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AN EMPIRICAL EXPERIMENT EVALUATING THE
EFFECTIVENESS OF
GROUP DECISION SUPPORT SYSTEMS (GDSS)

by

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September 1988

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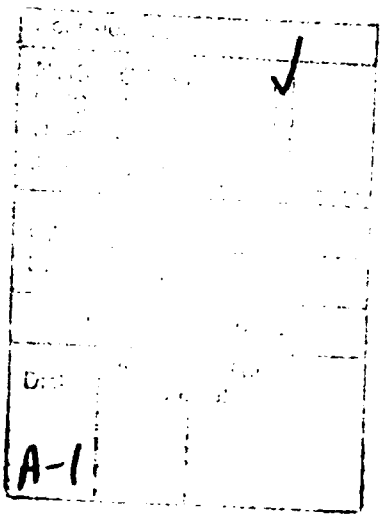

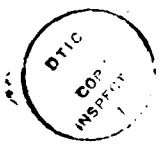

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An Empirical Experiment Evaluating the Effectiveness of Group Decision Support Systems (GDSS)

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ABSTRACT

An increasing reliance on group decision making and advances in computer technology have combined to spur research in an area of decision support known as group decision support systems (GDSS). Proponents of GDSS claim its unique features enable groups to make decisions faster, better, and with greater confidence and satisfaction than non-GDSS groups.

This study is an empirical experiment evaluating the effectiveness of a GDSS. A complex scenario covertly resembling the Cuban missile crisis was passed out to seven groups of four graduate students. Four groups were instructed to recommend a solution to the crisis scenario with the aid of a GDSS. The other three groups were instructed to do the same, but without computer aided support.

The analysis of the data indicated that there was not an appreciable difference in decision quality, speed, or satisfaction between the GDSS groups and the non-GDSS groups.

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I. INTRODUCTION

An increasing reliance on group decision-making and advances in computer technology have combined to spur research in an area of decision support known as group decision support systems (GDSS). Until recently, the use of computer technology and what it can offer in terms of decision support has been largely aimed at the single decision maker. Support for the individual is certainly important, but in today's complex society, many organizational decisions are made by groups of people.

Unfortunately, the difficulties and frustrations of working in groups are further aggravated by inhibiting influences that reduce the performance of interacting groups. Among the more important factors, according to Van de Ven and Delbecq, are the tendency for strong personality types to dominate the discussion, the pressure for low-status participants to go along with opinions expressed by high-status participants, the overconcentration on one or two approaches to the problem, and the premature evaluation of ideas [Ref. 1]. As a result, a need has developed for a computer-based system that will support groups of people who are jointly responsible for either making a recommendation or a decision.

Proponents of GDSS claim its unique features enable groups to make decisions faster and better than non-GDSS groups. Furthermore, they claim GDSS supported groups will be able to access more information, work more efficiently with each other and avoid groupthink [Ref. 2]. These GDSS advocates, however, have little empirical research from which to draw on to support their claims, since most of the research concerning GDSS has focused on its general design and specific system architecture.

A. PURPOSE OF THE THESIS

The purpose of this thesis is to assess the relative effectiveness of decision groups using a non-distributed GDSS as opposed to groups using the more traditional meeting *room* environment. Accordingly, the following hypotheses will be examined:

Ho(1): A GDSS supported group will make a better decision than a non-GDSS supported group.

Ho(2): A GDSS supported group will take less time to reach a decision than a non-GDSS supported group.

Ho(3): GDSS supported group members will feel greater decision confidence and satisfaction with their final decision than non-GDSS supported group members.

Additionally, the following questions will be addressed:

* Did the communication channels differ in the two groups?

* Did the groups differ in their perception of the decision process?

* How did the GDSS group members feel about GDSS in general?

* What did the GDSS group members think about Co-oP, the GDSS software used?

B. METHODOLOGY

A complex scenario (Appendices A and B), covertly resembling the Cuban missile crisis, was passed out to seven groups of four graduate students. Four groups were instructed to list possible alternatives and criteria, as well as a final decision, with the aid of Co-oP, a GDSS software package. The other three groups were instructed to do the same in a typical conference room without computer aided support. All seven groups filled out questionnaires (Appendix D) at the conclusion of each session in order to assess user satisfaction and confidence. The groups' decision quality (the number of alternatives generated and the closeness of the decision to the correct answer history provides), decision speed, and decision satisfaction were then analyzed to ascertain if there were appreciable differences between the GDSS groups and the non-GDSS groups.

Before examining the results of the experiment, it is important to review the applicable literature that has been written about this emerging subset of Decision Support Systems (DSS). Chapter II will define GDSS, discuss its characteristics and components, list the advantages and disadvantages of implementing such a system, and review

current literature. Chapter III provides the problem statement and statement of hypotheses. Chapter IV reviews the empirical experiment results. Finally, Chapter V will present the conclusions and issues for further research.

II. REVIEW OF LITERATURE

A. OVERVIEW

Because Group Decision Support Systems are a relatively new technology, there is a limited amount of research currently available. Most of the early research concerning GDSS focused on general design and specific system architecture. In the last two years, however, researchers have begun active experimentation with groups to determine the effectiveness and value of such systems. This trend away from the design and theory and towards experimentation indicates a maturing of the technology.

The challenge researchers now face is proving that GDSS can enhance a group's problem solving process. The following chronology illustrates the short history of GDSS:

1982-1984 Initial papers describing GDSS (Huber [Ref. 3], Gray [Ref. 4]).

1982-1987 Design and research agendas (Huber [Ref. 3]; DeSanctis and Gallupe [Ref. 5]; Bui Jarke [Ref. 6]; Bui, Suchan, and Dolk [Ref. 7]).

1986-1988 Active experimentation (DeSanctis, Dickson and Gallupe [Ref. 8]; Nunamaker, Applegate, and Konsynski [Ref. 9]; Fijol and Woodbury [Ref. 10]; Hughes and Webb [Ref. 11]).

This chapter will review the results of some of these experiments and discuss the advantages and disadvantages of implementing a GDSS. We begin by defining GDSS and

outlining the characteristics, components, and functions of such a system.

B. DEFINING GDSS

Among the many definitions of a GDSS are the following:

* A GDSS consists of a set of software, hardware, and language components and procedures that support a group of people engaged in a decision-related meeting [Ref. 3: p. 195].

* An interactive computer-based system which facilitates solution of unstructured problems by a set of decision makers working together as a group [Ref. 5: p. 3].

* A computer-based system that aims at supporting collective problem solving. A collective decision-making process can be viewed as a problem-solving situation in which there are two or more persons (i) each of whom is characterized by his or her own perceptions, attitudes motivations, and personality, (ii) who recognize the existence of a common problem, and (iii) who attempt to reach a collective decision. [Ref. 6: p. 9]

In short, GDSS are computer-based systems designed to facilitate the interactive sharing, retrieval, and use of information to assist a group in the problem solving process.

1. Characteristics of GDSS

A GDSS must possess certain general characteristics in order to be successful. In their article, "Group Decision Support Systems: A New Frontier", DeSanctis and Gallupe [Ref. 5: p. 4] list what they believe to be the most important GDSS characteristics:

* A GDSS is a specially designed system, not merely a configuration of already-existing system components.

* 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.

* A GDSS is easy to learn and easy to use. It accommodates users with varying levels of knowledge regarding computing and decision support.

* The GDSS may be "specific" (designed for one type, or class, of problems) or "general" (designed for a variety of group-level organizational decisions).

* The GDSS contains built-in mechanisms which discourage development of negative group behaviors, such as destructive conflict, miscommunication, or "groupthink".

Huber [Ref. 3] would add "frequency of use" to this list. Huber felt that infrequent use of a GDSS would result in a negative perception of the technology. DeSanctis and Dickson [Ref. 12] felt a workable system must be flexible and be able to support not only rational activities of decision makers, but the social-emotional needs (the need to release tension, express agreement, and explore solidarity or mutual antagonism) of a group as well. The common theme throughout the early researchers' lists of characteristics was user acceptance. Without user acceptance, a GDSS will most certainly fail.

2. Components of GDSS

DeSanctis and Gallupe [Ref. 5: pp. 4-5] state that the basic components of any GDSS are hardware, software, people, and procedures. To this, Bui and Jarke [Ref. 6]

would add a fifth component: communications. Each of these components will now be discussed in greater detail.

a. Hardware

Regardless of the GDSS structure, each group member must be able to have access to a computer terminal and displayed information. Hardware requirements include an I/O device, a processor, and a common viewing screen. More sophisticated systems may include touch sensitive screens or voice communication for non-typists. Graphics, computer conferencing, and video conferencing may also be integrated into the GDSS environment.

b. Software

Software components may include a data base, a model base, or specialized application programs. Some basic GDSS software features are file creation, modification, and storage; tutorials; word processing; worksheets; spreadsheets; and decision trees.

c. People

The people component of a GDSS includes the group members and a "facilitator" who assists the group with the GDSS technology. As DeSanctis and Gallupe point out, the facilitator's role is a flexible one, largely dependent on the group's familiarity and experience with the technology. When a GDSS is first installed, the facilitator will be relied upon quite heavily to actively coordinate the group's activities and serve as the interface between the

group and the technology. As group members become more familiar with the GDSS, the facilitator's responsibilities diminish, or may even be eliminated. [Ref. 5: p. 5]

d. Procedures

This component consists of procedures which serve as instructions to the group in the use and operation of the GDSS. These procedures may apply solely to the operation of the hardware and software, or may extend to include rules regarding group discussion (who speaks when and for how long and the flow of events).

e. Communications

Communications must be considered a part of any GDSS. This is especially true for a distributed GDSS, but as Gray [Ref. 4: p. 235] and Bui and Jarke [Ref. 6] point out, a decision room must have communication links as well. These links provide electronic mail among group members, access to other computers, and the ability to send messages to a public viewing screen.

3. Functions of GDSS

The most basic GDSS function is to assist the group in its problem solving process. A GDSS must be able to support the basic group activities of information sharing, retrieval, and use. In order to better understand what functions of a GDSS are required for a specific group task, DeSanctis and Gallupe, in their 1987 paper "A Foundation for

the Study of Group Decision Support Systems", established three approaches to supporting the group. These three levels represent varying degrees of intervention into the group's problem solving process. [Ref. 2: pp. 593-595]

Level 1 GDSS provide technical features aimed at removing common communication barriers known to inhibit group effectiveness. This level improves the problem solving process by facilitating information exchange among members. GDSS features within a Level 1 system are shown in in Table 1.

Level 2 GDSS provide decision modeling and group decision techniques aimed at facilitating the methods used by groups to reach decisions. A Level 2 GDSS may provide automated planning tools or other aids for group members to view simultaneously on the common viewing screen. GDSS features within a Level 2 system are shown in Table 2.

Finally, Level 3 GDSS are characterized by machine-induced group communication patterns that may determine who speaks when, in what order, to whom, and for how long. [Ref. 2: p. 597] GDSS features within a Level 3 system are shown in Table 3.

As DeSanctis and Gallupe point out, the higher the level of the GDSS, the more sophisticated the technology must be and the more dramatic the intervention into the group's natural, or unsupported, decision process. They also propose that research into the design and use of GDSS

TABLE 1 LEVEL 1 GDSS

Group problem or need	GDSS feature
Sending and receiving information efficiently among all parties or specific group members	Electronic messaging, broadcast or point-to-point
Access to personal data files or corporate data during the course of a meeting	Computer terminal for each group member, gateway to a local area network or central computer
Display of ideas, votes, data, graphs, or all tables to all members simultaneously	Large common viewing screen or "public" screen at each terminal
Reluctance of some members to speak due to their shyness, low status or controversial ideas	Anonymous input of ideas and votes
Failure of some members to participate due to laziness or "tuning out"	Active solicitation of ideas or votes from each group member
Failure to efficiently organize and analyze ideas and votes	Summary and display of ideas; statistical summary and display of votes
Failure to quantify preferences	Provide rating scales and/or ranking schemes; solicit and display ratings and rankings
Failure to develop a meeting strategy or plan	Provide a mock agenda which the group can complete
Failure to stick with the meeting plan	Continuously display the agenda; provide a time clock; automatically display agenda items at the appropriate time

TABLE 2 LEVEL 2 GDSS

Group problem or need	GDSS feature
Need for problem planning, structuring, and scheduling	Planning models, e.g., PERT, CPM, Gantt
Decision-analytic aids for uncertain future events	Utility and probability assessment models, e.g., decision trees, risk assessment
Decision-analytic aids for resource allocation problems	Budget allocation models
Decision-analytic aids for data-oriented tasks	Statistical methods, multicriteria decision models
Decision-analytic aids for preference tasks	Social judgment models
Desire to use a structured decision technique but insufficient knowledge or time to use the technique	Automate the Delphi, Nominal or other idea-gathering and compilation technique(s); provide an on-line tutorial for the group or facilitator

should proceed in an iterative manner, starting with Level 1 and Level 2 systems and advancing to Level 3 after some understanding of the required features and impacts of lower systems has been achieved. [Ref. 2: p. 595]

TABLE 3 LEVEL 3 GDSS

Group problem or need	GDSS feature
Desire to enforce formalized decision procedures	Automated parliamentary procedure or Robert's Rules of Order
Desire to select and arrange an array of rules for discussion	Rule base; facility for rule selection and application
Uncertainty about options for meeting procedures	Automated counselor, giving advice on rules and appropriate use
Desire to develop rules for the meeting	Rule-writing facility

C. ADVANTAGES AND DISADVANTAGES OF A GDSS

Each of the three levels that have been discussed have several advantages and disadvantages that must be considered prior to implementing a GDSS.

1. Advantages

One of the biggest benefits a Level 1 GDSS can offer is assistance in controlling inhibiting influences that can reduce the performance of an interacting group. Some of these influences include strong personality types dominating the discussion, pressure for low-status participants to go along with the opinions of other group members, and the overconcentration on one or two narrow-minded approaches to the problem. A GDSS can aid in reducing these undesirable

group traits through the use of anonymous inputs and evaluation of ideas. The Nunamaker, Applegate, and Konsynski experiment [Ref. 9], which will be discussed in the next section, stated that group members were less intimidated by the keyboard than by strong personalities. Anonymity in the idea generation (brainstorming) process can spur fresh ideas which might otherwise not be voiced. This anonymity can only help the group, as more alternatives will be considered.

An advantage of a Level 2 GDSS is its ability to gain quick access to a broad base of information. This information can come from an outside source, such as an external data base, or from within the group, such as a group member's opinion. This ability to access information quickly is especially helpful in handling ad hoc queries. As Gray states, "These technologies (GDSS) allow rapid information retrieval, rapid evaluation of new alternatives, and graphic display of complex information." [Ref. 13: p. 310]

A GDSS can also simplify the problem solving process by automating certain planning tools, such as PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method), therefore allowing the group to concentrate on the problem at hand.

A Level 3 GDSS can offer structure and guidance for groups who have not had prior experience working together. As DeSanctis and Gallupe mention, "Newly formed groups usually lack cohesion and a structure for operating. The GDSS should support the group during the initial phases of group formation." [Ref. 5: p. 8] The two authors further state that the decision room can be set up so that members are facing each other. Special GDSS software can also be used to evaluate members perceptions of what the group's function should be.

A GDSS also has the ability to control the tempo of a meeting. This can be advantageous to groups that go off on tangents and whose meetings are uncontrolled or unbearingly long. Such control can be dangerous, however, as a strict agenda may stifle innovation and reduce flexibility.

2. Disadvantages

GDSS have disadvantages as well. One drawback is an initial reluctance of senior executives to accept GDSS. Although computers have become widely accepted in the last several years, most senior executives still do not possess the expertise or confidence required to work with computers. Some executives do not know how to type, while others simply feel uncomfortable having computers assist in the decision making process.

Another disadvantage of a GDSS is cost. Gray [Ref. 4: p. 235] points out that a decision room must be elegantly

furnished and have the feel of an executive conference room. A GDSS also requires specific hardware, software, and communications and display equipment. Gallupe [Ref. 14: p. 520] adds that extensive time may be required to develop a specific GDSS. In short, acquiring a GDSS is an expensive proposition that requires a large capital investment.

A GDSS also requires a computer with minimal downtime. As Huber [Ref. 3: p. 198] states, if the group facilitator gets stuck in the technology, or the system goes down, the meeting, whose agenda is sometimes quite dependent upon the GDSS, may have to be adjourned. This could result in negative perceptions on the part of the group members toward GDSS, particularly for first time users.

Another disadvantage of a GDSS may be a possible loss of non-verbal communication. Suchan, Bui, and Dolk [Ref. 7: p. 448] point out that "Unless a GDSS is strategically designed, there may be the damaging potential for altering or freezing traditional communication channels." Nunamaker's experiment showed that the participants communicated mainly through the keyboard and that there was little interaction between participants [Ref. 9]. Apparently, much non-verbal communication (such as hand movement and eye contact) may go unnoticed by GDSS users.

Another disadvantage comes from empirical experiments that have shown a decline in decision confidence and

satisfaction among GDSS groups [Ref. 8]. This will be discussed in greater detail in the next section.

The advantages and disadvantages that have been discussed are summarized in Table 4.

TABLE 4 ADVANTAGES AND DISADVANTAGES OF A GDSS

Advantages:

- Anonymity can spur fresh ideas and reduce bias and prejudice
- Quick access to a broad base of information
- Ability to support ad hoc queries quickly
- Automates certain aspects of the problem solving process, thus simplifying the process
- Can offer special accommodations for groups who have no prior experience working together
- Can control tempo of meeting

Disadvantages:

- Initial reluctance of senior executives to accept GDSS
- Requires capital investment
- Requires extensive time to develop a specific GDSS or to tailor own system to an acquired GDSS
- Requires a reliance on computer uptime
- Possible loss of non-verbal communication
- Empirical experiments have shown a decline in decision confidence and satisfaction among GDSS users

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D. EMPIRICAL RESULTS

Active experimentation moved to the forefront of GDSS research in 1986. Addressing the importance of experimental research, Gallupe, in his paper "Experimental Research into Group Decision Support Systems: Practical Issues and Problems", had this to say:

> Experimental studies have been an important part of Management Information Systems/Decision Support Systems research since the early 1970's. These experimental studies have attempted to manipulate key information system variables, and then measure dependent variables intended to evaluate factors such as decision quality, user satisfaction, etc. [Ref. 14: p. 515]

The purpose of Gallupe's experimental study was to determine if the difficulty of the decision task had an impact on the effectiveness of a GDSS. The analysis of the data provided some interesting results:

* Decision quality is enhanced when decision making is supported by a GDSS, particularly for tasks of high difficulty.
* Decision time appears not to be affected by use of a GDSS or level of task difficulty.
* Confidence in the group decision and satisfaction with the decision making process are reduced when a GDSS is used, irrespective of task difficulty.
* The amount of participation by individual group members in the group decision making process is unaffected by GDSS support or by level of decision task difficulty. [Ref. 14]

Gallupe expanded this research when he teamed up with DeSanctis and Dickson two years later. Their experiment results, which appeared in the June 1988 issue of MIS QUARTERLY, sought to examine the effects of GDSS technology on group decision quality and individual perceptions within a problem-finding context. The authors found that decision quality was significantly better in those groups that used GDSS technology. The GDSS was especially helpful to the groups with a task of high difficulty. However, group

members' decision confidence and satisfaction with the decision process were lower in the GDSS groups. [Ref. 8]

Nunamaker, Applegate, and Konsynski [Ref. 9] conducted an experiment on the design, implementation, and evaluation of a GDSS for support of idea generation and analysis. The participants for the study were high level managers with varying backgrounds. One of the more striking observations was that all group members participated in the computer brainstorming session. However, in the verbal discussions only a few individuals participated. Analysis of the communication channels also revealed that the majority of verbal discussion was directed at the group facilitator rather than the other group members.

Factors inhibiting the idea generation process included lack of typing skills, the requirement to read the screen in order to access others' ideas, and the time spent waiting for the next screen. Despite these difficulties, the participants reported high levels of satisfaction with electronic brainstorming. The authors concluded that the technology does significantly influence the idea generation process.

Two theses recently completed at the Naval Postgraduate School continued the experimental research of GDSS and its impact on the problem solving process. The Fijol-Woodbury study [Ref. 10] examined the use of GDSS in two different problem-solving settings: face-to-face GDSS and distributed

GDSS. The study had three major findings and three minor findings. The major findings were:

* The distributed groups were more accurate in solving the case and, therefore, were considered to have produced higher quality decisions.

* 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.

* 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:

* There was no difference between the two group types as to satisfaction with the selection criteria they gathered.

* No determination could be made as to which group type generated the most creative criteria or even which generated simply the most criteria.

* The face-to-face groups preferred to meet face-to-face, but the distributed groups had no preference for setting.

The Hughes-Webb study [Ref. 11] used the same experiment variables as the Fijol-Woodbury study, but compared GDSS supported groups and non-GDSS groups. Their findings were:

* For this case (a case of high task, low relationship, and low complexity), a GDSS was a detriment to quality decision making.

* The 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.

The few empirical studies related to group decision support systems conducted have presented conflicting results. Gallupe concluded decision quality was enhanced when a group was supported by a GDSS; Hughes and Webb found GDSS to be a detriment to decision quality. Nunamaker, Applegate, and Konsynski stated that a GDSS allowed for more participation by all members; Gallupe concluded the amount of participation by group members was unaffected by GDSS support. Gallupe contended that decision time is not affected by the use of a GDSS; Hughes and Webb concluded that GDSS were a detriment to decision speed. Finally, Hughes and Webb stated that there was no difference between GDSS groups and non-GDSS groups in their satisfaction and confidence while Gallupe, DeSanctis, and Dickson reported that decision confidence and satisfaction were lower in the GDSS groups.

These conflicting results can be attributed to several factors that make GDSS research difficult: the lack of available software, an inadequate number of available participants, unsatisfactory GDSS settings and standards (decision task, variables, etc.), and a lack of empirical studies from which to draw on.

E. IMPLICATIONS OF THIS RESEARCH

The progression of GDSS research the last six years from theory and research towards active experimentation indicates a maturing of the technology. As Gray [Ref. 4: p. 234] points out, GDSS activity is currently centered in university research laboratories. If GDSS fails, it is better we find out now, in a laboratory setting, rather than in the field after large investment and failure.

This study continues the empirical experiment phase of the GDSS evolution. Chapter III will present the problem statement and hypotheses.

III. PROBLEM STATEMENT AND METHODOLOGY

A. PROBLEM STATEMENT AND HYPOTHESIS

Proponents of GDSS claim its unique features enable groups to make decisions faster and better than non-GDSS groups. Furthermore, they claim GDSS supported groups will be able to access more information, work more efficiently with each other, and feel greater overall satisfaction with their final decision. [Ref. 2] The following three hypotheses concerning GDSS and the effect it has on a decision outcome have been developed:

Ho(1): A GDSS supported group will make a better decision (that is they will create more alternatives and criteria and choose the most correct alternative) than a non-GDSS supported group.

Ho(2): A GDSS supported group will take less time to reach a decision than a non-GDSS supported group.

Ho(3): GDSS supported group members will feel greater decision confidence and satisfaction with their final decision than non-GDSS supported group members.

Additionally, the following questions were addressed:

Q1 : Did the communication channels differ in the two groups?

Q2 : Did the groups differ in their perception of the decision process?

Q3 : How did the GDSS group members feel about GDSS in general?

Q4 : What did the GDSS group members think about Co-oP, the GDSS software used?

A complex scenario (Appendices A and B) covertly resembling the Cuban missile crisis was passed out to seven groups of four graduate students. Four groups were instructed to list possible alternatives and criteria, as well as a final decision, with the aid of Co-oP, a GDSS software package. The other three groups were instructed to do the same in a typical conference room without computer aided support. All seven groups filled out a questionnaire at the conclusion of each session in order to assess user satisfaction and confidence. A more detailed discussion of the experiment process may be found in Section F.

B. SETTING

GDSS research has cited four possible decision making settings:

* Face-to-face non-GDSS--A group meeting face-to-face without GDSS support.
* Face-to-face GDSS--A group meeting face-to-face with GDSS support.
* Distributed non-GDSS--Group members independently provide input to a central decision maker who compiles the results without the use of a GDSS.
* 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. [Ref. 15: pp. 68-75]

This study compares the results of the first two settings. The face-to-face non-GDSS setting was held in a medium-sized conference room with a long table and comfortable chairs, much like that found in a typical boardroom. A

blackboard and chalk were provided to the non-GDSS groups. Two observers stayed in the back of the room.

The GDSS supported groups met in a computer laboratory. The lab was closed to all except the group of four participants, a facilitator, and an observer. Figure 3.1 depicts the lab lay-out. The four participants each had their own personal computer. The four computers were linked to a master computer operated by the facilitator. A large public viewing screen was located in front of the group.

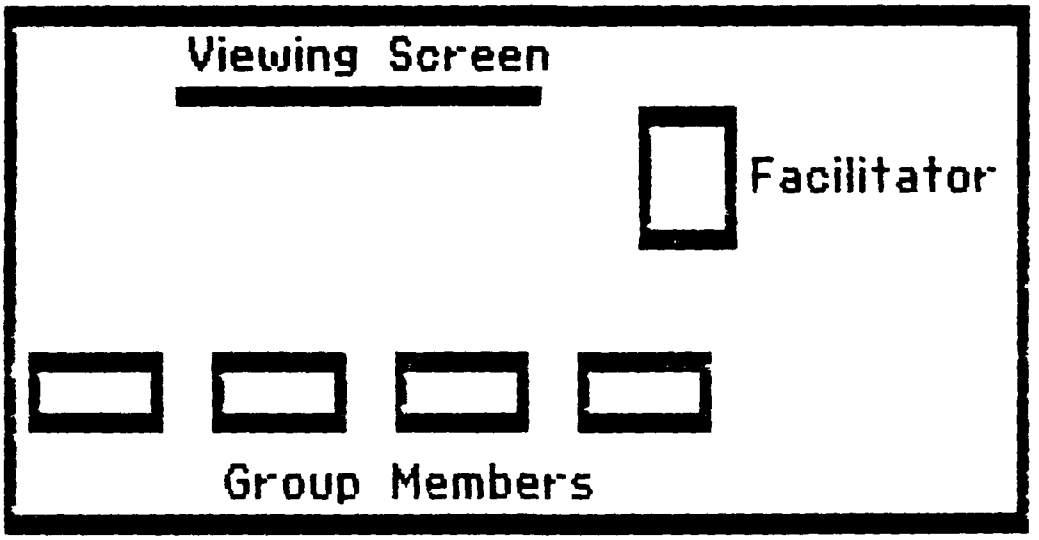


Figure 3.1 Lab Lay-out

C. PARTICIPANTS

The seven groups of four participants were drawn from the officer-student population of the Naval Postgraduate School (NPS), Monterey, California. The majority of

participants were students in their sixth and final quarter of the Computer Systems Management curriculum, so a fairly extensive knowledge of computer technology was present. Eight of the 28 volunteers were females. The average age was 32. All participants were middle-grade military officers with an average time in service of 10 years. Officers from the Navy, Marine Corps, Army and Coast Guard were represented.

The participants were a relatively homogenous group with similar management and educational backgrounds. Additionally, they knew each other well and had experience with group tasks from previous assignments at NPS. The participants judged their experience at making "real world" decisions in groups as medium to high and their level of experience working in groups as high (see questionnaire in Appendix D).

D. GDSS SOFTWARE

The software used in the study was Co-oP, a DSS for cooperative multiple criteria group decision making. Developed by Tung Bui of the Naval Postgraduate School in Monterey, California and Matthias Jarke of the University of Passau in West Germany, Co-oP is characterized by the following design characteristics:

* The design setting is <u>cooperative</u> as contrasted to hostile. Although negotiations take place, there is no consideration of intentional misrepresentation of data or preferences.

* Decisions are made in a distributed and democratic fashion. Each decision maker has his own workstation (personal computer) connected to others via a network. There is no group leader but only a chauffeur or secretary to expedite the discussion. The arbitration among different opinions (aggregation of preferences and negotiation support) is provided by the system itself rather than by a human. Norms for the group decision process are agreed upon by the group but enforced by the system automatically, although mechanisms are provided for changing the rules of discussion dynamically.

* Multiple Criteria Decision Methods (MCDM) form the kernel of the system and the basis for exchange of information among the decision makers. This together with game-theoretic axioms provides a formal basis for the otherwise very unclear tasks of group decision support. However, group decision making is not pressed into a static formal framework. Rather, the MCDM approach is embedded into a process-oriented group decision methodology that also includes the use of more informal group techniques, ranging from Delphi and Nominal Group Techniques to simple electronic mail and computer conferencing. [Ref. 16: pp. v-vi]

In addition to being used in both the Fijol-Woodbury and Hughes-Webb studies, Co-oP had the added benefit of being operational and readily available. Co-oP supported the group decision process by allowing the participants to generate alternatives and create criteria, establish weights for the alternatives selected, and perform statistical analysis of the inputs to determine a final solution to the problem. Though the software did create some limitations (see Section E), Co-oP did provide adequate support for the GDSS groups.

E. QUESTIONNAIRE

In order to assess group member confidence and satisfaction, a questionnaire was passed out at the conclusion of each problem solving session. The questionnaire was divided into five sections: background information, attitudinal questions, group communication questions, decision process questions, and GDSS questions for the GDSS supported groups. The questionnaire used a 5-point Likert scale with the answers often reversed to ensure each question was read carefully. The GDSS groups and the non-GDSS groups filled out the same questionnaire. The questionnaire and the results can be found in Appendix D.

F. EXPERIMENT PROCESS

The procedure followed by both the GDSS and non-GDSS groups was similar. The day before each group was to meet, they were handed a 3-page handout giving an overview of the scenario (Appendix A). The group members were instructed to familiarize themselves with the background information. The groups met at agreed times and locations with both researchers.

Co-oP, the GDSS software utilized, required establishment of a group norm and problem definition. This was taken care of by the researchers prior to the group meeting and was uniform throughout. Group norms included the following:

* The final computer generated solution would be determined by weighted majority rule.

* Each group member would assign a weight (from one to ten) to each alternative generated. The same weight could be assigned to more than one alternative.

* Each group member would have an equal vote.

* Information submitted by any member would be available to all group members for review.

Once the group was assembled, the second handout, the three page Threat Analysis and Response Case (Appendix B), was distributed. The group members were given sufficient time to read it. Once everyone had read the second handout, one of the researchers read an introduction detailing what the group was supposed to do (Appendix C).

The clock to time the groups was started after the introduction was read, therefore eliminating reading speed as a variable. In the GDSS group, one researcher acted as a chauffeur, walking the group through the software. The other researcher sat quietly in the back taking notes. In the non-GDSS groups, both researchers sat quietly in the back of the conference room.

The GDSS groups were more structured in that Co-oP walked the groups through the decision making process. The first step in these groups was for each individual to enter their own lists of alternatives and criteria at their respective terminals. After this was completed, the chauffeur displayed each of the members' lists, one at a time, on the public screen for all to see. Each group member was then given the opportunity to explain the rationale behind their

lists to the entire group. After the four group members had discussed their own lists, the group was instructed to draft a group list of alternatives and criteria. The chauffeur could go back to display the individual lists for further review, but software limitations prohibited him from displaying all four lists simultaneously.

After the group had decided on final alternative and criteria lists, each member assigned weights (from 1-10) for each alternative. Again due to software limitations, this could only be done one at a time (see Section G on Problems and Limitations). Following the fourth member's entry of the alternative weights, Co-oP calculated a final list of alternatives in prioritized order. The group was then instructed to make a final decision. They were told they could either accept or reject Co-oP's recommended answer.

The non-GDSS group did not have the benefit of such structure. Once the introduction was read, the non-GDSS groups were free to develop a list of alternatives and criteria and a final answer in any way they chose.

After the groups had given the researchers their final answer, they were given a questionnaire to fill out and instructed not to discuss the case with any other groups for a period of one week.

G. PROBLEMS AND LIMITATIONS

Although the experiment process went smoothly, the following problems and limitations were encountered while running the experiment:

1. THE SMALL NUMBER OF GROUPS

This was due, in large part, to the limited number of participants available. This experiment did use four people in a group vice the three used in the Fijol-Woodbury and Hughes-Webb studies. Some research suggests that the impact of group technology may be significant only in larger groups. DeSanctis and Gallupe say, "Because large groups experience more dramatic communication difficulties, GDSS may have a more positive impact in large groups." [Ref. 2: p. 598] In this respect, several more groups of five would have been optimum. Nevertheless, four group members is an improvement over three, although only seven total groups were tested.

2. THE LABORATORY SETTING

The computer lab available was a classroom with four rows of several personal computers. The chairs were fairly uncomfortable and the lighting was poor. The lab simply was not designed to be a GDSS room. The four computers used in the experiment were in a row rather than in the preferred semi-circle where the group members could better see each other. This limitation is merely a case of not having adequate resources. As Gray points out, "Because decision

rooms are designed for senior managers, they tend to have an executive feel to them". [Ref. 4: p. 235] The decision room located at the University of Arizona, with its plush carpeting, comfortable executive chairs and modern facilities would have been the ideal setting for the GDSS groups.

3. A FLAWED SCENARIO

One of the hypotheses stated that the GDSS group will make a better decision than a non-GDSS group. But what constitutes a better decision? Two aspects were considered: the number of alternatives and criteria generated (this was the easy part) and the closeness of the final decision to the "right" answer. The challenge was to draft a scenario that had a correct answer, but one whose solution was not intuitively obvious. This problem was encountered in the Fijol-Woodbury and Hughes-Webb studies when their scenario (choosing the most qualified candidate for a job) was too simplistic.

The Cuban Missile Crisis provided a complex military situation where history has shown that a blockade was the correct alternative. The scenario had to be enough like the Cuban Missile Crisis that blockade was in fact the best alternative, but not so obvious that participants would recognize it as such. Consequently, variables had to be added (such as the presence of other countries) that may have made other answers, such as diplomacy, just as correct.

While several groups mentioned the Cuban Missile Crisis as historical reference during discussion of the alternatives, none recognized the scenario as a disguised Cuban Missile Crisis. In this respect, the scenario was successful. However, in analyzing the correctness of each group's final decision, it had to be acknowledged that the case did not duplicate the Cuban Missile Crisis exactly and that blockade may not have been the only best answer.

4. SOFTWARE RESTRICTIONS

Although familiar with computer technology, the GDSS participants were not familiar with Co-oP, the GDSS software used. The single meeting experiment did not allow for learning through repeated use of the group technology. As Huber suggests, a GDSS must attain a minimum threshold of frequency-of-use in order to gain acceptance within an organization. [Ref. 3: p. 197-198] This impacted on the overall time to reach a decision as each group struggled through the software steps. Additionally, when it came time to enter each member's weighing of the alternatives, Co-oP did not allow for simultaneous entry. Consequently, three members sat idle while each took a turn entering data. This was taken into consideration when analyzing the time hypothesis and will be discussed in Chapter IV.

Despite these problems and limitations, the experiment provided some interesting insight and results. These empirical results will now be discussed in Chapter IV.

IV. EMPIRICAL RESULTS AND DISCUSSION

A. HYPOTHESES AND DISCUSSION

A discussion and analysis of the results gathered during the experiment is presented. Two sample t-tests were conducted and are discussed when they indicate significance either as a sign of difference between the two sets of groups or where similarity of response is meaningful.

1. Decision Accuracy

Ho(1): A GDSS supported group will make a better decision (that is they will create more alternatives, more criteria, and choose the most correct alternative) than a non-GDSS supported group.

Ho(1) was rejected. All three non-GDSS groups and three of four of the GDSS supported groups chose the best course of action. This result is consistent with the Hughes-Webb study [Ref. 11] where the non-GDSS groups were more accurate.

The GDSS groups developed more alternatives (on average 18.5 for GDSS to 13.67 for non-GDSS) than the non-GDSS groups (Fig. 4.1); however, the level of difference was not statistically significant. This lack of statistical difference was due largely to one outlier non-GDSS group which developed substantially more alternatives (21 for the outlier to 10 for the other two non-GDSS groups) than the other two groups. This points to the difficulties

GDSS Groups

```
       8.00      12.00      16.00      20.00      24.00

     N      MEAN    MEDIAN    TRMEAN     STDEV    SEMEAN
     4     18.50     18.50     18.50      2.08      1.04

   MIN       MAX        Q1        Q3
 16.00     21.00     16.50     20.50
```

Non-GDSS Groups

```
       8.00      12.00      16.00      20.00      24.00

     N      MEAN    MEDIAN    TRMEAN     STDEV    SEMEAN
     3     13.67     10.00     13.67      6.35      3.67

   MIN       MAX        Q1        Q3
 10.00     21.00     10.00     21.00
```

Figure 4.1
Number of Alternatives

experienced due to the relatively small number of groups participating in the study. Without this outlier group, the difference in the number of alternatives would have been significant at level alpha .05.

The GDSS groups developed a significantly (level alpha .05) larger number of criteria (on the average of

13.25 for the GDSS groups to 6.67 for the non-GDSS groups) on which to evaluate their alternatives (see Fig. 4.2). The GDSS groups handled the more complex problem by evaluating more alternatives and criteria than the non-GDSS groups. However, compared to the non-GDSS groups, this did not improve their decision quality. This is in contrast to Gallupe's study [Ref. 8] where use of a GDSS increased both the decision quality and the number of alternatives considered.

2. Decision Speed

Ho(2): A GDSS supported group will take less time to reach a decision than a non-GDSS supported group.

Ho(2) was rejected. The GDSS groups took approximately 10 minutes longer, on average, (Fig. 4.3) to complete the problem. This difference in time was not significant and can be attributed to the delay caused by limitations with the software requiring group members to input their evaluations of the alternatives one at a time rather than simultaneously.

The fact that the times to complete the task for both sets of groups were so close is in sharp contrast to the Hughes-Webb study [Ref. 11] where the non-GDSS groups were three times faster than the GDSS groups. However, this study's results are consistent with other research, notably the Gallupe study [Ref. 14], where using a GDSS did not add to the decision time.

GDSS Groups

```
                        :          .          .
---+---------+---------+---------+---------+---------
  6.00      9.00      12.00     15.00     18.00

      N     MEAN   MEDIAN   TRMEAN    STDEV   SEMEAN
      4    13.25    12.50    13.25     2.87     1.44

    MIN      MAX       Q1       Q3
  11.00    17.00    11.00    16.25
```

Non-GDSS Groups

```
.     .    .
---+---------+---------+---------+---------+---------
  6.00      9.00      12.00     15.00     18.00

      N     MEAN   MEDIAN   TRMEAN    STDEV   SEMEAN
      3    6.667    7.000    6.667    1.528    0.882

    MIN      MAX       Q1       Q3
  5.000    8.000    5.000    8.000
```

```
TWOSAMPLE T FOR GDSS vs Non-GDSS
 N      MEAN      STDEV   SE MEAN
 4     13.25       2.87       1.4
 3      6.67       1.53      0.88

 95 PCT CI FOR MU GDSS-Non-GDSS:(1.9,11.26)
 TTEST MU GDSS=Non-GDSS(VS NE):T=3.91 P=0.017 DF=4.7
```

Figure 4.2
Number of Criteria

GDSS Groups

```
+---------+---------+---------+---------+---------+---------+
40.00     48.00     56.00     64.00     72.00     80.00
                    minutes

        N      MEAN    MEDIAN   TRMEAN     STDEV   SEMEAN
        4     68.25     74.00    68.25     12.20     6.10

      MIN       MAX        Q1        Q3
    50.00     75.00     55.75     75.00
```

Non-GDSS Groups

```
+---------+---------+---------+---------+---------+---------+
40.00     48.00     56.00     64.00     72.00     80.00

        N      MEAN    MEDIAN   TRMEAN     STDEV   SEMEAN
        4     59.00     58.00    59.00     12.33     6.16

      MIN       MAX        Q1        Q3
    45.00     75.00     46.00     71.00
```

Figure 4.3
Time to Make a Decision

The complexity of a task is proportionate to the number of quality alternatives and criteria considered. As the number of alternatives and criteria generated increases, so does the complexity. The case used in this study and in the Gallupe study were more complex than the one used in the Hughes-Webb study. For lower complexity problems, using a

GDSS is no more efficient (perhaps even less efficient) than a piece of paper or a blackboard (given the relative simplicity of analysis and communication of alternatives in these tasks) [Ref. 8]. The relatively similar decision times between the GDSS and non-GDSS groups in this study, compared to the Hughes-Webb study, [Ref. 11] demonstrates that using a GDSS, in this case, was a viable option.

3. Decision Confidence and Satisfaction

Ho(3): GDSS supported groups members will feel greater decision confidence and satisfaction with their final decision than non-GDSS supported group members.

Ho(3) was rejected. This was based on the results of a post experiment questionnaire filled out by the group members. Questions used to evaluate Ho(3) were:

* In general, to what extent were you satisfied with today's meeting? (evaluated from very satisfied to very dissatisfied) (Fig. 4.4)
* To what extent do you feel committed to the group's solution? (evaluated from committed to not very committed) (Fig. 4.5)
* How confident are you that the group's final decision best solved the problem? (very unconfident to very confident) (Fig. 4.6)
* I would rate the quality of the group's decision as...(poor to very good) (Fig. 4.7)

Both groups were partially satisfied with the overall meeting (GDSS = 2.25 to 2.167 for non-GDSS with 2 being satisfactory and 3 being neutral). Both groups were committed to the group's solution to the problem (GDSS = 1.63 to 1.50 for non-GDSS with 1 being very committed and 2 being committed).

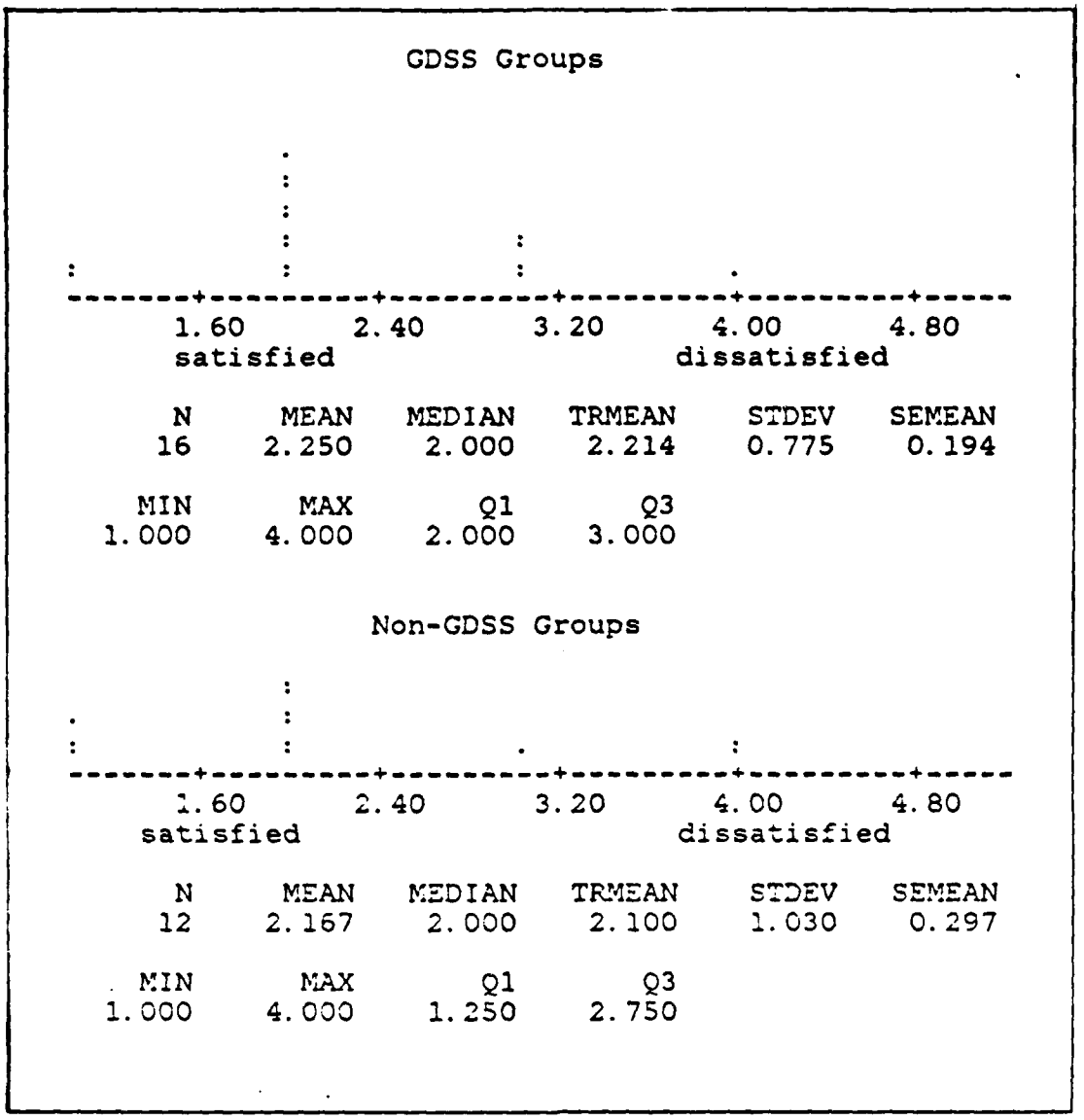


Figure 4.4
Satisfaction With Meeting

Since using a GDSS leads to a more in-depth analysis of the case, its use should contribute to group consensus. However, since groups supported by a GDSS generate more detailed alternatives [Ref. 8] compared to a non-GDSS group,

GDSS Groups

```
:              :
:              :
:              :
:              :              .
-------+---------+---------+---------+---------+-----
      1.60      2.40      3.20      4.00      4.80
          effective                  ineffective
```

N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
16	1.625	2.000	1.571	0.619	0.155

MIN	MAX	Q1	Q3
1.000	3.000	1.000	2.000

Non-GDSS Groups

```
:              :
:              :
:              :
-------+---------+---------+---------+---------+-----
      1.60      2.40      3.20      4.00      4.80
          effective                  ineffective
```

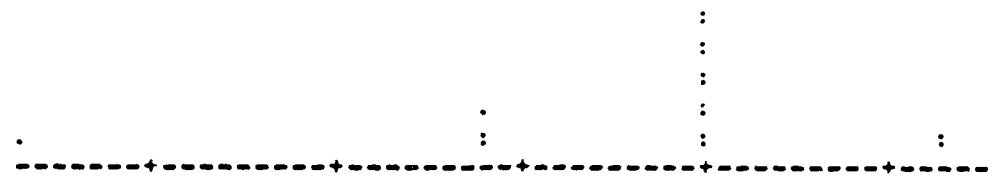
N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
12	1.500	1.500	1.500	0.522	0.151

MIN	MAX	Q1	Q3
1.000	2.000	1.000	2.000

Figure 4.5
Extent of Meeting Effectiveness

they have a more difficult decision to make. Once they have made a decision, they may be less satisfied because of the number and quality of the choices they had to assess.

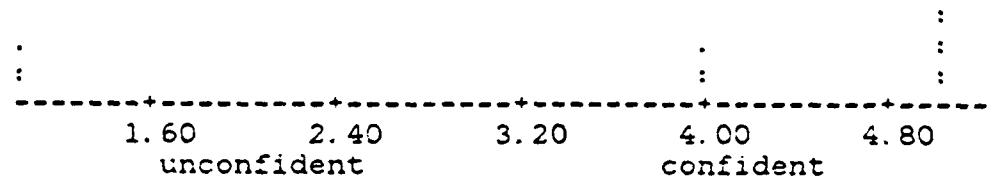
GDSS Groups



N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
16	3.750	4.000	3.857	0.931	0.233

MIN	MAX	Q1	Q3
1.000	5.000	3.250	4.000

Non-GDSS Groups



N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
12	3.750	4.500	3.900	1.712	0.494

MIN	MAX	Q1	Q3
1.000	5.000	1.750	5.000

Figure 4.6
Confidence in Group's Final Decision

Both sets of groups felt equally confident in their final decision (GDSS = 3.75 and non-GDSS = 3.75 with 4 being confident and 3 being neutral). However, although both groups rated the quality of their decision as good (GDSS =

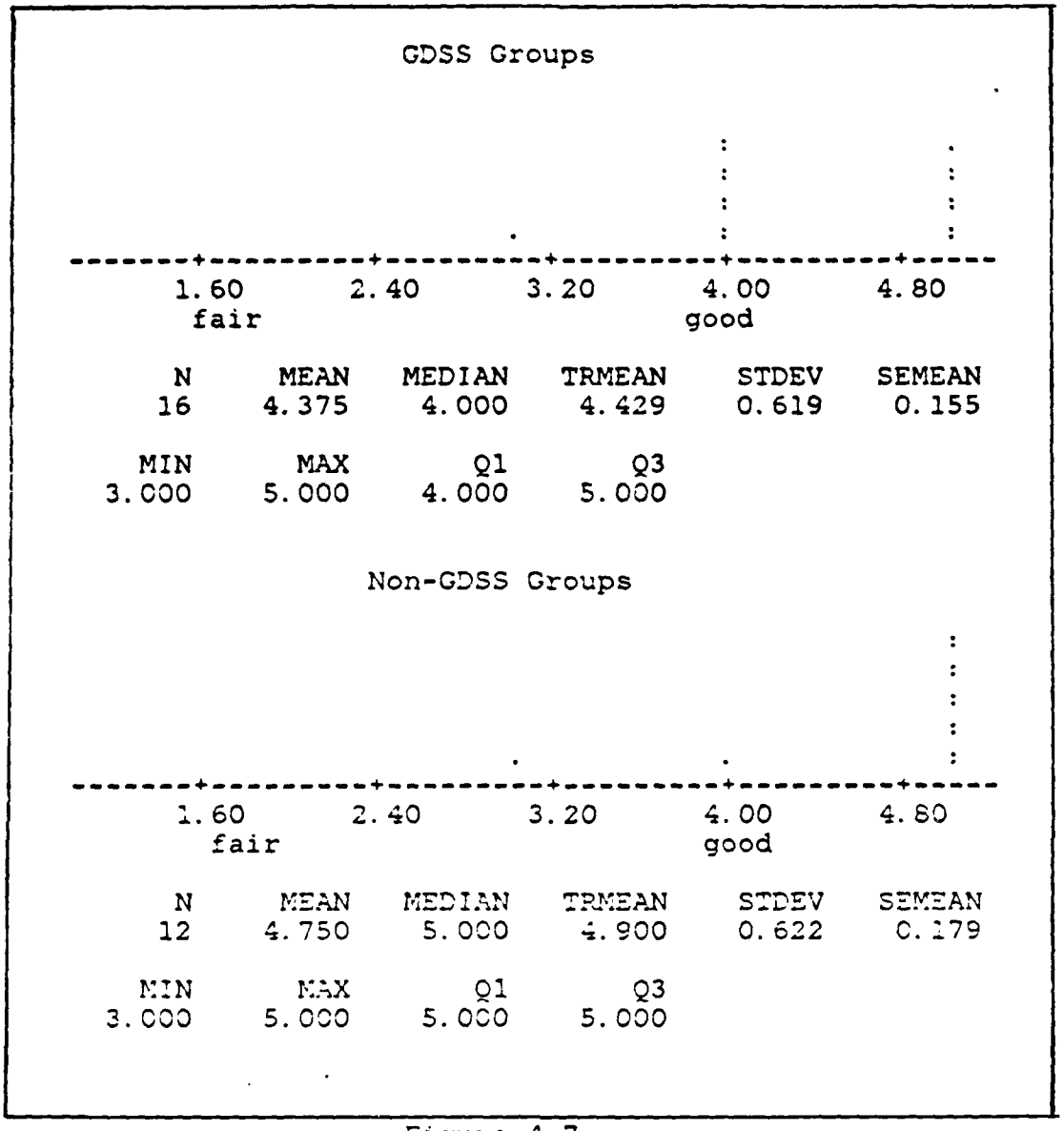


Figure 4.7
Quality of the Group's Decision

4.38 to non-GDSS = 4.75 with 4 being good and 5 being very good), the non-GDSS groups did evaluate their final decision as being of higher quality than the non-GDSS groups. Although not statistically significant, this perception of

quality is consistent with the Hughes-Webb study [Ref. 11], where the non-GDSS groups were very confident in their decision and the GDSS groups were slightly lower. This decision confidence result is in sharp contrast to the Gallupe study [Ref. 8], where GDSS groups felt more confident than the non-GDSS groups in their final decision.

B. QUESTIONS AND DISCUSSION

As a matter of interest, a series of additional questions were asked. These questions were evaluated to determine differences in communications between non-GDSS and GDSS supported groups, differences in perceptions of process, how the GDSS members felt about GDSS in general, and their thoughts about Co-oP.

1. Communication Channels

The following questions were asked to address this area:

* To what extent were you satisfied with the amount of communication between yourself and other group members (evaluated from very satisfied to very dissatisfied) (Fig. 4.8)
* To what extent did one individual or a group of individuals influence the groups decision? (high degree to not at all) (Fig 4.9)
* To what degree did you feel free to participate in the group discussion? (never to always) (Fig. 4.10)
* To what extent were you satisfied with the amount of verbal communication between group members? (very dissatisfied to very satisfied) (Fig. 4.11)

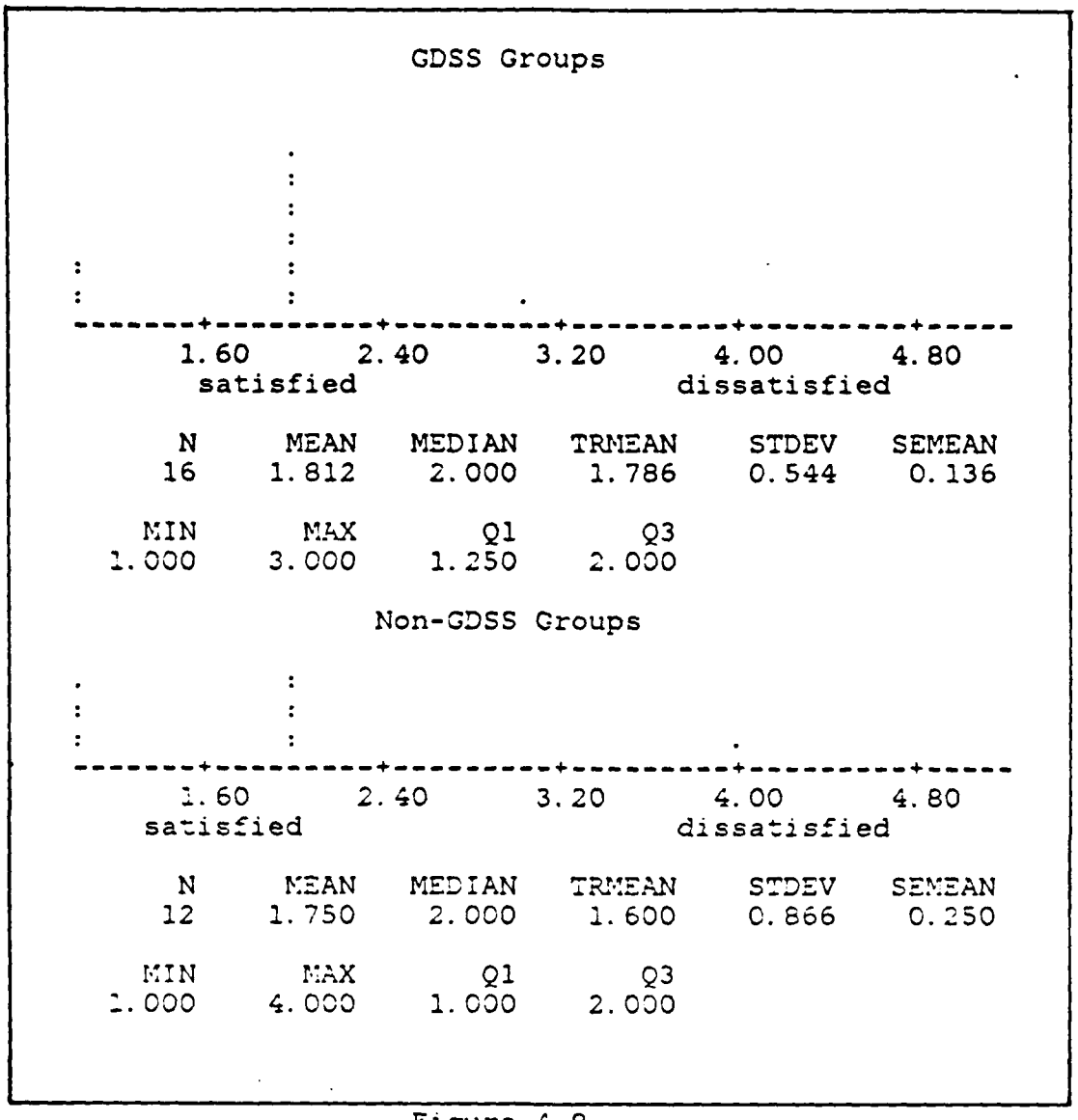


Figure 4.8
Satisfaction With Amount of Communication

* To what extent were you satisfied with the amount of non-verbal communication between group members? (very satisfied to very dissatisfied) (Fig. 4.12)

The two sets of groups indicated almost equal satisfaction with the amount of overall communication (GDSS = 1.81 to

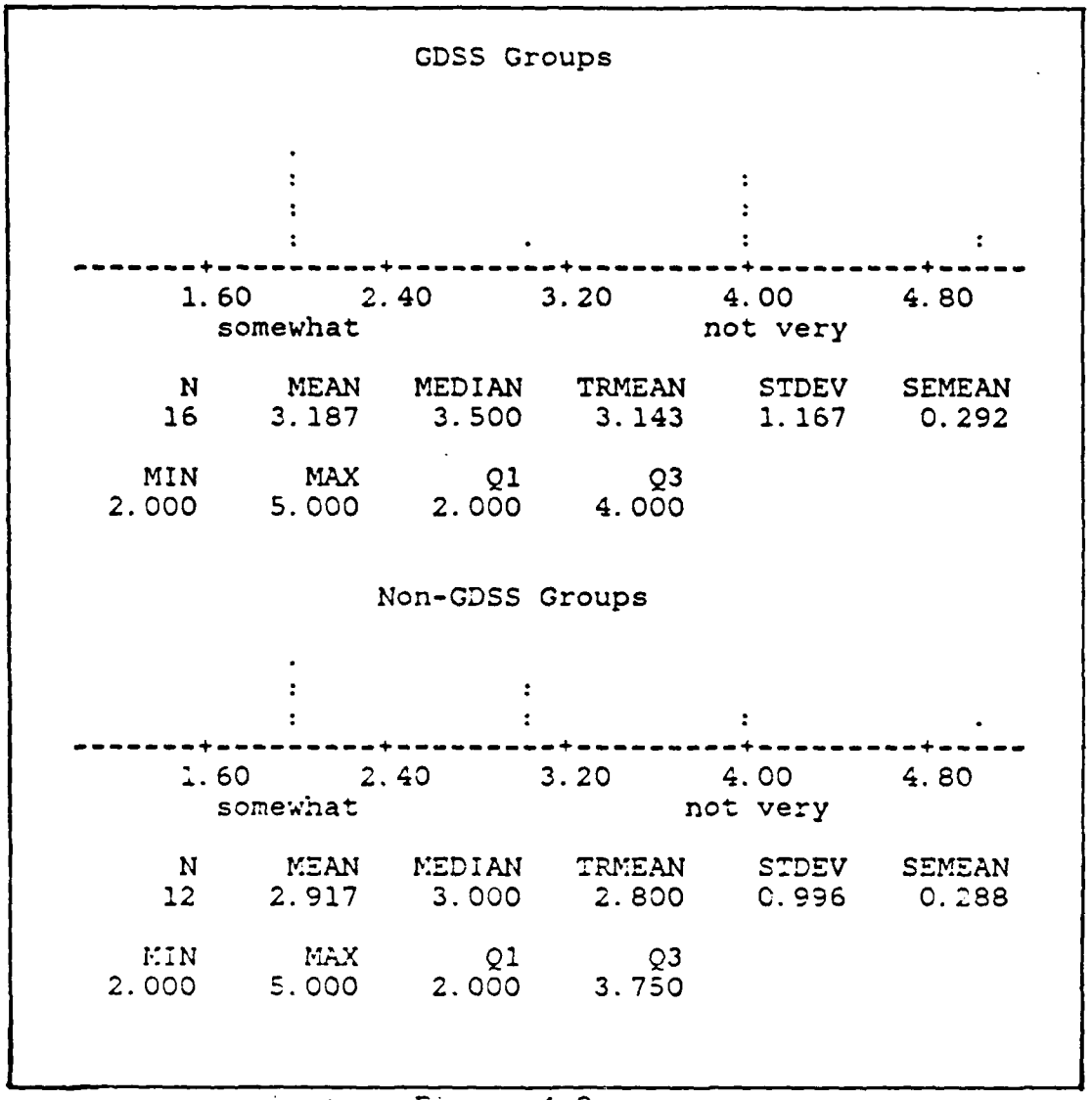


Figure 4.9
Degree an Individual Dominated The Meeting

1.75 for the non-GDSS with 2 being satisfied and 1 being very satisfied) during the problem solving sessions. However, the non-GDSS groups felt more satisfaction with verbal communications (GDSS = 4.06 and non-GDSS = 4.50 with 4 being

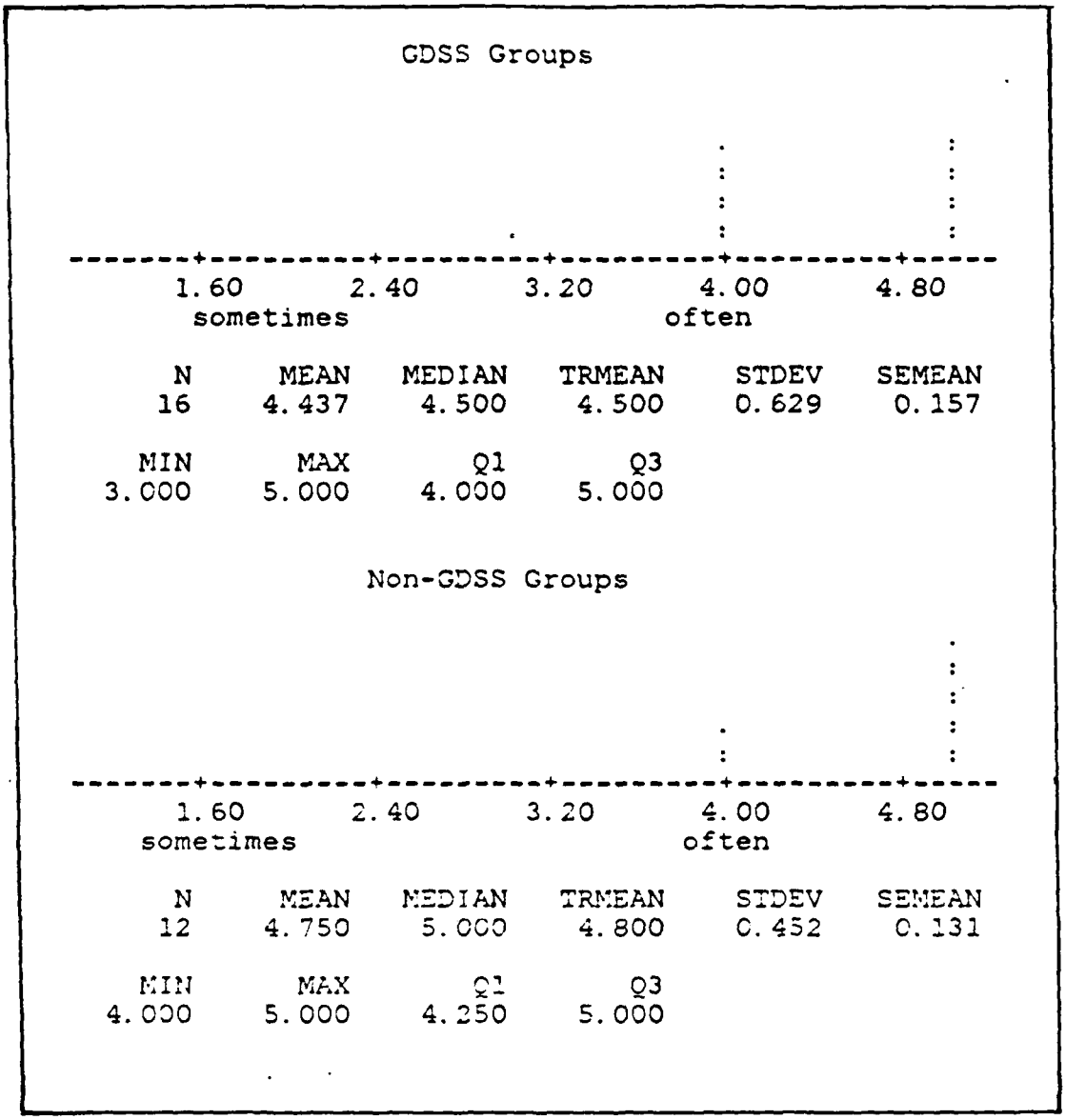


Figure 4.10
Degree of Freedom to Participate

satisfied and 5 being satisfied) and non-verbal communications (GDSS = 2.94 to non-GDSS = 2.50 with 2 being satisfied and 3 being neutral). These differences were not statistically significant. However, the group members' perception

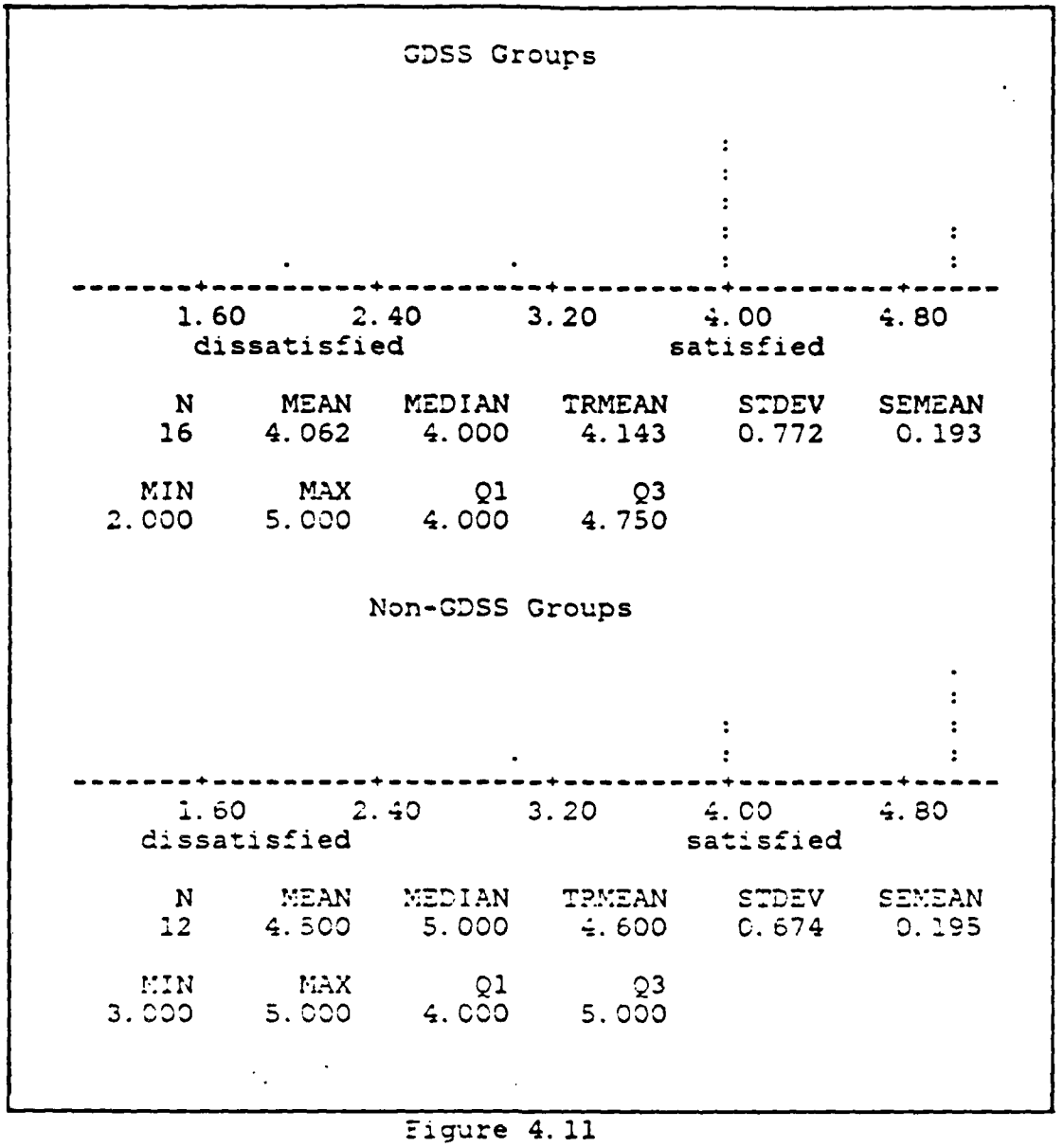


Figure 4.11
Satisfaction With Verbal Communication

of their satisfaction with verbal and non-verbal communications were decidedly lower for the GDSS groups than the non-GDSS groups even though both groups' evaluation of overall communication satisfaction showed no significant difference.

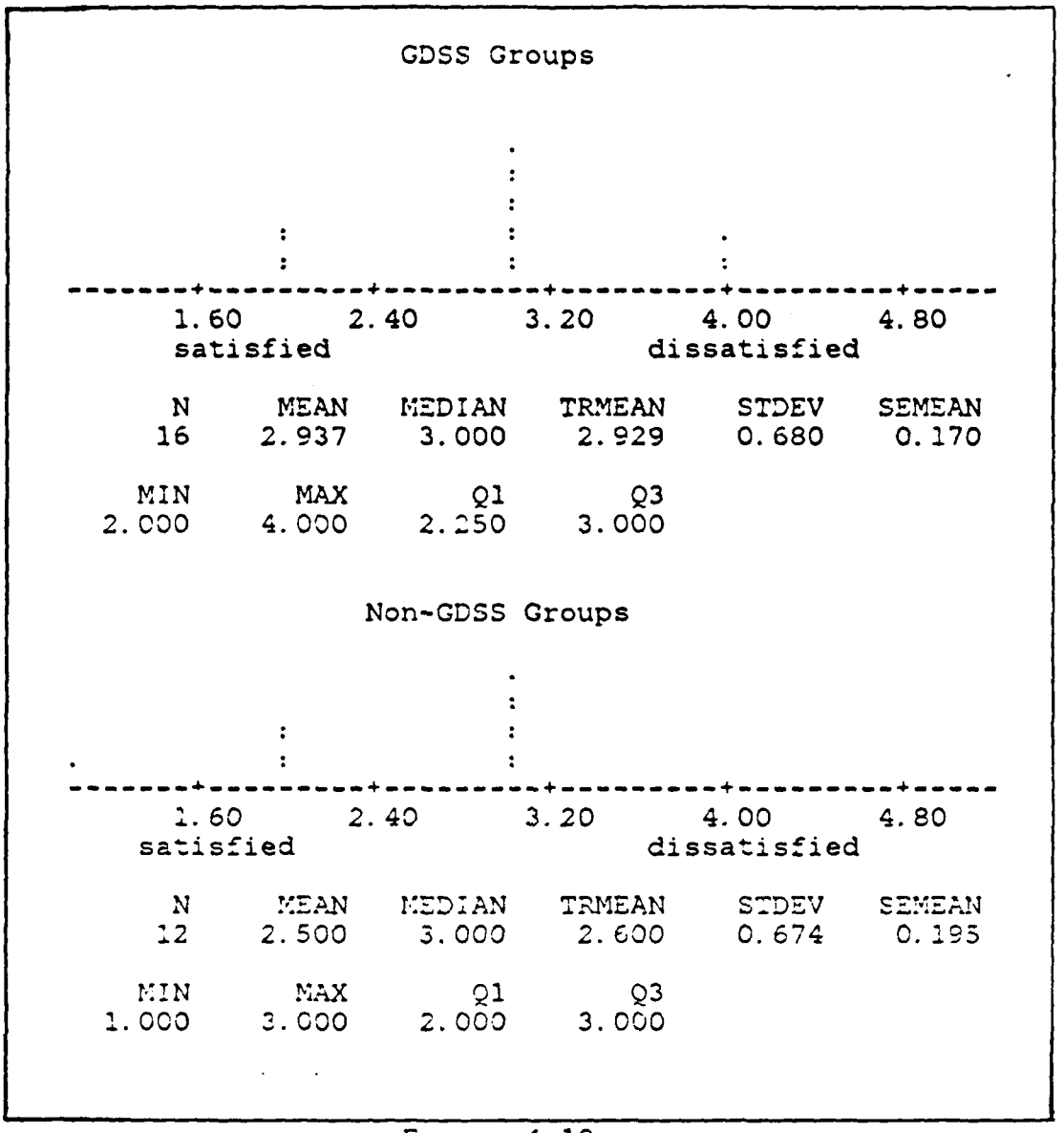


Figure 4.12
Satisfaction with Non-Verbal Communication

Apparently, instead of normal communication channels, the GDSS groups were satisfied with using the computer and GDSS software as a medium for much of their communication needs.

The lack of a designed GDSS decision room and the necessity to use an existing computer lab, albeit dedicated, prevented the GDSS groups from engaging in face to face discussions without extensive neck craning and moving of chairs. Because the difference in perception of communication overall was relatively small, these results cannot be interpreted to mean that general use of a GDSS decreases the amount of verbal and non-verbal communication. Rather, judging by the GDSS groups satisfaction with overall communication, in this case, the use of the GDSS made up for the difficulties in verbal and non-verbal communications.

There was a noticeable, although not significant, difference between the two groups' (GDSS = 4.44 to non-GDSS = 4.75 with 4 being often and 5 being always) perception of freedom to participate in the group discussion. The non-GDSS groups felt freer to participate. This perception is in contrast to Gallupe's study [Ref. 14] and the Hughes-Webb study [Ref. 11] which found no difference in levels of participation between GDSS and non-GDSS groups.

2. Decision Process Perception

The following questions were asked to address this area:

* I felt the group's problem-solving process was...(evaluated from very coordinated to totally uncoordinated) (Fig. 4.13)

* I felt the group's problem solving process was...(very efficient to very inefficient) (Fig. 4.14)

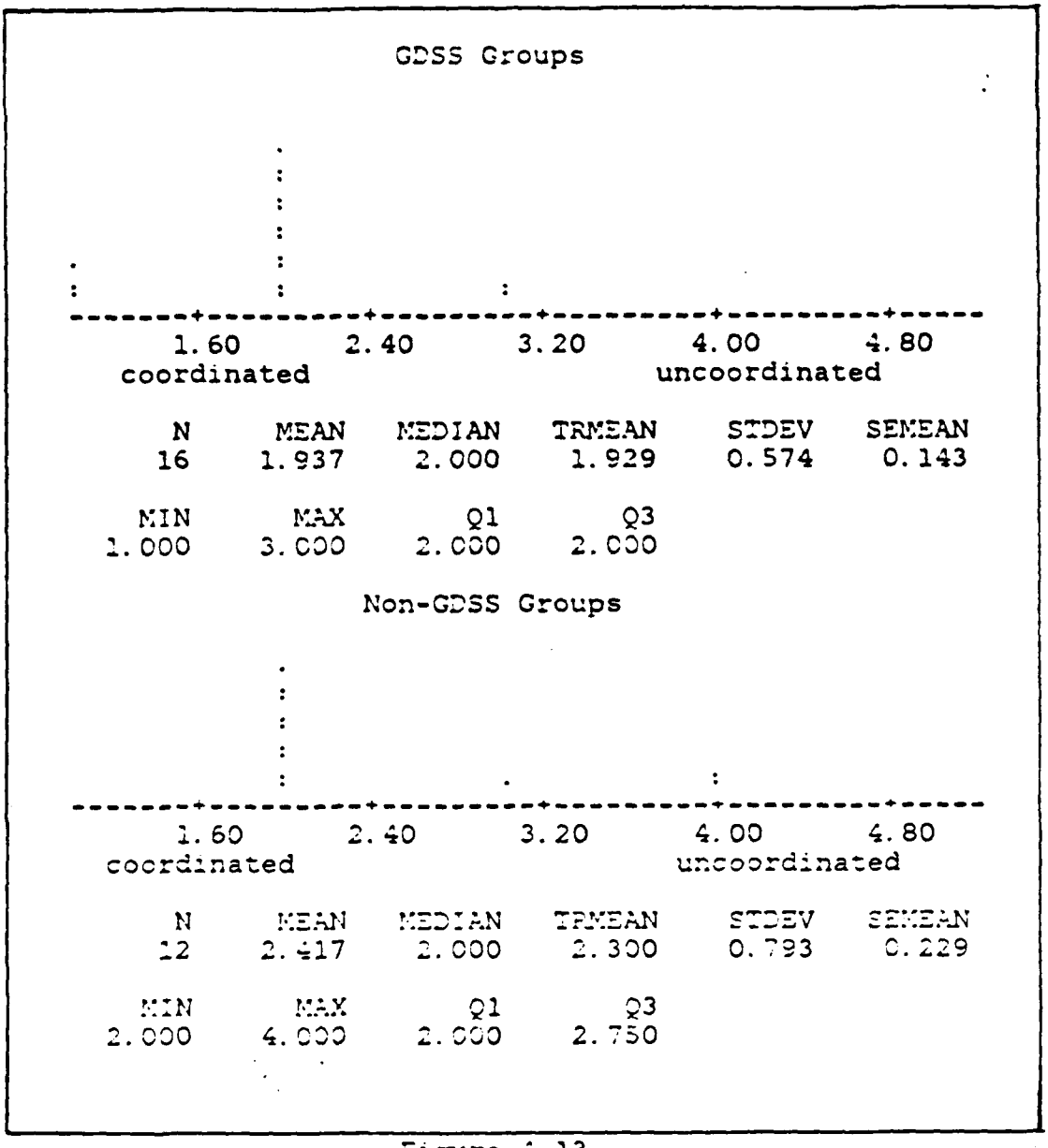


Figure 4.13
Coordination of the Problem Solving Process

* To what extent did you feel satisfied with the group's problem-solving process? (very dissatisfied to very satisfied) (Fig. 4.15)

At a level of significance of alpha = .10, the GDSS groups felt their process of decision making was more

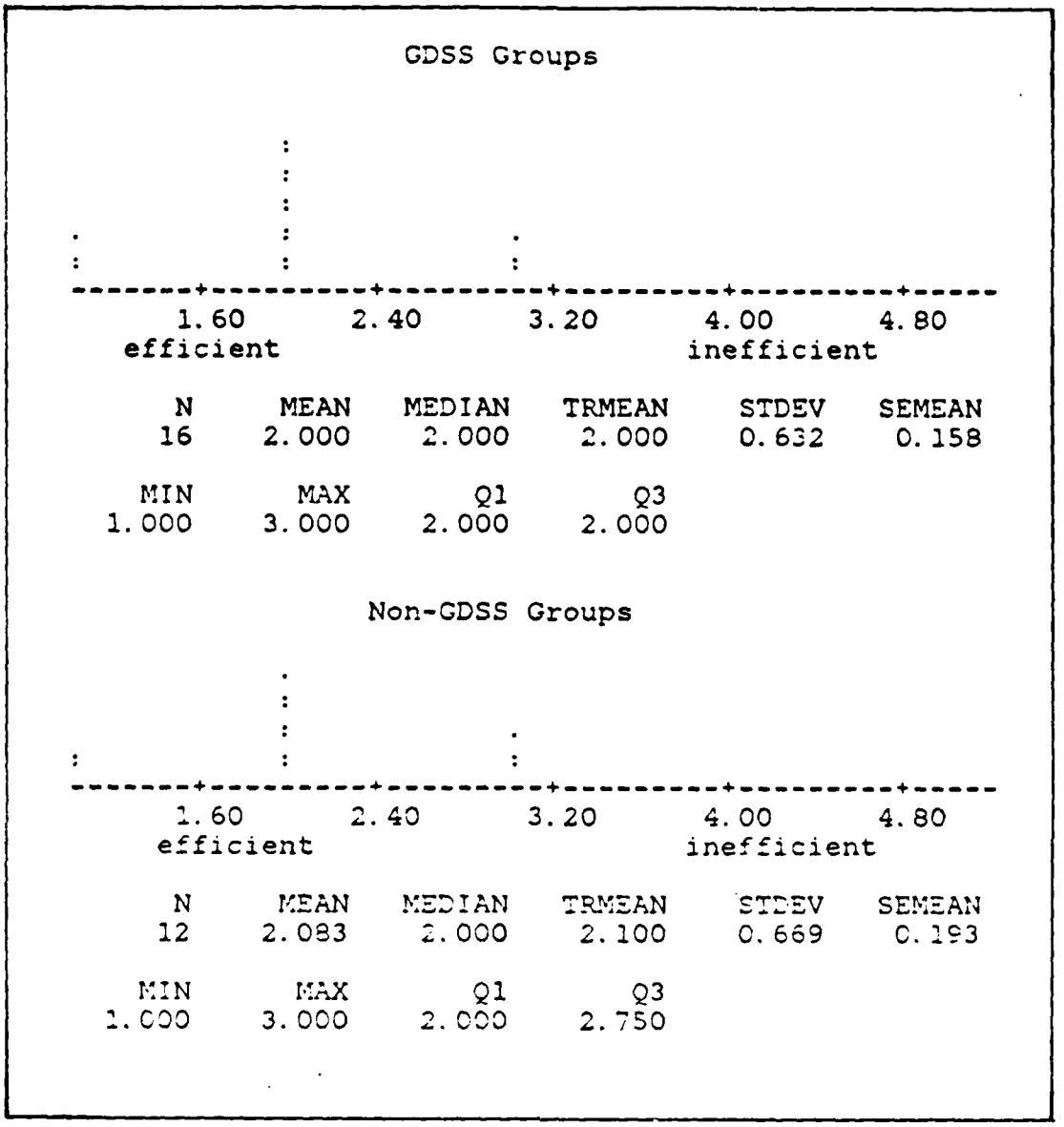


Figure 4.14
Efficiency of the Problem Solving Process

coordinated than the non-GDSS groups. This compares favorably to Gallupe's results [Ref. 8] where GDSS groups felt that the GDSS added an "agenda" or structure to the process. As previously mentioned, this facet of GDSS can be an

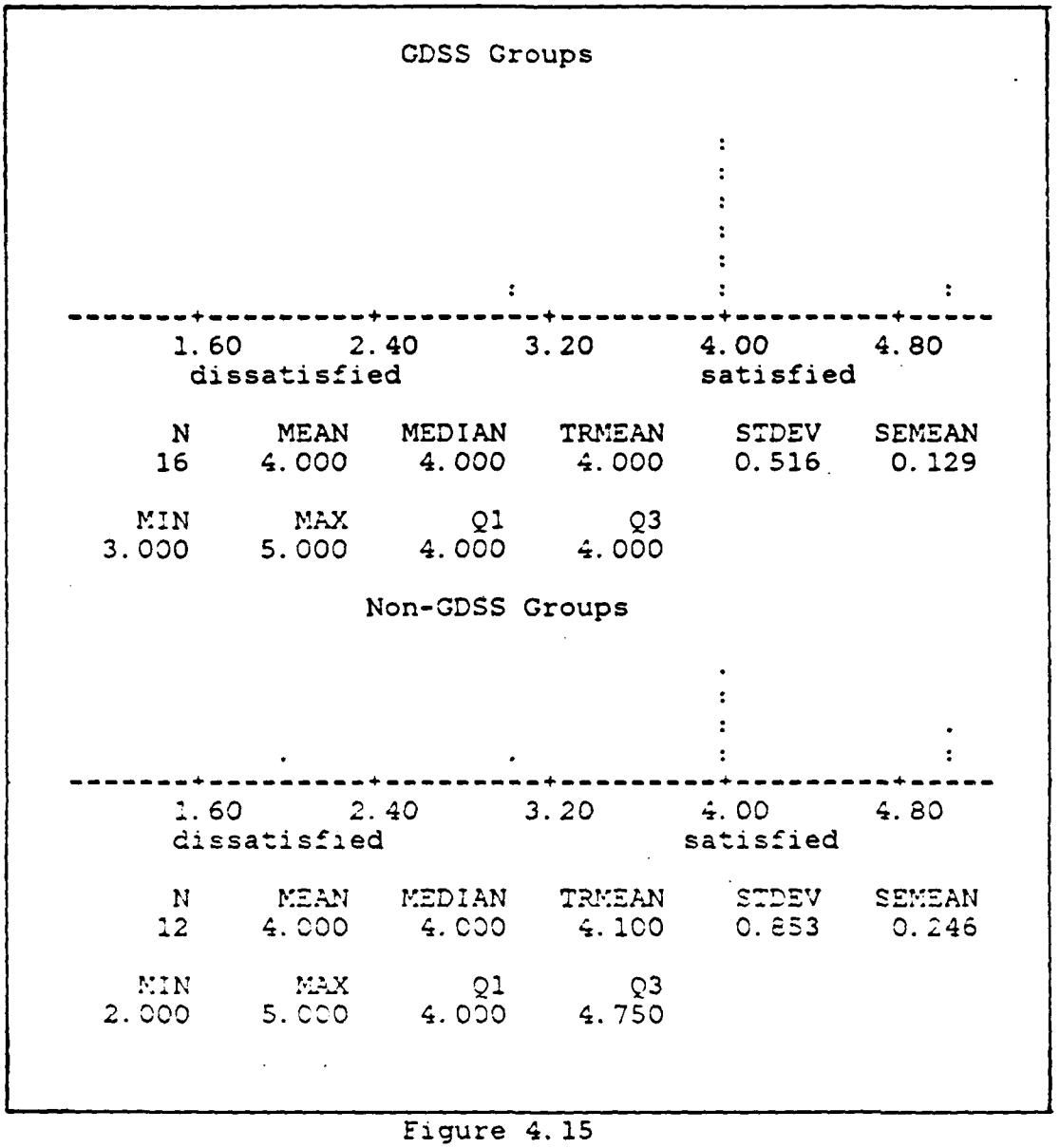


Figure 4.15
Satisfaction With Group Problem Solving Process

advantage to groups that are meeting for the first time or who have difficulty maintaining a focus on the decision task. It can also be a disadvantage for groups by stifling

creativity where innovation is required to reach a quality decision.

There was no perceived difference between the groups in the level of efficiency of the process used (GDSS = 2.0 to 2.08 for non-GDSS with 2 being efficient and 3 being neutral), and both sets of groups expressed equal satisfaction (4.0 = satisfied for both) with the group process. If efficiency in a group decision situation can be viewed as developing and evaluating more alternatives and criteria against the amount of time spent on the decision, as a whole, then the efficiency of the GDSS groups was 0.46 alternatives-criteria per minute. The corresponding efficiency of the non-GDSS groups was .34. Thus, the GDSS groups were more efficient regarding the number of alternatives and criteria considered. Observation of the groups during the experiment suggest that difficulties with the software reduced the perceived efficiency and satisfaction levels of the GDSS groups.

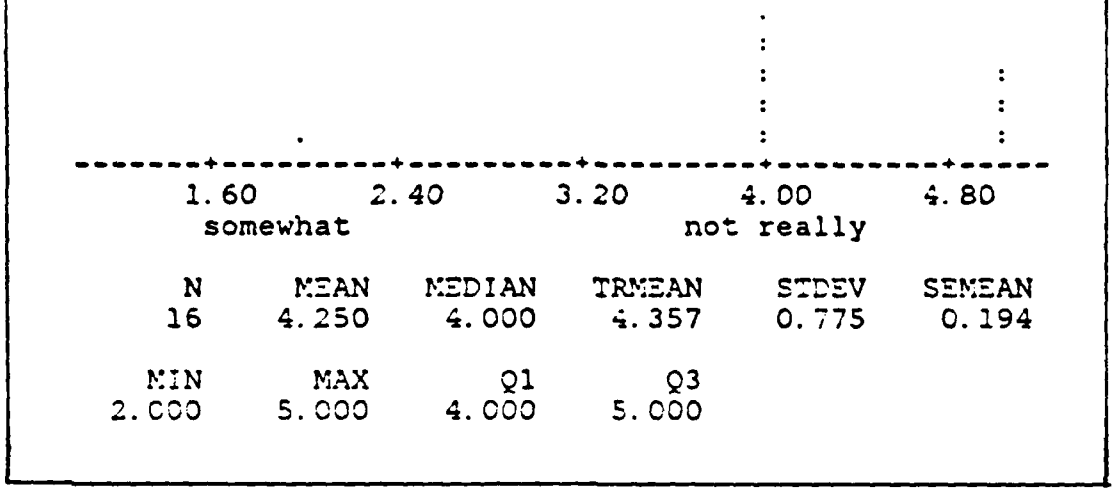
3. GDSS Perception

The following questions were asked to address this area:

* Did the GDSS environment inhibit you from speaking? (evaluated from to a large extent to not at all) (Fig. 16)

* To what extent do you believe this problem would have been better solved in a typical conference meeting room environment? (to a large extent to not at all) (Fig. 4.17)

GDSS Groups Only

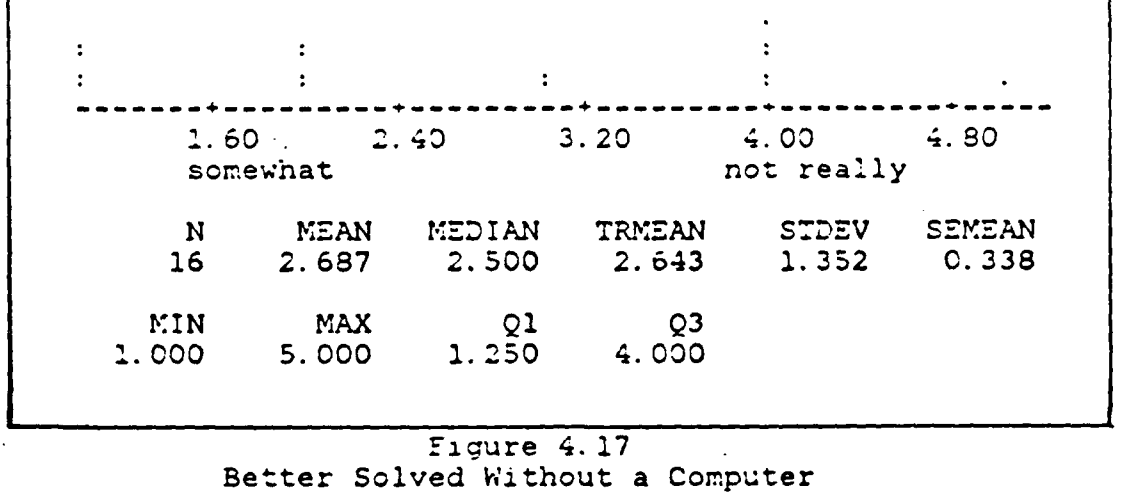


N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
16	4.250	4.000	4.357	0.775	0.194

MIN	MAX	Q1	Q3
2.000	5.000	4.000	5.000

Figure 4.16
Inhibition From Speaking

GDSS Groups Only



N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
16	2.687	2.500	2.643	1.352	0.338

MIN	MAX	Q1	Q3
1.000	5.000	1.250	4.000

Figure 4.17
Better Solved Without a Computer

These questions were directed only to the GDSS groups. They did not feel that the GDSS environment inhibited their speaking (GDSS = 4.25 with 4 being not really and 5 being not at all). They did feel that a typical conference room setting, without a computer, would have been a better environment in which to solve the problem. It is quite possible that the software used for the GDSS portion of this study may have dampened the GDSS impact.

After their final decision was submitted, the non-GDSS groups were asked if GDSS aid would have been helpful in solving this case. Nine out of twelve of the non-GDSS group members felt that a GDSS would have been helpful in making their decision. The response from both groups contrasts with the Hughes-Webb study [Ref. 11] where both GDSS and non-GDSS groups stated the problem could have been better solved without a computer. This difference would seem to be due to the increased complexity of this case warranting use of a computer to help in evaluating alternatives.

4. Co-oP Perception

Co-oP was the GDSS software package used during the experiment. The following questions were asked to address this area:

* To what degree was Co-oP user friendly? (evaluated from to a large degree to not at all) (Fig. 18)
* To what extent did Co-oP help you organize your thoughts? (evaluated from not at all to a large extent) (Fig. 19)

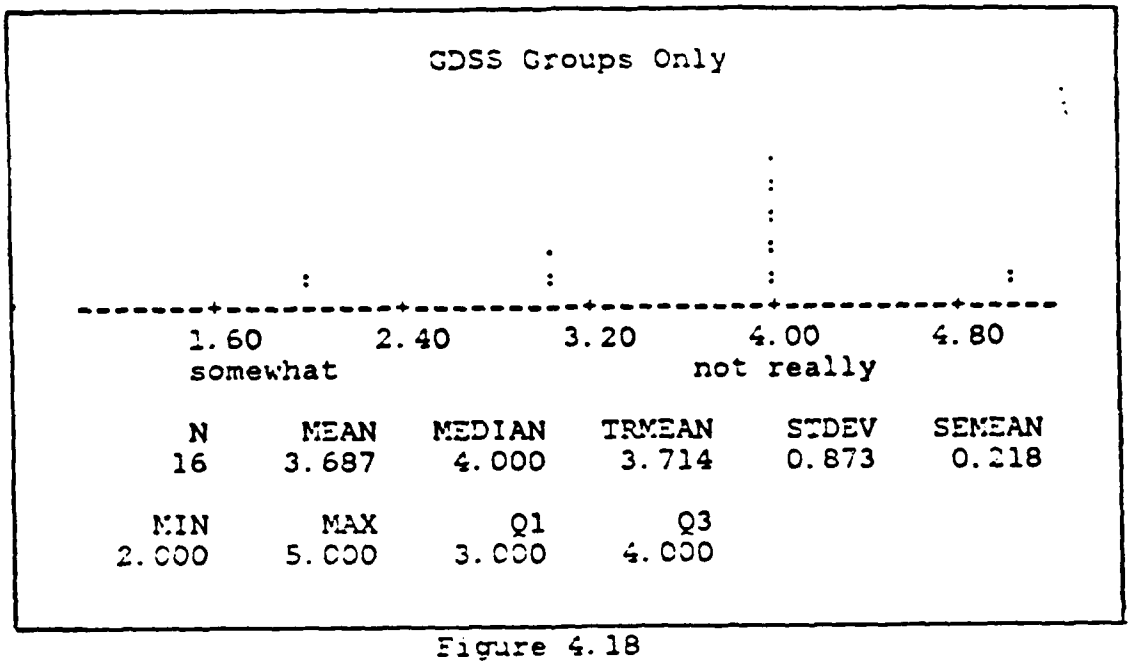


Figure 4.18
Co-oP User Friendliness

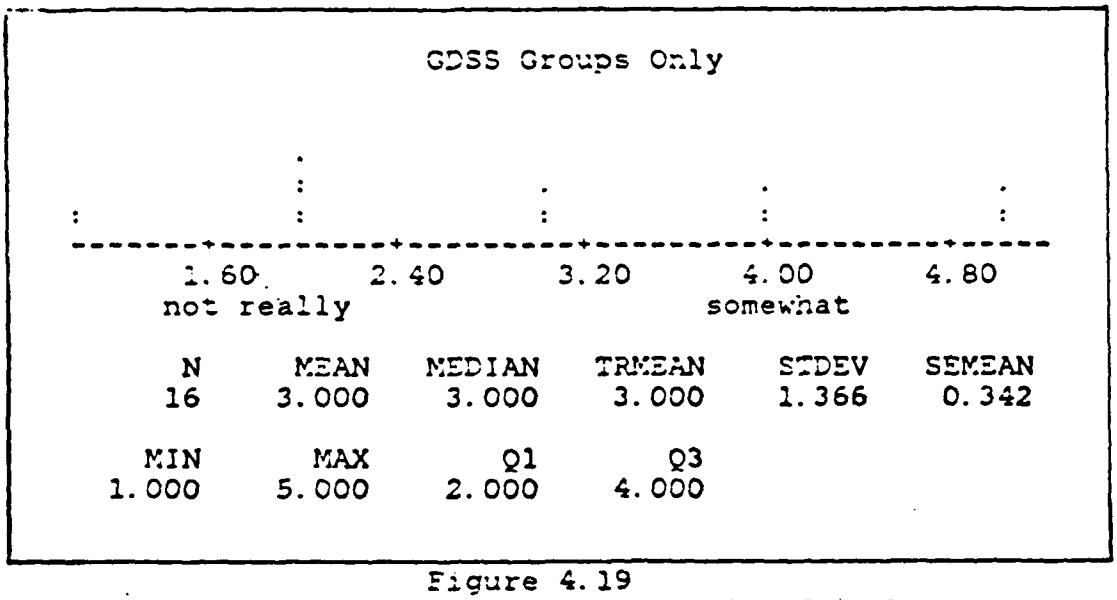


Figure 4.19
Effectiveness of Co-oP in Organizing Thoughts

The GDSS groups did not think that the software was user friendly (GDSS = 3.69 with 3 being neutral and 4 being not really). The software was initially designed for use as a distributed system allowing group members to input their data at any time during a set period. It was not designed for simultaneous input of data. Consequently group members had to wait while other individuals were doing their evaluation. This led to frustration on the part of the groups. As for Co-oP's impact on organizing their thoughts, the GDSS groups were neutral.

C. SUMMARY

Three hypotheses deemed important for evaluating the effectiveness of a GDSS were examined. Decision quality was not found to be significantly better for either the GDSS or non-GDSS groups. However, the GDSS groups developed more alternatives and significantly more criteria than the non-GDSS groups. Also, the groups using a GDSS did not make a faster decision than the non-GDSS groups. Finally, the GDSS groups did not experience higher levels of confidence and satisfaction in their decision.

In addition, four questions of interest were addressed. The communication channels differed in that the GDSS groups funneled some of their communications through the computer. No appreciable difference was noted in the groups perception of the decision process. GDSS groups were somewhat

ambivalent towards the GDSS environment and they did not develop a strong liking for the software used during the experiment.

V. CONCLUSION

A. RESULTS

1. Hypotheses

The following hypotheses were presented in order to test the effectiveness of using a Group Decision Support System (GDSS) to solve a complex problem.

Ho(1): A GDSS supported group will make a better decision (that is they will create more alternatives and criteria and choose the most correct alternative) than a non-GDSS supported group.

Ho(2): A GDSS supported group will take less time to reach a decision than a non-GDSS supported group.

Ho(3): GDSS supported group members will feel greater decision confidence and satisfaction with their final decision than no-GDSS supported group members.

a. Ho(1): A Better Decision

Ho(1) was rejected. Three out of four GDSS supported groups and three of three non-GDSS groups chose the best course of action. This difference was not significant because of the small number of test groups. In terms of number of alternatives developed, the GDSS groups did develop more alternatives, on average, than the non-GDSS groups. This difference though, was not statistically significant. The GDSS groups also developed a significantly greater number of criteria than the non-GDSS groups. By evaluating a greater number of alternatives based on more criteria, the

GDSS groups' decision process was more complex than the non-GDSS groups'.

Gallupe [Ref. 8] stated that for a GDSS to be of value, the problem must possess a certain degree of complexity. Although Ho(1) was rejected, use of the GDSS increased the efficiency of the groups who used it because they were able to assess the problem from more viewpoints than the non-GDSS groups.

b. Ho(2): Decision Speed

Ho(2) was rejected. The non-GDSS groups arrived at their final answer ten minutes faster, on average, than the GDSS supported groups. This difference was not significant and was attributed to the problems inherent in the GDSS software. The GDSS groups did not, however, show a time advantage over the non-GDSS groups. The GDSS groups generated more alternatives and criteria in approximately the same amount of time. This indicates a greater efficiency on the part of the GDSS groups.

c. Ho(3): Decision Confidence and Satisfaction

Ho(3) was rejected. GDSS groups were slightly less confident and satisfied with their final decision than the non-GDSS groups. Because the GDSS groups developed more alternatives there were more solutions to choose from. This apparently leaves greater doubt in the minds of the decision makers that they have selected the best possible answer.

Correspondingly, the level of satisfaction in the final decision is lower due to the uncertainty over that decision.

2. Questions

In addition to the stated hypotheses, the following questions were examined:

Q1. How did the communication channels differ in the two sets of groups?

Q2. Did the groups differ in their perception of the decision process?

Q3. How did the GDSS group members feel about GDSS in general?

Q4. What did the GDSS groups members think about Co-oP, the GDSS software used?

a. Communication Channels

Both groups were satisfied with overall communication. However, the non-GDSS groups were more satisfied than the GDSS groups with verbal and non-verbal communication. This result can be partially explained by the set-up of the GDSS decision room where the members were in a row facing a large projection screen. This stifled face-to-face communication and caused much information flow to go through the computer. A better design would have been to group the participants around a conference table in such a way that they could maintain eye contact, while still having access to their personal computer. The inclusion of a facilitator further hampered communication. Some group members in the GDSS room attempted to voice their opinions to him. Judging from the overall evaluation of communication satisfaction,

it appears that the GDSS assumed much of the communication load.

b. Decision Process

The GDSS groups felt the decision process was more coordinated. This result confirms prior research findings and is a possible advantage to a GDSS when a group is meeting for the first time. However, this facet could also be a detriment for groups operating in a situation where creativity is called for.

The participants saw no difference in the perceived level of efficiency of the group. This contrasts to the results regarding the greater number of alternatives and criteria generated by the GDSS groups. In actuality, the GDSS groups were approximately 30% more efficient than the non-GDSS groups during the problem solving process

c. GDSS in General

The GDSS groups did not feel inhibited by the software. The members had extensive experience using a computer and did not exhibit any "technophobia". The GDSS groups did feel that the problem could have been better solved in a typical conference room setting. This contrasts with nine out of twelve non-GDSS members who thought that computer aid would have been helpful.

d. Co-oP

Co-oP was used because it was readily available and had already been used by previous groups. This allowed

comparisons with other studies. Because Co-oP was not specifically designed for a decision room environment, the GDSS group members experienced some delay and frustration. The GDSS group members did not think Co-oP was user friendly and were neutral on its aid in helping organize their thoughts.

The results indicated that the GDSS did not improve the accuracy of the final decision. Decision speed was not appreciably affected, although non-GDSS groups were slightly faster.

Decision confidence and satisfaction with the decision was slightly higher in the non-GDSS groups. This is consistent with previous research. Levels of communication satisfaction were approximately equal for both groups. The non-GDSS groups were more satisfied with verbal and non-verbal communication. This was apparently caused by the poor design of the GDSS decision room. The GDSS groups felt their decision process was more coordinated. Perceived levels of efficiency and satisfaction with the process were approximately equal for both groups. The GDSS groups felt little inhibition brought on by the GDSS environment, but did feel a typical conference room could have handled the problem better. The GDSS groups did not like the software package used.

B. PROBLEMS ENCOUNTERED

The greatest difficulty encountered, during evaluation of the experiment, was the small number of test groups on which to base the results. Ideally, an experiment of this type would include at least twenty groups of five people.

The questionnaire itself, although extensive in the areas covered and evaluated, was designed on too narrow a scale. Instead of a five point Likert scale, a seven point Likert scale would have given a truer measure of the participants responses and allowed for more definite conclusions to be reached. Additionally, the point scale should have been continuous on a graded line, with participants allowed to place their answer to a question more precisely.

In order to have a better measure of comparison between a normal conference room setting and a GDSS decision room there must be a true GDSS decision room available. The room used in this study prevented easy face-to-face communication and forced a reliance on the GDSS.

C. FUTURE RESEARCH ISSUES

The results of this study suggest the following questions for future research:

* Why are levels of confidence in a final decision less for GDSS groups than non-GDSS groups?
* At what level of complexity does it become useful to use a GDSS?
* What characteristics should an effective GDSS possess?

Finally, it is hoped that further research might enhance the findings of this study.

D. SUMMARY

This study attempted to evaluate the effectiveness of using GDSS to solve a complex problem. Results obtained did not favor the GDSS environment. They did not, however, demonstrate a clear advantage for the non-GDSS method. Rather, there were areas such as group efficiency and coordination of the decision process where use of a GDSS was favorable. Other areas, such as communication and satisfaction, favored the non-GDSS environment.

Overall, the results of this study were inconclusive. It is therefore important to continue the empirical experiments of GDSS to determine the value and effectiveness of these systems in improving a group's problem solving process.

APPENDIX A

CASE BACKGROUND

Please familiarize yourself with background information about Drmecia by carefully reading several times the overview given below. This information will be important when you analyze the case given to your decision group. You should bring this overview to your decision session.

DRMECIA: AN OVERVIEW

BACKGROUND

Drmecia is a relatively large country (110 million people) that is the main economic, military, and political power in the Calnorian region. The government of Drmecia is unique; it is run by a Ministerial Council which has all the legislative, executive, and judicial power in the country. In short, this council makes laws, determines appropriate military action against adversaries, establishes trade policy, and so on. Although the council has extensive power, it is elected to four-year terms in open general elections by Drmecia citizens. The current council members are well regarded by the Drmecia citizens. And for the last 126 years Drmecia has enjoyed political stability.

GEOGRAPHIC LOCATION

As can be seen in Figure A.1, Drmecia is bordered on the west by an ocean, on the north by Nordland, on the south by Sudland, and on the east and northeast by Hinterland. All of these countries are relatively poor and could be viewed as targets of military opportunity by stronger nations. Two in particular, Nordland and Sudland, try to remain neutral in all conflicts; their poor economic base makes any armed conflict economically and politically unlikely.

Hinterland is the poorest of these countries. It has just undergone a military engineered revolution making it vulnerable and unstable at this time. Also, the current government is aggressive and particularly hostile to Drmecia. Hinterland is feared by both Nordland and Sudland, and is seen by Drmecia as a possible threat to the area's political and military stability.

THE MILITARY SITUATION

Approximately 750 miles west of Drmecia is Thorland, a military power equal in overall strength to Drmecia. Thorland's ruling body has had expansionist designs on smaller countries in other areas for many years. Consequently, Drmecia's Ministerial Council has been worried about the threat that Thorland poses to Drmecia's neighbors, particularly Hinterland. The council is particularly concerned that Thorland may use Hinterland as a staging ground for

attacks into Drmecia; or by arming Hinterland, Thorland may in effect be introducing an element of instability into the region that it could later exploit.

Thorland has an air force twice the size of Drmecia's. However, the distance to Drmecia--all across water--exceeds the sortie range of their fighters. Consequently, if Thorland were to attack Drmecia, their bombers would have to do so without fighter support, or they would have to rely on naval fighters launched from one small aircraft carrier. This ship is the queen of the Thorland fleet which is composed of 9 modern warships.

Drmecia currently does not fear an invasion or land attack from Thorland. However, a joint naval and air attack is possible, particularly in the area of Sloat where Drmecia's port and major industrial area is located. To protect itself, Drmecia has a mix of Army missile batteries, state-of-the-art Navy frigates, and Air Force planes, including various ground to air and sea to air missiles. Also, Drmecia has a surveillance system--Army radars and Navy "picket" ships--to watch for an enemy attack.

Hinterland does not have an air force, but it does have a large army of over 100,000 well-trained officers and men particularly adept at fighting a guerrilla-style war. Fortunately for Drmecia, the Hinterland army has little in the way of modern equipment. But Hinterland does pose a threat

to Drmecia because possible incursions across Drmecia's interior border.

DRMECIA'S POLITICAL-MILITARY POLICIES

The Drmecia Ministerial Council has formulated the following defense policy for the country:

* Drmecia wishes to be seen by other nations as a "fair", good neighbor that respects the autonomy of other countries.

* Drmecia wishes to project a posture of strength through appropriate exercise of its military and political power when appropriate.

* Drmecia will continue to maintain a surveillance capability that will provide it with sufficient warning so that it can use its anti-sea and anti-air coastal security forces to defend its borders.

* Drmecia will maintain an adequate armed forces to act as a deterrent from attack.

* Drmecia will not launch a first strike against another nation unless its national security is threatened.

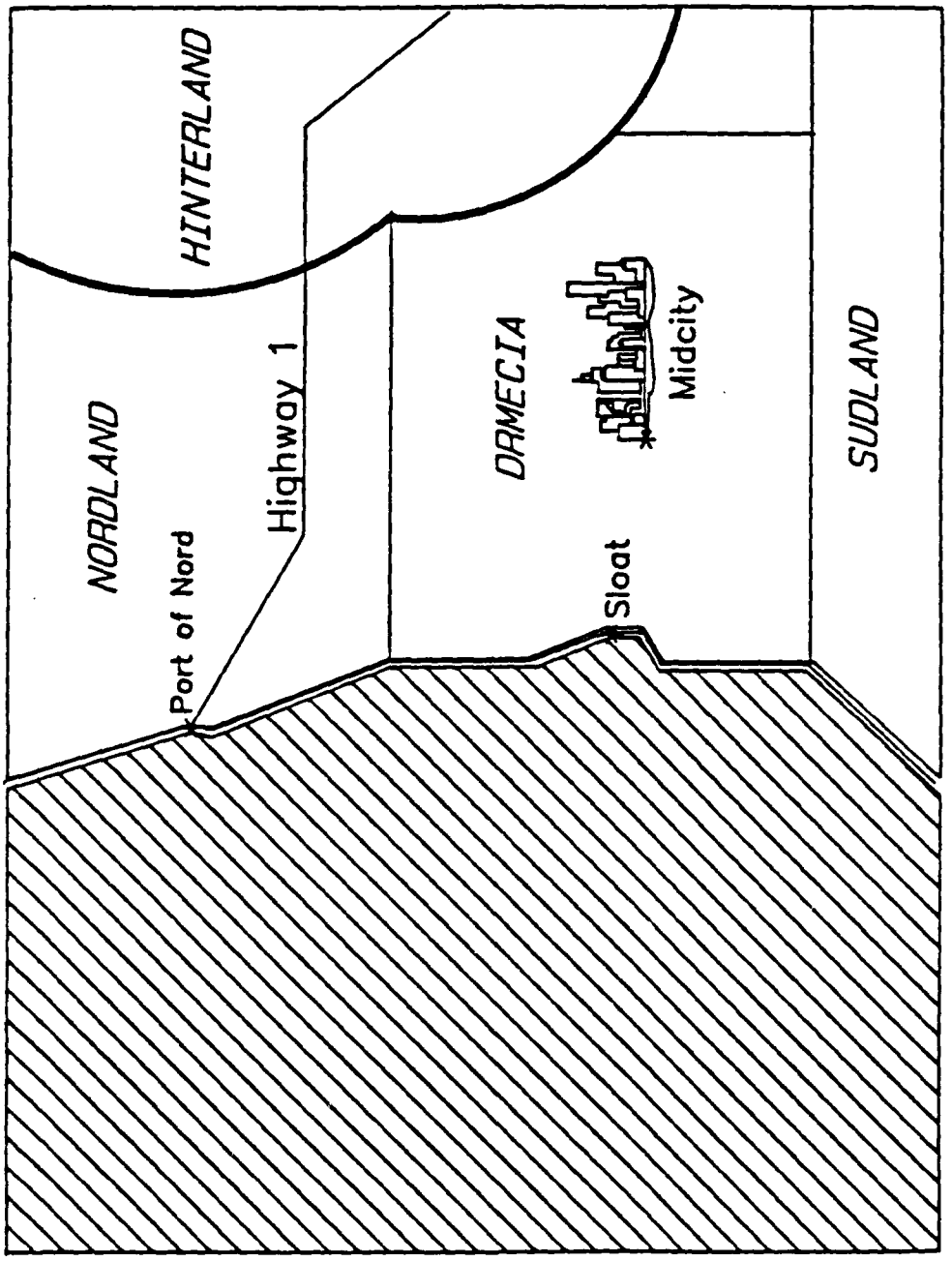


Figure A.1
Map

APPENDIX B

THREAT ANALYSIS AND RESPONSE CASE

Assume your group is the Ministerial Council for Drmecia. At this morning's Council meeting, your Chief of External Relations reports the following disturbing news.

THE THREAT

A confidential, highly reliable source from Nordland contacted a representative from Drmecia to report that Hinterland has almost completed negotiations with Thorland for a large shipment of Armored Personnel Carriers (APCs). At the same time, Hinterland's military leaders are pressuring Nordland to accept the APCs at the Port of Nord and allow their delivery via Route 1 to Hinterland (see map). The estimated delivery date of the APCs to the Port of Nord is one month from now. However, delivery may occur much sooner (in a matter of days).

NORDLAND'S POSITION

Traditionally Nordland has had a policy of neutrality and non-involvement toward Hinterland and other nations. Nordland's leaders are reluctant to agree to Hinterland's use of it's facilities because they are concerned that this decision could serve as an unacceptable precedent for other and even more disturbing requests. However, Nordland's

government is currently receiving subtle diplomatic, economic, and military threats from Hinterland. Because of Hinterland's large army, Nordland leaders believe their country would have difficulty staving off a Hinterland attack.

Nordland also receives a significant amount of economic aid from Drmecia; consequently, Nordland leaders felt compelled to contact Drmecia confidentially about the situation. The Drmecia Council, the shrewd statesmen that you are, quickly realize that the Hinterland threat may enable you to solidify your diplomatic, economic, and military relationship with Nordland by coordinating a treaty or some similar agreement. This alliance may enable both you and Nordland to exert diplomatic pressure on Hinterland and Thorland to solve this arms-delivery problem.

DRMECIA'S DEFENSE MINISTER'S VIEW

After receiving this news, you call on your Defense Minister for additional information. He states that if Hinterland receives the APCs, this will pose a significant threat to Drmecia. Because of the terrain capabilities of the APCs and their protective armor, the APCs could be used by Hinterland forces to attack Drmecia anywhere along their common border. Although the new Hinterland military government still faces pockets of resistance scattered through Hinterland, there is no credible internal threat that could justify the procurement of APCs to quell domestic strife.

This procurement may represent Hinterland's first step in the modernization of their Army.

After a lengthy discussion with your Defense Minister, you ask him to brief the Commanders in Chief of the Army, Navy, and Air Force and to require them to formulate position statements by late afternoon for your (the Council's) analysis.

SERVICE CHIEFS' POSITIONS

Army Commander in Chief: The army believes it has the capability to invade Nordland to intercept the APCs. The invasion would occur about mid-country where Nordland is rural and thus danger to Nordland citizens would be minimal. However, there is the possibility that evasive action by those transporting the APCs could extend the size and duration of the Nordland operation. The army commander, though, is confident that he has the resources and the expertise to destroy the transports and the APCs quickly and without significantly extending the scale of the operation.

If the APCs were attacked once they reached Hinterland, there may be difficulty finding the carriers (they could be quickly deployed to a number of staging areas). Also, Drmecia would face significantly stronger resistance fighting on Hinterland territory. The Army chief summarizes his position by stating, "If Hinterland is modernizing its army, I'd rather fight them now than later. Also, I want to fight

them in Nordland--I'd lose less of my people and equipment that way."

Navy Commander in Chief: The Navy Commander-in-Chief reports that the navy is capable of executing various sea options. For example, the APCs could be confiscated from Thorland freighters. If the freighters had military escorts, Navy frigates with the support of Drmecia air cover could inflict heavy damage on the Thorland navy and thus prevent the APCs from being delivered. Of course, Drmecia navy damage could be extensive.

Air Force Commander in Chief: The Air Force commander reports that an air strike against the freighters when docked at the Port of Nord can be conducted with minimal loss of aircraft. However, the complete destruction of the APCs cannot be guaranteed unless several attacks are made. These attacks may result in civilian casualties and the damage or even destruction of commercial ships from other countries. An air strike along Route 1 would be difficult because of the dense foliage and difficult terrain. Also, an attack against the APCs after they are delivered to Hinterland would risk loss of planes because of Hinterland's fairly effective air defense system.

MINISTERIAL COUNCIL'S JOB

You've gathered all the information and the opinions that you can. You realize that you must make a decision

that takes into account the political, military, and diplomatic implications of the situation. Since this is a complex decision, you decide to divide your decision-process into three steps:

* The formulation of alternatives to solve the problem.
* The creation of criteria--measures to use in assessing the effectiveness of alternatives such as world opinion, political risk, military risk, and so on.
* The selection of an appropriate alternative.

APPENDIX C

PARTICIPANT INSTRUCTIONS

Good morning/afternoon. Thank you for your time in participating in a group decision support system experiment, the results of which will be available for your review, if you desire, in about two weeks. You have been signed up for the GDSS/non-GDSS group.

By now, you should have read the overview of our fictional country known as Drmecia, as well as the Threat Analysis and Response Case you were just handed. Assume you are the Ministerial Council for Drmecia. At this morning's Council meeting your Chief of External Relations reports some disturbing news. All the information that is currently available is in the two and a half page case, so any further questions will be unanswered.

Your mission, as a group, is three-fold:

* Formulate alternatives to solve the problem.
* Create criteria--that is, measures to use in assessing the effectiveness of alternatives such as world opinion, political risk, military risk, and so on.
* Select an appropriate alternative.

These three tasks are reiterated at the end of the case. There is no time limit. At the conclusion of the session, you will be asked to fill out a brief questionnaire. To repeat what we would like from the group is a list of

alternatives, a list of criteria that you will use to weigh the alternatives, and a final decision as to what action you would take to solve the problem.

APPENDIX D

QUESTIONNAIRE

Please answer the following questions about the meeting you have just attended. Circle the answer that best reflects your opinion or attitude. If you have trouble answering a question, record your first impression or your "gut response". Some questions may seem similar to each other. Don't be concerned about this.

BACKGROUND INFORMATION

Age _____

Rank _____

Years in Service _____

1. Your level of experience working in groups (circle one)

Very High	High	Medium	Low	Very Low
1	2	3	4	5

2. Your level of experience making "real world" decisions in groups

Very High	High	Medium	Low	Very Low
1	2	3	4	5

ATTITUDINAL QUESTIONS

3. In general, to what extent were you satisfied with today's meeting?

Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
1	2	3	4	5

4. To what extent was today's meeting effective in solving the problem that the group confronted?

Very Effective	Effective	Neutral	Not Very Effective	Ineffective
1	2	3	4	5

5. To what extent do you feel committed to the group's solution?

Very Committed	Committed	Neutral	Not Very Committed	Very Uncommitted
1	2	3	4	5

6. How confident are you that the group's final decision best solved the problem?

Very Unconfident	Unconfident	Neutral	Confident	Very Confident
1	2	3	4	5

7. I would rate the quality of the group's decision as...

Poor	Fair	Average	Good	Very good
1	2	3	4	5

8. How satisfied were you with the number of decision alternatives your group generated?

Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
1	2	3	4	5

9. How satisfied were you with the number of criteria that your group generated?

Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
1	2	3	4	5

10. To what extent was agreement achieved among group members when determining the final criteria to be used to assess the problem alternatives?

Strong Disagreement	Disagreement	Neutral	Agreement	Strong Agreement
1	2	3	4	5

GROUP COMMUNICATION

11. To what extent were you satisfied with the amount of communication between yourself and other group members?

Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
1	2	3	4	5

12. To what degree did one individual or a group of individuals influence the group's decision?

High Degree	Somewhat	Neutral	Not Very Much	Not At All
1	2	3	4	5

13. The overall quality of the group discussion was...

Very Good	Good	Fair	Poor	Very Poor
1	2	3	4	5

14. To what degree did you feel free to participate in group discussion?

Never	Sometimes	Usually	Often	Always
1	2	3	4	5

15. To what extent were you satisfied with the amount of <u>verbal</u> communication between group members?

Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
1	2	3	4	5

16. To what extent were you satisfied with the amount of <u>non-verbal</u> communication among group members?

Very Satisfied	Satisfied	Neutral	Dissatisfied	Very Dissatisfied
1	2	3	4	5

<u>DECISION PROCESS</u>

17. I felt the behavior of the group was...

Very Goal Directed	Goal Directed	Neutral	Not Very Goal Directed	Aimless
1	2	3	4	5

18. I felt the group's problem-solving process was...

Very Coordinated	Coordinated	Neutral	Not Very Coordinated	Totally Uncoordinated
1	2	3	4	5

19. I felt the group's problem-solving process was...

Very Efficient	Efficient	Neutral	Inefficient	Very Inefficient
1	2	3	4	5

20. To what extent did you feel satisfied with the group's problem-solving process?

Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
1	2	3	4	5

21. To what extent did you feel that the group's problem-solving process was rational and scientific?

To A Large Extent	Somewhat	Neutral	Not Really	Not At All
1	2	3	4	5

GDSS GROUPS ONLY

22. To what extent did you feel that the GDSS environment inhibited communication among group members?

To A Large Extent	Somewhat	Neutral	Not Really	Not At All
1	2	3	4	5

23. Did the GDSS environment inhibit you from speaking?

To A Large Extent	Somewhat	Neutral	Not Really	Not At All
1	2	3	4	5

24. Do you feel that the GDSS environment changed the way you would solve a problem of the type your group faced?

Not At All	Not Really	Neutral	Somewhat	To A Large Extent
1	2	3	4	5

25. To what degree was Co-Op user friendly?

To A Large Degree	Somewhat	Neutral	Not Really	Not At All
1	2	3	4	5

26. To what extent do you believe this problem would have been better solved in a typical conference meeting room environment?

To A Large Extent	Somewhat	Neutral	Not Really	Not At All
1	2	3	4	5

27. To what extent did Co-Op help you organize your thoughts?

Not At All	Not really	Neutral	Somewhat	To A Large Extent
1	2	3	4	5

Thank you for your time and assistance! Results of the experiment will be available August 1 at your request.

RESULTS

	NON-GDSS	GDSS
AGE	31.67	33.69
SVC YRS	9.25	10.44
Q1	2.50	2.56
Q2	3.00	2.63
Q3	2.17	2.25
Q4	1.75	2.00
Q5	1.50	1.63
Q6	3.75	3.75
Q7	4.75	4.38
Q8	1.58	1.81
Q9	2.08	2.19
Q10	3.92	4.56
Q11	1.75	1.81
Q12	2.92	2.56
Q13	1.67	1.88
Q14	4.75	4.44
Q15	4.50	4.06
Q16	2.50	2.94
Q17	1.92	1.81
Q18	2.42	1.94
Q19	2.08	2.00
Q20	4.00	4.00
Q21	1.92	1.81
Q22	-	3.06
Q23	-	4.25
Q24	-	2.69
Q25	-	3.69
Q26	-	2.69
Q27	-	3.00

APPENDIX E

RESULTS

Group	Time (mins)	Number of Alternatives	Number of Criteria	Final Answer
GDSS #1	73	16	11	Diplomacy
GDSS #2	75	21	17	Locate/publicize
GDSS #3	75	19	14	Confirm threat & seek assurance from Thorland
GDSS #4	50	18	11	Alliance with Nordland
Average	68.25	18.5	13.25	
NON #1	75	21	8	Talk with Hinterland, Mobilize military, Prepare for blockade
NON #2	45	10	5	Blockade with strong diplomatic pressure on both Thorland and Hinterland
NON #3	57	10	7	Diplomacy with Nordland and blockade port
Average	59	13.67	6.67	

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