings and options, however,


| | |
|---|---|
| 20 DISTRIBUTION/AVAILABILITY OF ABSTRACT<br>☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS | 21 ABSTRACT SECURITY CLASSIFICATION<br>Unclassified |
| 22a NAME OF RESPONSIBLE INDIVIDUAL<br>Prof. Tung X. Bui | 22b TELEPHONE (Include Area Code)<br>(408) 646-2630<br>22c OFFICE SYMBOL<br>Code 54Bd |

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

#19 ABSTRACT (CONTINUED)

are feasible for all problem types. In addition to our study, we have developed a model, based on problem type, that recommends optimal settings and characteristics for GDSS use with a particular problem type.

S N 0102- LF- 014- 6601

Approved for public release; distribution is unlimited.

# A Comparative Study of GDSS Use: Empirical Evidence and Model Design

by

Amy L. Hughes
Lieutenant, United States Navy
B.A., Moravian College, 1979

and

Daniel H. Webb
Lieutenant Commander, Supply Corps, United States Navy
B.S., Florida State University, 1976

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN INFORMATION SYSTEMS

from the

NAVAL POSTGRADUATE SCHOOL
September 1987

Author: ______________________
Amy L. Hughes

______________________
Daniel H. Webb

Approved by: ______________________
Tung X. Bui, Thesis Advisor

______________________
Nancy C. Roberts, Second Reader

______________________
Willis R. Greer, Jr., Chairman,
Department of Administrative Science

______________________
James M. Fremgen,
Acting Dean of Information and Policy Sciences

The authors

This

# ABSTRACT


Although the technology is in its infancy, Group Decision Support Systems (GDSS) have attracted attention as a possible means of improving the effectiveness and efficiency of the ever-increasing number of group decisions that are made in modern organizations. ~~We have~~ conducted an empirical study in which groups of three were tested in two different settings. One setting involved unaided face-to-face problem solving and the other involved GDSS-aided face-to-face problem solving. ~~Our~~ study expanded the research of Fijol and Woodbury and thus, ~~we~~ replicated the conditions of their experiment. In support of a major premise of our model, it was ~~we~~ found that the case used was too simple to be efficiently solved using a GDSS. Further research is necessary to define precisely which characteristics and settings are best used to support each problem type and to make GDSS a useful management tool.

Research has suggested that a wide range of options may be included in a GDSS and that there are several possible settings for its use. Not all settings and options, however, are feasible for all problem types. ~~In addition to our study, we have developed~~ a model, based on problem type, that recommends optimal settings and characteristics for GDSS use with a particular problem type was developed. (Thesis)

TABLE OF CONTENTS

## LIST OF FIGURES

# I. INTRODUCTION

In organizations today a major issue for top management is coping with the scarcity of resources. One scarce resource often overlooked is management itself. In growing organizations, managers are often hard pressed to contend with the number of meetings and day-to-day decisions they face. When crises occur the problem is compounded. Adding more managers does not necessarily help the situation. Due to the difficulty in finding competent managers, and because the addition of managers often complicates communication interfaces, more complexity is created which can actually exacerbate the original problem. One answer to this dilemma is to discover new ways to make more effective use of the scarce resource, a manager's decision-making time.

## A. THE NEED FOR GROUP DECISION SUPPORT SYSTEMS

Research in the area of Management Information Systems (MIS) reveals a need for more efficiency in collecting, disseminating and using information in organizations. A study of MIS research between 1972 and 1982, conducted by Culnan, indicated that one of the emerging research trends of the time period was the use of Decision Support Systems (DSS) [Ref. 1]. In general, the concept of a DSS is to provide an interactive end-user-oriented system to facilitate the solution of complex, unstructured problems. These systems are distinguished from other Management Information Systems because they place an emphasis on decision models and databases [Ref. 2: pp. 81-82]. It must be emphasized that the DSS's role is to facilitate decision making, not to replace the manager.

Since that time there has been a large volume of new research in the field of DSSs, in general, and in a subset of this area, Group Decision Support Systems (GDSS), which is the focus of our research. We chose GDSSs because group decisions are considered to be of increasing importance since some of the most critical organizational issues require a consensus to ensure implementation [Ref. 3: p. 3], and we feel that it is possible for a GDSS to enhance group process. GDSS is a subset of the DSS field that is specifically oriented towards the support of group decisions and collective problem solving. DeSanctis and Gallupe have defined the group and the group's role to be

> two or more people who are jointly responsible for detecting a problem, elaborating on the nature of the problem, generating possible solutions, evaluating potential solutions, or formulating strategies for implementing solutions. The members of a group may or may not be located in the same physical location, but they are aware of one another and perceive themselves to be part of the group . . . . [Ref. 4: p. 590]

The purpose of a GDSS is to improve the efficiency of group decision making, or to decrease the amount of meeting time, and to improve the quality of the decision in some way. Designers have attempted to achieve this goal by studying group process and discovering ways to incorporate existing behavioral models, problem solving methodologies, and communications enhancing techniques into the GDSS.

Interest in developing a system to support managerial decisions began during the 1970's. At that time there were a few DSSs available for use on a mainframe. The advent of the microcomputer during the late 1970's and early 1980's, and the improvements in technology that allowed for faster processing and larger memories, encouraged the proliferation of spreadsheet programs, database management systems and software used to support decision-making. Recently, a more complex architecture for DSSs has evolved that includes the following components: a Diàlogue Manager (that controls the user/computer interface), a Model Manager (that controls the decision-making models), and a Data Manager (that controls the databases used to support the decision). In order to provide an architecture that is suitable for group decision support another component, the Communications Manager (that enables distributed group decision-making by controling communications between multiple users) has been added [Ref. 2: p. 82]. As can be seen from this brief chronology, the evolution of a GDSS has been very recent.

In the past much research has been conducted to determine the factors that are important to the design of Decision Support Systems. These studies have concentrated primarily on Individual Decision Support Systems (IDSS), rather than on Group Decision Support Systems (GDSS). IDSSs have existed for several years and are commercially available for use on a wide range of systems (from personal computers to mainframes), however, the concept of a GDSS has occurred only recently. The GDSS technology is not yet mature, in fact, the majority of GDSSs exist for research purposes and are not yet commercially available. A major barrier preventing these systems from reaching maturity is that several basic design issues are still unresolved.

The initial approach to designing a GDSS has been to adapt existing decision making models or to create new models on which to base the designs. A number of GDSSs have been developed recently that have been based on several different decision making models. A summary of the different decision making models used follows:

1. Nominal Group Technique - This technique involves anonymous generation of ideas, round robin listening to ideas, discussion and clarification, and voting and prioritization of ideas [Ref. 2,5: pp. 82, 588].
2. Consensus Mapping - This method allows users to structure ideas by producing a graphic map of interrelationships among individual ideas and to rearrange and supplement ideas as required [Ref. 5: pp. 587-598].
3. Analytic Hierarchy Processing - In this method, complex decision problems are arranged into a hierarchy, with the goal at the topmost level and the lower levels elaborating on the goal [Ref. 6: pp. 494-495].
4. Expert Systems - Several researchers are excited about the possible incorporation of an expert's knowledge into a GDSS. These systems are specially designed to solve problems by using rules and heuristics. [Ref. 7,8,9,10: pp. 936, 22, 474-477, 458].

Organizational changes to which the new GDSS technology must respond will include the need for faster and more frequent decision making, the need for more frequent innovations, and the need for organizational information gathering that is continuous and more wide-ranging than before [Ref. 7: p. 932]. More effective electronic support will be necessary because group decision making will be required more frequently to deal with the additional complexity, and there will be resistance to meetings because they are time consuming and inefficient. Mintzberg has stated that the manager's current decision making environment is poor and that managers require a systematic means for sharing information [Ref. 11: p. 60]. In the future Group Decision Support technology will change this so that meetings will become more efficient and the decision process will become more structured.

## B. ADVANTAGES AND DISADVANTAGES OF USING A GDSS

Several authors have suggested that the very nature of society is in transition from the industrial-based society, with which we are familiar, to an information-based society [Ref. 4,7,12,13,: pp. 509. 932-937, 109, 13]. The post-industrial society is characterized by a great deal of complexity and turbulence. This is caused by the rapid growth in the cumulative knowledge of society. In order to handle the ever increasing knowledge base, technology will improve and there will be more social and economic diversity, which will lead to societal interdependence and specialization [Ref. 7: p. 937]. Because people have a limited capacity for attention [Ref. 14: p. 271], the new technology must permit the manager to screen out unimportant data.

With the goal of improving the effectiveness and efficiency of group decision making in mind, there are advantages to using on-line systems to support decision making. Especially in solving complex problems, the use of a GDSS enables the problem to structure the decision making process with the use of models and databases, rather than to be limited by the lack of available tools to manipulate data [Ref. 15: p. 148].

Rapid turnaround is also a key advantage in using on-line systems. Specifically, Alter lists the following advantages to rapid turnaround:

1. Quick response to queries.
2. Few interruptions while waiting for a response thus preventing the user from breaking his or her train of thought.
3. Consideration of more alternatives is possible because more tests can be run.
4. Debugging is less frustrating because jobs can be rerun more quickly.
5. It is essential for real time operations. [Ref. 12: pp. 112-113]

Research conducted on the differences between group and individual problem solving has indicated that group problem solving has many advantages over individual. Groups have been shown to be better than individuals in solving problems that lack structure [Ref. 16: p. 82]. Other group strengths include the ability to handle assumptions, the ability to facilitate communications about conflicting ideas, an increased understanding of alternatives, and creativity in decision making [Ref. 17: p. 267]. Although there are advantages to the group process, the drawback of increased communications requirements for groups cannot be overlooked. It is necessary for GDSS designs to capitalize on the benefits of group processes while minimizing the expense of communications requirements.

Although there are advantages to using a GDSS in decision making, numerous disadvantages have been noted. Kafoglis enumerates the major drawbacks to using DSSs as time and expense of data gathering, management's lack of time and interest to learn about the systems, difficulty integrating components like statistical packages, graphics, and databases, and the fact that DSS departments do not have the right personnel for designing DSSs [Ref. 18]. To this Alter adds the concentration on technical issues rather than actual uses for the system, and the lack of support from the decision makers as stumbling blocks to the use of GDSSs [Ref. 19: pp. 97-98]. In addition, Van de Ven and Delbecq list the following pitfalls to group problem solving: the "focus effect" that causes groups to "get in a rut", self-weighting, covert judgments, pressure involving the status of group members, conformity pressure, domineering personalities, expenditure of additional effort to maintain the group and the tendency to rush into a decision without fully considering alternatives [Ref. 20: p. 206]. When considering implementing a GDSS, managers must weigh the possible pitfalls against the benefits of GDSSs, keeping in mind that special design provisions are possible to reduce or eliminate the impact of many of the disadvantages.

## C. DESIRABLE CHARACTERISTICS OF A GDSS

The designer of a GDSS must consider the major functional requirements of the system and be aware of the overall goals of the GDSS. Many authors have commented on the necessary functions for a system to be considered acceptable. DeSanctis and Gallupe claim that the important characteristics of a GDSS are:

1. The GDSS is a specially designed system, not merely a configuration of already existing system components.
2. A GDSS is designed with the goal of supporting groups of decision makers in their work. As such, the GDSS should improve the decision making process and/or decision outcomes of groups over that which would occur if the GDSS were not present.
3. A GDSS is easy to learn and easy to use. It accommodates users with varying levels of knowledge regarding computing and decision support.
4. The GDSS may be "specific" (designed for one type or class of problem) or "general" (designed for a variety of group-level organizational decisions).
5. The GDSS contains built-in mechanisms which discourage the development of negative group behaviors, such as destructive conflict, miscommunication, or 'groupthink'. [Ref. 21: p. 4]

In addition to the characteristics listed above, DeSanctis and Gallupe have suggested that a GDSS be capable of supporting the following activities: the ability to accommodate a wide range of decision processes in groups, the ability to plan meetings, support of both task and social needs, recognition that different groups have different patterns of interaction depending on the task and the individuals involved [Ref. 4: p. 592]. Alter has stated that interaction with the GDSS is not the most important aspect of the system. Instead, designers should direct their energies towards responsiveness of the system. Responsiveness is a combination of power (the system's ability to answer the most important questions), accessibility (the ability to provide answers quickly and consistently), and flexibility (the ability to adapt to changing needs) [Ref. 12: p. 114]. Improving the responsiveness of the system will make the group process more efficient in keeping with the goal of GDSS design.

The addition of flexibility in the design of GDSS has recently become an important issue. The newness of GDSS technology and the research that is being conducted in the area of improving GDSS effectiveness indicate that there is a need for flexibility. Because new patterns for the use of a GDSS tend to evolve, Rathwell and Burns have found that permitting the addition, deletion and modification of functions in a GDSS to be necessary [Ref. 17: p. 268]. Keen and Gambino have recognized that there is a need to design the initial system with procedures very similar to the way users work without a GDSS but, as users learn, to permit growth and change [Ref. 22: p. 152]. It has also been recognized that system flexibility will allow the system to be generalized to a variety of problems [Ref. 23: p. 20]. There is a problem, however, in providing the required flexibility in that once a need to change the system is recognized there is a delay in the time required to implement that change [Ref. 24: p. 152].

A concept in GDSS design that is relatively recent is that of creating a "shell" that will allow the users, through a facilitater, to customize the characteristics of the GDSS. DeSanctis and Gallupe propose that because of the complexity of GDSSs, the lack of definitive research on group dynamics, and the inherent variability of groups, the use of a menu-driven "shell", from which a group may select features specific to the task must necessarily replace the idea of providing a generalized GDSS design concept [Ref. 4: p. 596]. DeSanctis and Dickson plan to do extensive research on such a "shell" system [Ref. 25: p. 433].

## D. PURPOSE OF THE THESIS

Our experimental study is based on research conducted by Fijol and Woodbury in which they tested groups in two different settings. The first setting was a face-to-face group meeting with a GDSS and the second setting was a group that used a GDSS in a distributed setting, that is, group members met individually and never discussed the problem as a group. Their test was conducted on a total of twelve groups of three members, six groups in each setting. Each group was asked to solve a case study using a GDSS with the assistance of a chauffeur, who physically interfaced with the GDSS. Their purpose was to ". . . determine how the use of a GDSS would affect the decision outcome variables of distributed groups . . . and non-distributed groups" [Ref. 26: p. 9].

In our study, we selected two different settings. In the first, groups met face-to-face with a GDSS and in the second, groups met face-to-face without any computer support. We studied a total of eighteen groups of three members, twelve groups with the GDSS and six groups without the GDSS. In order to improve the statistical significance of our study, we carefully replicated the Fijol and Woodbury study, with the exception of setting, and combined the outcomes of their six face-to-face GDSS groups with our six face-to-face GDSS groups. The same case study was used as a decision task and subjects were drawn from a similar population. Our effort was to determine the effect of solving the task using GDSS support versus not using a computer. The subjects in groups that used a GDSS, used Co-oP, which is the same GDSS used in the Fijol and Woodbury study. The same decision outcome variables were used to measure the results in our experiment as were used in the Fijol and Woodbury study including decision quality, input speed, and group satisfaction with the decision.

Furthermore, it was our goal to review issues relevant to the design and successful use of a GDSS. Ideas pertaining to the design of a successful GDSS that have appeared in recent research are discussed. In addition, we propose a model, based on problem type, that recommends the use or non-use of a GDSS, an optimal setting, and design features for each problem type.

# II. DESIGN ISSUES FOR GDSS EMPIRICAL STUDIES

Because it is a relatively new field, little research has been conducted that directly pertains to GDSSs. The use of controlled experiments and non-experimental studies on existing GDSSs can help to improve future designs and the utility of present systems. While both controlled experiments and non-experimental studies provide valuable information, experimental designs permit researchers to determine causal relationships and are of more use in testing hypotheses [Ref. 27: p. 412].

In an experimental design the investigator creates a condition in which he or she can manipulate one variable (the independent variable), and measure the associated change in another variable (the dependent variable). Although this seems a simple enough task, there are many potential pitfalls in using experimental designs, especially when human behavior is measured. It has been noted that no firm rules have been associated with the conduct of high quality research on human behavior. Instead, "research is learned by doing and is taught mainly by contagion." [Ref. 27: p. 409]

Experimental research on GDSSs must be conducted in light of the fact that most existing systems are composed of a number of components and that there is a synergistic effect among the components. Research should concentrate on the whole system, rather than on individual parts, to be valid [Ref. 28: p. 28]. This requires that decision problems used for testing have a sufficiently broad range to test most of the features of a GDSS. If design errors are found through research on GDSSs, it is likely that they are of one of two types, either the system does not incorporate needed capabilities or the system is providing capabilities that are not cost effective [Ref. 29: p. 197].

## A. DESIGN OF GDSS STUDIES

Gallupe has stated that it is important to conduct research on GDSSs so that the types of tasks and appropriate features to be supported by GDSSs can be defined. He further notes that the design of GDSS experiments is somewhat specialized and cites four areas that are of interest to researchers:

1. The nature of the decision task.
2. **The development of a GDSS to support group decision making.**

3. **The experimental setting and subjects.**
4. **The types of dependent variables and their measurement.** [Ref. 30: pp. 515-516]

The group decision task is a problem, or problems, selected by the experimenter that is to test the overall use of the dependent variables. Many existing case studies are available from management texts and often have the advantage of having a suggested solution by the author. Alter chose to write his own case studies to test decision support systems but found drawbacks to this approach:

> it certainly isn't obvious whether any actionable conclusions can be drawn by comparing these situations. Worse yet, it isn't even clear whether there are variables or patterns which can be used to compare them in the first place. [Ref. 28: p. 29]

When selecting an existing case study for an experiment it should have the following characteristics: face validity, content validity, external validity, and it must be suitable for support by a GDSS [Ref. 30: p. 516].

The GDSS selected for use in an empirical study may be either "general" or "specific". Lewis developed his system, Facilitator, specifically to support tasks that he had chosen to study [Ref. 31: p. 78]. Bui, however, developed Co-oP as a multi-criteria decision making tool that would be suitable for solving a wide range of problems [Ref. 32]. For our experiment Co-oP was selected because it was used by Fijol and Woodbury in their research [Ref. 26: p. 18].

Both subject and setting for an empirical study are concerns of a GDSS researcher. Finding an adequate number of willing subjects who are suitable for the experiment and who have relatively homogenous backgrounds is necessary. Researchers may study specific characteristics of subjects, like age, sex, or management experience, or they may chose subjects randomly. The logistics of setting up group meetings, especially when large groups are involved, can be difficult. For our experiment we used groups of three to replicate the Fijol-Woodbury study [Ref. 26: p. 18].

The selection of a setting, or settings, is a detail that is often mitigated by the availability of meeting space, software, and hardware. If a distributed system is tested, there may be requirements to establish networking capabilities or other special hardware configurations [Ref. 30: p. 517]. In addition, the setting should be aesthetically pleasing, comfortable, and flexible enough for multiple uses, and the software, hardware, and protocols should be well-defined and provide adequate support [Ref. 33: pp. 124-128].

Experimenters must select a valid set of measurements and determine operational definitions of each before conducting the study. DeSanctis, Gallupe and Dickson differentiate between decision outcome variables (such as, decision quality, decision time, decision confidence, satisfaction with the group process, and amount of GDSS usage), and decision process variables (such as, the number of issues considered, the number of alternatives generated, and the amount of participation in decision making) [Ref. 34: p. 82]. Most importantly these variables must be defined in terms that are concrete and well-defined, so that, if another researcher decides to replicate the study, it is clear to him or her what was measured and how the measurements were obtained.

## B. VALIDITY AND EXPERIMENTAL DESIGN

The objective of performing experimental research on GDSSs is to develop facts in which there is some measure of confidence. Validity is the term used to express confidence in a study. Brinberg and McGrath have described validity as having three somewhat different meanings. The first is correspondence, or how well the internal variables of the study are related. A second is robustness, or how well the results can be generalized to other situations. Finally, there is value, or how well the elements and relationships provide substance, concepts and methods for study [Ref. 35: p. 6]. A good experimental design will incorporate all three meanings.

Four main types of validity have been defined to assist in determining the value of an experimental study. Internal validity is the extent to which a causal relationship can be determined among independent and dependent variables. External validity is the extent to which the results can be generalized outside of the experimental setting. Construct validity is the extent to which independent and dependent variables represent theoretical constructs. Finally, conclusion validity is the extent to which the statistical conclusions of a study are accurate. [Ref. 36: p. 24]

## C. PROBLEMS IN EXPERIMENTAL DESIGN

When dealing with experiments that attempt to measure human behavior, a high level of complexity is encountered, leading to a variety of different problems. Often interactions between the experimenter, the subjects, and the setting are overlooked.

Friedman suggests that several variables have an impact on experiments but are rarely controlled, including experimenter appearance, the way in which subjects are greeted, how well subjects and the experimenter know each other and the setting (different rooms can cause a difference in the outcome) [Ref. 37: pp. 74-83]. In addition, fakability (where participants deliberately fake answers to questionnaires or other behavioral measures), and response sets (in which subjects consistently overrate, underrate or provide socially acceptable answers) have been cited as problems [Ref. 38: p. 204]. In replications of studies, the impact of such variables can often lead to significantly different research conclusions derived from similar populations of subjects.

Face validity is a further concern of experimenters. In a study with low face validity, the experimenter and the subjects disagree on either the cause of a behavior, the effect of a behavior, or on the meaning of events [Ref. 39: pp. 41-42]. Disagreement of the subjects with the conclusions of the researcher can often call the validity of the experiment into question because it is possible that the experiment lacks internal validity or construct validity. Efforts to control and document problematic variables must be made to improve the reliability of experimentation.

Replication has been cited as being very important because it is a means to control these problems and to verify and validate experimental results. The replication of a study can help to rule out alternative explanations for relationships between independent and dependent variables, and thus strengthen causal relationships. Conversely, they can provide contradictory results that might lead to new ideas about the relationships among variables [Ref. 27: pp. 413-427]. Although the benefits of replication are obvious, few published replications of experiments exist.

## D. ISSUES IN THE MEASUREMENT OF BEHAVIOR

Because experimental design for GDSSs involves the participation of groups, it is necessary to consider reliable methods of measuring the behavior of the groups tested. The first task is to develop a concrete operational definition of the behavior that is being measured [Ref. 40: p. 43]. For example, decision quality is defined in our research as whether a group has agreed with the experts' solution to the case. The researcher must next decide how best to measure the behavior. Five approaches cited by Cozby include archival data, self-report measures (interviews or questionnaires), behavioral measures (direct observations of behavior by a researcher), physiological measures, and field observations (the researcher makes observations in a natural setting over a long period of time) [Ref. 40: pp. 44-54]. In GDSS research the most frequently used approaches are self-report and behavioral measures. Self-report, via questionnaires, is the method we selected for our study.

In general, the data obtained from GDSS experiments is ordinal type. That is, the absolute values of the numeric data from a group is not meaningful, except in comparison to the other groups [Ref. 27,31: pp. 434, 78]. This does not imply that the data itself is not meaningful, only that direct numeric comparisons cannot be made. For example, it can't be said that someone who agreed strongly with two statements that are positive towards a GDSS is half as favorable towards a GDSS as someone who agreed strongly with four positive statements. Therefore, ordinal measures have some limitations.

# III. AN EXPERIMENTAL RESEARCH DESIGN: GDSS VERSUS NON-GDSS

## A. SETTING

In GDSS research, four possible decision making settings have been cited:

1. Face-to-face GDSS - A group meeting face-to-face with GDSS support.
2. Face-to-face non-GDSS - A group meeting face-to-face without GDSS support.
3. Distributed GDSS - Group members do not meet in the same location or at the same time. Instead, they independently provide input to a central GDSS at their convenience.
4. Distributed non-GDSS - Group members independently provide input to a central decision maker who compiles the results without the use of a GDSS. [Ref. 41]

Since the concepts involved in the design and use of GDSS are new, a large amount of basic research is needed to pave the way for effective systems. The experiment we designed was based on research conducted by Fijol and Woodbury [Ref. 26]. Their study tested a total of twelve groups, all solving the same case. The groups were evenly split between two settings:

- face-to-face GDSS
- distributed GDSS

We similarly chose to evaluate a decision task in two settings, but varied one setting from what they used:

- face-to-face GDSS
- face-to-face non-GDSS

In order to expand on the Fijol-Woodbury research, our experiment studied a total of eighteen groups: six face-to-face GDSS and twelve face-to-face non-GDSS. We carefully replicated many of the details of the Fijol-Woodbury study (e.g., similar groups of three were used to solve the same task that they chose) so we could combine the results of their six face-to-face GDSS groups with our six face-to-face GDSS groups. This enabled us to use their data to improve the statistical significance of our project as well as verify some of their findings. Thus, in total, we compared twelve groups of face-to-face GDSS users with twelve groups of face-to-face non-GDSS users.

The Fijol-Woodbury study had three major findings and three minor findings. The major findings were:

1. The distributed groups were more accurate in solving the case and, therefore, were considered to have produced higher quality decisions.
2. The face-to-face groups spent less time reading the case, but more time interacting, and thus more total time problem solving, before reaching a consensus.
3. While both group types were satisfied with their individual solutions, the distributed groups were somewhat less satisfied with the group decisions than with their individual inputs.

The minor findings were:

1. There was no difference between the two group types as to satisfaction with the selection criteria they generated.
2. No determination could be made as to which group type generated the most creative criteria or even which generated simply the most criteria.
3. The face-to-face groups preferred to meet face-to-face, but the distributed groups had no preference for setting.

As seen in the above findings, the setting in which a decision is made can have an impact on the decision process. Some additional research has confirmed that the nature of the task can also have an effect on the decision outcome [Refs. 30,42]. Since there has not been widespread availability of GDSSs, more research is needed to determine the types of problems that are appropriate to solve using a GDSS and the characteristics of that GDSS. We have addressed some of those areas in this paper already and our experiment delves into them further.

## B. PARTICIPANTS

No study has been done that definitely suggests optimal group size for problem solving with a GDSS. In general though, a group size of three is recommended for research [Ref. 30]. Fijol and Woodbury chose three as their group size in order to facilitate research comparison (some prior experiments on GDSS impact used groups of three [Refs. 31,43,44]), to aid individual participation in the task by all group members, and because of the limited number of participants available [Ref. 26: p. 18]. We also used groups of three for the same reasons and to be consistent with the Fijol-Woodbury study.

Further, the population from which we derived our participants was as similar as possible to the Fijol-Woodbury population to ensure consistency. They were thus selected from the officer-student population of the Naval Postgraduate School (NPS), Monterey, CA. The majority of participants were students in the fifth quarter (out of six) of the Computer Systems Management curriculum. In addition, because of our larger number of groups (eighteen groups versus twelve groups), we also included students in the third quarter of Computer Systems Management, along with the Command, Control, and Communications and the Telecommunications Systems Management curricula. All participants had had at least one formal management course at NPS and had taken part in several group projects. Since the participant population was very similar to that used by Fijol-Woodbury, we believe their selection had no impact on the outcome of the experiment. We also were aware of the improvement to be realized in the statistical significance of the study by comparing a larger number of groups.

As in the Fijol-Woodbury study, the participants were a relatively homogenous group with similar management and educational backgrounds. Most formed their own groups for the experiment and knew each other well. They also had experience with group tasks from previous group project assignments at NPS. This is significant because it suggests that they had developed a relatively cooperative attitude, which would reflect a typical organizational decision making environment in which a similar culture and goals are shared.

Although the participants' experience at the Naval Postgraduate School was similar, their backgrounds prior to attending NPS, like the backgrounds of the participants in the Fijol-Woodbury study, were diverse. However, one common factor that characterized them was at least 3-5 years of military management experience.

## C. GDSS SOFTWARE

The software selected for this study was Co-oP, a multi-criteria GDSS. We selected Co-oP primarily because it was used in the Fijol-Woodbury study. They chose Co-oP because it was readily available, operational, and was suitable for use in the settings in which they were working. The use of an existing software package had the advantage of not requiring them to create their own special purpose GDSS or trying to find one of the few GDSS packages that are commercially available and that would be suitable to their experiment. Additionally, being an academic product, Co-oP was relatively untested and its developer was interested in involving it in more research.

Co-oP supported the group decision process in our empirical study by allowing the participants to generate selection criteria to be used in the case, to establish weights for the criteria, and to perform statistical analyses of the inputs to determine a final outcome. The software provided adequate support for both the face-to-face and distributed GDSS groups studied by Fijol-Woodbury, as well as our face-to-face groups.

## D. GROUP DECISION TASK

Fijol and Woodbury selected the Energy International case [Ref. 45] as the group decision task to be performed. It was designed as a case study to examine group interaction within a group of five persons, in which each member was not given complete information on which to base a decision. Since it was not a goal of their study to measure information sharing and since they were working with a smaller group size, the case was modified so all members received the same, complete information (Appendix A).

We also selected this case, as modified, for our study since it was considered by Fijol and Woodbury to be valid for the GDSS decision making settings and would enable us to combine the data from each study. They found the case to be somewhat complex, in that it could not be solved immediately after the first reading. The nature of the task is to evaluate a list of candidates for the position of head plant manager in a Brazilian mining operation and make a selection based solely on the scenario presented in the case. The face validity was considered to be high because the case apparently described a realistic situation. The case is best solved by determining criteria, weighing them, and then using a step-by-step approach. These factors make the case supportable by Co-oP. Since there were no conflicting facts within the case, its content validity was high. Also, the external validity was likewise found to be high because the case belongs to a general class of problems and does not portray a unique management decision making situation. Just how well this case truly fit the study is discussed in detail in Chapter IV. After observing the experiment and reviewing the findings, we do not consider the case as applicable as did Fijol and Woodbury.

Our comparison of face-to-face GDSS and non-GDSS groups was designed to measure whether the complexity of the task allowed it to be efficiently solved with a GDSS. We believe that a suitable problem to be used with a GDSS is one that can be described as high task (highly structured), low relationship (not involving group norms or attitudes), and high complexity (having many different and interacting variables). While the Energy International Case could be described as moderately high task and low relationship, the complexity of the case may not be sufficient to be efficiently solved using a GDSS.

## E. HYPOTHESES, VARIABLES, AND QUESTIONNAIRES

### 1. Hypotheses

We developed the following three hypotheses concerning the *expected* effects of the decision outcome variables on the two groups:

- $H_1$ : The face-to-face GDSS groups will be more accurate in solving the case than the face-to-face non-GDSS groups.
- $H_2$ : The time required to reach a decision, excluding the time to read the case, will be less in the face-to-face non-GDSS groups than in the face-to-face GDSS groups.
- $H_3$ : There will be no substantial difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their satisfaction with their group decision.

### 2. Variables

Several additional issues were considered interesting, both to compare our results with those of the prior study and to support the model we have designed. In the model problem characteristics (task, relationship, and complexity) are considered to determine the appropriateness of GDSS use and the recommended design features of the GDSS. The additional issues we studied include:

- What type of setting will the groups most prefer in solving this case?
- Which type of group is most likely to generate the case's base line criteria (criteria the experts defined as important in solving the case)?
- Will there be a difference in the number of supplemental (other than base line) criteria generated between the types of groups?
- Are the groups content with their ability to discuss the criteria and interact with other group members?

Three variables were measured using a questionnaire completed by each participant:

1. Decision task criteria - Did the case selected meet face validity, supportability, content validity, and external validity?
2. Satisfaction factor - Were the participants satisfied with the criteria they generated? with their decision making process? with their solution?
3. Setting preference - For this case, would the participants prefer to solve it with or without a computer? face-to-face or distributed group meetings?

Three other variables were measured during the experiment as we observed and timed the proceedings:

1. Decision quality - Did the group arrive at the experts' solution?
2. Input time - How long did the group spend actually solving the case?
3. Base line criteria - Did the group determine the minimal selection criteria?

3. Questionnaires

After each group of three finished solving the case and was told the correct solution, the questionnaires were completed. There were two questionnaires: one for the face-to-face non-GDSS groups (Appendix B) and one for the face-to-face GDSS groups (Appendix C). The questionnaires mostly used a 5-point Likert scale, with steps ranging from "strongly disagree" to "strongly agree", and concluded by asking for general comments. Our questionnaires were patterned after the one used in the Fijol-Woodbury study in order to verify, and subsequently use, some of their data. Some noticeable changes were made, including:

- while they used one questionnaire for both groups (containing questions applicable to either one group or the other, so that no group answered all the questions), we choose to split the questionnaire among the two groups so that each participant saw and completed a questionnaire that was totally applicable to the particular setting, i.e., GDSS or not.
- the questions were all worded to permit a consistent, uniform, and familiar scale for the participant's responses throughout the questionnaire (ranging from "strongly disagree" on the left to "strongly agree" on the right).

*a. Non-GDSS Questionnaire*

The "questions" for the non-GDSS groups were:

1. Immediately after reading the case study, the correct candidate was intuitively obvious to me.
2. I would say this case study could be an example of an actual decision making situation in an organization.
3. This case study seems realistic to me.

4. I am very satisfied with the number of criteria my group identified.
5. If you assigned weights to your decision criteria for selecting a candidate, it helped in your decision making process.
6. My group devised a very good solution to the case.
7. I am very satisfied with the decision making process that my group underwent to develop a solution.
8. I am very satisfied with the final result derived from my group's inputs.
9. My group completely accepted my contributions to solving the problem.
10. Everyone in my group had an equal chance to be heard.
11. This case would be better solved in a setting in which all members met face-to-face but had a computer available to help them compile their results.
12. This case would be better solved in a setting in which group members all had an input via a computer but did not meet face-to-face.

*b. GDSS Questionnaire*

The questionnaire for the GDSS groups was generally the same as that for the non-GDSS groups, but did contain some additional "questions" specifically related to the GDSS, i.e., Co-oP. The "questions" for the GDSS groups were:

1. Immediately after reading the case study, the correct candidate was intuitively obvious to me.
2. I would say this case study could be an example of an actual decision making situation in an organization.
3. This case study seems realistic to me.
4. This case lends itself well to support by Co-oP.
5. I am very satisfied with the number of criteria my group identified.
6. If you assigned weights to your decision criteria for selecting a candidate, it helped in your decision making process.
7. Co-oP is very helpful in formalizing my thoughts.
8. My group devised a very good solution to the case.
9. I am very satisfied with the decision making process that my group underwent to develop a solution.
10. I am very satisfied with the final result derived from my group's inputs.
11. My group completely accepted my contributions to solving the problem.
12. Everyone in my group had an equal chance to be heard.
13. This case would be better solved in a setting in which group members all had an input via a computer but did not meet face-to-face.
14. This case would be better solved without the use of a computer.

15. **What factor, if any, would you say inhibited and/or encouraged your generation of inputs?**
16. **Was Co-oP user friendly?**
17. **In what kind of decision making situation would you find Co-oP most useful?**

## F. PROCESS

The procedure followed in both the GDSS and non-GDSS groups was very similar. The groups met at agreed upon times and locations. Both researchers were present during the entire session for both types of groups. One researcher read a brief set of standard directions that differed between the groups only in that the GDSS groups received some instruction specific to using the GDSS (Appendix D).

Individuals in both groups read the case and, when they were finished reading, proceeded to discuss it as a group. Both researchers acted as observers in the non-GDSS groups, while in the GDSS groups, one acted as an observer while the other acted as a chauffeur of the GDSS. The observer recorded the read time and discussion time, and answered any questions not directly related to solving the case. The observer also recorded the criteria generated by the group, their final decision, and anything of interest in the decision process. The chauffeur was needed in the GDSS groups because it was impractical to spend enough time to teach the participants to operate the GDSS on their own and also to be consistent with the Fijol-Woodbury study, as they used a chauffeur. In addition, the use of a chauffeur has been found valuable in both research and organizational settings [Refs. 29,46]. Before the GDSS groups began generating input, some standard information, required by the software (e.g., group composition), was inputted so the groups did not have to wait on that. It should be noted that the chauffeur only inputted group information that was agreed upon by all group members during the session.

As stated above, the time required to read and absorb the case, as well as the time required to solve the case (decision time), was recorded for both types of groups. The read time was the time from when the case was handed out until at least two members of the group began discussing it. The decision time for the non-GDSS groups was from the end of the read time until a unanimous decision was reached. The decision time for the GDSS groups was from the end of the read time until the inputs were ready to be assembled and processed by Co-oP.

Immediately after a group finished the case, they were shown the correct solution (Appendix E) and any questions were answered. A questionnaire was then completed by all group members and collected before they left. Since the two different settings were used, a slightly different questionnaire was used for each type of group.

# IV. EMPIRICAL STUDY RESULTS AND DISCUSSION

## A. VALIDITY ANALYSIS OF DECISION TASK

The Fijol-Woodbury study found the Energy International case to be a valid group decision task, as determined by Gallupe's four essential characteristics - face validity, supportability, content validity, and external validity [Ref. 30]. In their study Fijol and Woodbury preportedly established

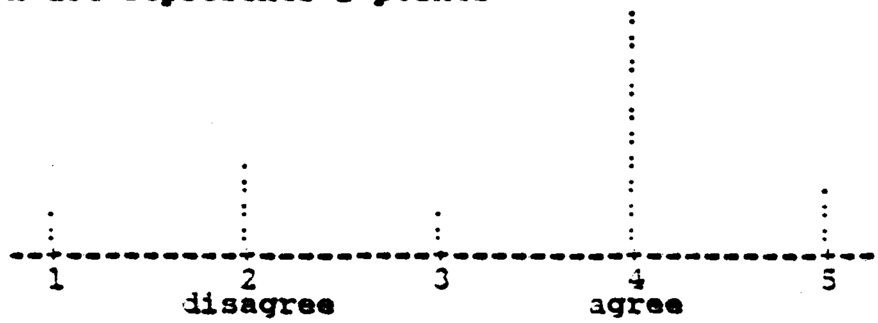
> that each essential characteristic was present, was well represented, and satisfied all requirements necessary to ensure the group decision task employed during this experiment was valid. [Ref. 26: p. 28]

We agree with most, but not all, of their findings in this area and thus will review each of these four characteristics.

### 1. Face Validity

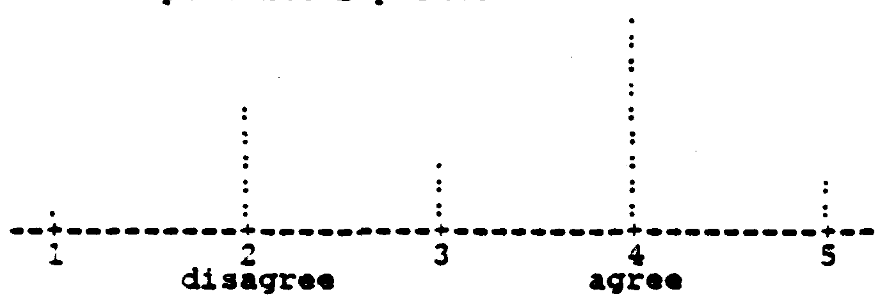
If the task appears to be an example of an actual decision making situation and is realistic to the participants, then this characteristic is satisfied. Items #2 and #3 of both questionnaires addressed this simply: "I would say this case study could be an example of an actual decision making situation in an organization" and "This case study seems realistic to me." The summary of the 72 responses (our eighteen groups plus the applicable six groups from the Fijol-Woodbury study, three people per group) are shown in Figure 4.1. As in the Fijol-Woodbury study, a significant majority rated the case both viable and realistic. However, it is now apparent that it is unclear exactly what they were rating. For example, were they saying it is likely that an organizational group would meet, evaluate applicants, and make a personnel selection decision? Were they saying it is realistic to hire the plant's General Manager solely based on the minimal personnel information given in the case? Were they saying senior management personnel are probably hired without a personal interview, without knowing their sex, and without establishing actual prior work performance vice just experience? We submit that the basic minimum wage earner is screened and interviewed more rigorously than the applicants were in this case. So why did the participants rate the case generally high as regards to "realistic" and "an actual decision making situation"?

**ACTUAL DECISION MAKING SITUATION**
**Each dot represents 2 points**




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 72 | 3.472 | 4.000 | 3.531 | 1.138 | 0.134 |
| | MIN | MAX | Q1 | Q3 | |
| | 1.000 | 5.000 | 2.250 | 4.000 | |

REALISTIC CASE
Each dot represents 2 points




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 72 | 3.361 | 4.000 | 3.375 | 1.079 | 0.127 |
| | MIN | MAX | Q1 | Q3 | |
| | 1.000 | 5.000 | 2.000 | 4.000 | |

Figure 4.1 Face Validity

We believe that they viewed the general task of a group choosing among job applicants (as this case does) as realistic, but not that an actual real-life hiring would take place solely on the facts as presented in this case. If the sex of an applicant was deemed important, such information would normally be obtained and provided to the decision makers. The decision makers would not have to guess at it, even if they could

**probably do so correctly. In fact, it is unlikely that a manager would be hired or even recommended without at least one interview. Selected written comments from the questionnaires support this view:**

- could have had more details - as in real life interview summary
- a real decision of this nature would involve far more input of an intuitive nature
- not enough info, so not realistic
- the information would be less cryptic, in reality
- this case was fairly easy, and realistically could have been pared down by non-management staff prior to submission to management
- managers would have access to full resumes, and more background information
- Too little information was supplied to make a good decision. I wouldn't hire anyone based on the information given. The group decision process was not a decision process so much as a process of elimination, until only one (candidate) was left. Based on the poor information, the "best" candidate may have been eliminated where a decision criteria may have over shadowed his/her otherwise clearly superior capabilities. A waiver (of a criteria) may have been called for.
- there was really no decision to be made - each candidate (but one) would be eliminated on the basis of the criteria
- if such a decision were actually being made, more info on the candidates would/should be available, e.g., personnel files
- trick question (sex)!! - there was really no decision making at all - just reading between the lines to deduce the facts
- the case should have been more specific (by stating) that of the listed schools, one was a women's school
- woman issue in the 80's is a tough question to deal with - how realistic is it to assume women's university graduate is actually female?
- the case itself was worded in a way to make it difficult to ascertain all the important points
- the case would have been clearer if the candidates were identified by male and female
- in a real life situation, the sex of an applicant would have been obvious at this final point of hiring - just as age was listed, so should have been sex, male or female, as this was crucial to the selection process

The sheer volume of these related comments from our limited number of participants makes one pause over the ratings they gave to items #2 and #3 of our questionnaire. While they may have overall *graded* the case as realistic, many also made the extra effort to write out comments to the contrary.

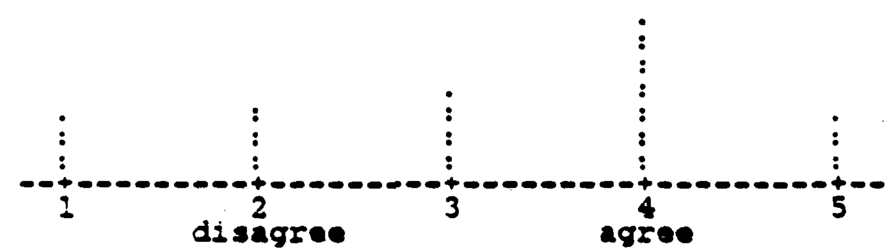
As seen below, the Fijol-Woodbury study received similar comments, yet they placed their emphasis on the numerical aspects of their questionnaires and considered face validity to be satisfied.

> On the whole, some participants commented on the lack of information they, as mangers, felt was essential in the selection process. They believed personal interviews would have been important for determining the candidate's personality, general health, and sex; all elements not as obvious in the case itself. . . . Likewise, one participant expressed a desire to evaluate candidates along the lines of 'adaptability' and 'growth potential'. . . . Performance evaluations were also lacking and their omission cited as significant. [Ref. 26: pp. 28-29]

The case has a valid premise (that of a group making a hiring decision), but the decision would not realistically be made for such an important job with the minimal information provided. In light of all these comments, our observations during the experiment, and our own knowledge of personnel hiring practices, we would rate the case's face validity "poor".

2. **Supportability**

CASE LENDS ITSELF WELL TO SUPPORT BY CO-OP




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 3.194 | 3.500 | 3.219 | 1.283 | 0.214 |

| MIN | MAX | Q1 | Q3 |
|---|---|---|---|
| 1.000 | 5.000 | 2.000 | 4.000 |

Figure 4.2 Co-oP Supportability

In considering supportability, we looked at how well Co-oP, the GDSS selected, lent itself to this case. This matter was, of course, not addressed by the twelve groups that did not use Co-oP, but was addressed by the six GDSS groups and by those in the Fijol-Woodbury study. Item #4 of the GDSS questionnaire dealt with this issue: "This case lends itself well to support by Co-oP." The groups in the Fijol-Woodbury study overall rated supportability slightly above those groups in our study. This is due in part to their groups having been previously introduced to Co-oP and its underlying methodology in a course they had taken. As seen in Figure 4.2, the participants still were very split on this matter, with the majority feeling Co-oP just adequately supported this case. Our observations during the experiment bore this out, thus supportability is rated "fair".

3. Content Validity

Neither the Fijol-Woodbury study nor ours contained any items with which to measure content validity; that is, the accuracy and consistency of the case's task description. They relied on the fact that the case was published and proven and thus its content validity could be safely assumed as "excellent". Unfortunately this did not turn out to be a valid premise in the final analysis. The problem centers around the candidate Hule, who is meant to be rejected for supposedly being a woman candidate. To come to the conclusion that Hule is a woman, and, in fact, the *only* woman, one must first make several assumptions:

- that the "list" of four schools is all inclusive (no one else awards a Degree of Mineralogy)
- that no male student attends a women's university
- that no female student attends a non-women's university

These assumptions could hardly have been safely made when the case was published in 1972, and certainly are not valid in 1987. So while it may be highly probably that Hule is a woman, one cannot be sure. And since the solution to the case hinges on this unknown, the case's content validity is also judged as "poor".

4. External Validity

As with content validity, no actual items with which to measure external validity were contained in our study. However, it can be safely stated that the task of choosing among job applicants is general in nature and does not represent one singularly unique situation. Additionally, the task would appear relevant to the participants in our study, as many (in their role as military managers) would have been familiar with trying to match personnel to jobs. Thus the case's external validity is rated "excellent".

### 5. Decision Task Validity Summary

In summary, we rate the decision task criteria for the Energy International case as follows:

1. face validity - poor
2. supportability - fair
3. content validity - poor
4. external validity - excellent

Considering the modifications made to the case for these studies, it is difficult to determine what this case is testing. For example, is it testing the ability to solve logical word problems or perhaps the current attitude toward women in the managerial work force? If so, what does a GDSS, as used here, have to do with this? For all these reasons, we strongly recommend this case not be used for further research along the lines of this or the Fijol-Woodbury study. A more appropriate case would be one fitting the model we propose in Chapter V.

Nevertheless, prior to that conclusion, we used the case to replicate the Fijol-Woodbury study and found that there was some information to glean from the findings.

## B. RESEARCH RESULTS

A discussion of the data we collected during the experimental studies follows. The analysis of research results is broken down by factors. Where relevant, *t* statistic tests were used to test for the mean values and for a significant difference between mean values. A statistical analysis of these *t* tests is given in Appendix F.

### 1. Satisfaction Factor

Four items on the questionnaires were devised to look at the satisfaction factor:

1. I am very satisfied with the number of criteria my group identified (Figure 4.3).
2. I am very satisfied with the decision making process that my group underwent to develop a solution (Figure 4.4).
3. My group devised a very good solution to the case (Figures 4.5,4.6).
4. I am very satisfied with the final result derived from my group's inputs (Figures 4.5,4.6).

The last two items above are essentially the same and were used as a small consistency check for the replies on the questionnaire. As seen in Figures 4.5 and 4.6, their responses to both items were overall consistent. Also readily apparent is the high level of overall solution satisfaction, even though, as we will see, only eleven of the twenty four groups matched the experts' solution. Recall that the subjects completed the questionnaires *after* they were given the solution. Such satisfaction, even when "wrong", is perhaps attributable to several factors - their dissatisfaction with the case, the fact that their choice was based on group consensus, or a general high degree of personal confidence, regardless of an "expert's" opinion. The Fijol-Woodbury study found a similarly high degree of satisfaction [Ref. 26: p. 34].

In all the satisfaction measures, the level of satisfaction is *slightly* less for the GDSS groups than it is for the non-GDSS groups. The difference is too small to derive any significant findings from it, especially since both settings yielded firmly positive satisfaction levels. Reasons for the difference can reasonably be surmised:

- The GDSS groups matched the experts' solution less often (as addressed in a following section).
- The GDSS groups were unfamiliar with the software used and had to rely on a chauffeur to interface with the computer. This probably made them feel less in charge of the task, while the non-GDSS groups ran the process totally.
- The GDSS on several instances selected a candidate over whom the group expressed surprise and displeasure. They sometimes felt it selected someone whom they definitely would not have chosen. This was due to the weights they had placed on certain criteria and their unfamiliarity with how Co-oP would mathematically processed their inputs.

### 2. Setting Preference

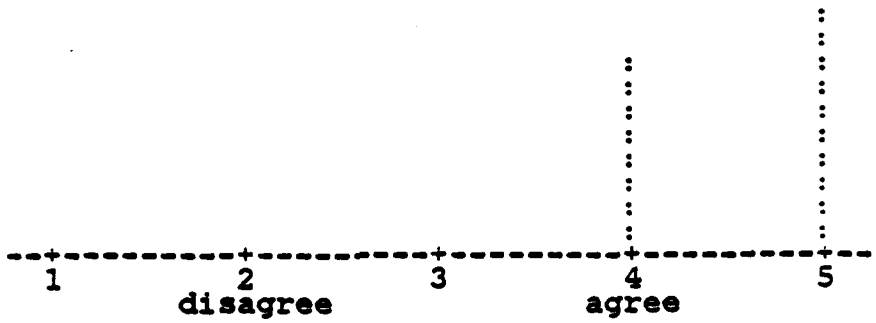
Three items on the questionnaires were devised to check the participants' opinions regarding solving this case with or without a GDSS, and in a face-to-face or distributed setting:

1. This case would be better solved in a setting in which all members met face-to-face but had a computer available to help them compile the results (Figure 4.7).
2. This case would be better solved without the use of a computer (Figure 4.7).
3. This case would be better solved in a setting in which group members all had an input via a computer but did not meet face-to-face (Figure 4.8).

The first item was asked of the non-GDSS groups, the second of the GDSS groups, and the third of both groups.

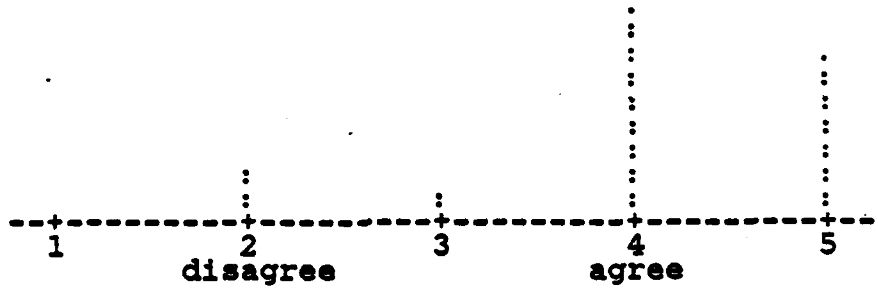
**VERY SATISFIED WITH NUMBER OF CRITERIA IDENTIFIED**

**Non-GDSS groups**




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.5556 | 5.0000 | 4.5625 | 0.5040 | 0.0840 |
| | MIN | MAX | Q1 | Q3 | |
| | 4.0000 | 5.0000 | 4.0000 | 5.0000 | |

GDSS groups



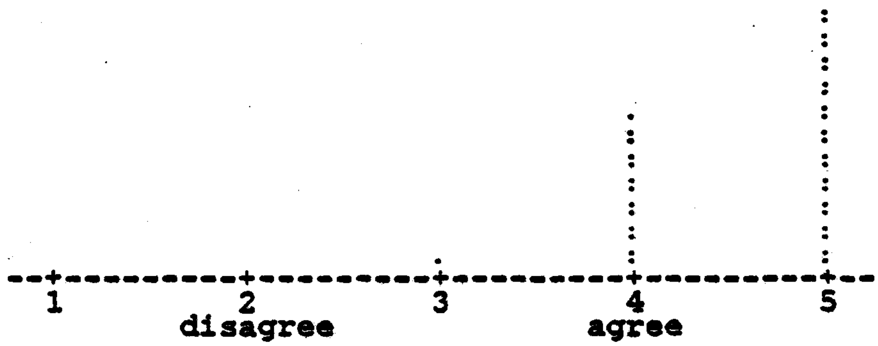

| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.083 | 4.000 | 4.156 | 0.937 | 0.156 |
| | MIN | MAX | Q1 | Q3 | |
| | 2.000 | 5.000 | 4.000 | 5.000 | |

Figure 4.3 Criteria Satisfaction

As seen in Figure 4.7, the non-GDSS groups only slightly disagreed that the case would be better solved with a computer, with the most frequent response being "neutral". Since most of the participants were in the Computer Systems Management curricula, they were familiar with the concepts and principals behind a GDSS and

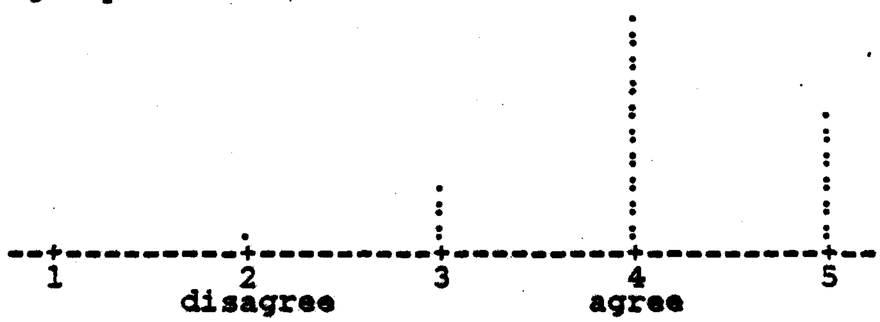
**VERY SATISFIED WITH DECISION MAKING PROCESS**

**Non-GDSS groups**




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.5833 | 5.0000 | 4.6250 | 0.5542 | 0.0924 |
| | MIN | MAX | Q1 | Q3 | |
| | 3.0000 | 5.0000 | 4.0000 | 5.0000 | |

**GDSS groups**




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.111 | 4.000 | 4.156 | 0.747 | 0.125 |
| | MIN | MAX | Q1 | Q3 | |
| | 2.000 | 5.000 | 4.000 | 5.000 | |

Figure 4.4 Decision Making Process Satisfaction

generally did not see one as necessary for *this* case. Their comments on the questionnaires spoke of the case being too simple for a GDSS (although most missed the solution) and of its not being a decision task as much as a logical process of

MY GROUP DEVISED A VERY GOOD SOLUTION


| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.444 | 5.000 | 4.531 | 0.735 | 0.122 |
| | MIN | MAX | Q1 | Q3 | |
| | 2.000 | 5.000 | 4.000 | 5.000 | |

I AM VERY SATISFIED WITH THE FINAL RESULT

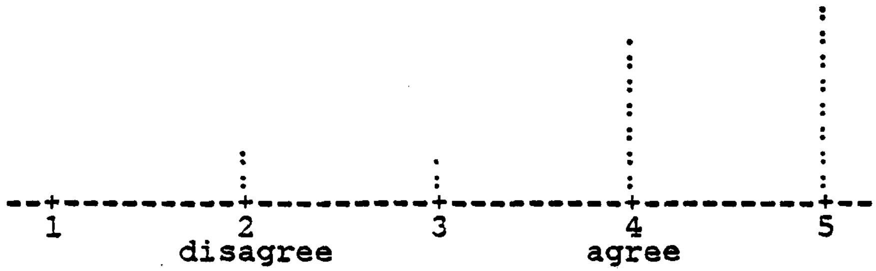

| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.444 | 4.500 | 4.500 | 0.607 | 0.101 |
| | MIN | MAX | Q1 | Q3 | |
| | 3.000 | 5.000 | 4.000 | 5.000 | |

Figure 4.5 Final Solution Satisfaction - Non-GDSS groups

elimination. Although in training for management in a high tech field, they were quite content to deal with this case the old fashioned way, which was also the more successful method.

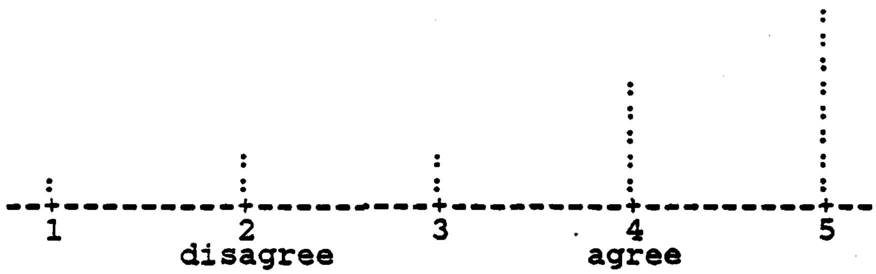
Figure 4.7 also shows that those who used the GDSS, and thus a computer, were perfectly split in their opinion regarding its usefulness, again, in *this* case. As

MY GROUP DEVISED A VERY GOOD SOLUTION




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.139 | 4.000 | 4.219 | 0.990 | 0.165 |
| | MIN | MAX | Q1 | Q3 | |
| | 2.000 | 5.000 | 4.000 | 5.000 | |

I AM VERY SATISFIED WITH THE FINAL RESULT



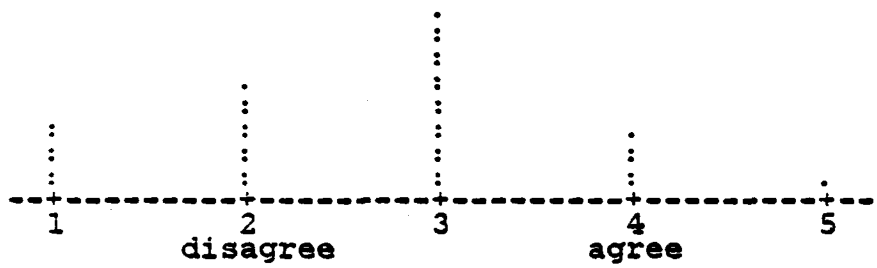

| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 3.944 | 4.000 | 4.062 | 1.241 | 0.207 |
| | MIN | MAX | Q1 | Q3 | |
| | 1.000 | 5.000 | 3.000 | 5.000 | |

Figure 4.6 Final Solution Satisfaction - GDSS groups

many subjects felt the case would be better solved without a computer as with a computer, and very few felt strongly one way or the other.

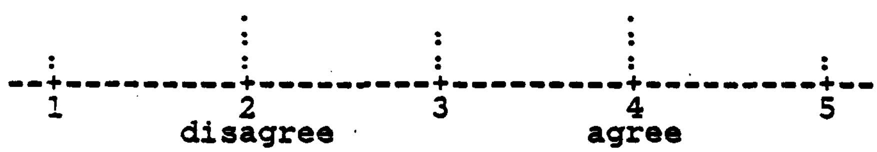
The cultural factor plays a part in the opinions of both groups. While they may be more used to computers than the average individual, they are generally not used to computers aiding their decision processes and they are certainly not used to them *making* their decisions. People are more comfortable with what they are familiar.

THIS CASE IS BETTER SOLVED WITH A COMPUTER
Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 2.611 | 3.000 | 2.594 | 1.022 | 0.170 |
| | MIN | MAX | Q1 | Q3 | |
| | 1.000 | 5.000 | 2.000 | 3.000 | |

THIS CASE IS BETTER SOLVED WITHOUT A COMPUTER
GDSS groups



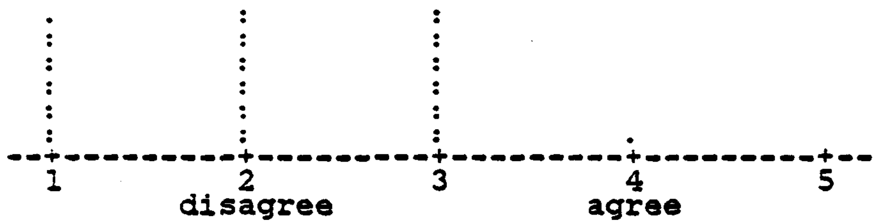

| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 18 | 3.000 | 3.000 | 3.000 | 1.237 | 0.291 |
| | MIN | MAX | Q1 | Q3 | |
| | 1.000 | 5.000 | 2.000 | 4.000 | |

Figure 4.7 Need of Computer

Figure 4.8 shows that both the GDSS and non-GDSS groups firmly believed a face-to-face setting would lend itself better to solving the case than a distributed setting. (In fact, the distributed groups in the Fijol-Woodbury study were more accurate in solving this case, than the face-to-face groups.) Our groups saw an overall advantage to a face-to-face setting, especially when one member would point out something another had overlooked in reading the case. Commonly held opinions were strengthened as participants realized they were being supported by other group members. All the groups in this study actually met face-to-face, so they were surmising

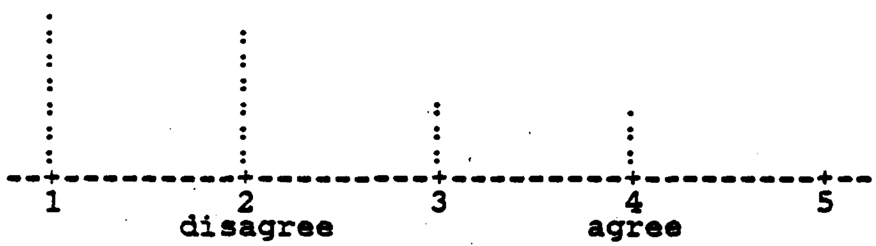
BETTER SOLVED WITH COMPUTER BUT NOT FACE-TO-FACE

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 2.083 | 2.000 | 2.062 | 0.874 | 0.146 |
| | MIN | MAX | Q1 | Q3 | |
| | 1.000 | 4.000 | 1.000 | 3.000 | |

GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 2.083 | 2.000 | 2.031 | 1.052 | 0.175 |
| | MIN | MAX | Q1 | Q3 | |
| | 1.000 | 4.000 | 1.000 | 3.000 | |

Figure 4.8 Face-to-Face vs Distributed

what it would have been like to be in a distributed setting. In the Fijol-Woodbury study, the groups were evenly split between face-to-face and distributed settings. Their finding matches ours in that the face-to-face groups firmly preferred that setting; however, they found that the distributed groups were only slightly in favor of a face-to-face setting [Ref. 26: p. 38].

### 3. Decision Quality

Of the non-GDSS groups, seven of the twelve groups correctly matched the experts' choice. For the GDSS groups, only four of the twelve matched. Clearly, the GDSS (Co-oP) was not helpful in improving decision quality. Since that is a GDSS's primary function, we have what might be called a serious malfunction. But why? Is the concept of a GDSS worthless? - no. Is Co-oP at fault? - not really.

As previously discussed in this chapter, there is no decision to make in this case, provided the assumptions regarding sex are made. The case essentially sets up criteria that each candidate *must* meet, and failure to meet one criteria causes each candidate to be dropped from consideration, until only one candidate remains. In this case, there are not multiple, viable alternatives from which to decide. Therefore, a GDSS should not be used with this case. Co-oP, in particular, is best able to support ranking *viable* alternatives with multiple criteria. It is not set up to process an alternative that is rated so low in one criteria that it eliminates that alternative from further consideration. For example, suppose Co-oP were processing two applicants and a mandatory criteria was "age at least 35", as in this case. Applicant A is rated "10" in all criteria except age, where he is rated "0" since he is under 35. Applicant B is old enough, but not such a shining star elsewhere, and is rated "6" in all criteria. Given a usual weighting of the criteria, Co-oP will chose Applicant A, even though he is ineligible, since it does not treat the "0" rating as "fatal" and remove Applicant A from further consideration. This type of processing resulted in at least three of our GDSS groups producing a Co-oP answer that they immediately rejected as not their choice. Given that Co-oP was apparently designed to handle only viable alternatives, one can argue that only the viable alternatives should have been entered and processed. For this case, that would mean only *one* applicant would be entered; and one hardly needs a GDSS for only one alternative. Therefore, this was not an appropriate case to use for GDSS testing, especially a GDSS with Co-oP's features.

This case is fairly high task, low relationship, and low complexity. As per our model in Chapter V, a GDSS is not generally recommended for such a task. This case can hardly be used realistically to pass any firm judgements against using a GDSS as an aide to management decision making since Co-oP was not designed for this sort of task.

### 4. Input Time

Figure 4.9 shows the input times in minutes for each of the 24 groups, broken down between the non-GDSS and GDSS groups. Input time was measured as the time from when the group members finished reading the case and began discussing it until they reached a final conclusion. It included the time spent actively solving the case as a group. For the non-GDSS groups, this time period ended as soon as they formed a consensus as to their final choice among the applicants. For the GDSS groups, it ended when they ranked the final applicant on the final criteria: Co-oP then produced their result in literally microseconds of processing. As is seen in Figure 4.9, solving the case with Co-oP took nearly four times as long as not using it.

```
Non-GDSS groups

      :  .              .   :    :     .     .  .        .
   ----+---------+---------+---------+---------+---------+--
      6.0       9.0      12.0      15.0      18.0

   N      MEAN    MEDIAN    TRMEAN     STDEV    SEMEAN
  12     10.58     10.50     10.40      4.03      1.16
           MIN       MAX        Q1        Q3
          5.00     18.00      6.75     13.75

GDSS groups

       .   . .    :      . . .    .  :                 .
   ----+---------+---------+---------+---------+---------+--
     27.0      36.0      45.0      54.0      63.0

   N      MEAN    MEDIAN    TRMEAN     STDEV    SEMEAN
  12     38.75     38.50     37.70     10.18      2.94
           MIN       MAX        Q1        Q3
         25.00     63.00     30.75     45.25
```

Figure 4.9 Input Time in Minutes

Since the participants interfaced with the GDSS through a chauffeur, none of their time was spent learning how to use Co-oP. What slowed the GDSS users was the inherent ability of Co-oP to best handle only viable alternatives. The non-GDSS groups, for example, would see that an applicant was not an American citizen and immediately drop him from further consideration, not even trying to grade him on any other criteria. This type of action rapidly reduced their list of alternatives and thus greatly aided their timely arrival at a final solution. In contrast, the GDSS groups could not as readily "drop" an alternative. Co-oP logically and methodically lead them through each criteria they generated and called on them to grade each applicant according to each criteria. The GDSS groups thus found themselves trying to come to a consensus on an applicant's grading ("8 or 7?") for a particular criteria when they knew they would not select that applicant due to his major failure in another criteria. They were spending time needlessly debating over an otherwise ineligible applicant. A few of the groups picked up on this problem and began grading non-viable applicants as "0" in all criteria. This ensured those applicants would not be selected by Co-oP and decreased their input time. Were Co-oP to be regularly used by the other groups, they would in time, no doubt, also discover this short cut. Further, as mentioned in the previous section, we believe they would soon learn to enter into the GDSS only the viable alternatives.

Consistent with our model in Chapter V, the Energy International case is simply too low in complexity to benefit from a GDSS. The task can be more quickly and more effectively solved without using a GDSS.

5. **Base Line Criteria**

By noting the criteria the groups used to evaluate the case's applicants, we were trying to determine if Co-oP's formalized thought process would hinder or aid criteria generation. Unfortunately, almost every group selected their base line criteria with an eye on the information given for each applicant. Thus, for example, the applicant's marital status was not a criteria since the subjects saw they had no such information on the applicants. In lieu of sex as a criteria, some other choices were experience in foreign countries, type of management experience, and number of languages known. Most groups generated only enough criteria to enable them to arrive at their final choice. It is certainly logical that if a selection will be made and only one alternative remains, why continue to seek criteria with which to evaluate it?

The Energy International case had five base line criteria:

1. Managerial experience required
2. Institute of Mineralogy Fellow required
3. American citizen required

4. Portuguese ability desired
5. Sex - male desired

Of the non-GDSS groups, five of the twelve groups generated the base line criteria, as a minimum. For the GDSS groups, it was six of the twelve. All the groups that failed to generate the base line criteria missed only one criteria - sex. As mentioned above, this was mainly because most of the groups saw no way to find an applicant's sex and did not list criteria for which they had no information. It was apparent from their discussions as the groups worked with the case that almost every group considered it vital that the applicant selected be a male. Two of the GDSS groups that listed sex as a criteria failed to determine how to correctly differentiate among the applicants on the criteria. One group graded two applicants (neither Hule) as probable females and derived an incorrect solution. The other group graded all applicants equally on sex, yet determined the correct solution just the same.

6. Group Interaction

Two items on the questionnaires dealt with group interaction:

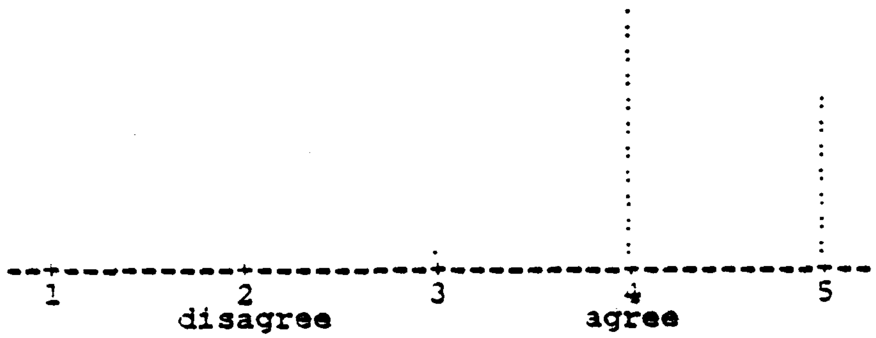
1. My group completely accepted my contributions to solving the problem (Figure 4.10).
2. Everyone in my group had an equal chance to be heard (Figure 4.11).

These variables were used in an attempt to see if the GDSS had any impact on group interaction. Would it stifle the exchange of ideas among the group? Would there be more of a group leader evident in the non-GDSS groups? Or perhaps would a computer oriented individual dominate the GDSS groups?

As seen in Figures 4.10 and 4.11, there was virtually no difference in group interaction among the two groups. Both felt very strongly that their contributions were completely accepted and felt even more strongly that everyone had an equal chance to be heard.

**MY GROUP COMPLETELY ACCEPTED MY CONTRIBUTIONS**

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.3611 | 4.0000 | 4.3750 | 0.5426 | 0.0904 |
| | MIN | MAX | Q1 | Q3 | |
| | 3.0000 | 5.0000 | 4.0000 | 5.0000 | |

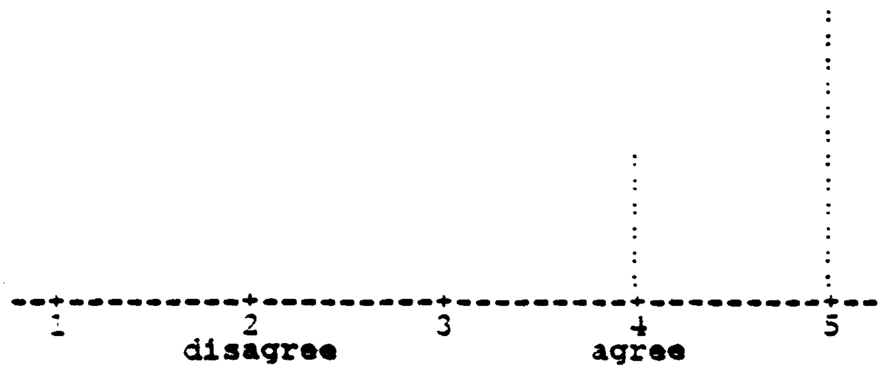
GDSS groups


| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.306 | 4.000 | 4.375 | 0.786 | 0.131 |
| | MIN | MAX | Q1 | Q3 | |
| | 2.000 | 5.000 | 4.000 | 5.000 | |

Figure 4.10 Accepted My Contributions

**EVERYONE IN GROUP HAD EQUAL CHANCE TO BE HEARD**

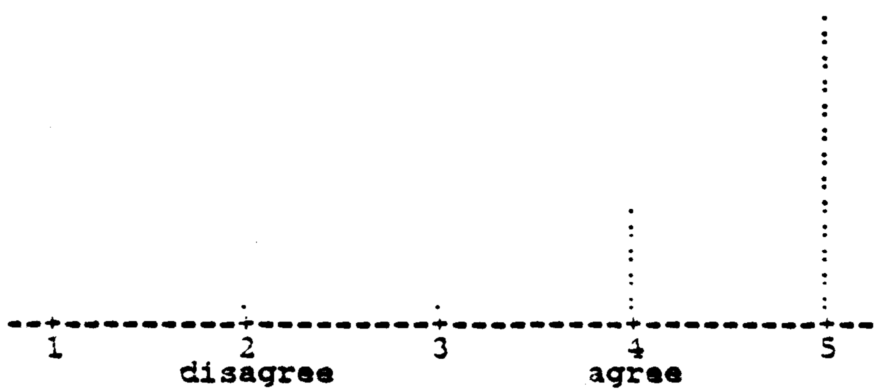
Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.6667 | 5.0000 | 4.6875 | 0.4781 | 0.0797 |

| MIN | MAX | Q1 | Q3 |
|---|---|---|---|
| 4.0000 | 5.0000 | 4.0000 | 5.0000 |

GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.611 | 5.000 | 4.719 | 0.688 | 0.115 |

| MIN | MAX | Q1 | Q3 |
|---|---|---|---|
| 2.000 | 5.000 | 4.000 | 5.000 |

Figure 4.11 Equal Chance to be Heard

# V. A MODEL FOR THE USE OF GDSS

As we have noted in Chapters III and IV, not all problems are suitable for use with a GDSS. In our study we found that the Energy International case lacked the necessary complexity to be solved effectively with a GDSS. We selected the case primarily to replicate the details of the Fijol-Woodbury study. In this Chapter, we propose a model, based on problem type, that discusses the design features and settings most appropriately used with each problem type. We also state that a certain level of complexity is required to use a GDSS effectively with a given problem. The decision problem that we used in our experimental study falls outside of the realm of our model and is not recommended for further use with a GDSS.

A major problem of the GDSS designer is determining the factors that will make his or her system successful. A great deal of energy has been spent on studying the factors that contribute to the success of a GDSS. In spite of such research, the success of a GDSS is usually considered to be intangible, based on intuition rather than hard, fast measurement. It is also important to consider that group decision making situations are fundamentally different than individual decision making situations and, as such, factors that contribute to the success of an IDSS may not affect a GDSS in the same way. No firm, definitive meaning can currently be ascribed to a "successful GDSS".

Several specific factors have been discussed in the literature on ways to improve the effectiveness of a GDSS, or minimize its chance of failure. Cerveny and Clark have stated that the failure of systems is often the result of "our inability to identify the real users of a system, secure their commitment to the system and articulate their concerns and goals in system development" [Ref. 47: p. 151]. It is important to note that for a system to succeed, it must be used frequently enough for users to gain a level of familiarity with the system [Ref. 42: p. 443]. Several authors have focused on the problem type and the nature of group behavior [Ref. 33,34,42,48,49: pp. 17, 81, 444, 342, 87]. Our proposed model, presented later in this paper, also focuses on problem type and the situations in which the GDSS is used. In addition, Sanders and Courtney list the following factors that have been cited in the literature as contributing to GDSS effectiveness: user involvement in system development, consideration of user cognitive styles and individual differences, user attitudes and expectations, technical system quality, the impact of power redistribution, user motivation, top management support and training, accuracy and relevance of output, experience as a decision maker, and the relationship between cost effectiveness and GDSS success [Ref. 49: p. 77].

Dealing with the requirements discussed above is a major problem for the designer of a GDSS. At the present time, GDSSs are in their infancy and it is doubtful that any existing system meets all of the requirements. As more research is conducted and the field advances, it is unlikely that the requirements will remain the same. Advances in technology may allow designers to provide options that have not previously been considered.

## A. THE SUCHAN, BUI, AND DOLK CONTINGENCY MODEL OF GDSS USE

### 1. Discussion of the Contingency Model of GDSS Use

Modern managers are confronted with a wide range of problem types on a daily basis to which they must respond effectively. More and more frequently problems encountered by managers require group interaction to determine an appropriate solution. A GDSS is a tool available to managers to assist them in more effectively solving problems that require group interaction. GDSS use may not be appropriate under all circumstances, however. Suchan, Bui and Dolk have proposed a model, based on problem type, that is designed to assist a user in determining the suitability of GDSS use, see Figure 5.1. Many authors have cited problem type as a major issue in determining the effectiveness of GDSS use, and therefore, a model developed using this approach is reasonable.

The two characteristics on which Suchan, Bui and Dolk have focused are task and relationship. High task problems, in the context of their model, are defined to be ". . . well-defined, technical and highly structured." [Ref. 42: p. 444] Problems high in relationship are those in which there is ". . . an impact on the psychological domain of both workers and managers as well as the "cultural" or internal makeup of the department, division or corporation" [Ref. 42: p. 444]. These two variables are present to some degree in all problems and the model described by Suchan, Bui and Dolk is based on their interaction.

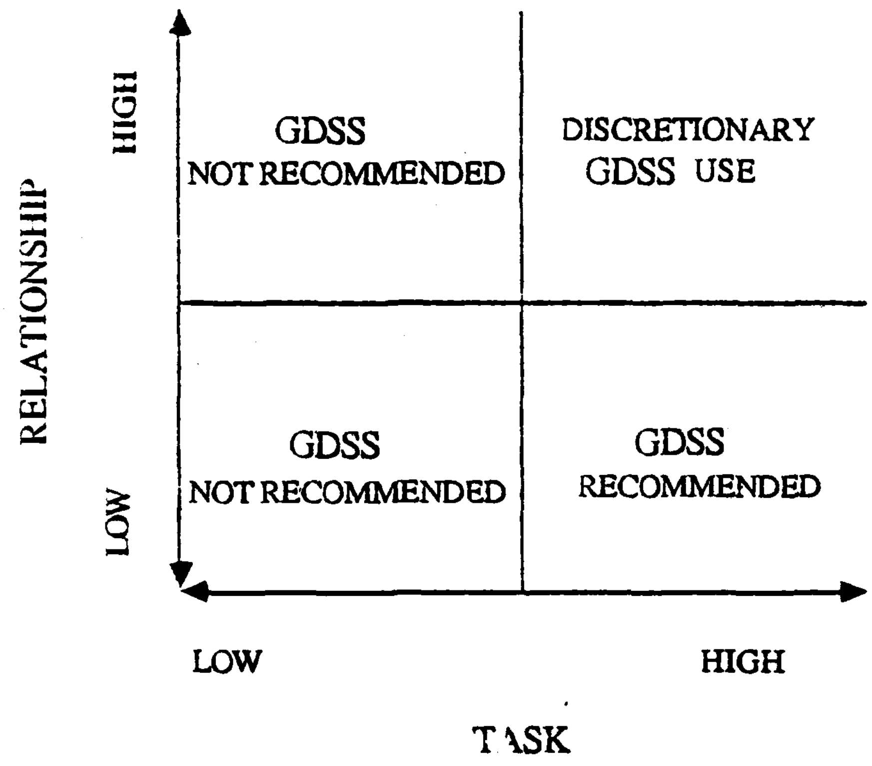



Figure 5.1 Suchan, Bui, Dolk's Contingency Model

2. **Limitations of the Contingency Model**

The model discussed by Suchan, Bui and Dolk is limited because is does not consider some important variables related to problem type and setting as major factors that impact GDSS effectiveness. It also considers only systems that are currently available. In the future, GDSS configurations could be available so that the use of some form of GDSS is practical with any problem type. DeSanctis and Gallupe have proposed a taxonomy of possible GDSS settings in which member proximity and group size are variables, see Figure 5.2, [Ref. 4: p. 598]. We propose that complexity is a significant variable affecting problem type that must be considered in a model designed

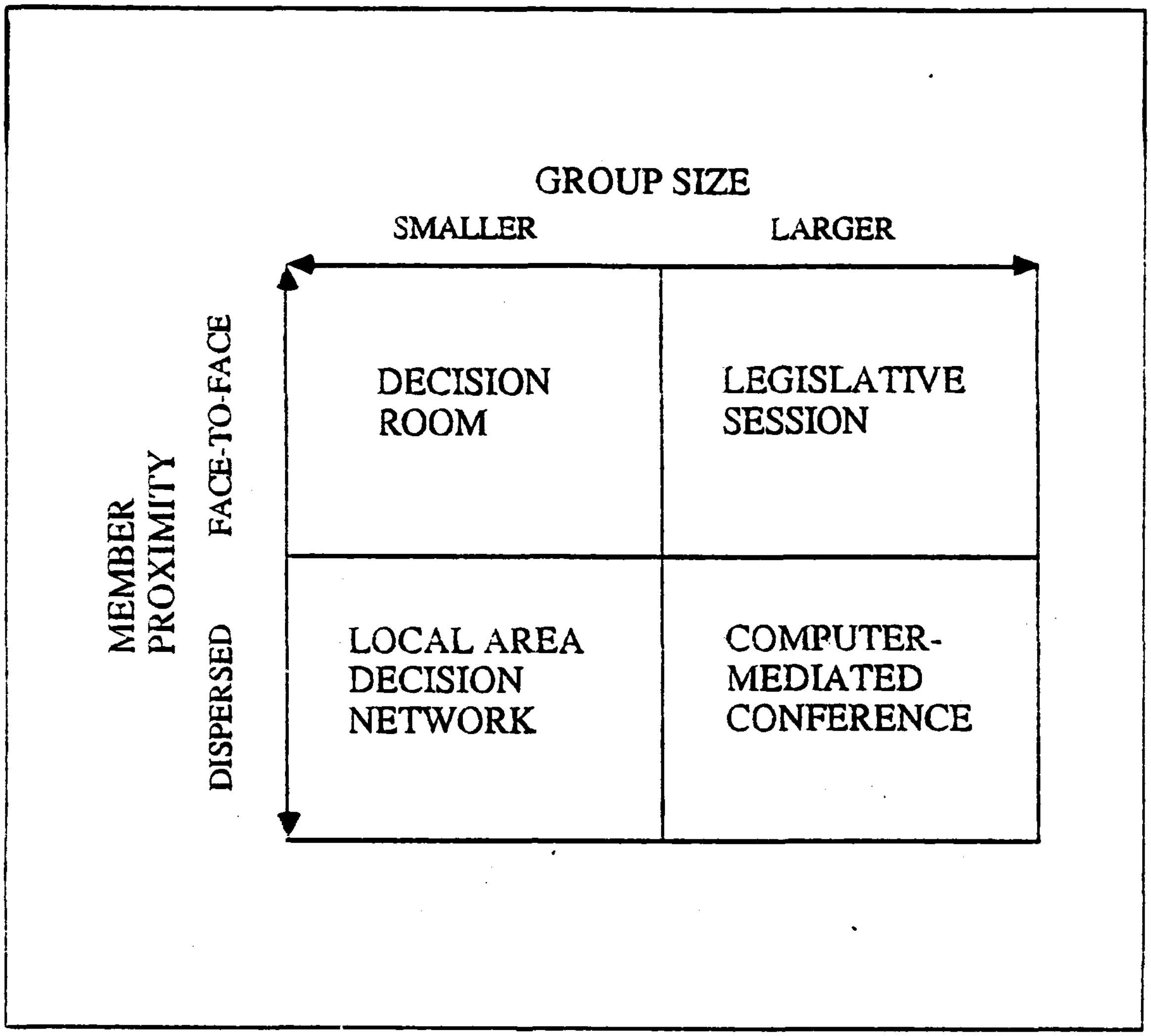



Figure 5.2 Taxonomy of Possible GDSS Settings

to make recommendations for GDSS use. Problems high in complexity have a large number of interacting variables. We further propose that not all settings are suitable for use with all problem types. Under most circumstances problems that are high task or high complexity are suitable for use with a GDSS in any setting. High relationship problems, however, may involve hidden agendas and political motives that are more suitably handled in smaller groups and face-to-face. It is possible that high relationship problems may be completely unsuitable for the use of a GDSS in any setting, depending on the types of relationships involved.

## B. PROPOSED ELEMENTS OF A MODEL FOR GDSS USE

### 1. Task and Relationship

As in the Suchan, Bui and Dolk model we have selected task and relationship as major variables determining problem type. The meanings are synonymous with the terms described above in their model. High task problems are cold, business-oriented or economic-oriented problems that do not involve human relationships, such as economic analyses. High relationship problems are those that affect a group's power structure, the interpersonal relationships in a group, or organizational norms, such as internal promotions.

### 2. Complexity

We have chosen to add complexity to our model because it has been stated by several authors that decision support is best used as a means for managers to handle a complex environment [Ref. 49,50: pp. 86, 4]. Because of this, we feel that problems lacking a certain amount of complexity are not well suited for GDSS support. In fact, the GDSS may actually interfere with the solution of a problem if the group involves itself with the system and neglects the problem. This happened to some extent in our experimental study. We feel that the case that was selected was too simple for use with a GDSS because there were not enough interacting variables. Therefore, we do not recommend the case for use in further GDSS research.

For the purpose of our model, we define complexity as a problem in which there are a large number of interacting variables. Characteristic of this problem type is a high degree of interaction and interrelation among the variables and a low degree of structure to the point that the group is overwhelmed and requires some form of automation to handle the highly complex problem. In a problem of this type, it might even be difficult to identify variables that have a valid impact on the solution. Generally speaking, problems that are highly complex lend themselves well to the use of decision aids because the various tools available can assist by providing memory aids, some structure and operations that allow the user to determine the impact of a decision on the various interacting variables. Highly complex problems, in general, are best solved face-to-face, using the GDSS as an additional communications channel. The face-to-face interaction may be necessary for clarity in view of the lack of structure and the large number of interacting variables. GDSS Support will be beneficial because tools can be made available to permit efficient decomposition of highly complex decision problems and the memory aids provided by a GDSS can also be useful.

It should be noted that the solution of low complexity problems is not necessarily immediately obvious. Yet they are problems that can be solved relatively easily by a group in a very short period of time without the use of a decision aid. They may be problems that management has deemed necessary to be solved by a group but that otherwise might be solved by an individual. They might also be problems that are solved by a group to improve acceptance of and commitment to the outcome. At the other extreme, high complexity problems are those in which there are a large number of variables and that will require a large amount of time to solve. As mentioned above, this definition is somewhat subjective and the user should consider it a guideline.

## C. DISCUSSION OF THE PROPOSED MODEL

The model we propose describes the interaction of the variables task, relationship, and complexity as they relate to the use of a GDSS. We will describe each of the eight quadrants in the model below, see Figure 5.3, and discuss the types of problems that might fit within each quadrant. In addition, we will discuss the optimal setting for coping with each type of decision and suggest any design features that may improve the quality of the decision. The descriptions are broad and somewhat subjective and thus serve as guidelines for the optimal use of the GDSS.

We will discuss each of the possible problem types and any suggested optimal settings below. We refer to suggested limitations because we realize that there may be special circumstances that may prohibit the use of an optimal setting. For example, it might be necessary to solve a high relationship decision in a computer mediated conference because it may be too expensive to gather the required parties in one place. We are not saying that using a GDSS will not work under the circumstances, only that a GDSS should be used with caution and that the setting is less than optimal.

We will also discuss special design recommendations. While it is important for a GDSS to have a comprehensive set of tools, we have mentioned the tools that we feel will be most useful in that setting. The incorporation of these tools in a GDSS designed to be used with a specific problem type should be beneficial.

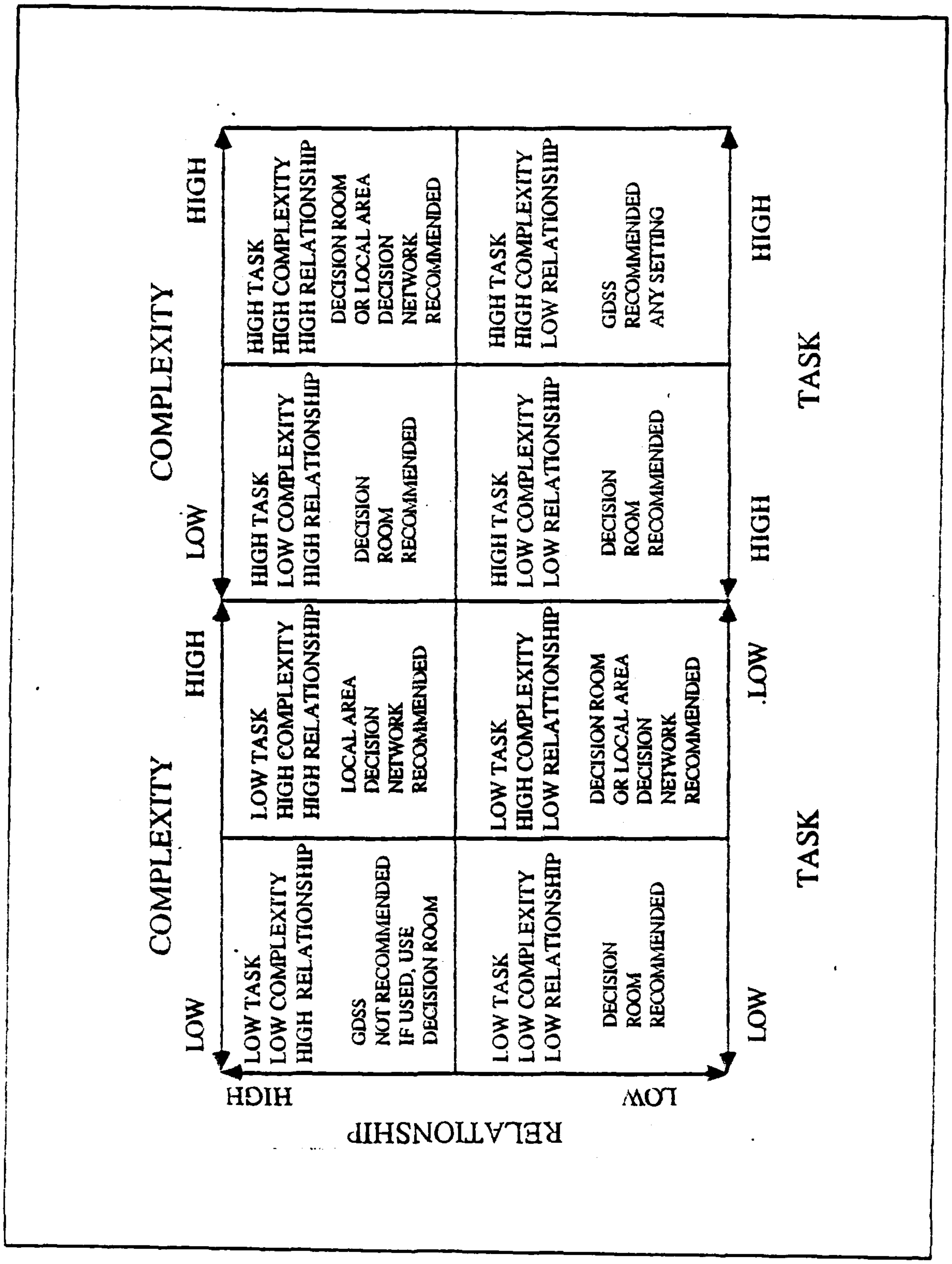



Figure 5.3 Problem Type Model for GDSS Use

### 1. Low Task, Low Complexity, High Relationship

This type of problem is not generally recommended for use with a GDSS. Since the problem lacks a large number of interacting variables and since there is no precise method that can be used to solve it, the GDSS may be unnecessary. The use of a GDSS in a low task, high relationship environment might impede the decision process because it is an incorrect communications channel [Ref. 42: p. 445]. This type of problem is probably a relatively small, personnel administrative problem that can be most effectively solved by a small group meeting face-to-face. If a GDSS were used to support this type of decision, useful design features might include a decision model including anonymity, a means of providing conflict resolution, and the ability to send private or public messages to other group members.

### 2. Low Task, Low Complexity, Low Relationship

This type of problem is not generally recommended to be supported by a face-to-face GDSS, however, a distributed GDSS could be used for its solution. Because it lacks complexity and does not deal with human relationships, the GDSS can effectively serve as the primary communications channel. Although there is no specified methodology for solving this type of problem, the details can easily be inputted and retrieved from the GDSS. A face-to-face GDSS is not recommended because it is likely that the group will elaborate on ideas that lack the level of complexity to justify this expenditure of time. Research has shown that groups using a decision aid tend to use all the time they are permitted to discuss all alternatives [Ref. 44: p. 549], whether the problem warrants the expenditure of time or not. A further drawback to using a GDSS is that a system may be used because users are interested in the technology of the system, even though the system is unsuitable for the problem that they are solving [Ref. 19: p. 102]. An example of this type of problem could be a simple decision on the ordering of supplies. A useful design feature would be the inclusion of a means for listing alternatives, ranking them, and rating them and voting on them.

### 3. Low Task, High Complexity, High Relationship

A GDSS should be used with care in solving this type of problem. This type of decision problem might be a negotiation or bargaining problem. It is a special class of problem and might warrant the use of a special purpose GDSS to deal with both the rational and social/emotional needs of the group. Since a high degree of relationship is involved, we recommend that the best setting for solving this problem is a small group, meeting face-to-face. The use of a GDSS will serve as an additional communications channel and will provide tools needed to cope with the complexity of the problem while the face-to-face interaction of group members will ease the possible political tension and be useful in dealing with the hidden agendas that are sometimes present in high relationship decision problems. GDSS can be helpful in focusing attention on the main task and allowing users to keep a clear picture of the negotiation process [Ref. 51: p. 245]. Useful design considerations might include the use of anonymous or private voting, a behavioral model that includes a method for conflict reduction, memory aids and a method to decompose the problem to handle the high level of complexity.

### 4. Low Task, High Complexity, Low Relationship

A GDSS is recommended for use in solving this type of decision task. This type of problem is characterized as being difficult and requiring a large amount of time, but one that can benefit from the creativity of a group. The best setting for this type of decision problem is a small group meeting face-to-face. A small group is recommended over a large group because the formality necessitated by a large group might limit the participation of individual group members and thus reduce its creativity. A small group meeting face-to-face with a GDSS can best manage complexity and add structure to this kind of task. Examples of this type of problem include portfolio analysis and other decisions that have a large number of interacting variables and that are normally based more on hunches than on a precise methodology. The use of decision models (such as Nominal Group Technique of the Delphi Method), memory aids, the ability to decompose the problem, list alternatives, and rate and rank them are recommended design options.

### 5. High Task, Low Complexity, High Relationship

A GDSS could be used in solving this type of problem, however, it should be used carefully. While this kind of problem is solved using a standard methodology, there are personnel issues that may inject political undertones into the scenario. An example might be selecting a candidate for a job based on standardized test scores. The recommended setting for use of a GDSS in solving this type of decision problem is face-to-face in a small group, primarily because it is high relationship. Useful design features include the ability to send messages publicly or privately to group members, anonymous or public voting and input, and behavioral models that include conflict reduction techniques.

### 6. High Task, Low Complexity, Low Relationship

This type of problem lends itself well to the use of distributed GDSS and moderately well to the use of a GDSS in a face-to-face setting. The problem can easily be handled by a large or a small group, but the use of a GDSS in a face-to-face setting may increase the decision time significantly. The reason for this is that group meetings require a certain amount of overhead time to be spent on information unrelated to the problem, but a distributed group limits social interaction. A distributed GDSS could improve communication for this type of problem by standardizing communications [Ref. 19: p. 102]. This type of problem is usually standard and familiar. Special algorithms could be added to the GDSS to handle it. Another desirable design factor could include software that aids in ranking and rating criteria and voting.

### 7. High Task, High Complexity, High Relationship

The use of a GDSS in a face-to-face setting with a small group is recommended for solving this type of problem. The decision might be one that has a many interacting variables, but includes some standard procedures for structuring the problem and dealing with this complexity. It also affects personnel and, therefore, can involve hidden agendas and political motivations. Examples of this type of problem could be cost reduction, a decision about whether to close a department, major reorganizations, or other strategic decisions. Design features of the GDSS should include decision and behavioral models (like Nominal Group Technique), a means of conflict reduction, the ability to decompose the problem to cope with its complexity, the ability to rank and rate criteria and vote, the use of anonymity, and the ability to send messages publicly or privately to group members. These are typically very difficult problems to contend with, but can be some of the most important to the organization.

### 8. High Task, High Complexity, Low Relationship

GDSS use in solving this type of problem is highly recommended. It is the type of problem that can be solved in a face-to-face or a distributed group and in a small or large group; although because of the level of complexity, a small group is slightly preferred. An example of this type of problem could be a decision on a complex technical issue, such as the purchase of hardware. This type of problem will best show the effectiveness of a GDSS because the GDSS will be able to efficiently deal with communications and handle the large number of conflicting variables by

**allowing problem decomposition. In addition, the GDSS will provide memory aids that will assist in handling the large number of variables and could provide a method of ranking and rating criteria and voting.**

## D. SUMMARY OF THE MODEL

The model described above is very general and will require a very large body of research before it can be validated. Research on GDSSs has primarily involved graduate students as subjects. A reason for this is that there are few GDSSs in use in the private or government sectors to support a large scale empirical study. Still, the need for support involving management is not diminished. There are at least four main problems encountered when studying graduate students. First, even when using graduate students with some management background, it is not possible to obtain a truely representative population. Second, it is difficult to secure graduate students in sufficient numbers to commit enough time to solve a highly complex decision problem. Third, it is difficult to test high relationship problems in a graduate school setting because the result of the group's decision will never be felt by the group. Finally, the testing of large groups is difficult due to an inability to secure enough subjects whose schedules do not conflict. Research gaps in these areas can probably best be filled by a survey of organizations actually using a GDSS, once suitable systems are available and sufficiently used.

Our experiment, described in Chapters III and IV, involved solving a case that can best be described as high to moderate task, low complexity, and low relationship. We consider the case selected for our experiment to be high to moderate task because it required generating criteria for decision making and groups could develop an algorithm to solve the case. The case can be further described as low relationship because the subjects did not know the candidates, were given very limited information about them, and would feel no lasting consequences of their decision. Low complexity was also a characteristic of this case because, although the solution was not intuitively obvious, the authors of the case suggested only five criteria. In addition, there were only seven candidates, and it is clear from inspection that the case can easily be solved by a group in a short period of time.

The GDSS design issue is an area that is changing greatly. Advances in technology and research are fueling these changes and they are expected to continue for the foreseeable future. If the nature of organizations is truly changing, the need for an automatic group decision aid is evident. We expect that many of the tools and techniques that are considered state-of-the-art in today's GDSS technology will be passe very quickly with the advent of expert systems, the use of "shells", and other technical advances that will improve response times of systems. In the distant future we may see the "user-seductive" systems described by Vogel, Nunamaker, Applegate, and Konsynski [Ref. 33: p. 11]. When systems that are more than merely "user-friendly" are available, GDSS technology will become almost a necessity in organizations.

# VI. CONCLUSIONS

## A. EXPERIMENTAL RESULTS

### 1. Hypotheses

In Chapter III we introduced the following three hypotheses concerning the *expected* effects of the decision outcome variables on the two groups:

- $H_1$ : The face-to-face GDSS groups will be more accurate in solving the case than the face-to-face non-GDSS groups.
- $H_2$ : The time required to reach a decision, excluding the time to read the case, will be less in the face-to-face non-GDSS groups than in the face-to-face GDSS groups.
- $H_3$ : There will be no substantial difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their satisfaction with their group decision.

Let's review our findings on these hypotheses, as delineated in Chapter IV.

#### *a. $H_1$ : Accuracy*

We saw that of the non-GDSS groups, seven of the twelve groups correctly matched the experts' choice. For the GDSS groups, it was only four of the twelve groups. The difference in the two types of groups is significant and thus the hypothesis is clearly rejected. We are not saying GDSSs are not, in general, a useful management decision tool. We are saying that, for *this* case, a GDSS was a detriment to decision making. This is largely due to the case being characterized as fairly high task, low relationship, and low complexity, which is inappropriate for use with a GDSS. In particular, the complexity of this case was too low to be used as a means of formulating a definitive judgment on GDSS usefulness. The case would also be more applicable to GDSS testing (particularly Co-oP) if it were more of an actual decision task (having viable alternatives) and not just an elimination task.

Another possible reason for the poorer performance by the GDSS groups is that they relied on the GDSS to make the selection of an applicant, vice just assist them with that selection. (DSSs, by their very title, are decision *support* systems, not decision *making* systems.) In contrast, the non-GDSS groups were forced to come to a final decision on their own and this may have caused them to more fully examine the case. The GDSS users were largely a group whose members had computer backgrounds, and who had been exposed to GDSS theory, had confidence in such theory, and thus had high expectations for the system - a system that most had not seen before and that certainly none had used extensively. They could not have fully appreciated how Co-oP would work their inputs, and were not cognizant of its limitations, its strengths, etc. These matters would be understood by someone who routinely used Co-oP and thus experienced users could be reasonably expected to produce better quality outcomes than our inexperienced users. The GDSS users were probably confident they had provided the system enough bits and pieces of information to formulate the correct solution; unfortunately they were wrong. Again, it is largely due to the nature of this case (deliberately hiding key data - sex) and not to a GDSS deficiency. Regardless of all that, the basic validity of the case is still questionable because an important personnel decision would probably not have been made without more information and because a GDSS would not be actually used to make the *final* selection, but "merely" to aid in that selection.

*b. $H_2$ : Input Time*

As we clearly saw, the input time (time spent actually solving, and not also reading, the case) for the GDSS groups was about four times as long as it was for the non-GDSS groups (39 minutes versus 11 minutes). This also is mainly because the case is so low in complexity. It simply does not need to be solved with computer assistance; and in fact is more quickly solved without a GDSS. Several of the applicants could be readily dropped from further consideration by the non-GDSS groups while the GDSS users did not have that option. It is expected that, with experience, the Co-oP groups would learn how to use the software more efficiently (e.g., not rank non-viable alternatives). Of course, better still, would be to only enter the viable alternatives, since they alone can be realistically rated and ranked. This is how Co-oP best functions and this would become clear to the users as they became more experienced with the system. Because there was only one viable applicant, the rating and ranking features of the system were not used effectively. This again illustrates that Co-oP was not well suited for the case.

If a case was of sufficient complexity (numerous criteria *and* numerous viable alternatives) to readily fit the computer environment (perfect memory; large data manipulation capability), then it is certainly conceivable that a group of managers,

**experienced with a GDSS, might improve their decision making time by using their GDSS. Finding a sufficient number of volunteers with such experience and with the time to solve such a complex case would indeed be a formidable task.**

#### c. $H_3$ : *Decision Satisfaction*

Here we saw that both the non-GDSS and GDSS groups were very satisfied with their final group decision, their decision making process, and the criteria they generated. Although there was no *significant* difference in this area between the two groups, the satisfaction level was slightly less for the GDSS groups in all satisfaction variables.

### 2. Variables

Some additional issues were also researched, both to compare our results with those of the prior study and to support the model we designed:

- What type of setting will the groups most prefer in solving this case?
- Which type of group is most likely to generate the case's base line criteria (criteria the experts defined as important in solving the case)?
- Will there be a difference in the number of supplemental (other than base line) criteria generated between the types of groups?
- Are the groups content with their ability to discuss the criteria and interact with other group members?

Let's review our findings from Chapter IV on these variables also.

#### a. *Setting*

The non-GDSS participants slightly preferred that setting, that is, preferred not to use a computer for this case. The GDSS users were perfectly split in their opinion on the computer's usefulness - with most having no strong feelings one way or the other. Those who used the GDSS, however, tended to rate the computer's usefulness as slightly higher, even if they were very split in their views. So experience with Co-oP does seem to have a somewhat positive impact on its perceived usefulness, even for an inappropriate task. About all we can truly conclude from this result is that users feel that a very low complexity problem is not suitable for GDSS use and, therefore, a GDSS should not be specifically designed for such a problem. That is consistent with our model, in that a GDSS is not recommended for low complexity tasks.

**There was a very strong preference for a face-to-face setting over a distributed setting, regardless of whether a GDSS was used or not, and even though none of our subjects actually experienced a distributed setting during our experiment.** The Fijol-Woodbury study (which used both face-to-face and distributed) also found that subjects tested in a face-to-face setting preferred to meet face-to-face (their distributed groups were non-committal on the matter). This finding could be related to the positive effects of social interaction and the fact that people are still more familiar with face-to-face communications, even in light of fairly recent technological innovations in the field of distributed communications.

*b. Criteria*

We unsuccessfully attempted to determine if Co-oP's formalized thought process would hinder or aid criteria generation. Since both the non-GDSS and GDSS groups selected their criteria based largely on the information provided on each applicant, and generally limited the criteria to only what was available and necessary to select a single applicant, no determination could be made regarding one group versus the other. If a group was able to cleverly step through the case information and withdraw the intentionally hidden gender data, then sex was selected as a criteria - the GDSS was not a factor in that. Had the groups generated their criteria *before* being allowed to view the candidate summary sheet, perhaps some finding could be determined. Yet the GDSS could not be considered a factor even then, because criteria generation is the first thing Co-oP requires (once the problem has been set up, as was done in advance for our groups), and thus is completed before Co-oP "does" anything. The effect of Co-oP's formalized thought process is not apparent at this point beyond requiring completion of the criteria before moving on and beginning the evaluations. The non-GDSS groups were more able, if desired, to change their criteria in the midst of the evaluations.

*c. Interaction*

The GDSS had no measurable impact on group member interaction. Both the non-GDSS and GDSS groups felt very strongly that their contributions were completely accepted and felt even stronger that everyone had an equal chance to be heard. Members of both types of groups seemed equally active in the process, with no observed intimidation on anyone exposed to the GDSS, either by the GDSS itself or individuals perhaps more computer oriented.

### 3. Findings Summary

- The Energy International case, being of high task, low relationship, and low complexity, in not recommended for GDSS testing, especially in view of its poor face and content validities.
- For this case, a GDSS was a detriment to quality decision making.
- For this case, a GDSS was a detriment to decision speed.
- There was no substantial difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their satisfaction with their group decision.
- There was a very strong preference for a face-to-face setting over a distributed setting, regardless of whether a GDSS was used or not.
- The GDSS had no measurable impact on the interaction among the group members.

## B. METHODOLOGICAL FINDINGS IN GDSS RESEARCH

In order to make a GDSS useful to decision makers, researchers have concentrated on the characteristics of the problems to be solved and on design features that will be beneficial in the systems. Suchan, Bui, and Dolk have proposed a model based on problem type [Ref. 42: p. 444]. DeSanctis and Gallupe propose that setting is also an important factor in determining the success of a GDSS [Ref. 4: p. 598]. Although these factors are important, the mistake of considering them separately should not be made. In the case of GDSS the whole is equal to more than the sum of the parts.

In the model that we have proposed in Chapter V, we have considered problem type, setting, and design characteristics. Although we recognize our model is untested, we feel that it is, at least, an initial attempt to explore the synergy that exists where GDSS is concerned. It is expected that further research will be able to broaden the model considerably by adding more variables that impact on problem type and by increasing the number of factors that impact the GDSS. Thorough research in these areas and improved technology will produce systems that will be of vital importance to the largely information-reliant organizations of the future. Specifically, issues related to communications, group dynamics, and conflict resolution are of particular relevance.

### 1. Group Communications Needs and the GDSS

Inherent in the GDSS technology is the need to provide effective communications among group members, whether the GDSS is used face-to-face or in a setting that is distributed in time or location. Communications can be considered the key to group problem resolution and group decision making. It has been observed that decision makers use conversation as their primary means of making commitments [Ref. 17: p. 257]. Mintzberg has found that managers prefer using verbal media, such as telephone calls and meetings, to conduct their business [Ref. 11: p. 52]. The role of GDSS in the decision making process is, therefore, of great importance. Bui and Jarke, [Ref. 2,52: pp. 614, 1], Alter [Ref. 19: p. 97], and Lin [Ref. 3: p. 3] are among the authors that have recognized the necessity of providing communications support in a GDSS.

Using a GDSS in a distributed setting forces the designer of a GDSS to accommodate for the lack of face-to-face interaction that normally occurs during meetings. Bui and Jarke have proposed several communications characteristics that are desirable in a distributed setting. Format transparent information exchange will permit users to communicate through the GDSS without the requirement for special formats. A user should be given the option of providing information to all group members or privately to any member or members he or she selects. The communications component of the GDSS should not be rigid, but should allow communications to evolve depending on the nature of the task and the group. Bui and Jarke also discuss limiting communications as a means of reducing conflict [Ref. 52: pp. 3-4].

### 2. The Effect of Group Dynamics on GDSS Design

Group dynamics play a role in GDSS design that is increasingly difficult to ignore. The nature of automated decision support should be to minimize group process losses (which includes certain overheads, such as distractions that divert the attention of the group from the problem) and maximize group process gains (which includes the benefits attributed to group interaction, such as consideration of more alternatives, etc.) due to group interaction [Ref. 33: p. 119]. Changing the nature of interpersonal relations is the key to increasing the effectiveness of GDSSs, and the larger the change, the more noticeable the effect on group productivity [Ref. 4: p. 591]. GDSS designers must consider group dynamics to be of critical importance and should capitalize on the unique nature of group interactions to make their systems more effective.

Factors that have an impact on group dynamics have been reported frequently, and it is necessary for GDSS designers to understand them. One factor, the use of anonymity in communications and voting, is often found in GDSS designs. While anonymity can increase creativity and reduce conformity, it can also heighten conflict because users become more blunt with each other [Ref. 33: p. 12]. Group leadership is another factor that can be adversely affected by the use of a GDSS because equal participation by all members is encouraged and the leader's control is limited [Ref. 16: p. 88]. A positive contribution of a GDSS is that it can redirect the focus of the group to the problem, if the group should become sidetracked [Ref. 33: p. 17]. Size is a factor that can effect group dynamics by creating increasingly complex communication interfaces as the number of group members increases [Ref. 4: p. 591]. The nature of the decision making environment is thought to be a factor that may impact the required characteristics of the GDSS. [Ref. 53: p. 9].

The setting (for example, face-to-face versus distributed in time or location) has a significant impact on group dynamics. Lin suggests that non-verbal communication establishes the very nature of the group, and removing the group from a setting in which they can work face-to-face or in which they can expect a prompt response to their input, will have a substantial impact on the group [Ref. 3: p. 2]. While problem solving in a distributed setting required less time, and thus it is implied that it was more efficient, the satisfaction of group members is not necessarily enhanced [Ref. 26: p. 41]. Member satisfaction is likely to be an important factor in the frequency of use of a GDSS and should be considered by designers.

Introducing a computer to a group setting is a factor that has been demonstrated to be significant. The use of computerized conferencing may increase the number of daily communications between group members by a factor of between two and ten [Ref. 16: p. 89]. Graphics and CRT output have been shown to produce better and faster decisions, requiring less data [Ref. 54: p. 921]. Designers must realize that computers can have an effect on the perceived quality of worklife which, if the effect is negative, can have a negative impact on productivity [Ref. 55: p. 1217]. Excessively complex systems may cause such low satisfaction with the system to effectively undermine its implementation [Ref. 54: p. 921]. Thus, "user-friendliness" and convenience are necessary to the successful implementation of GDSSs.

### 3. Conflict Resolution in Group Decision Making with a GDSS

The circumstances that lead to conflict in groups and a means to deal with conflict effectively are concerns of the GDSS designer. It must be noted that conflict is not always harmful to group processes but when it becomes distracting and disruptive, some form of conflict resolution is required. Anonymity in communications or the use of distributed settings can often increase the level of conflict in groups to the point where the conflict becomes an impediment to group process. The use of behavioral techniques such as those described by Fogg and Levy [Ref. 56,57: pp. 332-358, 584] could be useful in making GDSS decisions more efficient by reducing the level of disruptive conflict. COLAB is a meeting room equiped with a GDSS that is specially designed to study group decision making in a face-to-face setting. Conflict reduction was seen by COLAB's designers as desirable in this setting and has already been incorporated into the system [Ref. 58: pp. 38-40]. A great deal of research is needed in the area of conflict resolution to improve the effectiveness of GDSS design.

Negotiations are a special class of group problem involving multiple parties, each of whom has his or her own view of a given problem situation, and each of whom must come to an agreement. Since the negotiation process often involves politics and hidden agendas, there is a significant potential for destructive tension and a need for conflict resolution in systems designed to handle negotiations. Because it is a specialized task and has specific requirements, designing a special purpose GDSS for negotiation has been considered by some researchers to be effective. GDSSs can be designed to provide additional channels for communications but face-to-face interaction is important in negotiation, so a distributed setting should not be used [Ref. 3: p. 4]. Critical tasks in negotiation involve the analysis and ranking of alternatives [Ref. 59: p. 470], as well as the use of conflict resolution and reduction techniques, both of which can be incorporated into a GDSS. An example system designed specifically for, and used successfully, in negotiation is Nego [Ref. 51: p. 254]. Nego assists users in coming to agreement by focusing their attention on main points and by helping them to keep a clear view of the negotiation process. However, further experimental research should be conducted to evaluate the effective use of these systems.

## APPENDIX A
## ENERGY INTERNATIONAL CASE

You are one of the General Managers of Energy International (EI), a young, medium-sized, growing corporation. The prime mission of EI is to locate and develop mineral claims (copper, uranium, cobalt, etc.).

The company's business has grown very rapidly, especially in South America, where your organization has been made welcome by the governments. In a recent meeting the board of directors decided to develop a new property near Fortaleza, in northeastern Brazil. The operation will include both mining and milling production.

The date is 1 May 1987. You have come from your respective plants in different locations. This is the initial session of your annual meeting. Your first order of business today is to select a new General Manager for the Brazilian plant from among the candidates on the attached list.

Fortaleza, Brazil has a hot climate, one railroad, a scheduled airline, a favorable balance of trade, a feudal attitude toward women, considerable unemployment, a low education level, a low literacy level, and a strongly nationalistic regime.

The government has ruled that the company must employ Brazilians in all posts except that of manager. It has also installed an official inspector, who will make a monthly report which must be countersigned by the General Manager. None of the government inspectors and company's employees or staff can read or write any language but Portuguese.

The General Manager must have had at least three years of experience as a manager in charge of a mining operation, be a Fellow in the Institute of Mineralogy, and be an American citizen.

Fellowship in the Institute of Mineralogy can be obtained by those over 35 years of age who have otherwise qualified for General Membership in the Institute. To qualify for General Membership, a candidate must have a degree in mineralogy with a passing grade in paleontology and seismology.

There are a number of schools offering degrees in mineralogy. The smaller universities require three, the larger four, special subjects as part of their graduation requirements. The smallest is a women's university. The largest university, the New York School of Mines, requires geology, paleontology, geophysics, and seismology for graduation. The New Mexico Institute of Earth Sciences requires geology, seismology, and paleontology, in addition to the usual courses. The Massachusetts Institute of Sciences requires geology, seismology, oceanography, and paleontology. St. Francis University, which is not the smallest school, requires paleontology, geophysics, and oceanography.

Using the above information and the attached candidate summary sheet, you are to develop your own criteria and based on them choose one best candidate for the position.

## CANDIDATE SUMMARY SHEET

| | |
|---|---|
| Name: | R. Illin |
| Age: | 35 |
| Passport: | L3452 - USA |
| Education: | New York School of Mines - degree in mineralogy - 1972 |
| Languages: | English, French, German, Portuguese |
| Employment: | Research Assistant, New York School of Mines - 1973-75 |
| | Lecturer, Mineralogy, University of Bonn - 1975-85 |
| | Manager, Utah Copper Mining Co, Plant - 1985 to date |

| | |
|---|---|
| Name: | S. Hule |
| Age: | 42 |
| Passport: | H4567 - USA |
| Education: | New Mexico Inst. of Earth Sciences - degree in mineralogy - 1970 |
| Languages: | English, French, Portuguese |
| Employment: | Management Trainee, Uranium Unlimited - 1970-72 |
| | Geology Officer, Anaconda Copper Co., Montanta area - 1973-80 |
| | Manager, Irish Mining Co., Ltd. - 1980 to date |

| | |
|---|---|
| Name: | T. Gadolin |
| Age: | 41 |
| Passport: | L7239 - USA |
| Education: | New York School of Mines - degree in mineralogy - 1970 |
| Languages: | English, Portuguese |
| Employment: | Management Trainee, United Kingdom Mining Board - 1970-72 |
| | Assistant Manager, N.D.B. Cheshire Plant - 1973-81 |
| | Manager, Idaho Cobalt Minerals - 1981 to date |

| | |
|---|---|
| **Name:** | **U. Samar** |
| **Age:** | **33** |
| **Passport:** | **H6259 - USA** |
| Education: | Massachusetts Inst. of Sciences - degree in mineralogy- 1974 |
| Languages: | English, German, Swahili, Portuguese |
| Employment: | Jr. Engineer, W. Virginia Mining Research Station - 1974-83 |
| | General Manager, Liberian State Mining Plant - 1983 to date |

| | |
|---|---|
| Name: | V. Lute |
| Age: | 36 |
| Passport: | K62371 - USA |
| Education: | New York School of Mines - degree in mineralogy - 1971 |
| Languages: | English, French, Welsh, Pekingese |
| Employment: | Jr. Development Mineralogist, Ontario Mining Constr. Ltd. - 1971-74 |
| | Assistant Chief Mineralogy Officer, Canadian Dev. Board - 1975-78 |
| | Plant Manager, Welsh Mining Co.,Ltd. - 1979 to date |

| | |
|---|---|
| Name: | W. Noddy |
| Age: | 43 |
| Passport: | H63241 - USA |
| Education: | St. Francis University - degree in mineralogy - 1968 |
| Languages: | English, Portuguese, Russian, Arabic |
| Employment: | Assistant Manager, Societe Debunquant D'Algerie - 1968-72 |
| | Manager, Kemchatka Mining Co. - 1973 to date |

| | |
|---|---|
| Name: | X. Lanta |
| Age: | 36 |
| Passport: | Q123YB - Canada |
| Education: | University of Quebec - diploma in English - 1970 |
| | Massachusetts Inst. of Sciences - degree in mineralogy - 1973 |
| Languages: | Spanish, English, Portuguese |
| Employment: | Tech. Officer, Sardinia Mining Corp. - 1975-83 |
| | Manager, Moab Valley Mining Plant - 1983 to date |

# APPENDIX B
# QUESTIONNAIRE FOR NON-GDSS GROUPS

The following questionnaire was completed by the non-GDSS group members immediately after they finished solving the case. Below the scale for each question is a circled number that represents the number of individuals who selected that response to the question. The responses to these questionnaires are the source of raw data that we used to derive our statistical analyses.

# QUESTIONNAIRE : NON-GDSS

(THE CIRCLED NUMBERS INDICATE THE RAW DATA COLLECTED IN OUR STUDY)

PLEASE RESPOND TO THE FOLLOWING STATEMENTS BY CIRCLING THE RESPONSE THAT BEST MATCHES YOUR FEELINGS TOWARD THE STATEMENT. THANK YOU FOR YOUR HELP.

## I. CASE

1. IMMEDIATELY AFTER READING THE CASE STUDY, THE CORRECT CANDIDATE WAS INTUITIVELY OBVIOUS TO ME.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 11 | 12 | 10 | 2 | 1 |

2. I WOULD SAY THIS CASE STUDY COULD BE AN EXAMPLE OF AN ACTUAL DECISION MAKING SITUATION IN AN ORGANIZATION.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 3 | 4 | 5 | 21 | 3 |

3. THIS CASE STUDY SEEMS REALISTIC TO ME.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 1 | 11 | 4 | 18 | 2 |

## II. SELECTION CRITERIA

4. I AM VERY SATISFIED WITH THE NUMBER OF CRITERIA MY GROUP IDENTIFIED.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 0 | 0 | 16 | 20 |

5. IF YOU ASSIGNED WEIGHTS TO YOUR DECISION CRITERIA FOR SELECTING A CANDIDATE, IT HELPED IN YOUR DECISION MAKING PROCESS.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 1 | 1 | 14 | 16 | 4 |

## III. RESULTS

6. MY GROUP DEVISED A VERY GOOD SOLUTION TO THE CASE.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 1 | 2 | 13 | 20 |

7. I AM VERY SATISFIED WITH THE DECISION MAKING PROCESS THAT MY GROUP UNDERWENT TO DEVELOP A SOLUTION.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 0 | 1 | 13 | 22 |

8. I AM VERY SATISFIED WITH THE FINAL RESULT DERIVED FROM MY GROUP'S INPUTS.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 0 | 2 | 16 | 18 |

9. MY GROUP COMPLETELY ACCEPTED MY CONTRIBUTIONS TO SOLVING THE PROBLEM.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 0 | 1 | 21 | 14 |

10. EVERYONE IN MY GROUP HAD AN EQUAL CHANCE TO BE HEARD.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 0 | 0 | 12 | 24 |

11. THIS CASE WOULD BE BETTER SOLVED IN A SETTING IN WHICH ALL MEMBERS MET FACE TO FACE BUT HAD A COMPUTER AVAILABLE TO HELP THEM COMPILE THEIR RESULTS.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 6 | 9 | 15 | 5 | 1 |

12. THIS CASE WOULD BE BETTER SOLVED IN A SETTING IN WHICH GROUP MEMBERS ALL HAD AN INPUT VIA A COMPUTER BUT DID NOT MEET FACE-TO-FACE.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 0 | 1 | 13 | 22 |

COMMENTS:

# APPENDIX C
# QUESTIONNAIRE FOR GDSS GROUPS

The following questionnaire was completed by the GDSS group members immediately after they finished solving the case. Below the scale for each question is a circled number that represents the number of individuals who selected that response to the question. The responses to these questionnaires are the source of raw data that we used to derive our statistical analyses.

# QUESTIONNAIRE : GDSS

(THE CIRCLED NUMBERS INDICATE THE RAW DATA COLLECTED IN OUR STUDY)

PLEASE RESPOND TO THE FOLLOWING STATEMENTS BY CIRCLING THE RESPONSE THAT BEST MATCHES YOUR FEELINGS TOWARD THE STATEMENT. THANK YOU FOR YOUR HELP.

## I. CASE

1. IMMEDIATELY AFTER READING THE CASE STUDY, THE CORRECT CANDIDATE WAS INTUITIVELY OBVIOUS TO ME.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 8 | 12 | 3 | 5 | 3 |

2. I WOULD SAY THIS CASE STUDY COULD BE AN EXAMPLE OF AN ACTUAL DECISION MAKING SITUATION IN AN ORGANIZATION.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 2 | 9 | 1 | 18 | 6 |

3. THIS CASE STUDY SEEMS REALISTIC TO ME.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 1 | 8 | 6 | 15 | 6 |

4. THIS CASE LENDS ITSELF WELL TO SUPPORT BY CO-OP.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 5 | 6 | 7 | 13 | 5 |

## II. SELECTION CRITERIA

5. I AM VERY SATISFIED WITH THE NUMBER OF CRITERIA MY GROUP IDENTIFIED.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 4 | 2 | 17 | 13 |

6. IF YOU ASSIGNED WEIGHTS TO YOUR DECISION CRITERIA FOR SELECTING A CANDIDATE, IT HELPED IN YOUR DECISION MAKING PROCESS.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 1 | 5 | 6 | 21 | 3 |

7. CO-OP IS VERY HELPFUL IN FORMALIZING MY THOUGTHS.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 5 | 4 | 7 | 13 | 7 |

## III. RESULTS

8. MY GROUP DEVISED A VERY GOOD SOLUTION TO THE CASE.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 4 | 3 | 13 | 16 |

9. I AM VERY SATISFIED WITH THE DECISION MAKING PROCESS THAT MY GROUP UNDERWENT TO DEVELOP A SOLUTION.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 1 | 5 | 19 | 11 |

10. I AM VERY SATISFIED WITH THE FINAL RESULT DERIVED FROM MY GROUP'S INPUTS.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 2 | 4 | 4 | 10 | 16 |

11. MY GROUP COMPLETELY ACCEPTED MY CONTRIBUTIONS TO SOLVING THE PROBLEM.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 1 | 4 | 14 | 17 |

12. EVERYONE IN MY GROUP HAD AN EQUAL CHANCE TO BE HEARD.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 0 | 1 | 1 | 9 | 25 |

13. THIS CASE WOULD BE BETTER SOLVED IN A SETTING IN WHICH GROUP MEMBERS ALL HAD AN INPUT VIA A COMPUTER BUT DID NOT MEET FACE-TO-FACE.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 13 | 12 | 6 | 5 | 0 |

* 14. THIS CASE WOULD BE BETTER SOLVED WITHOUT THE USE OF A COMPUTER.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| STRONGLY DISAGREE | DISAGREE | NEUTRAL | AGREE | STRONGLY AGREE |
| 2 | 5 | 4 | 5 | 2 |

* This question was not asked by Fijol and Woodbury, therefore the raw data shows fewer responses.

## IV. OVERALL IMPRESSION

15. WHAT FACTOR, IF ANY, WOULD YOU SAY INHIBITED AND/OR ENCOURAGED YOUR GENERATION OF INPUTS?

16. WAS CO-OP USER FRIENDLY?

17. IN WHAT KIND OF DECISION MAKING SITUATION WOULD YOU FIND CO-OP MOST USEFUL?

COMMENTS:

# APPENDIX D
# PARTICIPANT INSTRUCTIONS

## DIRECTIONS FOR NON-GDSS GROUPS

1. Each member of your group will be receiving an Energy International Case Data Sheet and Candidate Summary Sheet. The purpose of our experiment is to test out a Group Decision Support System called Co-oP. We are specifically comparing the impact of Co-oP by looking at two decision making settings. In one setting a group meets face-to-face with a GDSS, and in the other setting a group meets face-to-face without a GDSS. Your group will be meeting without the GDSS.

2. You will be asked to read the data and summary sheets and, when all members of your group are finished reading, you will discuss the case within your group and try to reach a consensus as to which candidate best meets the case requirements. You may keep the data and summary sheets and refer to them during the discussion. You may also take notes, but please don't write on the case or summary sheets.

3. Your group will be timed from the time you begin reading until the time all members have finished reading, and from the time you begin to discuss the case until you reach a final consensus. There are, however, no time limitations or goals. You are encouraged to take your time, read the case carefully and then discuss it to all members' satisfaction. Your goal is not to finish quickly, but to arrive at a quality decision, based solely on the information given.

4. Both of us will be present during the time you're reading and solving the case in order to answer any procedural questions. Please note, there is one best answer to the case, per the "experts". In order to keep from biasing the experiment, we can't answer non-procedural questions once you begin discussing the case.

5. When you have completed the case, we will briefly discuss the best solution and you will be asked to fill out a questionnaire and return it before you leave. The questionnaire ends with a place for comments; any that you have will be helpful, and thus are welcome.

6. Thank-you very much for your time and effort.

7. When you are finished reading you may begin discussing the case.

## DIRECTIONS FOR GDSS GROUPS

1. Each member of your group will be receiving an Energy International Case Data Sheet and Candidate Summary Sheet. The purpose of our experiment is to test out a Group Decision Support System called Co-oP. We are specifically comparing the impact of Co-oP by looking at two decision making settings. In one setting a group meets face-to-face with a GDSS, and in the other setting a group meets face-to-face without a GDSS. Your group will be meeting with the GDSS.

2. You will be asked to read the data and summary sheets and, when all members of your group are finished reading, you will discuss the case within your group and try to reach a consensus as to which candidate best meets the case requirements. You may keep the data and summary sheets and refer to them during the discussion. You may also take notes, but please don't write on the case or summary sheets.

3. Your group will be timed from the time you begin reading until the time all members have finished reading, and from the time you begin to discuss the case until you reach a final consensus. There are, however, no time limitations or goals. You are encouraged to take your time, read the case carefully and then discuss it to all members' satisfaction. Your goal is not to finish quickly, but to arrive at a quality decision, based solely on the information given.

4. Both of us will be present during the time you're reading and solving the case in order to answer any procedural questions. Please note, there is one best answer to the case, per the "experts". In order to keep from biasing the experiment, we can't answer non-procedural questions once you begin discussing the case.

5. We will act as your interface with the computer. What you have to determine (as a group) is the criteria you will use to select the individual, assign weights to each criteria (equal weights are acceptable), and then rank each individual according to each criteria. Co-oP will then number crunch and produce the selection based on your inputs. For example, two criteria might be color and height, weighted 8 and 6 respectively (on a 0 to 10 scale). Sub-criteria are permitted, if desired. For example, under color might be hue and brightness.

6. When you have completed the case, we will briefly discuss the best solution and you will be asked to fill out a questionnaire and return it before you leave. The questionnaire ends with a place for comments; any that you have will be helpful, and thus are welcome.

7. Thank-you very much for your time and effort.

8. When you are finished reading you may begin discussing the case.

## APPENDIX E
## CASE SOLUTION

The following is the solution agreed upon by experts. Before I read the solution I want to make it clear that all groups are using the same case study. Because of this, I ask that you do not discuss the case outside this session.

The criteria that the experts used to rate the candidates were as follows:

- Languages spoken (must speak Portuguese)
- Years of mine management experience (at least 3)
- Nationality (US Citizen)
- Sex (Because of the feudal attitude toward women, a woman should not be considered.)
- Fellowship in the Institute of Mineralogy

Illin - has only two years of mine management experience.

Hule - attended New Mexico Institute of Earth Sciences (NMIES) which is one of the two smaller schools since they offer only three special subjects. St. Francis is not the smallest, so NMIES must be. This means it is a women's university and Hule is thus a woman.

Gadolin - meets all the above criteria.

Samar - at 33, is too young to be a Fellow.

Lute - does not know Portuguese.

Noddy - went to St. Francis which does not offer seismology; qualification for General Membership is thus not met, which means neither is qualification for Fellow.

Lanta - is not an American citizen.

Since each candidate, except Gadolin, is disqualified for not meeting at least one of the criteria, Gadolin is the best choice.

Any questions?

Please turn in all materials and we ask that you take a few moments to fill out a questionnaire before you leave.

# APPENDIX F
# ADDITIONAL STATISTICAL ANALYSIS

Where relevant, *t* statistic tests were used to test the mean values and to test for a significant difference between mean values. As in the Fijol-Woodbury study, a 0.05 level of significance for each test was used to decide whether or not the null hypothesis $H_0$ should be rejected.

## 1. HYPOTHESES

We developed the following three hypotheses concerning the expected effects of the decision outcome variables on the two groups:

- $H_1$ : The face-to-face GDSS groups will be more accurate in solving the case than the face-to-face non-GDSS groups.
- $H_2$ : The time required to reach a decision, excluding the time to read the case, will be less in the face-to-face non-GDSS groups than in the face-to-face GDSS groups.
- $H_3$ : There will be no substantial difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their satisfaction with their group decision.

The *t* test is not applicable to $H_1$ since there is no mean for decision quality - either a group solved the case correctly or they did not. The *t* tests for $H_2$ and $H_3$ follow.

### a. $H_2$ : Input Time

The null hypothesis is:

- $H_0$ : There will be no significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their time required to reach a decision.

The alternative hypothesis is:

- $H_1$ : There will be a significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their time required to reach a decision.

As seen in Figure F.1, the difference is significant and $H_0$ is rejected. The non-GDSS groups had an average input time of almost one fourth that of the GDSS groups.

```
Non-GDSS groups

      :  .          .  :   :     .   .  .          .
    --+---+---------+---------+---------+---------+--
         6.0       9.0      12.0      15.0      18.0

      N      MEAN    MEDIAN    TRMEAN     STDEV    SEMEAN
     12     10.58     10.50     10.40      4.03      1.16


GDSS groups

       .   ..   :     ...   .  :                  .
    ---+---------+---------+---------+---------+--
       27.0      36.0      45.0      54.0      63.0

      N      MEAN    MEDIAN    TRMEAN     STDEV    SEMEAN
     12     38.75     38.50     37.70     10.18      2.94


      T        DF         t        Significant Difference?
   -8.91      14.4     -2.139               yes

                    Thus reject H0.
```

Figure F.1 Input Time in Minutes : t test

b. $H_3$ : **Satisfaction Factor**

The null hypothesis is:

- $H_0$ : There will be no significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their satisfaction.

The alternative hypothesis is:

- $H_1$ : There will be a significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their satisfaction.

There were four variables surveyed for satisfaction:

1. number of criteria identified
2. decision making process
3. final result
4. very good solution devised

Of these four variables, the last two are essentially the same and were used as a consistency check for the responses to the questionnaires.

Figures F.2, F.3, and F.4 show $H_0$ being rejected, while Figure F.5 has $H_0$ being accepted. The results are mixed, but all the mean pairs are fairly close upon inspection. From the $t$ tests, we find that there is a statistically significant difference between the two types of groups in satisfaction level, with the GDSS group being less satisfied. While we concur that the numbers are statistically different in a purely analytical analysis, we do not believe the difference to be "significant" in the non-statistical use of the word. Our Likert scale is not so exact as to firmly conclude that there is a difference in a mean of 4.6 and 4.1, because we surveyed opinions, which cannot be so precisely measured. We consider the difference in satisfaction to be slight, but still worthy of mention. In that light, reasons for the difference are presented in Chapter IV.

### 2. VARIABLES

#### a. Setting

We surveyed preferences for two settings:

- with or without a computer/GDSS
- face-to-face or distributed meetings

##### *1. Need of computer*

The non-GDSS groups were presented the statement: "This case is better solved *with* a computer"; the GDSS groups were presented the statement: "This case is better solved *without* a computer". In order to compare the two results, we will change the GDSS groups' statement from "without" to "with" and reverse the questionnaire data according (which will actually look the same on the dot plot since the GDSS groups' responses were symmetrical on this item).

The null hypothesis is:

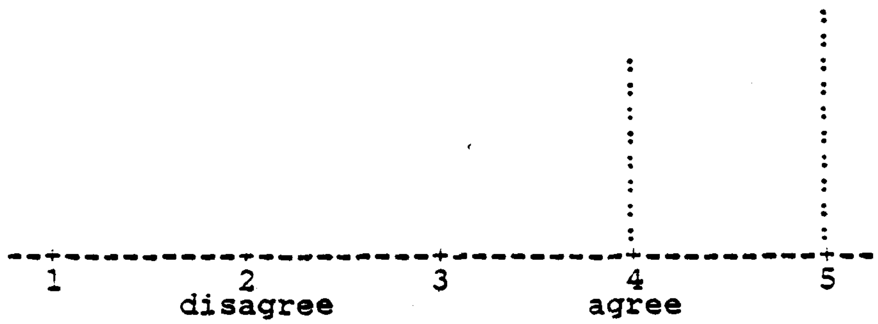
- $H_0$ : There will be no significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their opinion regarding solving this case with a computer.

The alternative hypothesis is:

- $H_1$ : There will be a significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their opinion regarding solving this case with a computer.

**VERY SATISFIED WITH NUMBER OF CRITERIA IDENTIFIED**

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.5556 | 5.0000 | 4.5625 | 0.5040 | 0.0840 |

GDSS groups


| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.083 | 4.000 | 4.156 | 0.937 | 0.156 |

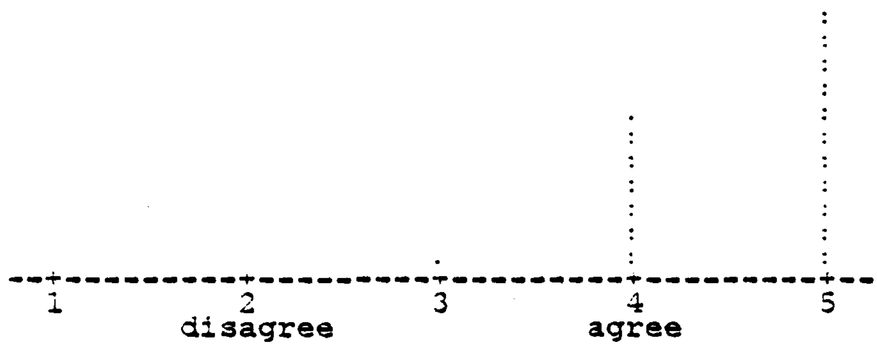
| T | DF | t | Significant Difference? |
|---|---|---|---|
| 2.66 | 53.7 | 2.007 | yes |

Thus reject $H_0$.

Figure F.2 Criteria Satisfaction : t test

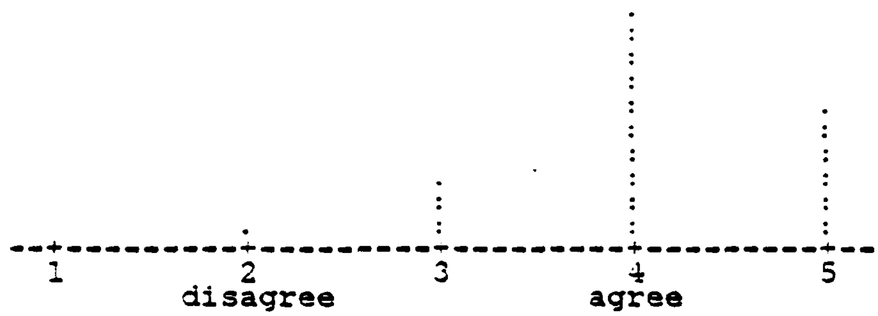
## VERY SATISFIED WITH DECISION MAKING PROCESS

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.5833 | 5.0000 | 4.6250 | 0.5542 | 0.0924 |

GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.111 | 4.000 | 4.156 | 0.747 | 0.125 |

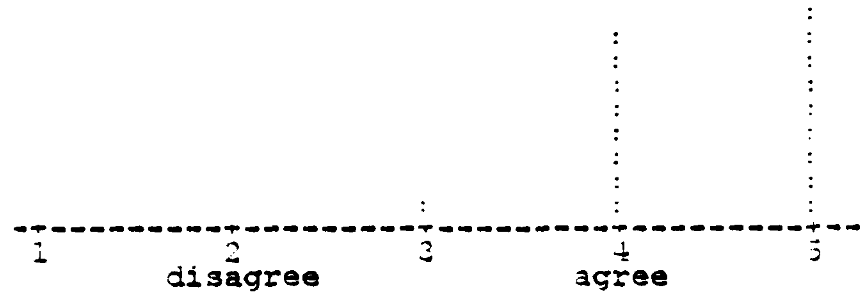
| T | DF | t | Significant Difference? |
|---|---|---|---|
| 3.04 | 64.6 | 1.998 | yes |

Thus reject $H_0$.

Figure F.3 Decision Making Process Satisfaction : t test

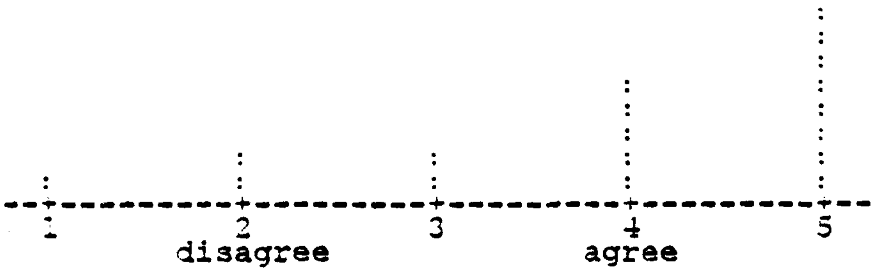
**I AM VERY SATISFIED WITH THE FINAL RESULT**

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.444 | 4.500 | 4.500 | 0.607 | 0.101 |

GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 3.944 | 4.000 | 4.062 | 1.241 | 0.207 |

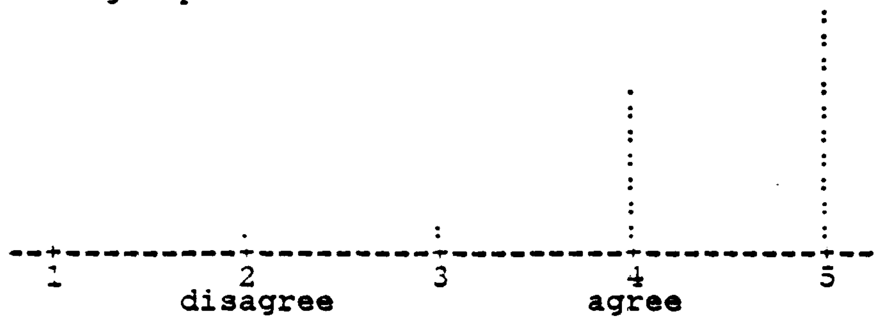
| T | DF | t | Significant Difference? |
|---|---|---|---|
| 2.17 | 50.8 | 2.010 | yes |

Thus reject $H_0$.

Figure F.4 Result Satisfaction : t test

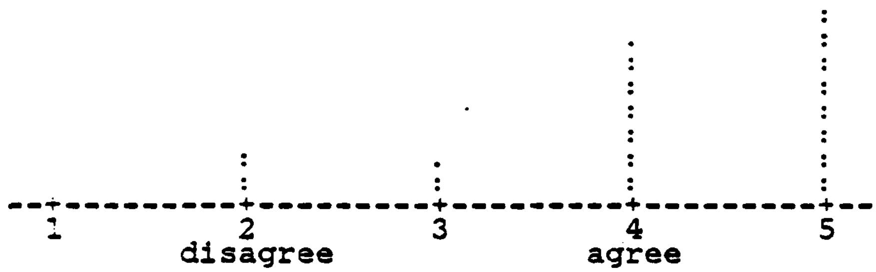
MY GROUP DEVISED A VERY GOOD SOLUTION

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.444 | 5.000 | 4.531 | 0.735 | 0.122 |

GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.139 | 4.000 | 4.219 | 0.990 | 0.165 |

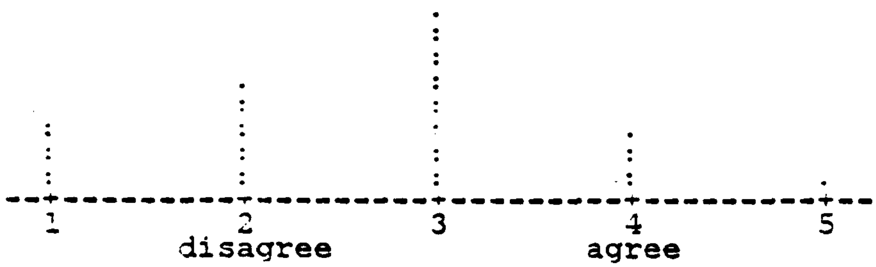
| T | DF | t | Significant Difference? |
|---|---|---|---|
| 1.49 | 64.6 | 1.998 | no |

Thus accept $H_0$.

Figure F.5 Solution Satisfaction : t test

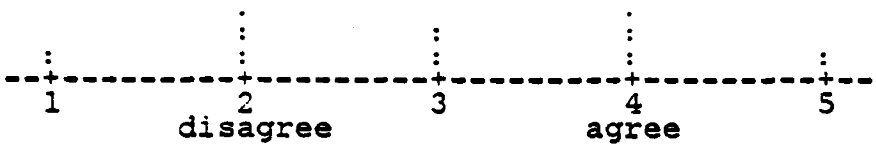
**THIS CASE IS BETTER SOLVED WITH A COMPUTER**

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 2.611 | 3.000 | 2.594 | 1.022 | 0.170 |

GDSS groups (not addressed in Fijol-Woodbury study)




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 18 | 3.000 | 3.000 | 3.000 | 1.237 | 0.291 |

| T | DF | t | Significant Difference? |
|---|---|---|---|
| -1.15 | 29.0 | -2.045 | no |

Thus accept $H_0$.

Figure F.6 Need of Computer : t test

As seen in Figure F.6, there was no significant difference between the two groups in their perceived usefulness of a computer in this case and thus the null hypothesis $H_0$ is accepted.

#### 2. *Face-to-face vs distributed*

The null hypothesis is:

- $H_0$ : There will be no significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their preference regarding a face-to-face setting.

The alternative hypothesis is:

- $H_1$ : There will be a significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their preference regarding a face-to-face setting.

Figure F.7 shows $H_0$ is accepted; both groups were equally adamant in their preference for a face-to-face meeting over a distributed meeting.

### b. Group Interaction

We surveyed two interaction variables:

- contribution acceptance
- chance to be heard

#### 1. *Contribution acceptance*

The null hypothesis is:

- $H_0$ : There will be no significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their acceptance of a member's contributions.

The alternative hypothesis is:

- $H_1$ : There will be a significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their acceptance of a member's contributions.

As seen in Figure F.8, the null hypothesis is accepted; both groups readily accepted inputs from their group members.

#### 2. *Chance to be heard*

The null hypothesis is:

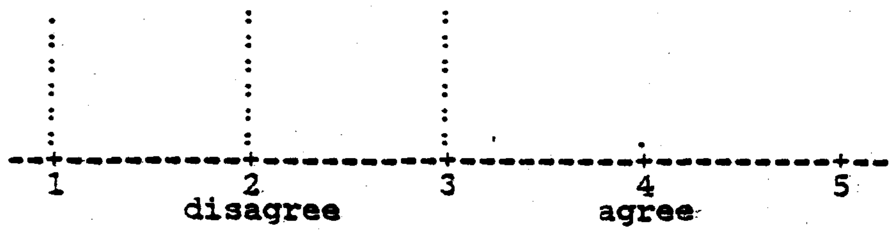
- $H_0$ : There will be no significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their allowing group members an equal chance to be heard.

The alternative hypothesis is:

- $H_1$ : There will be a significant difference between the face-to-face non-GDSS groups and face-to-face GDSS groups in their allowing group members an equal chance to be heard.

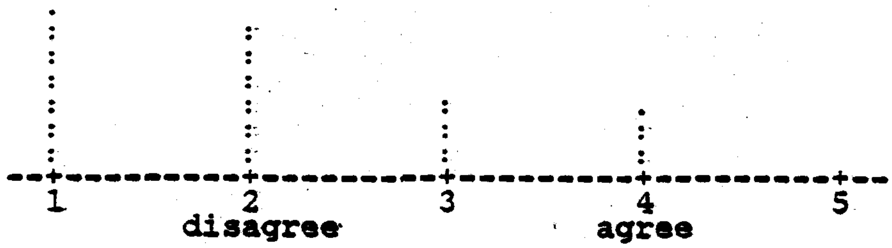
**BETTER SOLVED WITH COMPUTER BUT NOT FACE-TO-FACE**

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 2.083 | 2.000 | 2.062 | 0.874 | 0.146 |

GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 2.083 | 2.000 | 2.031 | 1.052 | 0.175 |

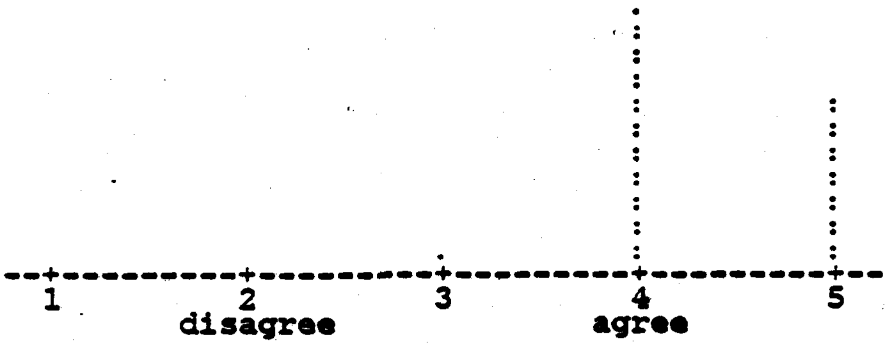
| T | DF | t | Significant Difference? |
|---|---|---|---|
| 0.0 | 67.7 | 1.999 | no |

Thus accept $H_0$.

Figure F.7 Face-to-Face vs Distributed : t test

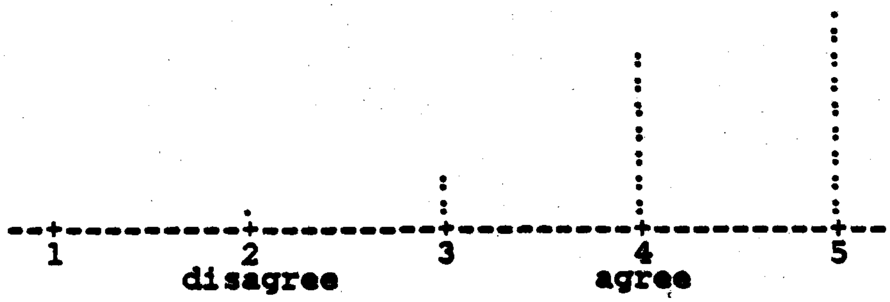
**MY GROUP COMPLETELY ACCEPTED MY CONTRIBUTIONS**

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.3611 | 4.0000 | 4.3750 | 0.5426 | 0.0904 |

GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.306 | 4.000 | 4.375 | 0.786 | 0.131 |

| T | DF | t | Significant Difference? |
|---|---|---|---|
| 0.35 | 62.2 | 2.000 | no |

Thus accept $H_0$.

Figure F.8. Accepted My Contributions : t test

Figure F.9 shows the null hypothesis is accepted; both groups very definitely allowed everyone an equal chance to be heard.

### c. Decision Task Criteria

Three variables were surveyed in the questionnaires in order to ascertain the validity of the Energy International case for GDSS research:

- actual decision making situation
- realistic case
- supportability

#### *1. Actual decision making situation*

The null hypothesis is:

- $H_0$ : This case study could not be an example of an actual decision making situation in an organization.

The alternative hypothesis is:

- $H_1$ : This case study could be an example of an actual decision making situation in an organization.

The null hypothesis is rejected. The case was rated by our participants as an example of an actual decision making situation (Figure F.10). However, we took exception with that rating, as explained in Chapter IV.

#### *2. Realistic case*

The null hypothesis is:

- $H_0$ : This case study does not seem realistic to me.

The alternative hypothesis is:

- $H_1$ : This case study does seem realistic to me.

As seen in Figure F.11, the null hypothesis is rejected. The case was rated by our participants as realistic. Again, we took exception with that rating, as explained in Chapter IV.

#### *3. Supportability*

The null hypothesis is:

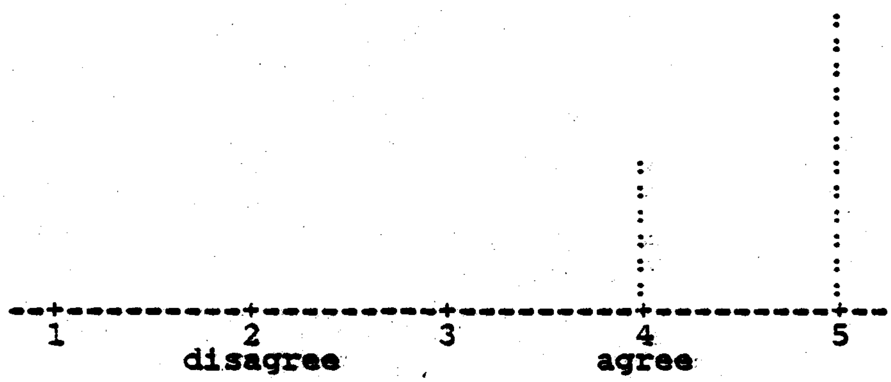
- $H_0$ : This case does not lend itself well to support by Co-oP.

The alternative hypothesis is:

- $H_1$ : This case does lend itself well to support by Co-oP.

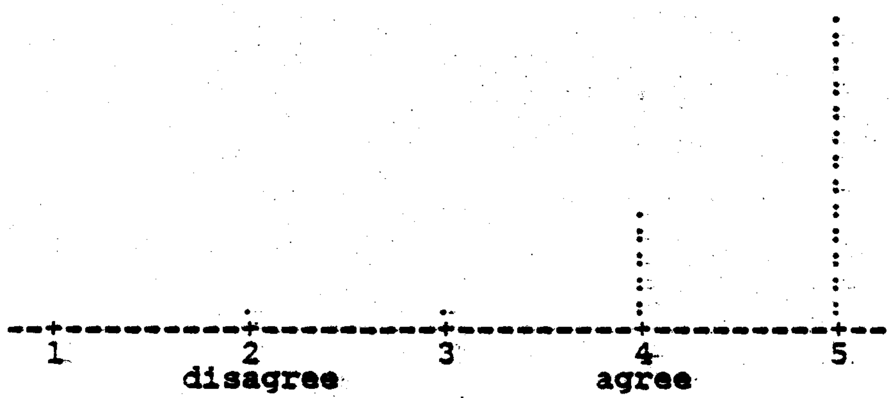
**EVERYONE IN GROUP HAD EQUAL CHANCE TO BE HEARD**

Non-GDSS groups




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.6667 | 5.0000 | 4.6875 | 0.4781 | 0.0797 |

GDSS groups



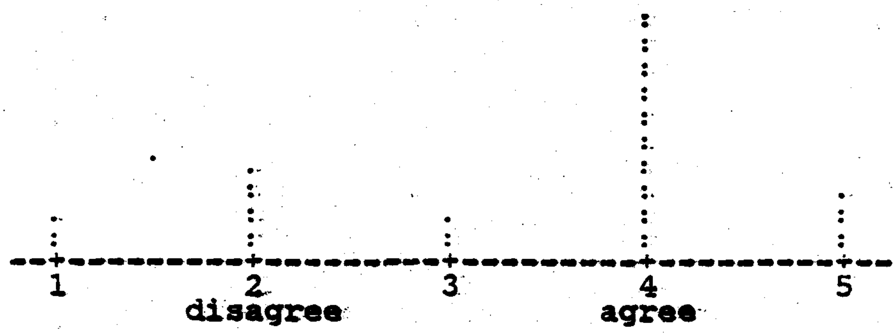

| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 4.611 | 5.000 | 4.719 | 0.688 | 0.115 |

| T | DF | t | Significant Difference? |
|---|---|---|---|
| 0.40 | 62.4 | 2.000 | no |

Thus accept $H_0$.

Figure F.9 Equal Chance to be Heard : t test

**EXAMPLE OF AN ACTUAL DECISION MAKING SITUATION**
**Each dot represents 2 points**




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 72 | 3.472 | 4.000 | 3.531 | 1.138 | 0.134 |

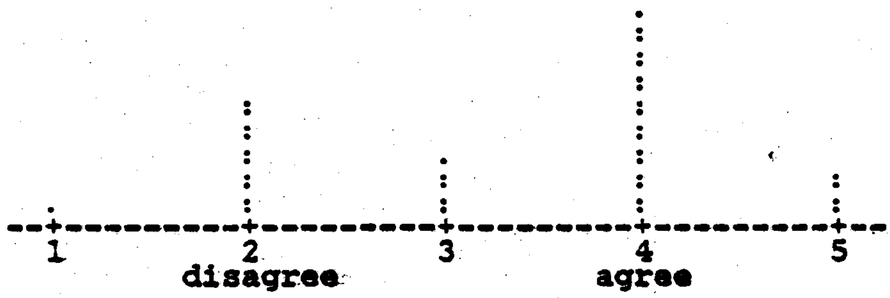
| T | DF | t |
|---|---|---|
| 3.52 | 71 | 1.669 |

Thus reject $H_0$.

Figure F.10 Decision Making Situation : t test

As seen in Figure F.12, $H_0$ is accepted. This case does not lend itself *well* to support by Co-oP. As discussed in Chapter IV, this is not a judgement against Co-oP, but one against Energy International as a case for this type of study. Consistent with the model proposed in Chapter V, this case is not suitable for use with a GDSS, much less one with features similar to Co-oP.

CASE STUDY SEEMS REALISTIC
Each dot represents 2 points

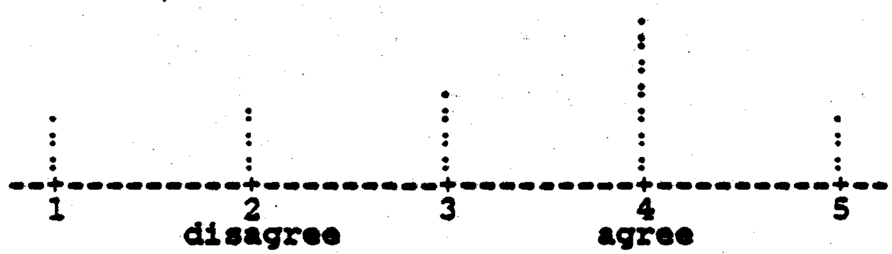



| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 72 | 3.361 | 4.000 | 3.375 | 1.079 | 0.127 |

| T | DF | t | |
|---|---|---|---|
| 2.84 | 71 | 1.669 | Thus reject $H_0$. |

Figure F.11 Realistic Case : t test

CASE LENDS ITSELF WELL TO SUPPORT BY CO-OP




| N | MEAN | MEDIAN | TRMEAN | STDEV | SEMEAN |
|---|---|---|---|---|---|
| 36 | 3.194 | 3.500 | 3.219 | 1.283 | 0.214 |

| T | DF | t | |
|---|---|---|---|
| 0.91 | 35 | 1.691 | Thus accept $H_0$. |

Figure F.12 Co-oP Supportability : t test

## LIST OF REFERENCES


1. Culnan, Mary J., "The Intellectual Development of Management Information Systems, 1972-1982: A Co-Citational Analysis," *Management Science*, Vol 32, No 2, February 1986, pp. 156-172.

2. Bui, Tung X. and Jarke, Matthias, "Communications Design for Co-oP: A Group Decision Support System," *ACM Transactions on Office Information Systems*, Vol 4, No 2, April 1986, pp. 81-103.

3. Lin, Jimming Tzu-Ming, *The Impact of Computer-Mediated Communications Systems on Interpersonal Relations and Task Performance*, Doctoral Consortium, San Diego, CA, December 1986.

4. DeSanctis, Gerardine and Gallupe, R. Brent, "A Foundation for the Study of Group Decision Support Systems," *Management Science*, Vol 33, No 5, May 1987, pp. 589-609.

5. Hart, S., Boroush, M., Enk, G., and Hornick, W., "Managing Complexity Through Consensus Mapping: Technology for the Structuring of Group Decisions," *Academy of Management Review*, Vol 10, No 3, 1985, pp. 587-599.

6. Hamalainen, R. P., Seppalainen, T., and Ruusunen, J., "A Microcomputer-Based Decision Support Tool and its Application to a Complex Energy Decision Problem," *Proceedings of the Nineteenth Annual HICSS*, Honolulu, HI, 1986, pp. 494-502.

7. Huber, George P., "The Nature and Design of Post-Industrial Organizations," *Management Science*, Vol 30, No 8, August 1984, pp. 928-951.

8. Applegate, L., Chen, T. T., Konsynski, B. R., and Nunamaker, J. F., "Knowledge Management in Organizational Planning," *Journal of Management Information Systems*, Vol 3, No 4, Spring 1987, pp. 20-38.

9. Licker, Paul S. and Thompson, Ron L., "Consulting Systems: Bridging the DSS/AI Gap," *Proceedings of the Nineteenth Annual HICSS*, Honolulu, HI, 1986, pp. 471-478.

10. Shane, B., Goul, M, and Tonge, F., "Knowledge Based Decision Support Systems in Strategic Planning Decisions: An Empirical Study," *Proceedings of the Nineteenth Annual HICSS*, Honolulu, HI, 1986, pp. 453-461.

11. Mintzberg, Henry, "The Manager's Job: Folklore or Fact," *Harvard Business Review*, July/August 1975, pp. 49-61.

12. Alter, Steven, "Why is Man Computer Interaction Important for Decision Support Systems?" *Interfaces*, Vol 17, No 2, February 1977, pp. 109-115.

13. Bell, Daniel, *The Coming of Post-Industrial Society*, Basic Books, Inc., Publishers, 1973.

14. Simon, Herbert A., "Applying Information Technology to Organizational Design," *Public Administration Review*, May/June 1973, pp. 268-277.

15. Thomas, R. C. and Burns, A., "The Case for Distributed Decision Making Systems," *The Computer Journal*, Vol 25, No 1, 1982, pp. 148-152.

16. Turoff, Murray and Hiltz, Starr Roxanne, "Computer Support Versus Individual Decisions," *IEEE Transactions on Communications*, Vol Com-30, No 1, January 1982, pp. 82-91.

17. Rathwell, Margaret A. and Burns, Alan, "Information Systems Support for Group Planning and Decision-Making Activities," *MIS Quarterly*, September 1985, pp. 255-271.

18. Kafoglis, Charles, "A Powerful Tool for Cunning Executives," *Data Management*, Vol 23, No 6, June 1985, pp. 24-27.

19. Alter, Steven, "How Effective Managers Use Information Systems," *Harvard Business Review*, November/December 1976, pp. 97-104.

20. Van de Ven, Andrew and Delbecq, Andre L., "Nominal Versus Interacting Group Processes for Committee Decision Making Effectiveness," *Academy of Management Journal*, Vol 14, No 2, June 1971, pp. 203-212.

21. DeSanctis, Gerardine and Gallupe, R. Brent, "Group Decision Support Systems: A New Frontier," *Database*, Winter 1985, pp. 3-10.

22. Keen, Peter G. W. and Gambino, Thomas J., "Building a Decision Support System: The Mythical Man Month Revisited," Bennett, John L., ed., *Building Decision Support Systems*, Addison-Wesley Publishing Co, 1983, pp. 133-172.

23. Carlson, Eric D., "An Approach for Designing Decision Support Systems," Bennett, John L., ed., *Building Decision Support Systems*, Addison-Wesley Publishing Co., 1983, pp. 15-39.

24. Cerveny, Robert P. and Clark, Thomas, Jr., "Conversations on 'Why Information Systems Fail- And What Can Be Done About It'," *Systems, Objectives, Solutions*, Vol. 1, 1981, pp. 149 -154.

**25. DeSanctis, Gerardine and Dickson, Gary W., "GDSS Software: A 'Shell' System in Support of a Program of Research," *Proceedings of the Twentieth Annual HICSS*, Honolulu, HI, Vol 1, 1987, pp. 431-440.**

26. Fijol, Young-OK and Woodbury, Mary A., *Group DSS and Decision Outcome Measures: A Comparative Study in Distributed versus Non-Distributed Settings*, Masters Thesis, Naval Postgraduate School, Monterey, CA, March 1987.

27. Mills, Judson, *Experimental Social Psychology*, The Macmillan Company, Collier. Macmillan Limited, London, 1969.

28. Alter, Steven Lewis, *A Study of Computer Aided Decision Making in Organizations*, Ph. D. Thesis, Massachusetts Institute of Technology, June 1975.

29. Huber, George, "Issues in the Design of Group Decision Support Systems," *MIS Quarterly*, September 1984, pp. 195-204.

30. Gallupe, R. Brent, "Experimental Research into GDSS: Practical Issues and Problems," *Proceedings of the 19th Annual HICSS*, Honolulu, HI, 1986, pp. 515-523.

31. Lewis, L. Floyd, II, *Facilitator: A Microcomputer Decision Support System for Small Groups*, Ph.D. Thesis, University of Louisville, Louisville, Kentucky, 1982.

32. Bui, Tung X., *Co-oP: A DSS for Cooperative Multiple Criteria Group Decision Making*, Ph.D. Dissertation, Department of Computer Applications and Information Systems, New York University, New York, 1985.

33. Vogel, D., Nunamaker, J., Applegate, L., and Konsynski, B., "Group Decision Support Systems: Determinants of Success," *DSS-87, Transactions of the Seventh International Conference on Decision Support Systems*, San Francisco, CA, 1987, pp. 118-128.

34. Gallupe, R. B., DeSanctis, G., and Dickson, G. W., "The Impact of Computer Based Support on the Process and Outcomes of Group Decision Making," *International Conference on Information Systems*, December 1986, pp. 81-83.

35. Brinberg, David and McGrath Joseph E., "A Network of Validity Concepts Within the Research Process," Brinberg, David and Kidder, Louise, eds., *Forms of Validity in Research*, Jossey-Bass Inc., Publishers, 1982.

36. Judd, Charles M. and Kenny, David A., "A Research Design and Validity," Brinberg, David and Kidder, Louise, eds., *Forms of Validity in Research*, Jossey-Bass Inc., Publishers, 1982.

37. Friedman, Neil, *The Social Nature of Psychological Research*, Basic Books, Inc., Publishers, 1967.

38. Aiken, Lewis R., *Psychological T sting and Assessment*, 2nd Edition, Allyn and Bacon, Inc., Boston, 1976.

39. Kidder, Louise, "Face Validity from Multiple Perspectives," Brinberg, David and Kidder, Louise, eds., *Forms of Validity in Research*, Jossey-Bass Inc., Publishers, San Francisco, 1982, pp. 41-57.

40. Cozby, Paul C., *Methods in Behavioral Research*, Mayfield Publishing Co., 1977.

41. Bui, Tung X., "Identifying Organizational Opportunities for GDSS Use: Some Experimental Evidence", *DSS-87, Transactions of the Seventh International Conference on Decision Support Systems*, San Francisco, CA, 1987, pp. 68-75.

42. Suchan, J., Bui, T. X., and Dolk, D., "GDSS Effectiveness: Identifying Organizational Opportunities," *Proceedings of the Twentieth Annual HICSS*, Honolulu, HI, Vol 1, 1987, pp. 441-449.

43. Barefoot, John, Wiggins, Beverly and Latane, Bibb, "Computer-Mediated Communication: Decision Making and Informal Interaction," *ONR Technical Report*, February 15, 1985.

44. Steeb, Randall, and Johnson, Steve C., "A Computer-Based Interactive System for Group Decision Making," *IEEE Transactions on Systems, Man, and Cybernetics*, Vol SMC-11, No 8, August 1981, pp. 544-552.

45. Pfeiffer, William J. and Jones, John E., *The 1972 Annual Handbook for Group Facilitators*, Iowa City, IO: University Associates, 1972, pp. 25-35.

46. Ginzberg, Michael J., "Redesign of Managerial Tasks: A Requisite for Successful Decision Support Systems," *MIS Quarterly*, Vol. 2, No. 1, March 1978, pp. 39-52.

47. Cerveny, Robert P. and Clark, Thomas, Jr., "Conversations on 'Why Information Systems Fail and What Can Be Done About It'," *Systems, Objectives, Solutions*, Vol 1, 1981, pp. 149-154.

48. Hare Paul A., *Handbook of Small Group Research*, The Free Press, 1976.

49. Sanders, G. Lawrence and Courtney, James F., "A Field Study of Organizational Factors Influencing DSS Success," *MIS Quarterly*, March 1985, pp. 77-92.

50. Bennett, John L., ed., *Building Decision Support Systems*, Addison-Wesley Publishing Co, 1983.

51. Kersten, Gregory E., "Nego-Group Decision Support System," *Information and Management*, Vol 8, 1985, pp. 237-246.

52. Bui, Tung X. and Jarke, Matthias, "Communications Requirements for Group Decision Support Systems," *Journal of Management Information Systems*, Spring 1986.

53. Huber, George P., "The Nature of Organization Decision Making and the Design of Decision Support," *MIS Quarterly*, June 1981, pp. 1-10.

54. Dickson, G. W., Senn, J. A., and Chervany, N. L., "Research in Management Information Systems: The Minnesota Experiments," *Management Science*, Vol 23, No 9, May 1977, pp. 913-923.

55. Turner, Jon A., "Computer Mediated Work: The Interplay Between Technology and Structured Jobs," *Communications of the ACM*, Vol 27, No 12, December 1984, pp. 1210-1217.

56. Fogg, Richard W., "Dealing with Conflict, A Repertoire of Creative, Peaceful Approaches," *Journal of Conflict Resolution*, Vol 29, No 2, June 1985, pp. 330-358.

57. Levy, Marc A., "Mediation of Prisoner's Dilemma Conflicts and the Importance of Cooperation Threshold," *Journal of Conflict Resolution*, Vol 29, No 4, December 1985, pp. 581-603.

58. Stefik, M., Foster, G., Bobrow, D. G., Kahn, K., Lanning, S., and Suchman, S., "Beyond the Chalkboard: Computer Support and Problem Solving in Meetings," *Communications of the ACM*, Vol 30, No 1, January 1987, pp. 32-47.

59. Lax, David, "Optimal Search in Negotiation Analysis," *Journal of Conflict Resolution*, Vol 29, No 3, September 1985, pp. 456-472.

## INITIAL DISTRIBUTION LIST

| | | No. Copies |
|---|---|---|
| 1. | Defense Technical Information Center<br>Cameron Station<br>Alexandria, VA 22304-6145 | 2 |
| 2. | Library, Code 0142<br>Naval Postgraduate School<br>Monterey, CA 93943-5002 | 2 |
| 3. | Chief of Naval Operations<br>Director, Information Systems (OP-945)<br>Navy Department<br>Washington, DC 20350-2000 | 1 |
| 4. | Curricular Office, Code 37<br>Department of Computer Technology<br>Naval Postgraduate School<br>Monterey, CA 93943-5004 | 1 |
| 5. | Tung X. Bui, Code 54BD<br>Department of Administrative Sciences<br>Naval Postgraduate School<br>Monterey, CA 93943-5004 | 1 |
| 6. | Nancy C. Roberts, Code 54TC<br>Department of Administrative Sciences<br>Naval Postgraduate School<br>Monterey, CA 93943-5004 | 1 |
| 7. | Taracad R. Sivasankaran, Code 54SJ<br>Department of Administrative Sciences<br>Naval Postgraduate School<br>Monterey, CA 93943-5004 | 1 |
| 8. | James E. Suchan, Code 54SA<br>Department of Administrative Sciences<br>Naval Postgraduate School<br>Monterey, CA 93943-5004 | 1 |
| 9. | LT Y. O. Fijol<br>Officer-in-Charge<br>Navy Data Automation Facility (NAVDAF) Moffett Field<br>Building 12-2, Naval Air Station<br>Moffett Field, CA 94035-5021 | 1 |

10. LT M. A. Woodbury 1
Officer-in-Charge
Navy Data Automation Facility (NAVDAF) Lemoore
Building 773, Naval Air Station
Lemoore, CA 93245-5006

11. LCDR D. H. Webb 2
USS CONCORD (AFS-5)
FPO New York 09566-3034

12. LT A. L. Hughes 2
Commander, Naval Military Personnel Command
NMPC-1662
FOB #2, Arlington Annex
Washington, DC 20370