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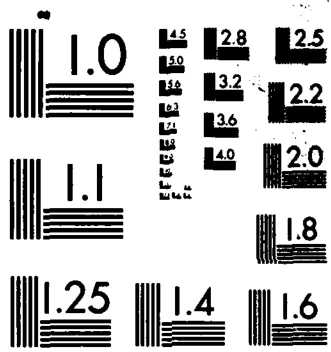

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TECHNOLOGY TRANSFER
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User Considerations
In the Acceptance and Use of
AI Decision Aids

Robert R. Mackie
and
C. Dennis Wylie

November, 1985



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## In the Acceptance and Use of
## AI Decision Aids

**Robert R. Mackie**

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**C. Dennis Wylie**



**November, 1985**

**Prepared By:**

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The purpose of this study was to identify critical user acceptance issues in applying artificial intelligence (AI) technology (e.g., "expert systems") to military decision aids, and to develop a technology transfer plan. The application of new technology does not necessarily yield a "good" product, and even good products do not necessarily succeed on their own merits. Product development and introduction must consider the perspectives of potential users, especially when use of the innovation can be regarded as

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A selective literature review was conducted and 229 U.S. military officers were surveyed using a structured rating and interview technique. The officers generally expressed optimism about the potential value of AI, and most believed: decision rules in their area could be used in AI; AI could be a major asset in relaxed time decision making; AI could allow consideration of more data per unit time; and AI could allow identification of more decision options. However, negative beliefs held by many officers need to be considered carefully: compared to humans, AI is limited by lack of "gut feeling" which is considered important in tactical decision making; AI cannot emulate human thinking; AI will not be useful in time-constrained situations; an "expert" data base does not guarantee operational validity; AI will probably increase the decision maker's workload; inexperienced officers may use AI uncritically, and become dependent on it; AI may hamper decision-making freedom because decisions with bad outcomes may be unfavorably compared to recordings of what the AI device recommended.

A number of general design issues were identified, and several man-machine interface preferences were determined, including the desire for: display of historical data on request; use of probability estimates; embedded training and on-line tutorial; auto mode settings with user override; easy updating; suggestive rather than authoritative output; and brief rather than conversational output.

A technology transfer plan based on the findings of this study is presented which stresses communications with potential users, involvement of users in design, design for acceptance, and demonstration.

# ACKNOWLEDGEMENTS

Many people gave generously of their time to help us meet the objectives of this project. We are particularly indebted to Professor Sovereign at the Naval Postgraduate School, Cdr. Lassman at Fleet Combat Training Center Pacific, and Capt. Steutzer at Tactical Training Group Pacific for coordinating our interviews at those establishments. We are grateful to the numerous professors and instructors who arranged for their classes to participate. Most importantly, we sincerely thank the men and women of all branches of the military who participated in the survey. Their professionalism was clearly evident, particularly in their written comments and remarks during group discussions. We believe they have made an important contribution to the process of transferring new technology to practical military application.

We are also grateful to our technical monitor, Dr. Mort Metersky of Naval Air Development Center, and to Lt. Lee Goodman. They gave us the benefit of their ideas during several useful planning sessions, constructively reviewed the survey procedure in action, and even assisted in some on-the-spot data tabulation to facilitate quick feedback to the survey participants. The project definitely benefited from this close working relationship.

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## SECTION 1
## EXECUTIVE SUMMARY

### INTRODUCTION

The purpose of this study was to identify critical user acceptance issues in regard to applications of artificial intelligence (AI) technology for aiding military decision making, and to develop a plan to maximize beneficial applications of this technology in a way that will ensure user acceptance. The Navy's research and development community is devoting considerable resources to artificial intelligence and "expert systems" technology in relation to decision aids. These developments hold great promise of enhancing system performance. However, to date, the history of innovation acceptance in the Navy in the domain of decision aids has been largely disappointing. The present state of knowledge regarding innovation acceptance suggests many reasons why. Some relate to a mismatch between the user's perception of need and the nature of the decision aiding device; some relate to problems encountered by the device in the operational environment; some relate to operator interface problems; some relate to reservations about the data base and rules of prediction; and some relate to issues of training and device supportability.

It is of paramount importance that issues and perceptions of the intended users of innovative devices be addressed as early in the design process as possible. Good products do not necessarily succeed on their own merits. The potential user's perspectives must be brought to bear especially with any equipment whose use is likely to be regarded as optional. Although earlier studies had been directed at acceptance issues in regard to decision aids (for example, Mackie 1980), the application of AI technology to the domain of decision making in the Navy had never before been addressed, and it was felt that there could be special considerations, either favorable or unfavorable, that needed to be taken into account in a strategy that would ensure long term use and acceptance of such developments by Navy personnel. To this end, a structured rating and interview procedure was conducted with 229 U.S. military officers (80% of whom were Naval officers) to identify attitudes, beliefs, and requirements that are likely to affect acceptance of AI in the area of decision augmentation.

## OVERVIEW OF RESULTS

The survey results indicated that AI technology applied to the decision making function is perceived as having a number of important, positive attributes that can be used by a Change Advocate to promote acceptance of this new technology. (For the role of the Change Advocate in innovation acceptance, see Figure 2, page 12). However, AI technology is also perceived as having a number of potentially negative attributes that need to be addressed either by the dissemination of accurate technical information to potential users or by demonstration projects, or both. These perceptions, together with some other general system design considerations are briefly summarized below. A detailed discussion of each item can be found in the main text using the page number reference provided.

### Perceived Positive Attributes of AI Decision Aids

Following are the most agreed upon positive perceptions about AI decision aids:

- Most military officers are optimistic about the potential value of AI technology for aiding the decision making function. (Page 22)
- Most believe it is technically feasible to incorporate decision making rules into a data base in their area of technical expertise. (Page 25)
- Most believe that AI decision aids would be a major asset to decision making during mission planning and other relaxed time applications. (Page 37)
- Most believe that an AI based decision aid will enable them to consider more information per unit time than they can unaided (this addresses a major perceived need). (Page 47)
- Most believe that an AI based decision aid would enable them to identify more options for decision making and that the device would also help them in evaluating those options. (Page 47)

## Negative Perceptions

The Change Advocate will need to address the concerns listed below, either by providing authoritative information to counter these negative beliefs (where that is appropriate) or by demonstration (operational trial).

- AI decision aids are limited because they cannot incorporate considerations reflected in the "gut" feeling of the military decision maker about the situation. (Page 28)
- Most officers doubt that AI devices can "satisfactorily" emulate human thinking processes. (Page 28)
- A significant minority of officers do not think AI decision aids will be of practical use in urgent (time-constrained) situations. (Page 41)
- Incorporation of the best available "expertise" into the data base is not considered adequate insurance that the AI decision aid will promote better decisions (operational demonstration is essential). (Page 35)
- Many officers believe that an AI decision aid will increase, not decrease mental workload. (Page 54)
- There is concern that inexperienced officers may accept the output of an AI decision aid in an uncritical fashion, and, that they may become heavily dependent on such a device. (Page 63)
- There is concern about possible career consequences if the decision maker rejects the suggestions of the decision aid and post hoc analysis shows that he might have made a better decision if he had accepted those suggestions. (Page 68)

## General Operational Issues

Navy officers have a number of other perceptions about AI decision aids that, while neither strongly positive nor strongly negative in orientation, are matters that can significantly impact the acceptance process.

- Most officers want to understand how the decision rules function. (Page 33)
- Most officers believe that generalizability of the decision aid's outputs to new tactical situations will necessitate means for rapid, frequent updating of the data base and the decision rules. (Page 44)

- There is no clear perception concerning the value offered by AI systems in dealing with uncertain data. (Page 51)

- Most officers are not really convinced that AI decision aids will help them under high stress conditions. This is associated with the fact that they regard it as impractical to consult a decision aid under circumstances that call for rapid critical decisions. (Page 57)

- There is considerable uncertainty as to how easy it will be for the user to communicate (interface) with an AI system, or to amend the data base. (Page 85, 87)

- Most officers are uncertain about whether an AI based decision aid will be more, or less, acceptable than aids based on conventional mathematical algorithms. (Page 64)

- Most officers believe that although a decision aid may work extremely well in the laboratory, there is danger of catastrophic failure in the operational environment. This makes demonstration in the operational setting a necessity. (Page 52)

- Officers with extensive computer system backgrounds are generally more positive toward the application of AI technology to decision making than officers with little or no computer background. This may be important to the advocacy process. (Page 22)

## General Design Issues

Although many design considerations will be specific to a particular application, the following general design guidelines were important to this sample of military officers.

- There should be user control of the number of situation/decision alternatives the AI device should display under a given circumstance. (Page 73)

- There should be user control of system functions that permit him to determine the basis for recommendations made by the AI device. (Page 78)

- There should be user control of the call-up and display of historical data in the AI system that bears on the decision at hand. (Page 80)

- The display of probability or confidence estimates for each alternative recommendation is strongly desired, preferably ordered from highest to lowest. (Page 81)

- Computer knowledge required to operate the decision aid should be minimal. (Page 82)

- An embedded training system is strongly desired, as well as tutorial assistance during operation. (Page 83)

- There should be automatic setting of operating and display modes, with the capability for user override. (Page 84)

- It should be easy to modify, delete, or add decision rules (although many officers believe that this capability, if provided at all, must be strictly controlled). (Page 87)

- A suggestive, rather than authoritative output tone is desired. (Page 91)

- A conversational (human-like) output tone, while regarded as "user friendly," is less preferred than brevity of output and a tone that would be appropriate for a staff officer (many officers viewed consulting an AI decision aid as similar to consulting a staff officer for inputs related to the decision at hand). (Page 91)

- The potential capability of an AI system to adapt to the particular decision making style of an individual user is considered of dubious value. (Page 96)

It is notable that, for the most part, the views outlined above did not differ as a function of the officers' primary profession in the Navy (surface warfare, air warfare, engineering, administration), or as a function of rank. As previously noted, those with strong computer backgrounds were generally more positive toward the concept of AI decision aids than officers with little computer background, but all groups were basically favorable.

In Section 4 of this report the detailed results for 45 different considerations relating to the perceived usefulness and design of AI decision aids are reported in detail. The reader is encouraged to examine the data that support the generalizations listed in this summary. We have included representative and/or particularly salient comments volunteered by the officers on most of these issues. These comments, perhaps more than anything else, will provide the reader with an appreciation of the many considerations raised by the potential users of AI decision aids.

## TECHNOLOGY TRANSFER PLAN

A technology transfer plan was developed based on the findings of this study. A schematic representation of this plan is shown Figure 1. The plan is discussed in detail in Section 5 "A Plan for Technology Transfer." We believe that implementation of a plan like this as part of an AI decision aid development would significantly enhance the probability of user acceptance and the beneficial application of the new technology.

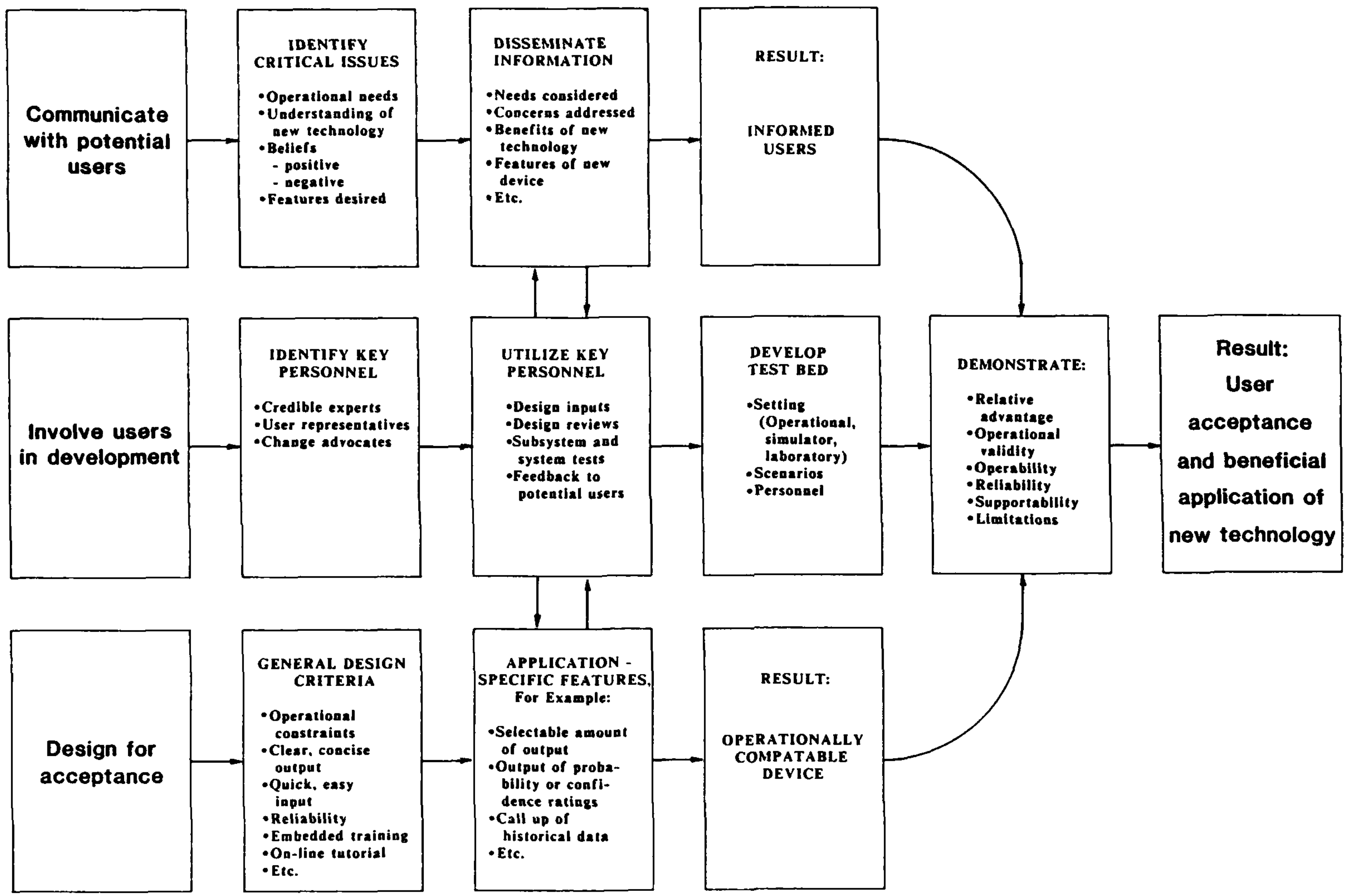



Figure 1. "A Technology Transfer Plan"

# SECTION 2
# BACKGROUND AND STUDY METHODOLOGY

## INTRODUCTION

Recent advances in the technology of artificial intelligence and decision aids offer the promise of optimizing the decision making process in many areas of Naval warfare. However, to assure that the maximum benefit is obtained from this new technology, a number of considerations regarding technology transfer and user acceptance must be taken into account. User acceptance of innovative technology is often highly application-specific, and therefore appropriate information must be developed concerning the factors that influence acceptance or rejection in a proposed application. This study was directed at the development of general and specific knowledge regarding the application of artificial intelligence and expert systems to decision making in the Navy. It deals with a behavioral domain that traditionally has been the province solely of human beings.

### The Problem

The Navy's research and development community is devoting considerable resources to artificial intelligence (AI) and "expert systems" technology. These developments hold great promise of enhancing system performance and fleet readiness through their application to decision augmentation. They could be especially important in situations where information complexity is great and the time available for decision making is minimal. Research has shown that people experience considerable stress under these circumstances, (e.g., Wylie and Mackie, 1985) and, under stress, it is known that decisions are sometimes made on the basis of a narrowed focus of attention, with the inadvertent exclusion of some relevant items of information, and interpretive errors that would not be made under less stressful circumstances.

Despite the promise of artificial intelligence and expert systems for ameliorating these problems, experience to date, and a good body of prior research as well, has suggested that the acceptance of such innovations by Navy personnel may be contingent upon considerations sometimes quite subtle, that systems designers are not likely to take into account. Prior research (Mackie, 1980; Mackie and Wylie, 1981) has clearly shown that a wide variety of factors influence the acceptance of innovative developments. Other research (Wylie and Mackie, 1982) has shown that organizational factors in the Navy have major impacts on the acceptance of innovative features in new equipment design. The result has sometimes been a series of disappointments with respect to the process of technology transfer to the operational setting.

## Information Requirements

The approach offered by artificial intelligence systems differs in significant ways from earlier decision aid developments, and it was not at all clear how this new technology might influence acceptance of decision aids that incorporated it. Because of the potential benefits of AI technology, and in order to realize the benefits from the substantial investments the Navy has made, it was considered important to research the issues and identify the steps that need to be taken to maximize the probability of user acceptance in arenas where this technology is most likely to be beneficial. The operational Navy's general attitude toward the value of expert systems, the conditions under which such systems might be used, and the nature of reservations that might influence acceptance on the part of the users needed to be identified. Further, it was desired to learn whether there were general considerations that apply across all areas of Navy warfare, or whether some of them were specific to particular areas of application or operating environments. It was felt that the issues might be technical (e.g., how confident is the user of the expertise of the "expert" system), or organizational (how does use of a decision aiding device affect the officer's responsibilities for the outcome) or, they might be practical (to what extent do various constraints in the operating environment determine the user's acceptance).

The last significant research on these types of issues had been performed 5 years earlier (Mackie, 1980). A great deal of advancement in AI technology had occurred since that time and public awareness of expert systems had increased. It was considered likely that there presently exists within the Navy a far different set of considerations with respect to the advantages and problems of operationalizing this technology today than was true 5 years ago. In the interest of effective direction of future developments and maximizing the probability of successful technology transfer, it is important that the perspectives of the potential users be identified and taken into account in all such new developments. It was the purpose of this study to identify those perspectives as they presently exist and to formulate a strategy for introduction of AI based decision aids that would maximize the likelihood of user acceptance and ultimate benefit to the Navy.

## Technical Approach

Since the application of AI technology/expert systems for the augmentation of the decision process is in its infancy, there was no history of successes or failures in military applications that might be looked to as "lessons learned" that might apply to the design of newly developing systems. Because the focus of our concern was on issues that would influence acceptance in the decision making domain, it was considered necessary to identify the perceived characteristics of such systems (i.e., what they would be like in the future and what would make them acceptable or unacceptable) from a representative sample of the potential users, i.e., naval officers in vàrious specialty areas. The operational Navy's general attitude toward the value of expert systems, the conditions under which they might be used, and the nature of reservations they may have that influence acceptance had to be identified. Further, it was desirable to determine whether there are general considerations that apply across all areas of Navy warfare, or whether some of them were specific to particular areas of application.

## User Acceptance is not Guaranteed

Given the increasing demands on human decision makers posed by modern Naval warfare, it might be presumed that AI decision augmentation would enjoy enthusiastic acceptance and use. The history of innovation acceptance however, both in the Navy and other institutions, strongly cautions against this assumption. Not only have other innovations not achieved acceptance and use, but many have proved particularly vulnerable to misuse and even outright rejection. Many factors operate to determine the level of acceptance and method of use of innovations. Behavioral scientists have identified certain principles of innovation acceptance which, if tailored to specific applications, will enhance the likelihood of acceptance. While following these principles will no ensure acceptance of a poorly designed product, ignoring them may well lead to unnecessary resistance and even rejection of products that are fundamentally "good."

## Psychological Factors Are Important

There can be apparent psychological overtones to the non-acceptance of innovative developments. As Rogers and Shoemaker (1971) have pointed out, all innovations carry some degree of subjective risk to the individual. Some innovations appear to involve an erosion of responsibility in the intended user's established area of expertise, and thus pose a threat to self esteem. In addition, a strong "not invented here" syndrome sometimes develops among personnel who consider themselves experts in the subject matter addressed by the innovation, but who feel that their expertise was not properly consulted during its design. This can be a source of resistance even in a military organization where the decision to adopt the innovation is apparently made by authority. In fact, Rogers and Shoemaker suggest that changes brought about by the authoritative approach are more likely to be discontinued than those brought about by more participative approaches.

## Special Problems In Regard To Decision Aids

It is likely that some innovations will suffer greater "psychological" resistance than others. Decision aids appear to be a particular candidate for resistance because they are viewed by some as encroaching on an area traditionally viewed as the exclusive domain of expert judgment and operational experience. It should be noted that it makes little difference whether the decision aid actually unsurps some of the decision makers traditional prerogatives or not; the important issue is whether or not it is perceived as doing so. Senaiko (1977) in reviewing ONR's program of development for operational decision aids observed that there has been a long and not always satisfactory history of R&D aimed at automating certain elements of Naval command and control systems. He feels that a great deal of attention will have to be paid to the process of introducing new decision aids into existing Naval systems.

## Importance of the User's Point of View

One of the most important and perhaps difficult tasks for a development agency is understanding the user's needs from the point of view of the user. Efforts to introduce improvements often fail because the developers are more invention minded than they are user oriented. They sometimes "scratch where the user does not itch." It seems obvious that an innovation program will generally be successful to the degree to which the program is compatible with user needs. What is not so obvious is that the user's felt needs may be quite different from what the development agencies think they are. Notice that this problem is not necessarily based on what the user truly needs (or will need), but rather his current perception of the need. The two are not necessarily the same. For example, it is quite possible that at the time an innovation is proposed, the user may not fully appreciate the extent to which it will be required in the future.

## Rational Obstacles to Acceptance

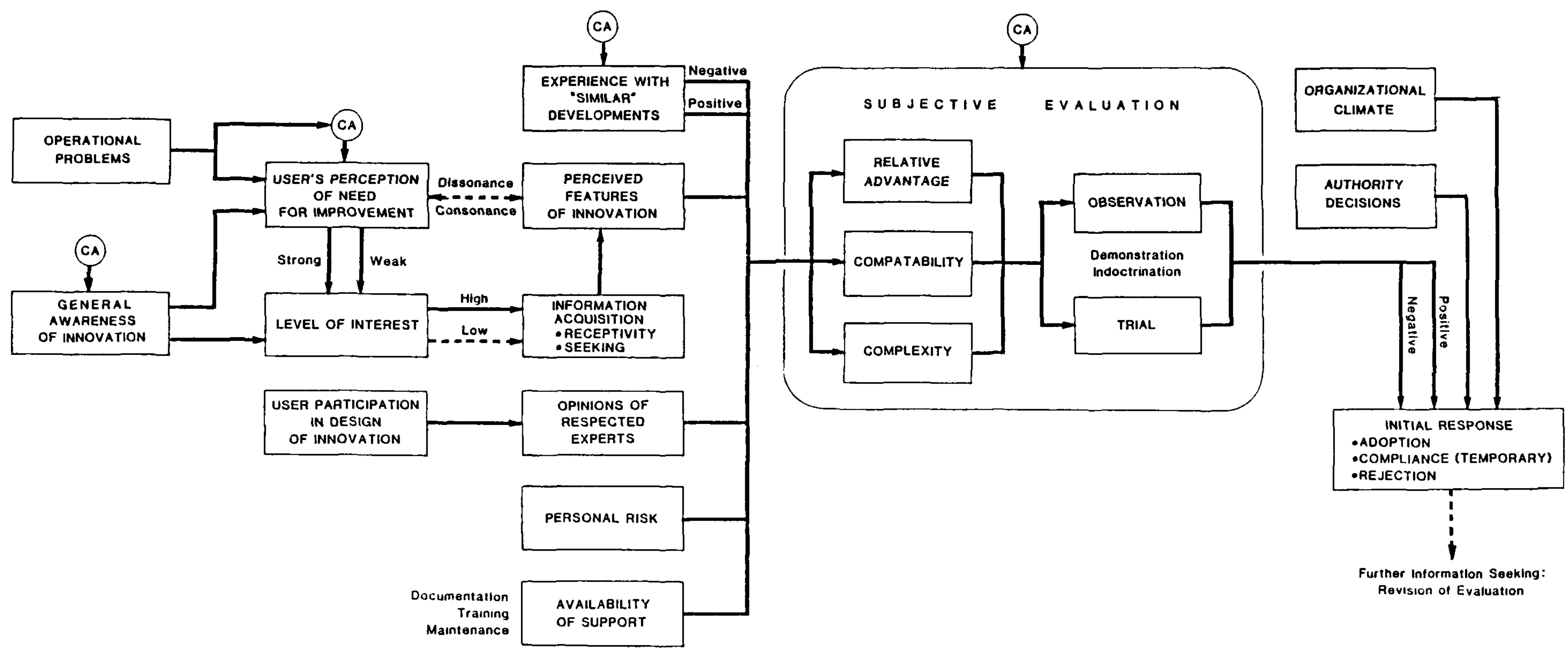
While these and other subjective influences can have substantial effects on innovation acceptance, in many cases there is a strong element of rationality in the rejection of innovative devices. In short, there is sometimes a real mis-match between the user's and the designer's perception of the operating problem, or a failure by the designer to recognize certain constraints faced by the users in the operating environment. Rightly or wrongly, Naval personnel often feel that system designers have failed to adequately appreciate their operational needs and constraints. To the extent that this is true, user resistance is both rational and to be expected.

## A Model of the Acceptance Process

Technology transfer has been a subject of intense study for many years by psychologists, sociologists, and other researchers, and a voluminous research literature exists. Mackie (1980) reviewed the problem from the standpoint of factors affecting acceptance of decision aids in the Navy, and formulated a model of the acceptance process which is shown in Figure 2. It is evident that many factors play a role, and many of them interact, in determining user acceptance of new technology. These factors are defined and their interrelationships are described in more detail in Appendix A. Briefly however, it should be noted that the user's subjective evaluation of an innovation depends upon a diversity of influences including how well its perceived features match what is perceived as needed for improvement, the user's appraisal of the relative advantage of the innovation compared to how things are done now (this involves a number of subordinate issues including but not limited to operational complexity and compatibility with other parts of the total system within which it is to be used), his assessment of how well

Figure 2

MODEL OF INNOVATION ACCEPTANCE PROCESS




Note: CA = Change Advocate. For explanation see Appendix.

respected expertise has been incorporated into the innovation, the degree of personal risk or erosion of his own expertise that adoption of the innovation suggests to him, and the availability of required support for using and maintaining the innovation. In addition to all of these personal kinds of considerations, there can be important organizational influences that can act to either facilitate or inhibit acceptance.

## METHODOLOGY

The advent of AI based decision aids creates a host of considerations that may differ from earlier decision aid developments, and it was not at all clear how experience with previous developments might apply. Because of the potential benefits of this technology, and in order to realize the benefits from the substantial investments the Navy is making and is planning to make, it was important that research be conducted to identify factors that will influence, one way or the other, the likelihood of user acceptance.

The operational Navy's general attitude toward the value of AI decision augmentation systems, the conditions under which they might be used, and the nature of reservations they may have that influence acceptance were to be identified. Further, it was desired to determine whether there are general considerations that apply across all areas of Naval warfare, or whether some of them were specific to particular areas of application.

### The Research Tasks

The study methodology employed involved five identifiable tasks:

1. Establish information requirements. The first objective was to identify characteristics of AI based decision aids that were hypothesized to possibly relate to the acceptance of this technology by potential Navy users. Two approaches were used: 1) discussions were held with the representatives of the development agencies concerning general characteristics that might be implemented in AI decision aids; 2) a review was conducted of technical and semi-technical publications on AI, particularly where those developments had been aimed at decision augmentation. There had been some previous developments with apparent successful application of AI

technology in the decision making arena, but there was only sketchy evidence that these developments were regularly being used for their intended purpose. The purpose of the literature review was to identify claims and issues, and various claimed advantages of AI decision aiding systems, that should be explored in a survey of the attitudes, beliefs, and preferences of a representative sample of Naval officers.

2. Develop survey instruments and survey procedures. Based upon the information requirements identified during step one, appropriate survey instruments and procedures were developed. These included briefing materials to acquaint the survey participants with the objectives of the study and the procedures they were expected to follow. The basic survey instrument was a series of 44 rating scales calling for an expression of agreement/disagreement with particular issues. Each scale was devoted to one issue or claim relating to the benefits of AI/expert systems in support of the decision making process. In many cases there was no existing hard evidence, one way or the other, in support of the various claims. It was important nonetheless, particularly in terms of the model of the acceptance process (Figure 2) that the current state of knowledge and belief among the potential users of AI decision aids be established with respect to each of these claims and characteristics. Special attention was directed toward the development of a rating format that was economical of the participants' time, yet highly productive of well considered viewpoints concerning the acceptance issues.

   An example of the questionnaire is included as Appendix B. Only the first page of rating scale statements is included, but all the statements are repeated verbatim in Section 4, "Results and Discussion."

3. Conduct Survey. The survey instrument was designed to generate useful information on its own. However, it was also to be used as a stimulus to more in-depth consideration of the issues. It was felt that a great deal of important qualitative information would be forthcoming through discussion of the responses to various items in the survey instrument. Therefore the following general procedure was used with all officer groups that participated in the survey (with a few exceptions):

   Project representatives briefed each participating group on the Navy's purpose in conducting the survey and then passed out the rating booklets. Since the participating officers varied extensively in their knowledge of AI/expert system concepts, a written introduction was provided along with the survey instrument to provide, as much as possible, a common frame of reference against which the survey questions were to be answered. Although even professionals in the field have some difficulty in defining what they mean by an AI system, we believe that this introduction by example was successful for its intended purpose. (See Appendix B).

   As the officers responded to each of the 44 items in the survey instrument, they were encouraged to volunteer their written comments with respect to any or all of the items as they saw fit. On the average it took about 40 minutes to complete the questionnaire.

After the questionnaires had been collected, project personnel retired to a convenient working location and performed a quick data analysis (medians and inter-quartile range) for each item. These were then plotted on images of the rating scales themselves for presentation by vugraph. A day or two following each groups' completion of the questionnaire, these preliminary results were presented for discussion. Each item was considered in turn and the survey participants were invited to offer their comments concerning the reasons for the response pattern. This procedure often developed lively discussions, and healthy debates, that reflected a variety of perspectives on the issues that could not have been obtained in any other way. These discussions were recorded and later transcribed for analysis.

In the interest of economy it was necessary to concentrate the data collections where small groups of Naval officers were available as opposed to trying to contact individuals on a one-to-one basis. For this reason, and also because of the practical difficulties involved in interrupting shipboard routines, the survey was conducted at Navy training institutions where officers were in various courses of advanced instruction. Data collection concentrated at the Naval Postgraduate School, Monterey, California, the Fleet Combat Training Center, Pacific and the Tactical Training Group, Pacific, San Diego, California. Details concerning the technical backgrounds and experience of these officers is provided in Section 3. Every effort was made to ensure participation of officers with a wide variety of backgrounds and military specialties so that the results could be generalized to many areas of application within the Navy. The participating groups generally ranged from 10 to 20 in number.

4. Analyze Data. The rating scale data were analyzed using a variety of statistical procedures (see Appendix C for details). Handwritten comments and the recorded group discussions were transcribed and collated.

5. Report Results. This report was prepared to summarize the work performed in the first four tasks and to present the implications of the findings for the design and introduction of AI-based decision aids.

## SECTION 3
## SURVEY PARTICIPANTS

### GENERAL CONSIDERATIONS

The validity of any survey is, of course, a direct function of the degree of which the sample of personnel surveyed is representative of the population to which one wishes to generalize. With respect to the acceptance and use of innovative technology, particularly in the domain of decision aids, the question of representativeness has to be answered with respect to the expected applications. Presumably, some applications might be oriented only toward very senior Naval officers (e.g, Battle Group Commanders). In other cases they might more likely be oriented toward middle grade officers performing command staff support functions, or tactical control functions. Presumably they might also be used by very junior officers because, theoretically at least, they might be the group most likely to benefit by ready access to the "expertise" of others. (For reasons discussed later, however, Navy officers have some reservations about the use of AI based decision aids by officers who have relatively little operational experience.)

A second kind of consideration has to do with who will make the decision as to whether, or under what circumstances AI decision aids are to be used. This decision might fall to senior officers because of the authority of their positions. While this may in some instances be true, we are inclined to think that the attitudes of experienced middle grade officers, upon whom senior officers depend for much of their information, might have more to do with how well user acceptance eventually develops.

Another consideration has to do with the extent to which relatively senior versus more junior officers are "comfortable" with computer based systems. It has been suggested that there may be a "generation gap" with respect to new technology in this regard. For reasons that we document later, we doubt that this is a particularly important consideration. Acceptance or rejection, we believe, is going to depend on far more fundamental issues which have to do primarily with the demonstrated benefits of the system.

## KEY CHARACTERISTICS OF THE SURVEY PARTICIPANTS

### Branch of Service

Because many of the survey participants were contacted at the Naval Postgraduate School, there were a few non-Navy participants. Of the total sample of 229 U.S. officers, 80% were from the Navy (including 4% from the Marine Corps), 10% were Army, 6% were Coast Guard, and 4% were Air Force. In the course of analyzing the data, as well as in the group discussions, it was clear to us that the major considerations with respect to AI decision aids did not differ fundamentally as a function of the branch of service. This was not to say that there would not be system specific considerations when any particular application of AI technology is developed, but simply rather that the general considerations were fundamentally the same for all officers. Occasionally, there were differences as a function of the officer's military specialty, and these are described in the text. These were rarer than might be expected however, and we are inclined to believe that the results not only are generalizable both to Navy officers in general, but perhaps to military officers in general.

### Military Experience

The officers who participated in this study had a mean of 9.7 years of active duty, with a standard deviation of 4.8. The distribution of rank was as follows:

| | | | |
|---|---|---|---|
| Ensign | (0-1) | - | 5% |
| Lt. JG | (0-2) | - | 5% |
| Lt. | (0-3) | - | 52% |
| Lt. Cmdr. | (0-4) | - | 28% |
| Cmdr. | (0-5) | - | 7% |
| Capt. | (0-6) | - | 1% |

The distribution is clearly peaked at the middle grades. For the reasons discussed above, we consider this entirely appropriate for the objectives of the survey. Further, as will be seen in Section 4, the rank of the participants very rarely had anything to do with the opinions and beliefs that were elicited by the survey instrument, i.e., there were no differences as a function of military experience.

## Military Specialties

The survey participants represented virtually all major areas of activity in the Navy:

| | | |
|---|---|---|
| Surface Warfare | - | 29% |
| Air Warfare | - | 21% |
| Administration | - | 24% |
| Engineering | - | 15% |
| Land Combat | - | 6% |
| Submarine | - | 2% |

## Education

85% of these officers held bachelors degrees, 13% had masters degrees, and 1% had Ph.D.s. Their major areas of undergraduate emphasis were: science, math, and engineering, 46%; liberal arts, 28%; administration, 26%

## Computer Experience

It was hypothesized that officers' attitudes and beliefs, and indeed knowledge of AI systems and their possible application to decision augmentation, would vary as a function of their prior exposure to computer based systems. Indeed, our only concern about the representativeness of the survey participants was that those from the Naval Postgraduate School might be more at ease with computer systems, and therefore more receptive of computer-based decision aids.

. To determine whether the degree of computer experience was a determining factor in officer attitudes toward the applications of AI systems in the Navy, a "computer experience" score was developed for each participant from information he supplied on a biographical data sheet. This score was a composite taken from several entries made by the participant in the following areas:

1. Prior experience in working directly with computers.
2. Actual experience in writing computer programs, including familiarity with more than one language.
3. Completion of computer science courses.
4. Degree of acquaintance with artificial intelligence.
5. Courses taken in cognitive science or behavioral science that relate to decision making.
6. Direct experience with computer based operational decision aids.

A summary of these data is given in Appendix B showing what percentage of the total sample responded in various ways to the specific items making up the 6 categories listed above. Using these data, a composite score was developed (using procedures described in Appendix C) which was treated as a single variable reflecting overall computer experience. (Figure 48 in Appendix C shows the distribution of these composite scores.) In the extreme, they ranged all the way from individuals who professed "little interest" in computers, who had never taken a computer science course, were unfamiliar with AI, and had no experience with courses or devices relating to decision making, to, at the other extreme, officers who had extensively used a "personal" computer, had written computer programs in multiple languages, had taken many computer science courses, had read technical articles or books about AI, and so forth.

The survey results were systematically analyzed not only as a function of rank, military specialty and current assignment (Naval Postgraduate School vs. Fleet Combat Training Center and Tactical Training Group), but also in terms of "computer experience" as defined by this variable. As will be seen in Section 4, computer experience often made a difference in the attitudes, beliefs and other viewpoints expressed, whereas rank, military specialty, and current assignment did so only rarely. It will be seen however, that computer experience usually related more to the strength of conviction about a particular issue rather than to a fundamentally different viewpoint.

## A Word About Organization of the Results

The results of the survey are presented in the next section. The rating scale itself was comprised of 27 items that related primarily to beliefs or attitudes about AI-based ydecision aids and 17 items that related to specific design considerations. The results for each of these 44 items and much of the associated commentary are presented but not necessarily in the same order as in the rating scale because coherency of presentation is better achieved by grouping various items together. However, the original item numbers are shown so that the reader will know where in the sequence it appeared when the participants performed their ratings.

## SECTION 4
## RESULTS AND DISCUSSION

### BELIEFS HELD BY OFFICERS THAT MAY AFFECT ACCEPTANCE OF AI DECISION AIDS.

#### Military Officers are Basically Optimistic About the Potential Value of AI Decision Aids

Figure 3 shows the distribution of responses of the survey participants reflecting their view about the likelihood that computer based decision aids will be of value to the military decision maker. It will be seen that on a scale of from 1 to 9 there was a pronounced modal response of 7 and well over 1/2 of the total participants rated this item as 7 or higher. There were no significant differences in the response pattern as a function of military specialty, rank, or current assignment. Personnel with high scores on the computer experience variable were significantly more optimistic ($p < .05$) than those with low scores, although there were very few pessimists in any sub group.

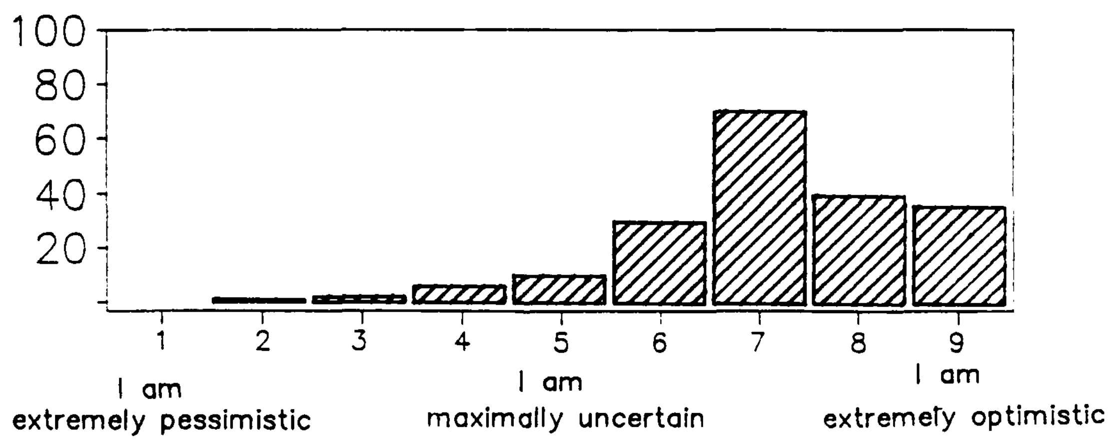



Figure 3. Whether or not you have had prior experience with computer-based decision aids, from what you presently know how do you feel about their potential value to the military decision maker?

Since this was the first scale that the survey participants responded to, and the question was asked at the end of the written introduction to AI concepts, this can be interpreted to mean that the notion of computer based decision aiding is greeted favorably by most military officers. Indeed, this group of subjects, nearly half of whom described themselves as "unfamiliar" with AI, seemed to reflect the basic optimism expressed by most people when they are first exposed to the concepts of this new technology. Viewed from the standpoint of the process of innovation acceptance, this means that the system developer is basically facing a friendly audience. It should be remembered, however, that this response occurred in a general context, and that specific proposed applications might be viewed with more or less initial optimism (or skepticism). This point will be reemphasized as we proceed to more detailed considerations about the design and operational use of AI decision aids. Nevertheless, the prevailing atmosphere is substantially on the optimistic side of the scale.

<u>Officers Generally Endorse the Idea of the Usefulness for Decision Making of a Computerized Knowledge Base and Decision Rules.</u>

The results in Figure 4 suggest a high level of confidence on the part of military officers concerning the usefulness of a computerized knowledge base and decision making rules for aiding decision making. Agreement on this point was particularly strong, with less than 10% of the group expressing disagreement. Of considerable interest is the fact that opinions did not differ as a function of military specialty, rank, current assignment, or experience with computer based systems. Voluntary positive responses to this item included comments such as:

> "The intelligence and potentially hostile countries experts could perhaps provide a dynamic AI base for current threat assessment."

> "Most fleet officers do not have the time to read all the background material they need. An expert system incorporating this knowledge would help."

> "It would be useful to have historical data readily available."

But, on the other hand:

> "There could be a major (maybe fatal) difficulty in deciding who are the experts - choose the wrong ones, and you curse us all!"

> "The Navy may not be able to verbalize gut feelings based on years of experience."

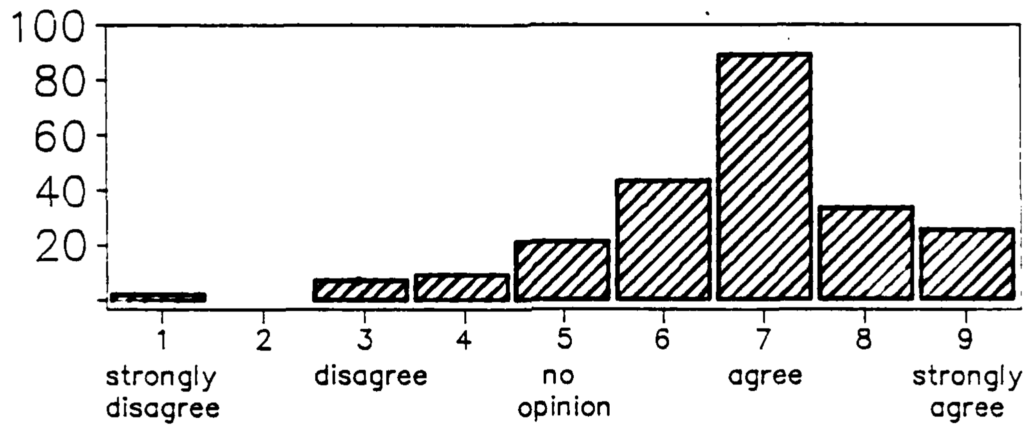



Figure 4. (Q1) There exists, in my military speciality, a group of experts whose knowledge and decision making rules, if encoded into a computer program, would greatly aid my own decision making.

Despite the minority opinion, we view the results of this first basic issue to be basically favorable with respect to user acceptance of AI based decision aids. Most of the officers believe that their own decision making would be aided by an expert knowledge base and decision making rules. In any particular application, the magnitude of the minority opinion would undoubtedly depend on the conviction that appropriate expertise and decision rules were indeed incorporated in the device and we would expect this to be the case for all officers, not just the optimists. The matter of "gut feeling" in the decision making context, is an issue that appeared several times in group discussions. This potential stumbling block to user acceptance seems to reflect a sincere concern that the military decision maker takes into account factors that he may not be able to fully verbalize in making a decision of the moment, and which would be difficult if not impossible to incorporate into the AI decision aid. We will return to this consideration in later sections dealing with operational use of such a system.

## Officers are Basically Positive About the Feasibility of Incorporating Decision Making Rules into an AI System.

The second item in the rating scale differed from the first primarily in that it addressed the question of whether or not officers believe that it is technically feasible to incorporate decision making rules into an AI decision aid. The data in Figure 5 indicate clearly that the majority of officers believe that this can be achieved. Again there is a strong mode at a scale value 7 although the median value (6) was lower than it was for item 1. It is clear that a somewhat larger number of survey participants had either no opinion regarding this possibility, or disagreed with it. There were no significant differences among the officers as a function of rank, military specialty, computer experience, or present assignment.

Officers who agreed with this statement sometimes gave examples of where they thought it would be feasible:

> "Aviation maintenance faces similar diagnosis problems as given in the medical example..."

> "Tactical cryptology is to some extent an art - lots of judgment - but if doctors can use AI..."

> "(It would apply to) CU flight deck management functions, outer air battle, aircraft tanking/replacement logic."

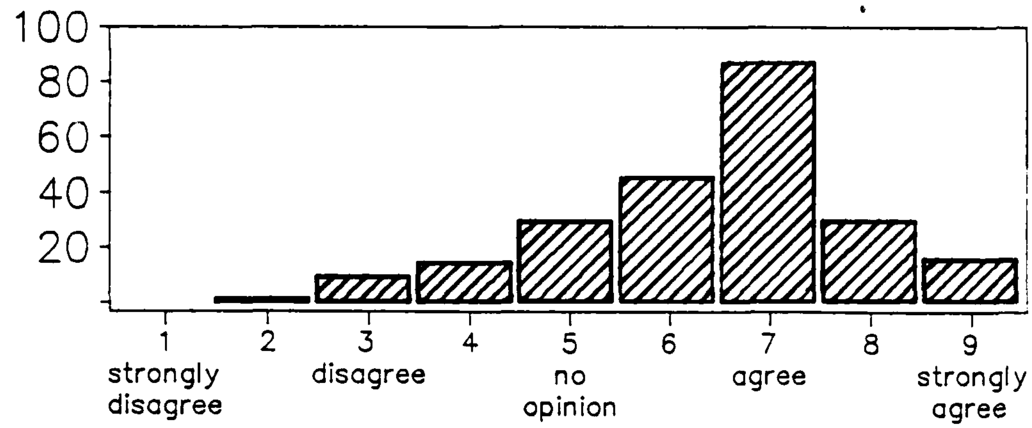



Figure 5. (Q2) The decision-making rules used in my area of expertise can be incorporated into an AI knowledge-based system.

Those whose views were negative tended to suggest that not all of the decision making rules in their area of expertise could be codified. There was concern with generalizability to new tactical situations and uncertainty in regard to how sophisticated the AI decision aid might be.

__Officers are Confident About the Emulation of Knowledge.__

Although the most frequent response to Question number 4, Figure 6, was one of agreement that AI systems can be made to emulate the thinking of experts, the number of officers having no opinion or disagreeing approached 20% of the sample. However, because the percent in basic disagreement was relatively small, the issue of knowledge emulation is probably not a major concern to innovation acceptance.

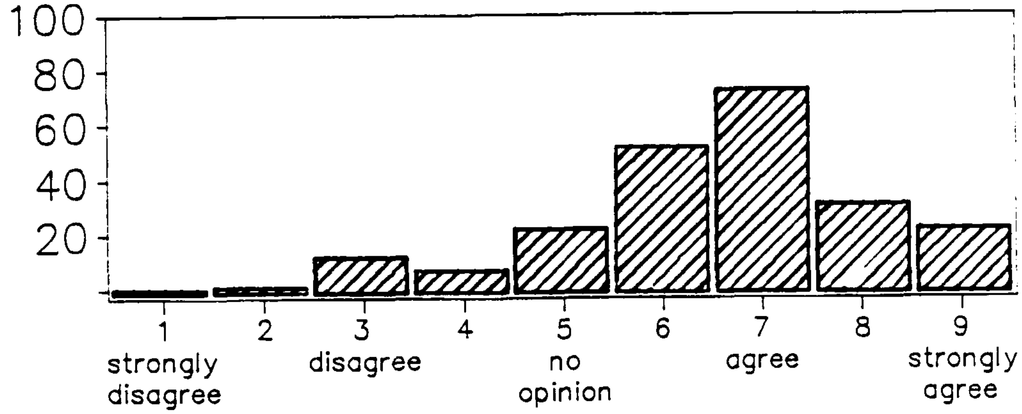



Figure 6. (Q4) AI systems can be made to emulate the knowledge of the best decision makers in my area of technical expertise.

Several officers expressed the opinion that while documented knowledge such as intelligence reports of the threat, recommended counter measures, weapons employment procedures, and other knowledge bases with "well defined bounds" could appropriately be emulated in an AI system, less well defined emulations of knowledge were another matter. The capability for rapid change and updating was an issue in this regard:

> "It would have to change constantly as communications/electronics is a very volatile field - the AI could become outdated very quickly - it must be flexible."

## Summary

An overview of the data in Figures 3 through 6 leads to the conclusion that a strong majority of military officers are optimistic about the possibilities of decision aiding with AI systems, that they believe the required knowledge base and decision making rule can be incorporated into the system, and that much of the knowledge of highly regarded decision makers can be emulated by the system. These are positive beliefs that pave the way for a strategy of innovation acceptance. There are other areas, however, where such positive beliefs are not found.

Military Officers Exhibit Wide Disagreement About Computer Emulation of Thinking

Unlike the basically positive beliefs reported in the previous section, Figure 7 shows that military officers are almost evenly divided with respect to the belief that AI systems can be made to emulate the thinking of the best decision makers. A substantial proportion of the officers had no opinion on this issue, but roughly 38% disagreed with this statement. In terms of the innovation acceptance process therefore, suggestions that AI systems can emulate the thinking of human decision makers must be made with care.

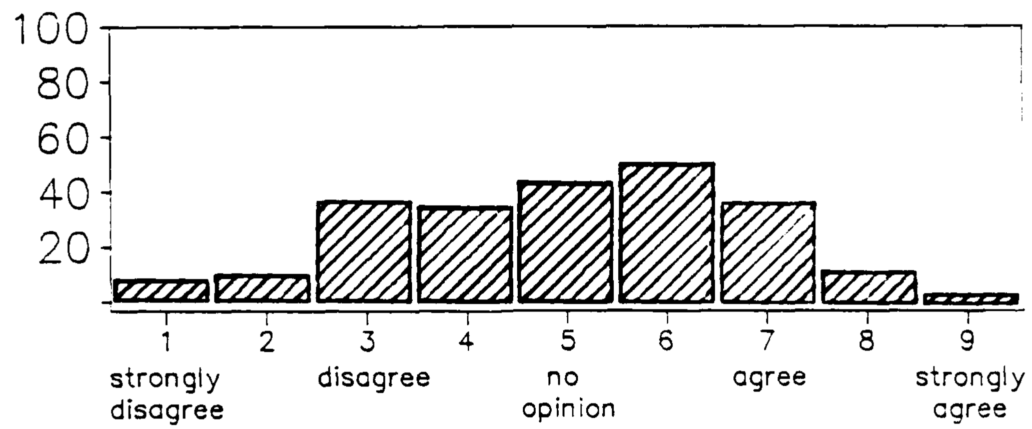



Figure 7. (Q3) AI systems can be made to emulate the thinking of the best decision makers in my area of technical expertise.

Many survey participants distinguished between the believability of this item and those previously discussed. The following comments are representative:

> "I would like to comment that I think perhaps it is not a good idea for AI to set as a goal emulating human thought. The AI systems have a different set of abilities, strengths, and weaknesses than the human mind, and the human mind is still poorly understood, so AI should perhaps exploit what it has and what it can work with better. It can do some things better than we can and some things not as well."

"... I am making a little bit of a distinction here between the precise thought process that someone goes through and the application of the knowledge that he has and that he can make some rules or he can emulate some of the rules that are implied by his knowledge base, but there are some things in thought that I don't think we are going to be able to capture very well in AI, and perhaps it is better to say that we will take the knowledge base and try to emulate that, rather than the actual thought process."

"I differentiated it from (item 4) which said knowledge, which (meant) to me you could just stuff the computer full of facts; but thinking to me is logical processes and frankly ... it's the programming that bothers me and therefore ... I was more negative."

"I think thinking is something we haven't defined yet, it's called a gut reaction, even when all the logical processes might point one way your guts telling you "hey, that ain't right, don't do it". So I think that would be tough to put into a computer. I was very pessimistic about it."

"Maybe instead of pessimism about AI its more like an optimism about the human mind. I wouldn't like to think that a machine could do everything my mind could do..., that's a direct attack ..., the machine is going to think just like me and I would kind of like to think it never will."

"One other aspect that I always think about is for particularly higher level decision makers within the military, one of the things that you are taking into consideration at all times is the interaction of other human beings within the system, and I am not sure that we can accurately quantify that into a machine to allow it to consider that kind of thing."

The resistance to this item seems to be closely associated with the suggestion that the computer might do the officer's thinking for him and there is strong rejection of that suggestion. As one officer said:

"... When I interpreted the term "thinking", I remembered instances where the logical part, the thinking part, said do something, but I didn't feel right doing it. It just, it wasn't the way I wanted to do it, and I couldn't justify doing it that way so I went and did it some other way. And that's why I hesitated to say that I am going to let the computer think for me." (Emphasis ours).

"AI might be able to logically determine threat and response in an ideal way, but to take into consideration the capabilities of those people who help you, how good, tired, etc., they are, requires judgment which I don't think AI is capable of."

"I do not believe that machines will be able to have 'gut feelings' or the ability to take or recommend calculated risks that real people or tactical commanders can."

The above comments are primarily negative but in large part because the survey participants who felt negative about this issue were the more vocal ones. It should be noted that many officers felt that AI systems could be made to emulate the thinking of the best decision makers. However, the negative view was sufficiently pronounced that we must conclude that this is an area of potential resistance to AI decision aids. It is notable that the pattern of response was essentially similar for all officers. There were no significant differences as a function of military specialty, rank, present assignment, or level of computer experience.

"Better" Simulation of Human Thought Processes May Be An Acceptance Issue

Figure 8 shows that although many officers had no opinion on this issue, roughly 1/2 felt that better simulation of human thought processes than we have today will be necessary for AI to be helpful. Again there was general agreement among all the officers, there being no significant differences as a function of military specialty, rank, present assignment, or computer experience.

A second substantially sized group of officers had no opinion in regard to this requirement, although it is notable that very few disagreed with the possibility. There were in fact essentially two camps: those who agreed that better simulation of human thought processes would be necessary, and those who had no opinion on the matter. A few officers volunteered that we can produce useful products with what we know today, and one suggested that "we would probably be better off not simulating human thought processes because the computer has a different set of strengths/weaknesses (than the human)".

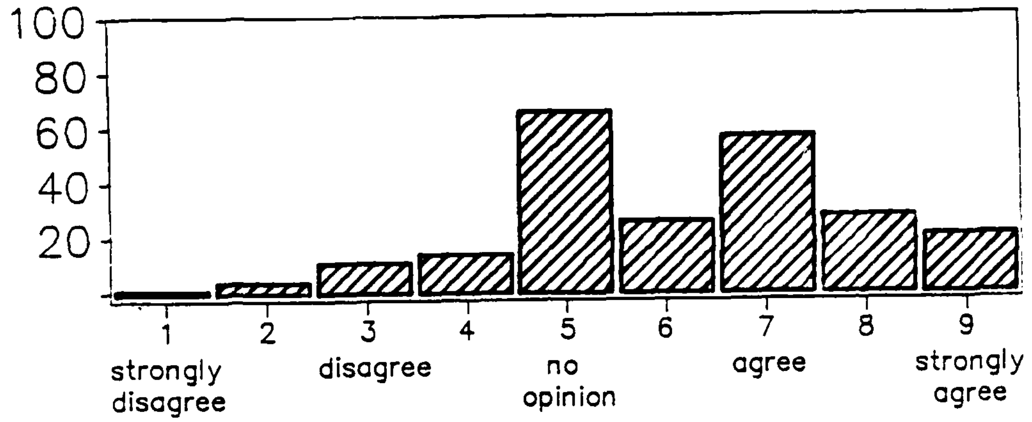



Figure 8. (Q5) To be helpful, AI requires better simulation of human thought processes than we have today.

## Appearances May Be Important

Despite the fact that the survey participants were generally resistant to the notion that AI systems can or should "think" like human decision makers, the results in Figure 9 show that the potential users would regard an AI decision aid as more acceptable if it appeared to analyze a problem in the manner similar to the way in which they themselves analyze it. Approximately 1/2 of the officers agreed or strongly agreed with this proposition, although there was a clearly identifiable minority who felt this was unimportant. There were no differences of opinion as a function of officer rank, military specialty, or current assignment. However, there was a significant ($p < .05$) inclination for officers with greater computer experience to disagree with this proposition. However, although significant, the differences were relatively minor. As one officer commented:

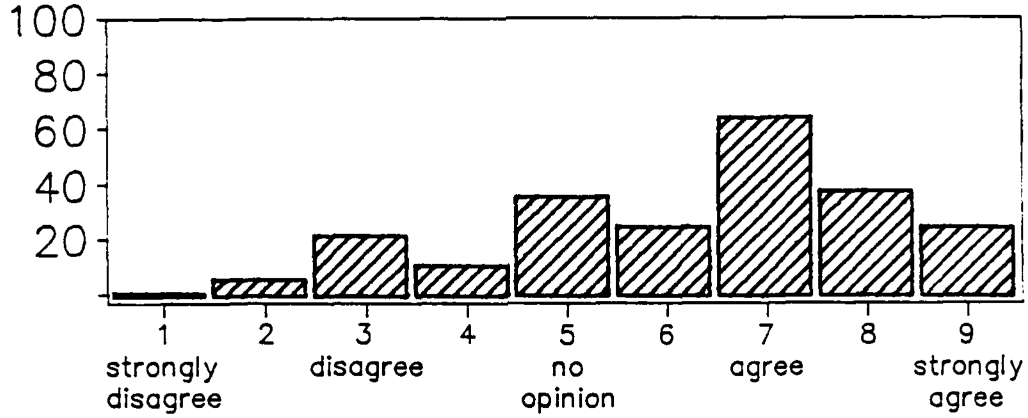



Figure 9. (Q17) For an AI system to be acceptable, it must appear to analyze the problem in a manner similar to the way in which users analyze it.

> "Initially this would probably be more palatable to end users - perhaps as they become more computer educated it would not be required."

> "The user will have more confidence in the product if he sees similar techniques to his own (ones he can relate to) utilized."

A somewhat different consideration had to do with "user friendliness." One officer commented that if it appeared to analyze the problem in a familiar way, it would make man machine communications easier. Another said "I/O must be user friendly - who cares what goes on inside?" A similar view was "If it's good enough, the answers can appear out of thin air - who cares?"

A perhaps more thoughtful response was the following:

> "... If a user is to believe the results he is getting from an AI system, he has to feel confident that he can inquire of the system 'what are you making these assumptions based on?' Someone who is interested in ground combat, he wants to hear things about fields of fire and avenues of maneuver, cover and concealment and all those things that mean something to him from his technical training. If he is not going to get that kind of response, then he is not going to believe what he has been told."

And another,

> "I think the cost that making a wrong decision is going to have, will dictate how much inquiry you are going to make of the machine. Costing and resources. You have a choice between three alternatives, you pick one, and if you are not right you will lose the war. You are certainly going to want to ask that machine a lot of questions to confirm in your mind if this alternative is a good one."

Indeed it may boil down to a matter of trust:

> "... As long as you trust the information you are getting, I don't really care how it is arrived at. As long as it gives me the information I don't care if it did it like a human or not. It doesn't matter."

## Understanding the Decision Rules is Essential

The results in Figure 10 are highly similar to those just discussed, except the scales are reversed in polarity. The great majority of participants in this survey felt a strong need to understand the AI system's decision rules regardless of the fact that they may be based on the judgments of the best available experts. Opinions were stronger in this regard than they were concerning whether or not the AI decision aid appeared to analyze problems in a manner similar to which they were familiar. Nevertheless, there was again a minority of officers who disagreed, holding to the view that it is the end result that counts, not how the computer got there. The minority view was more strongly endorsed by officers with greater computer experience ($p < .01$), but there were otherwise no differences as a function of rank, military specialty, or current assignment.

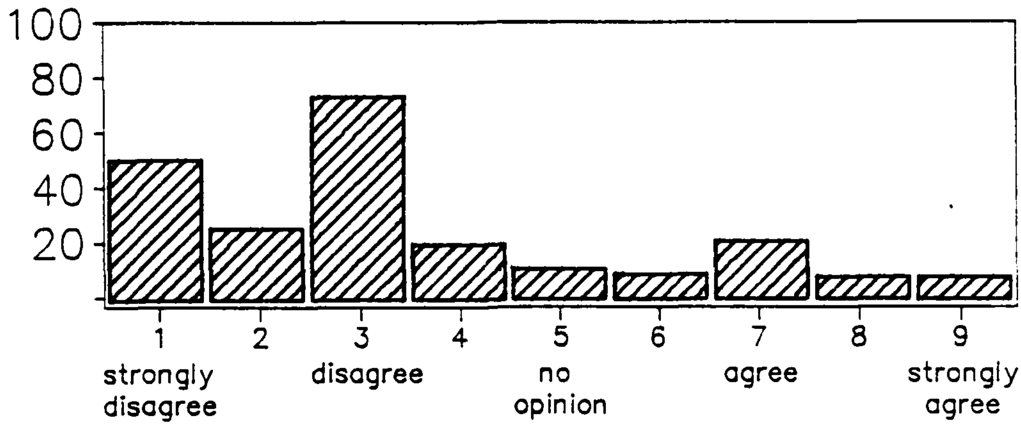



Figure 10. (Q18) It's unimportant for the user to understand the AI system's decision rules, since they are based on the judgements of the best available experts.

The majority of sentiment was expressed as follows:

"He needs faith in the system."

"He must know if AI is making decisions the same way he would."

"... The user must know something of how the computer is operating in order to decide when it has gone astray..."

"The user should always have some insight into why the machine made the recommendation it did."

"It's important to know the bias of the decision makers."

"People don't trust what they don't understand."

But in contrast:

"(If) the user has to understand the detailed elements of the system, he may not need the system."

## The Best Available Expertise Does Not Imply Operational Validity

There was pronounced disagreement with the suggestion that incorporation of the best available expertise would ensure operational validity of an AI decision aid. In an interesting reversal of previous results, the more experience the officers had with computers, the more negative they were toward the presumption of operational validity. This probably reflected their greater insight into the problems of implementation. Other than this, there were no differences in the opinion patterns expressed by these officers as a function of seniority, military specialty, or current assignment.

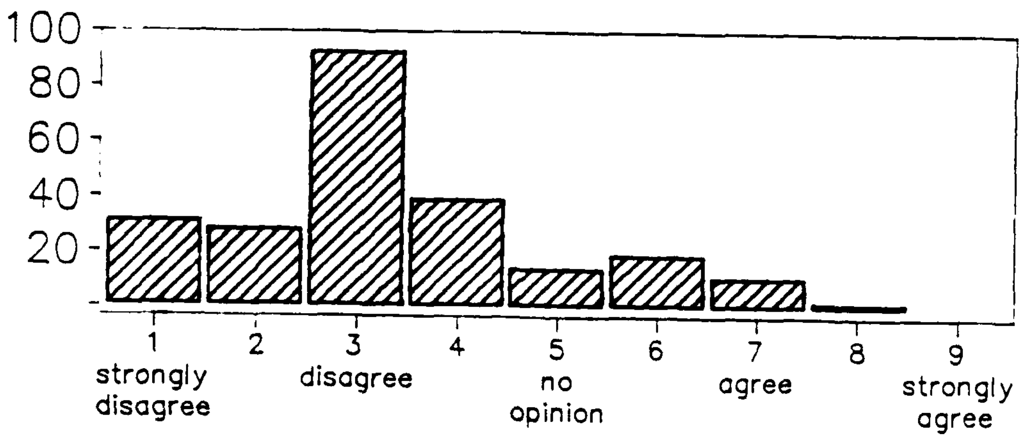



Figure 11. (Q21) Knowing that an AI system embodies the best available expertise should be sufficient to assure the user of its operational validity.

This result is not surprising, perhaps because the proposition in this item flies in the face of operational validation:

> "Any user should test and thoroughly learn the system."

> "AI systems must be validated/verified by testing, etc. like any other software system."

> "Will only provide a general model. The circumstance may preclude the existing expertise."

> "Even the experts can be dead wrong."

> "All people don't trust computers yet. Maybe they shouldn't. One still must have the ability to come up with the answer independently to know if the computer is fouled up."

> "Assurance comes from experience."

> "Test test test."

## Summary

It is clear from responses to the 5 items discussed in this section that acceptance of AI decision aids at this point in time will be enhanced if the real or imagined capability of the system for emulating human thought processes is down played. At the same time it helps if the device appears to analyze the problem in ways that are familiar to the users. Innovation acceptance is almost bound to suffer if: 1) the user is unable to understand the decision rules being applied or unable to get access to them; and 2) claims to validity are made without operational demonstration. This position is strongly supported by our previously developed model of the acceptance process and validates the results of our previous survey (Mackie, 1980) of issues related to the acceptance of ASW decision aids.

## PATTERNS OF USE

There are many circumstances of use which may impact the perceived value of AI decision aids to the decision maker. These include considerations of relaxed time versus real time operations, level of mental workload, and stressful operating circumstances.

### Major Asset to Relaxed Time Decision Making

Figure 12 shows that military officers are in almost unanimous agreement that an AI decision aid can be a major asset to decision making under relaxed time conditions. Fewer than 5% disagreed with this assertion, and another 5% had no opinion.

Some comments included:

> "Improved efficiency in operational planning."

> "Can be helpful in training preparedness, but is not a major asset in real time environment. AI is an aid in any environment."

> "What we use in real time should also be used in relaxed time to gain experience/familiarity; AI may merely be a backup in relaxed time."

> "I feel more comfortable to agreeing to this. The few computer systems I have used are somewhat slow."

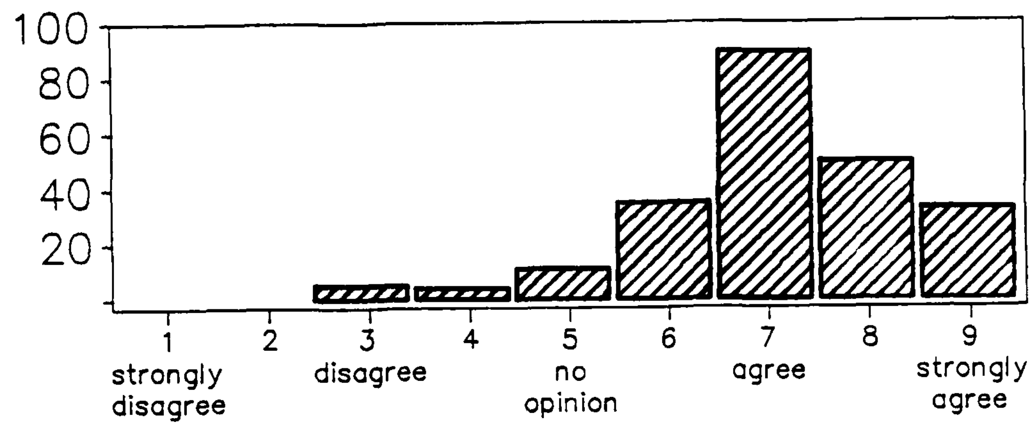



Figure 12. (Q7) AI is likely to be a major asset to decision making in relaxed-time conditions.

## AI Considered Valuable in Tactical Planning

The perceived usefulness of AI decision aids for the planning function was further supported by the responses to Item 9 which addressed tactical planning directly (see Figure 13). Emphasis was placed on the generation and evaluation of alternative courses of action. The strong pattern of agreement is similar to that obtained in response to Item 7 on relaxed time conditions. Only 2% of the officers disagreed with this proposition while about 6% had no opinion. It is notable that there were no responses with a scale value less than 4. Officers who were high in computer experience were even more positive than medium or low experienced officers ($p < .05$). As with the previous question on relaxed time use, there were no differences of opinion as a function of rank, military specialty, or present assignment.

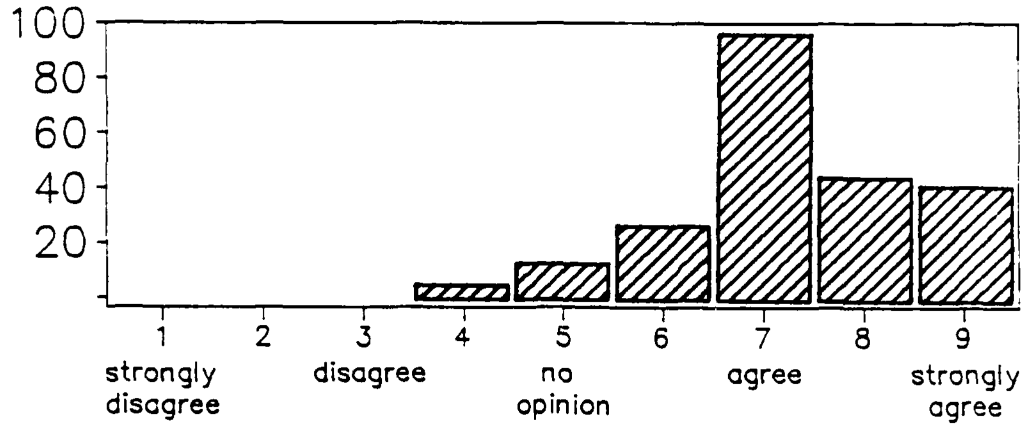



Figure 13. (Q9) AI is likely to be valuable in tactical planning, i.e., generation and evaluation of alternative courses of action.

The strength of the endorsement of this use for AI decision aids was underscored by some of the voluntary comments:

> "Its most vital use."

> "Only planning, not decisions."

> "Multi scenario becomes much easier."

> " 'Outlaw shark' is an excellent example of the utilization of computer software to aid the decision maker."

> "Especially in passive ASW, also in fault diagnosis for the engineers and technicians."

## Positive Toward Tactical Situation Assessment

Figure 14 suggests that a great majority of officers were basically positive about the usefulness of AI decision aids in tactical situation assessment. However, there was a larger percentage of disagreements than with the two earlier items which clearly emphasized relaxed time use. As we shall see, as the context turned toward real time operational considerations, more and more skepticism emerged. It is noteworthy that officers with substantial computer experience were significantly more favorable ($p <.001$) toward the use of AI decision aids for situation assessment than were officers with little computer experience. The latter much more frequently reported "no opinion". Interestingly, junior officers were more positive toward this application than senior officers, although traditional statistical significance criteria were not met ($p <.07$). There were no differences as a function of military specialty or present assignment.

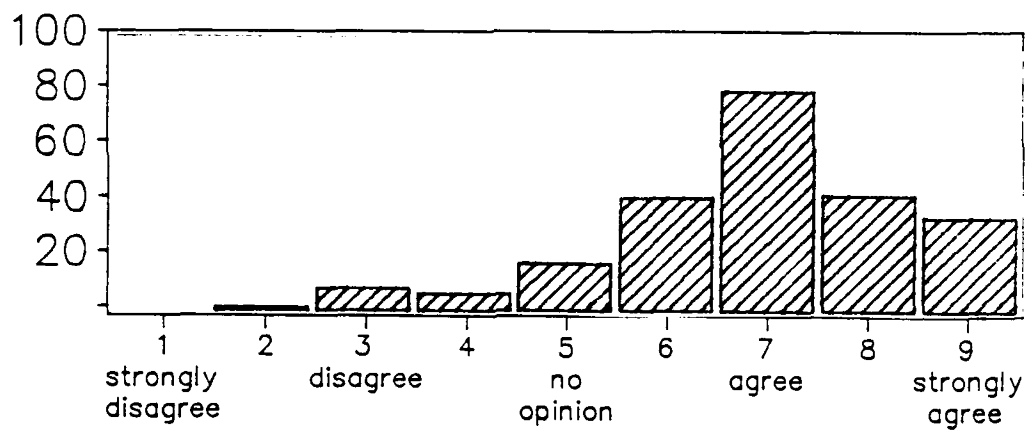



Figure 14. (Q8) AI is likely to be valuable as an aid to tactical situation assessment.

Some evidence of the doubts about tactical situation assessment is reflected in the following quotes:

> "Humans will always be required to have enough knowledge in the operating environment to have an intuition as to the correctness of the computer solution - speed may be too great to wait for the computer."

> "This would be difficult to program. The variables are so immense that to properly program the computer for all of the different situations which could occur within a 60 second period of a tactical situation, would be virtually impossible. Human intuition plays a massive portion of the decision making process. Gut feeling, although probably based on logic, is probably too undefinable to program."

> "I feel it would be a good program for planning purposes, but in our current tactical situation, there is not enough time to keep asking an AI source. Again, in the future, (there may be) faster computers, better algorithms, larger memories, etc."

## Reservations About Real Time Applications

Figure 15 shows a somewhat different distribution from the three previous items. Although many officers were basically in agreement with the value of AI decision aids for real time operations, the group discussions revealed recurring skepticism which could have considerable impact on the process of innovation acceptance. Once again, officers with high computer experience were more positive than those with medium or low experience, but there were no differences as a function of rank, military specialty, or present assignment.

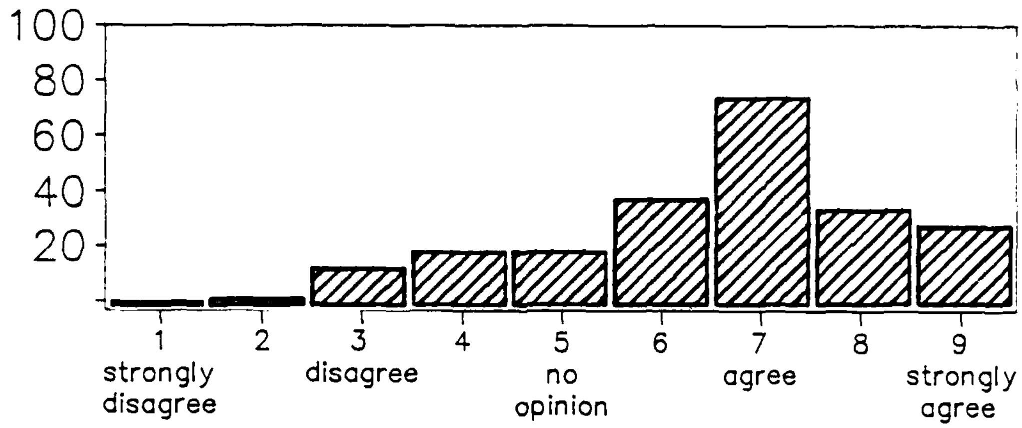



Figure 15. (Q6) AI is likely to be a major asset to decision making in real-time operational conditions.

Some of their volunteered comments with respect to this issue were as follows:

> "Real time in a crisis situation - maybe not. Most Commanders don't trust non-intuitive systems.

> "Can be helpful in training and preparedness, but is not a major asset in real time environment."

> "Again, input data would seem to be the stumbling block."

> "For shipboard work we need larger, faster, more expensive computers than we can afford."

> "There are too many incoming facts to be evaluated adequately by humans alone."

> "Humans will always be required to have enough knowledge in the operational environment to have an intuition as to the correctness of the computer solution - speed may be too great to wait for the computer."

"Again, I don't know how sophisticated your machines are. I do feel strongly about this however; if it's going to help in a real time environment, it had better require little prompting and be fast.

"I don't have a feel as to the amount of time required to answer a lot of AI generated questions to deal with the situation. I suspect it would be too lengthy (time consuming)."

"(It would be o.k.) if it is hooked up into ship's sensors such as the AEGIS system."

"In the future, after the human thought processes have been better simulated."

"Unless material is concisely presented, in a 'high threat' tactical environment the information will be time late for the user."

"Only if the system did not fail (power system halted, etc.). Potential exists to be totally dependent on system on (the AI) system and no decision made."

Summary

In this group of four items, we are confronted with results that, on one hand, are strongly encouraging to innovation acceptance in the AI decision aiding domain, and on the other hand raise serious cautions. The possibility for decision aiding for the planning function and other relaxed time conditions were strongly endorsed by this sample of officers and represent a major inroad for acceptance. In contrast, there are important reservations about real time utility. Although there may be operating circumstances where the time constraints felt by military officers can readily be met by AI devices, the degree of skepticism expressed will make it essential to demonstrate that the system can be operated effectively within permissible time constraints.

## Application to New Tactical Situations

Since an AI system's knowledge base and rules reflect historical data and experience, its application to new technical decision making situations might be questioned. Figure 16 shows the results of the survey on this point. It will be seen that a majority of the officers did not feel that the application of an AI decision aid would be questionable in new tactical situations. However, it will also be seen that there was a sizable minority (roughly 27%) that felt this could be a problem. The issue this raises of course, is that of system updating and how easily updating can be accomplished. There was considerable commentary on this issue:

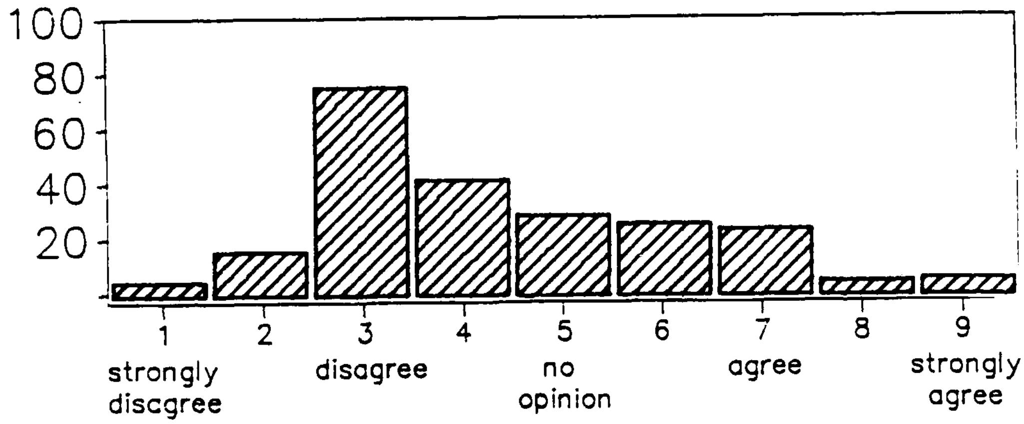



Figure 16. (Q19) Since the AI system is based on past data and experience, its applicability to new tactical decision making situations is questionable.

"To be effective, the system would require weekly updates to remain current."

"User should be able to add new rules."

"We make decisions based on past experience. Intuition, hunches, and odds may be based on past experience; however a tactical decision maker must be able to open himself quickly to entirely new probabilities."

"It is true that an antiquated data base will degrade the performance of the expert system."

"Only if there is no provision to provide new data as the situation progresses."

"It may only provide trends, where the situation may require a new approach."

"But so is past data and experience of human - must be weighted and evaluated by human for use - example of inexperienced personnel relying too much on the machine."

"The user is going to obviously have to be able to decide, is the machine working in the environment it's programmed in, or have we got something new here ... Any good person in charge is going to be doing his own calculations along with the machine."

"I think that's a critical point. There are already many tasks and many responsibilities for all the soldiers and sailors in the military, and here we are going to add one more that could be particularly crucial that this machine get updated on a regular basis, and if it does not, the output is going to be drastically degraded. I think that's a real concern when you are in a tactical situation and the situation is rapidly changing. Are we going to have time to update this thing so the decisions we get out of it are going to be worth the time we spent on it?"

"The hard copy ... equivalent to (the updating problem) is our tactical pubs in which the fleet (is eons behind). I don't think there is a person in this room that hasn't dealt with that frustration ... There are constantly messages on the street that come out and say 'hey, listen, we are really going to put up this change here, it'll be out in June and it'll be reflected. In the meantime use this interim procedure.' And it's not that June, or the next June, or two Junes after that before you ever see the thing in hard copy. ...The same thing in NTDS software, you pick up a problem in an NTDS package and it takes way too long before ... the fix can be implemented because the system's getting so big. You run the same risk with this (AI decision aid) especially if you start relying on it. The more you rely on it, the more important it is for that data base update to be as near real time ... as is possible. ...The user ... has to understand the tactical decision process that the machine or the aid, or whatever is using because if it's based on a data base that ... is out of date, you have to assign some kind of credibility weight to any kind of decision that it does recommend."

"...If you are just going to give me a machine and say 'listen, we went out and we scoured the best minds and it makes good decisions', then frankly there is a lot of people who made good decisions 15 years ago that may not make good decisions now. You need to be able to update the rules that the machine uses and I would like to really be able to custom tailor it to the way I make decisions."

On the other hand, the following was expressed:

"I think that the AI system based upon old data would be good for new tactical decisions because, what are our decisions based upon? They are based upon our past experiences, and if you are (making) your model in an artificial intelligence system to think like we do, then you know, it should be able to do just as good a job as we could because we are using our past experiences to make the new decisions."

It is of interest that although the general distribution of responses to this item did not differ as a function of rank, military specialty, or current assignment, officers with a higher degree of computer experience were significantly more cautious about applicability to new situations ($p < .05$) than were officers with little computer experience. Perhaps this reveals somewhat greater sophistication with respect to the issue of generalizability to new situations.

## Consider More Information Sources Per Unit Time

Figure 17 shows that the survey participants strongly agreed that the availability of an AI decision aid would enable the user to take into account more information sources and decision rules per unit time than he could do without it. There was no sizable minority group in this case, and it can be concluded that this is seen as one of the major virtues of an AI system. There were no differences of opinion as a function of rank, military specialty, current assignment, or degree of acquaintance with computer based systems. Comments were made to the effect, however, that achieving this objective will heavily depend upon an effective man/machine interface, an issue that will be discussed later.

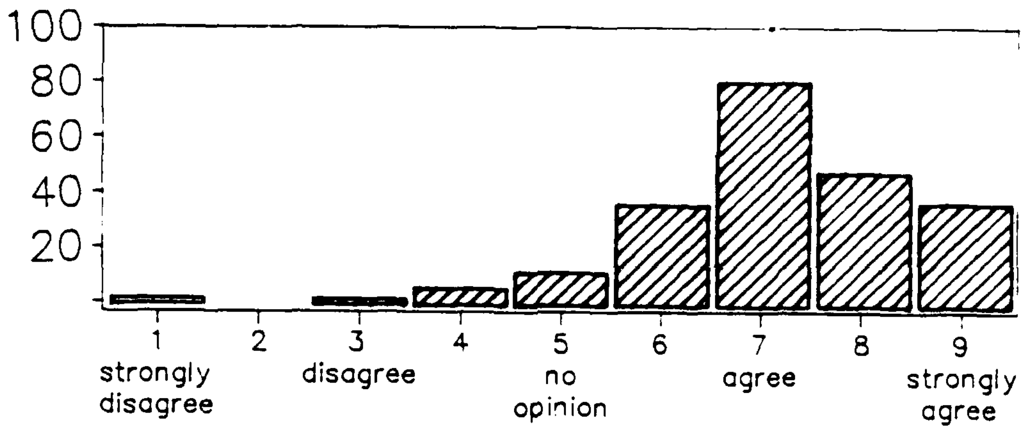



Figure 17. (Q16) AI will enable the decision maker to take into account more information sources and decision rules than he could without it.

## Identifying Options for Decision Making

Another strong virtue of the AI decision aid is seen to be its capability for enabling the "average" officer to better identify a wide variety of options for decision making (Figure 18). There was wide scale agreement with this proposition with only a very small minority disagreeing. There were no differences with respect to rank, military specialty, or current assignment in the extent of endorsement. A matter of some interest however, is the fact that officers with a high degree of experience with computer systems were significantly more positive (p <.01) than those with less experience.

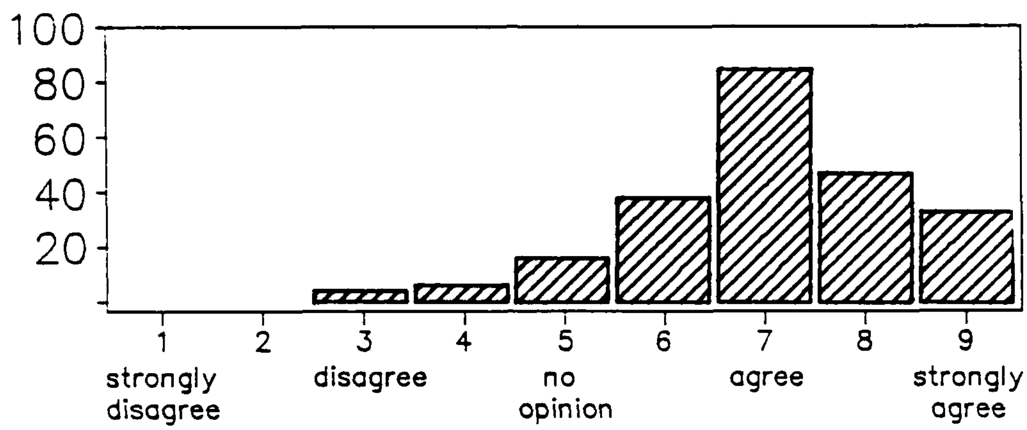



Figure 18. (Q10) The average officer will perform better in identifying a wide variety of options for decision making if he is aided by AI.

Some reservations were expressed, however, about how this capability relates to mode of use. The consideration again was real time versus relaxed time, and a few participants felt that the real time situation is too volatile for AI to be helpful in generating options for decision making even though it might be in a more benign environment.

Some of the positive comments included:

> "I think when you are looking at the ... question of identifying alternatives ... AI holds a lot of promise in that regard. Just the fact that somebody else is there that has possibly identified another solution to a problem that I may not have thought (of) (would be) a benefit."

"Well, even the fact that with the more experience one gets (there is a) tendency to get more tunnel vision and it might be kind of an awakening process for a lot of people that have been in a particular field for a long time, to find out the other approaches that might be available."

## Evaluating Alternative Courses of Action

Figure 19 shows the distribution of responses to the proposition that the "average" officer will perform better in evaluating alternative courses of action if he is aided by an AI device. The officers surveyed generally endorsed this statement but there was a small minority (roughly 10%) that did not. There were no differences in viewpoint as a function of rank, military specialty, or present assignment. However, as was the case in the previous item, officers with substantial computer experience endorsed this statement more positively than those with less experience.

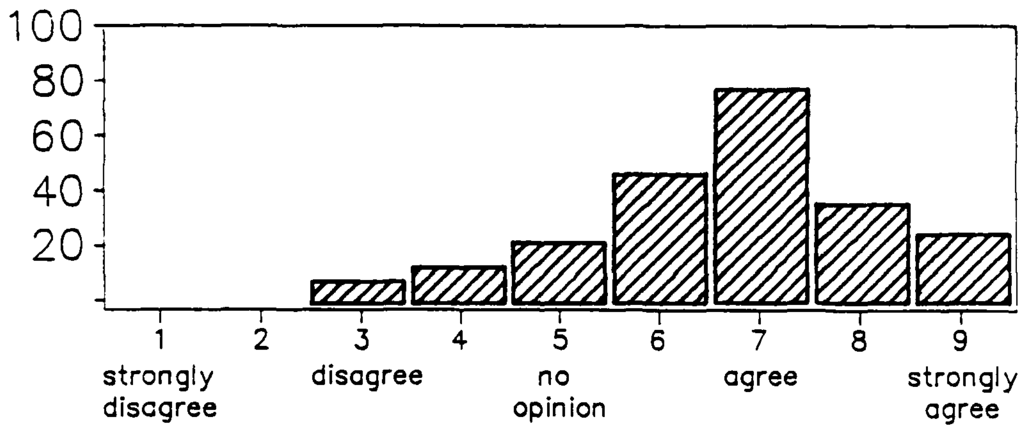



Figure 19. (Q11) The average officer will perform better in evaluating alternative courses of action if he is aided by AI.

Despite the generally positive endorsement, there were some reservations:

> "I am not sure how an individual will behave when given computer-aided evaluation. Especially if he has not had extensive 'brain-washing' to convince him of the 'reliability' of the system."

> "Maybe. The average officer may also be led down a wrong path! Just as a mediocre diagnostician could simply have settled for MYCIN'S answers above."

> "AI in this instance would block innovative tactics and thought. Slaved dedication to machine recommendations based on previous responses will inhibit tactical development."

> "How will enemy expectations be accounted for?"

## Summary

The major themes in the above group of items are for the most part positive for innovation acceptance. AI is strongly perceived as enabling the decision maker to take more information sources into account, and identifying a wide variety of options for consideration. The viewpoint is somewhat less positive, but still basically so, toward the usefulness of AI in evaluating alternative courses of action. The major reservation expressed within this group of items was in respect to the generalizability of past data and operating rules to new tactical decision making situations. In this regard there are major doubts that need to be addressed and rationalized in a program of innovation acceptance. Finally, it should be noted that degree of computer experience is strongly related to the view points held in regard to most of these items. Personnel with a high degree of computer experience are generally more favorable about AI usefulness in identifying options and evaluating alternatives. Interestingly, they are significantly more doubtful about the successful application of past data and experience to new tactical situations.

## Dealing With Uncertain Data

It was of interest to learn whether or not military decision makers viewed the ability of AI systems for operating with uncertain data as an advantage for decision making. The results in Figure 20 show that the majority of the survey participants agreed with this notion but not very strongly. Additionally there was a sizable group who had no opinion. There were no differences among officers of different rank, military specialty, or current assignment. However, officers with more extensive computer experience were significantly ($p < .001$) more positive towards the usefulness of this feature of AI systems than were officers with lesser computer experience. Those having little or no computer experience were major contributors to the "no opinion" category.

One officer commented that this feature of AI would be "particularly helpful when probabilities are provided to the user which account for the uncertain inputs," and another commented that knowing the degree of uncertainty in the output would be essential. One participant was concerned that this feature could make uncertain data <u>look</u> uncertain. Several others commented "garbage in, garbage out."

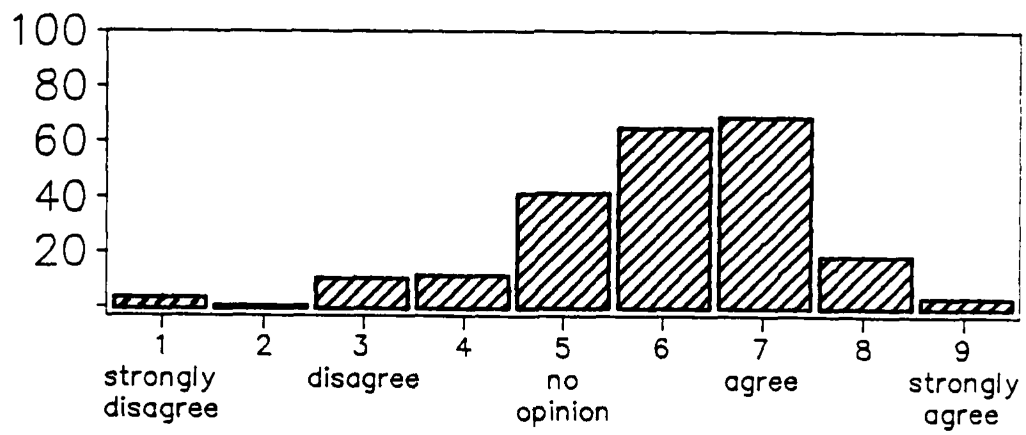



Figure 20. (Q23) Because AI can operate with uncertain data, the outputs can be very useful for decision making in an environment of uncertainty.

In general, the ability of AI systems to operate with uncertain data does not seem to be a feature having either particularly positive or particularly negative impact with respect to the issue of innovation acceptance. The matter of displaying probabilities at the output however, is regarded as highly desirable. This will be touched on again when specific design features are discussed.

<u>**Possibility of Catastrophic Failure**</u>

There was a wide dispersion of opinion about the possibility that an AI decision aid might fail catastrophically in the operational environment (Figure 21). Generally speaking more officers agreed with this proposition than disagreed, although many had no opinion. There were no differences associated with rank, military specialty, current assignment, or degree of experience with computer systems.

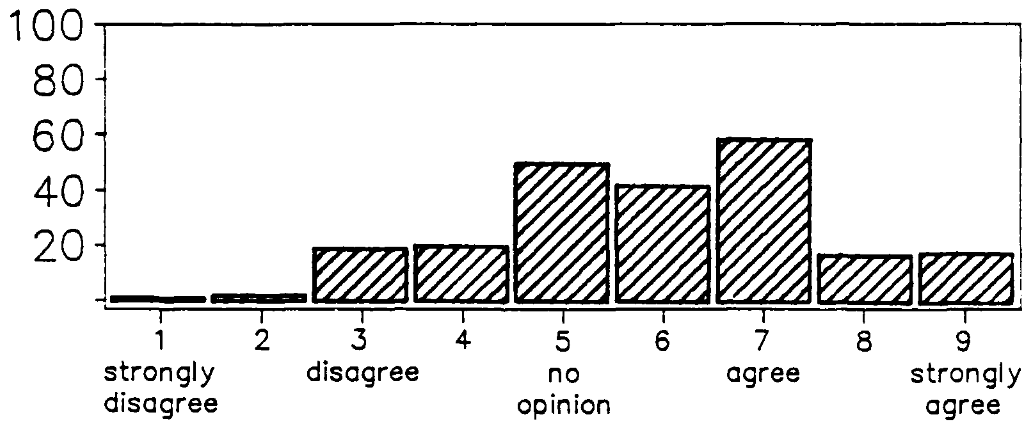



Figure 21. (Q20) AI systems that appear to work under benign conditions may fail catastrophically in the operational environment.

Some of the concerns were as follows:

> "I think you have to look at this in two aspects. You have got one as the aspect of (the) physical reliability of the system and it seems a lot of things work well out in civilian industry. As soon as you paint them green or gray, they aren't worth a damn. For the most part, systems aren't soldier or sailor proof. Out in the field there is the possibility of it being dropped off the back of a truck, you could misplace a cable, and if this is a critical piece of your decision making equipment, like a radio or something like that, you can't afford to be without it. So you have to face the fact that you may lose this thing. It can't be your be-all and end-all from a physical point of view. An alternative viewpoint is that since we cannot guarantee the proof of correctness of our software programs that we have now, can we absolutely guarantee that there will be (no) flaws in this AI system? And is a real time operational environment the time to find that out?

> "I have dealt with decision aids in the ASW operation system at sea, and they were always putting, they were always giving us aids to put on the ship. Of course they are going to work at the laboratory but once you get out and they are rocking and rolling around, everything just goes to hell, and it's just another headache. I think that's really important if you are going to design something like this because it is going to go on a ship or an airplane, make sure it works on that (them). I think it would make it a smashing success.

> "They used to put HP computers on the ship, acoustic prediction, things like that. You know we would get tapes and the radar repeaters would wipe them out. ...If nothing works, it's just another headache.

> "If you are talking about hardware, I think I would agree with that (previous speaker). But if you are talking about software, I would disagree. Software doesn't know if it's operational or if it's (in a) benign (environment). ...I think perhaps (this) question should break down into a hardware/software (consideration).

## Reduction of the Decision Maker's Mental Workload

Perhaps no other single issue in this survey produced more widespread disagreement than the suggestion that a benefit of an AI system lies in its ability to lessen the decision maker's mental workload. It will be seen in Figure 22 that virtually equal numbers of officers agreed and disagreed with this proposition. There were no significant differences among the officers as a function of rank, military specialty, current assignment, or computer background.

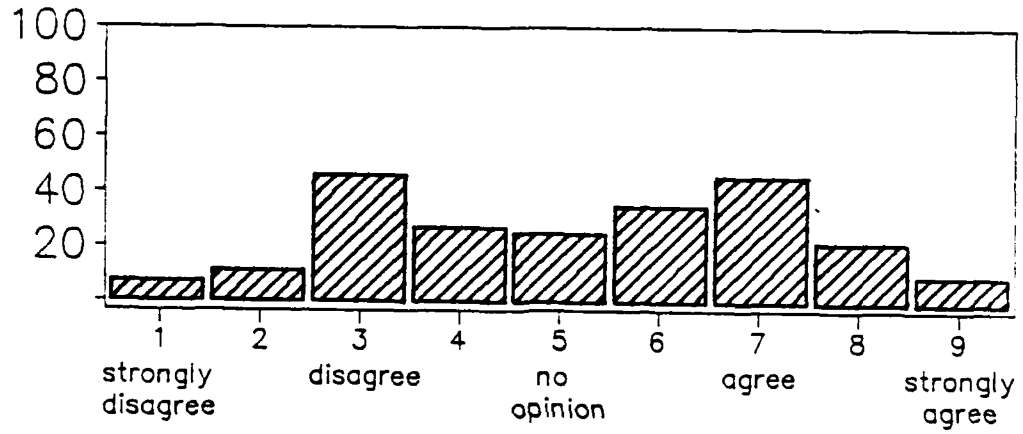



Figure 22. (Q15) An important benefit of an AI system will lie in its ability to lessen the decision maker's mental workload.

The following sampling of the commentary reflects the diverse viewpoints:

> "They will help the decision makers suppress details. We can concentrate on the 'big picture'."

> "The principal value in my book is how much more data the machine can store and that can be readily called up."

> "I would say broaden his options and force him to consider more not less."

"Isn't this why AI?"

"It will never really lessen. The workload will always be there."

"A lot of attention resources will be expended answering the AI questions. Workload will be more structured but still high."

"If this works, and the decision maker doesn't (have to) spend more time evaluating the validity of AI's decisions."

"In many military decision making models, the normal interaction between a Commander and his staff is for a Commander to make his own estimate of the situation, and the staff to make an independent estimate. The staff then submits their estimate to the Commander, and he compares it to his own view and then from those two inputs, makes a decision. In my viewpoint, the Commander is still going to have to make an independent estimate, independent of the AI system. I would prefer to see the AI system used by the staff to help them prepare their detailed analysis and then let the Commander compare his independent, his own judgment that he is making from his own background and compare that with the results he is getting from the system to see if they make sense. So I don't think it's going to lessen his workload. It may show him a few ideas he hadn't considered before, but he is still going to have to think.

"My experience has been that I have never met a computer system yet that decreased my workload. Wherever I have been, always at the bottom of the heap, I am the guy plugging the data into it in some form or other, and it's a workload increase, normally without increased personnel to support it."

"I would say that the decision maker's mental workload may not be reduced, but one of the problems that we've got with our existing systems, AI not included, is we are getting too much information. There is too much information and people have lost the ability to evaluate the information so the decision maker is getting bombarded with all sorts of information from all sources and it is very difficult to sort out the wheat from the chaff and most of it is chaff. There may be one little fact that is wheat, that's very important that he get but if it's very difficult for a single person to take an undistilled flood of data and make a good decision. If the AI or any other machine can perform the evaluation or if we can train our people to do the job that they are supposed to ... evaluating and passing on that which bears on the problem, then the mental workload is not going to change but the decision will probably be better."

"I think that the response, to me, depends on what time frame you are talking about. I think maybe 50 years from now if AI is introduced successfully and proves itself as people learn that they can rely on it, I think that yes, it will lessen the decision makers mental workload. But I think in the transition period which I think is going to be maybe a generation of military people's careers, I think people are not going to trust it and I think it is going to increase their mental workload because, in addition to evaluating all of the data and the factors in arriving at their own independent judgment just as they have always done, they are also going to have to deal with the decision recommended by the AI system and if that disagrees with their own decision, they are going to have to analyze why the AI system disagreed. ...I think it's just going to be, by virtually a factor of two, a compounding of the factors and the variables the decision maker is going to have to deal with."

It should be clear from the above commentary that reduction of mental workload on the part of the decision maker, although possibly a major motive for the development of AI decision aids, can by no means be presumed to be seen as a realizable objective by military officers. To a very large extent this has to do with their belief that it will be necessary to process all of the information mentally anyway, then compare the results with the AI system solution, and in the event of conflicting outcomes take the additional steps necessary to rationalize a defensible decision. Perhaps no other concern expressed by these officers so completely emphasizes the need for a demonstration project as a part of the strategy of the innovation acceptance. It is only when the military officer can see to his own satisfaction that a decision aid saves him work, or makes his own decisions better, or both, that he will be convinced of its ability to lessen his load. As our model of innovation acceptance clearly suggests (Figure 2) the perceived negative possibilities in this area may outweigh any perceived advantage.

Value of AI Under High Stress Conditions

Research on human performance under high stress conditions suggests that information assimilation and, consequently, decisions based on that information may be narrowed in scope and therefore less effective than under non-stress conditions. If this is so, one benefit of an AI decision aid might be its imperviousness to adverse effects of stress and consequent benefit to the user. Figure 23 summarizes the officer's beliefs in this particular attribute of AI systems. It is evident that the majority of the survey participants agreed that this might be a possible benefit of AI technology; however, over 20% disagreed and a substantial number had no opinion. There were no significant differences in pattern of response as a function of the officer's rank, military specialty, current assignment, or experience with computer based systems.

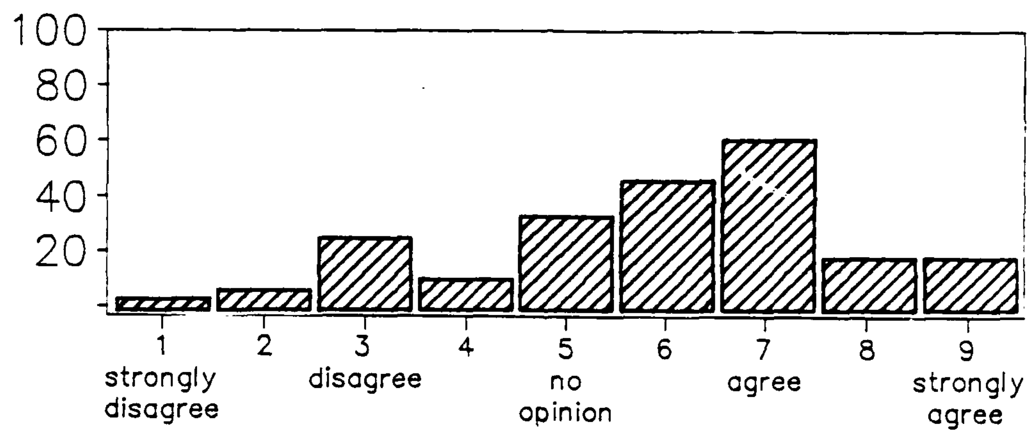



Figure 23. (Q13) An AI system will be particularly helpful to the decision maker under operational circumstances that are highly stressful.

Some of the comments, on both sides of the fence, follow:

"Depends on his trust in the system."

"It will be helpful, but I doubt it will relieve the stress. It will be just another tool."

"Again, intuition plays a big role in stressful situations. How does the machine account for intuition? How does it recommend an intuitive response?"

"Highly dependent upon "usability" of the presentation of information."

"Yes, but he may be inclined to accept AI decisions without assessing it under pressure."

"If a person has confidence in the system that they programmed into it and everything it could be helpful to them. If they don't have confidence it could be more stressful."

"I keep visualizing a scenario where if the programmer had the option of loading in the data I think that's a good idea, but if he has done that then I think he is already starting to format in his mind the decision that is going to be made when that highly stressful situation comes up. So I think in the time period leading up to that point the AI might be able to help him with alternatives. Once it starts, I can't really visualize any person really relying on that. It seems to me his decision is pretty much in the back of his mind anyway. I should think that in any real scenario, you will have real world events that are happening that will let you know which way the scenario is going."

"The way I look at this question, I think, just being my nature, if you are going through a stress situation you are going to look for as much information as you can in order to help you with the decision. You might not use this information in your final decision but any information you can get is going to make it easier for you to make the decision..."

"I think it directly relates back to something on an earlier slide about the idea about relaxed time versus highly stressful time. I know within, in the Army, in maneuver units like Infantry or Armor, times that are most stressful are the times that you have the greatest, in terms of human factors, stimulus inputs. You are gathering everything at a tremendous rate and having to make decisions that are very time related, instantaneous, if you will. It's very difficult for me to believe that AI, some AI aid, is useful in making those decisions, because ...our technology at this point in time, being able to develop to the point that it can take in the same amount as I can and make the same decisions, although I think you can emulate the rule. I mean you can get the rules down and put them into or input them into some aid and that can help you make decisions but at a time when everything is happening all at once ..."

"...I think the data is going to be coming in so fast that you won't be able to update your data base quick enough. And even at fairly high levels, where the data that is coming in for troop position and things like that, is dependent upon input from low level folks. For a Division Commander ...to be able to depend on the accuracy of the last position ...I am really not sure that he can even at relatively high levels ...update the situation as fast as he is going to need to have it updated ..."

"I think it depends upon the situation. ...I am an Air Defense Artillery Officer and some of our missile systems ...we have artificial intelligence systems in there and the operator is sitting behind that console, there is a whole bunch of aircraft coming in, it gets to the point where he just flat can't handle them all. So he has an automatic mode, puts the system into automatic, the computer then makes the decisions on which of the highest or ...priorities and it actually does everything to launch the missile. So I think it depends on the situation, like in the situation where the human operator physically cannot handle a saturation air attack, he can just sit back and put it in automatic and just have to trust the artificial intelligence, because it's just obvious that he does not have the capability ...to make the decisions that fast."

"That goes back to what I said before, the real time and relaxed. I would rate this strongly agree, because I think it's at that point where if you have a proliferation of objects or options or whatever that you are considering that the computer or AI can help you sort through those and categorize them or whatever, and provide you an opportunity to think more quickly, compare or decide whatever you have to do with them, at a time when you are really trying to move fast."

"You have to present so many options that it inundates the decision maker and it is just going to augment the stress, it's just going to make it worse.

## Summary

The above group of four items identified a number of cautions with respect to the strategy of introducing AI decision aids. First, there are officers who are in essential agreement with each of the points: that AI is useful in dealing with uncertain data; that AI might under certain conditions lessen the decision maker's mental workload; and that AI might be particularly useful under operational circumstances that are highly stressful. On the other hand, each of the four items identifies possible sources of resistance. A case for AI in dealing with uncertain data needs to be demonstrated since this does not seem to be an area where the virtues are well recognized. The issue of reduction of mental workload is truly moot because it is closely tied to the presumption that the user is going to have to perform all of his usual tasks and in addition monitor, and perhaps reconcile, the output of the AI device. Third, the value of an AI device under stressful conditions is closely tied in the officer's minds with real time combat conditions and extraordinarily high information load. It is also tied up with what is viewed as an almost impossible requirement to update the data base. Finally, a majority of officers feel that there is a distinct possibility of catastrophic failure of an AI device in the operating environment. Thus, even if the device is accepted as a useful decision making aid, when the chips are down dependence on the device may get one in trouble.

Each of these major sources of resistance needs to be addressed in a systematic innovation acceptance effort. Many of the concerns expressed by these officers reflected their own situation-specific considerations. Since the survey was conducted on very general terms it is difficult to know precisely how their fears might have been allayed in a particular operational context. This is a matter that will need to be addressed on a case-by-case basis because the validity of their concerns could vary greatly depending upon the specific design and purpose of a given AI decision aiding device.

## Value of AI as a Function of Officer Experience

Item 12 in the survey dealt with the proposition that an AI based decision aid might be mostly helpful to officers who are relatively inexperienced in a military specialty. Figure 24 shows that the majority of officers disagreed with this proposition, although a fair-sized minority (22%) agreed. The response pattern to this item varied significantly depending upon amount of computer experience, present assignment, and military specialty, although it did not vary as a function of rank.

Officers with substantial computer background held the most negative views toward this proposition and those with little computer experience showed the greatest uncertainty. This item was one of the few where current assignment also made a difference. ($p < .002$) Officers assigned at the Naval Postgraduate School disagreed with this proposition strongly, while those assigned to the Combat Training Center were more inclined to agree or have no opinion. ($p < .001$). The response pattern to this item was also unusual in that military specialty made a difference. Officers assigned to Surface Ships and as Flight Officers showed the strongest agreement pattern while Administrative Officers showed the strongest disagree pattern. It should be noted however that all groups disagreed with this proposition more than they agreed.

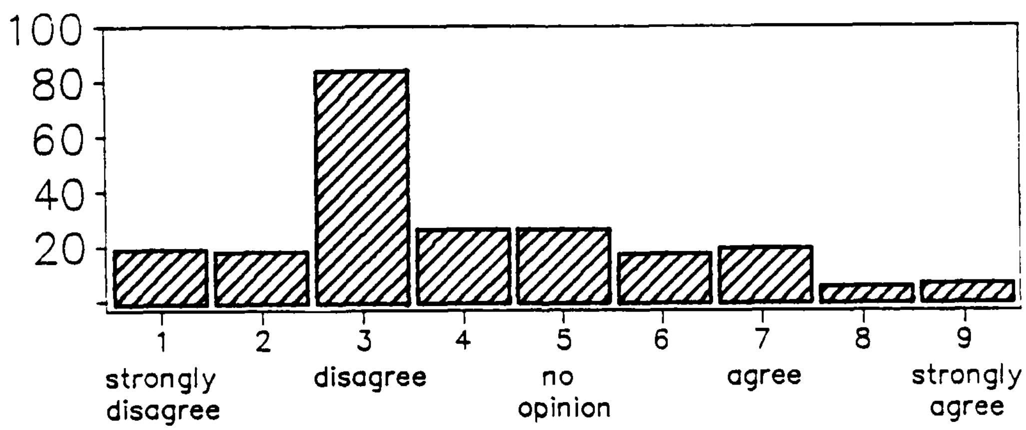



Figure 24. (Q12) AI will be helpful mostly to officers who are relatively inexperienced in my area of technical expertise.

There was a great deal of opinion expressed with regard to this item, a sample of which is reproduced below:

> "I believe you must have fundamental experience prior to utilizing decision aids/AI equipment to ensure that the equipment is not lying to you and/or that the course of action makes sense."

> "... the possibility that an inexperienced officer will rely too heavily, or even entirely, on AI could pose a serious problem."

> "Virtually all officers in my area are insufficiently experienced."

> "Humans must be able to have at least a feel for the correctness of a computer solution."

> "Could be extremely harmful. When does the individual know with absolute certainty the program will not give a wrong answer? The person who has the least amount of experience could be hurt the most."

> "Assuming robust AI, the more experienced officers will be aided the most."

> "AI could overload and actually degrade the performance of inexperienced personnel - another danger is that humans, by relying on the 'machine,' might not learn enough to evaluate realistically the machine product or the function without it in down periods."

> "I think this ties a little bit into the remark that I made previously and that is, there is some analysis involved even in accepting or choosing between the alternatives that are given to you and I think that an inexperienced person really has no basis on which to analyze those results. An experienced person on the other hand has a fairly strong basis and can perhaps analyze these in real time himself and say they are believable, this one in particular is the one I want to apply,

> and these are not. Let's throw those out and we will think about these. So I think the experienced technical person is going to be able to make much greater use of the AI response he gets ..."

> "... On the other side I think though it would be a good idea to have it for them (the inexperienced) because that allows them to see the experience and knowledge of the experts that are used for the data base. That gives them a kind of an accelerated experience level, I guess, as they use the system."

> "I think even an experienced individual can still use it because a lot of times you may forget an option that you have and ... just kind of refresh your memory, that's all. I think that's why we kind of all disagree because I think anybody can use it. It's just for memory purposes."

> "... What concerns me is the fact that you have an inexperienced person who is relying on this black box, he's never going to establish for himself the maturity and thought process to question the output of that box. Just like kids and calculators, they can't add anymore than the second grade. I think the same thing is going to happen if you take an 0-1, 0-2 and give him this great black box, he's never going to be sure..."

Concern About Undue Influence

The issue of undue influence of inexperienced military officers by an AI decision aid was raised directly in survey Item 22. The results are shown in Figure 25 and it is clear that there was very strong agreement about this possibility. Only a handful of officers disagreed with this proposition and there were no differences of opinion as a function of rank, military specialty, current assignment, or computer experience. Comments supporting this concern included:

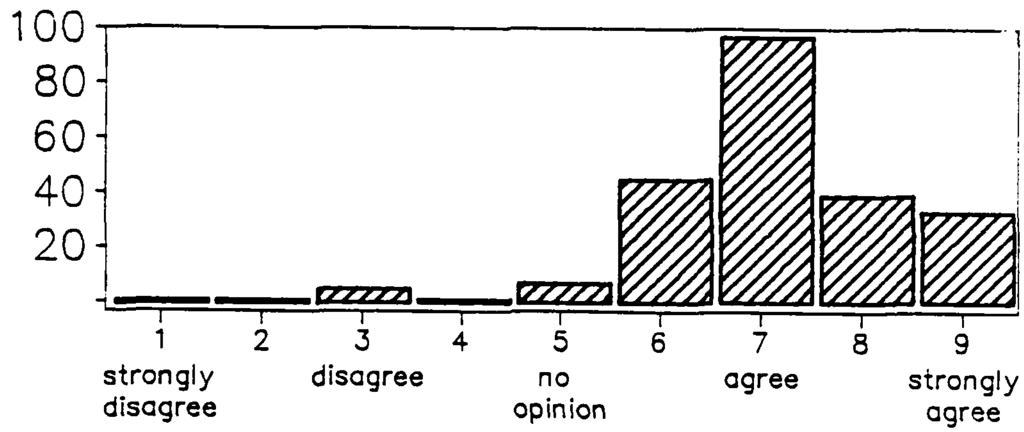



Figure 25. (Q22) Inexperienced decision makers are likely to be overly influenced by an AI system simply because it "appears to know what it is talking about."

> "Possible, officers who use AI decision aids from earliest training may become only dependent upon it."

> "Inexperienced decision makers are easily influenced by most anything. That's one reason they are called inexperienced."

Several of the officers commented that this is a problem that will have to be monitored very closely and that the answer lies in training. But it is clear from the distribution of responses in Figure 25, and the uniform agreement among all officer groups surveyed, that this is a significant issue that must be addressed as a part of the innovation acceptance process.

## AI Versus "Conventional" Decision Aids

Most military officers are well acquainted with a variety of computer based systems that generate information for decision making using "conventional" mathematical algorithms. Few people would argue with the superiority of computers in that role or with generating information that can be used to aid decisions that are primarily the result of complex computations that cannot possibly be done by the human in a timely and accurate fashion. But because AI based decision aids incorporate a qualitatively very different kind of data base and decision rules, it was thought that this might have an impact on the acceptance of such devices as contrasted to devices based on more familiar computational procedures.

Figure 26 presents the results on this issue. A wide diversity of opinion is clearly evident. The distribution of responses did not differ depending on officer rank, military specialty, current assignment, or computer background.

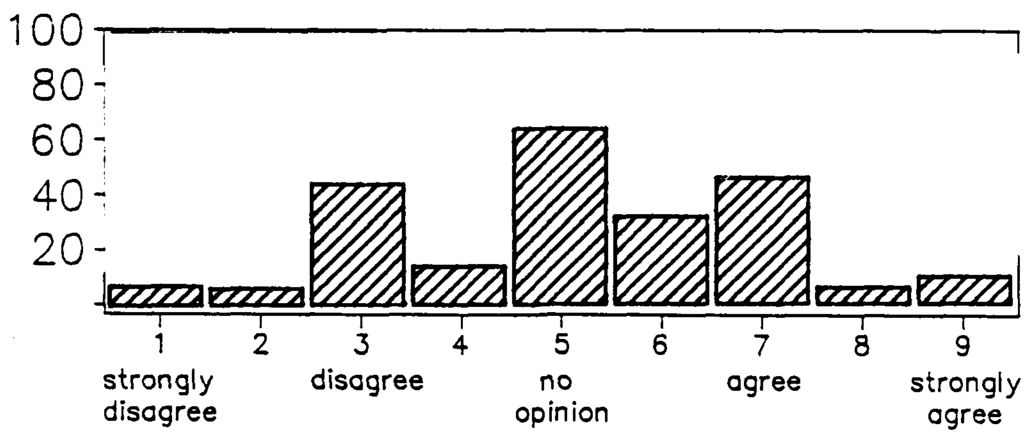



Figure 26. (Q27) AI decision aids will meet with greater user resistance than conventional algorithmic decision aids.

Among those that disagreed that AI decision aids would experience particular resistance, perhaps the most succinct, pragmatic position was:

"Show me it works - I will use it."

Also on the positive side,

> "I would think that a true AI system would be indiscernible from an assistant. User friendly and non-abrasive."

> "People are looking forward to its evolution."

> "Ease of use is the key."

> "Usability. Validation."

But on the more negative side:

> "Commanders do not want to be told that their primary task - tactical decision making in a complex environment - will be performed by a machine."

> "AI decision aids will be readily embraced by users and will be viewed... with skepticism by those who review their decisions (COs, XOs, etc.).

> "Validity of the rules, if/then statements, may or may not represent resistance potential."

> "They are more powerful - that alone engenders fear. There have been literary horror stories depicting AI type systems gone berserk. And if they appear 'too human' there may even be a religious outcry."

In the course of discussion the difficulty of generalizing about this issue was noted by one officer:

> "... I think this can be highly system dependent. The user interface will have a lot to do with it - the promotion of an AI system, its extent and result of testing as it is being developed and introduced. There are so many variables there that you could easily introduce an AI system that meets with a solid wall of resistance. Likewise you could introduce one that could be readily accepted. It's hard to answer a question like that."

> "It goes right back to the very earliest questions, whether you believe or not that the computer has the ability to think logically, thought process. You know (if) you've got a traditional algorithmic model or whatever and you just know its (valid). But if I'm skeptical and I think a lot of people are, a computer that thinks? Come on!"

> "I think it's a foreboding of a big brother that we fear, it's a fear of being controlled, so we don't want that."

> "I think related to that also is ...who the users of this AI will be and I envision, from my perception of it, there will be battlefield Commanders at one level or another, probably relatively senior people initially (who) didn't grow up with computers and decision aids and AI. ...To them the objection will be based on, 'I'm not familiar with it, I don't like it, I don't need it'."

In response to these kinds of concerns, however, it was frequently pointed out that "...it's an aid ...and will not make the decision for you. It will aid you with your decisions. If it took over and started making decisions for you and you really rely 100%, that's another issue."

That there might be a problem with conventional algorithmic decision aids as well as a potential problem with AI decision aids was reflected in the following commentary:

> "First of all I have been working with ...both manual and automated systems for over 7 years. ...I have worked in 3 automated systems and 2 other manual systems, 5 systems altogether and this is the first time anyone's ever asked how I feel about it. ...I think that was a really good question because we have had automated systems and decision aids with us for over 25 years ...and there is still a lot of distrust about that computer because our alternative method is a circular slide rule. We figure out our intercept headings and our tack headings. Well, you can sit down and if you make a mistake you can look at the decision and point out (that) this input was bad or this was wrong or something like that and everyone goes 'oh yeh, o.k. I made a mistake and it wasn't the algorithm', but the minute he misses an intercept with a computer it was the computer's mistake. And there is still a healthy percent of people out there that are convinced that

> the biggest enemy of the weapons controller is the computer because they can't sit down and analyze and look at that, and they're just convinced that it wasn't their mistake it was the computer's mistake. So 25 years later we still have high resistance to that kind of thing."

It is clear that there will be a delicate balance to be achieved during the introduction of any decision aid between the perception that the device is nothing but an aid and leaves the user in full control, versus the perception that the device encroaches upon the officer's authority by the very nature of its expert data base and its possibly very authoritative output. This issue was dealt with more directly, as discussed in the following section.

## Undermining of Decision Making Authority

It is evident from the distribution in Figure 27 that the majority of officers disagreed with the proposition that AI technology might undermine their decision making authority. There was a significant minority however (about 27%) who expressed concerns that are important to the strategy of innovation acceptance. Fewer officers who had extensive computer experience felt that this was a problem ($p < .05$) than officers with less computer experience. Those with the least computer experience tended to express the most uncertainty. There were no differences as a function of rank, military specialty, or current assignment.

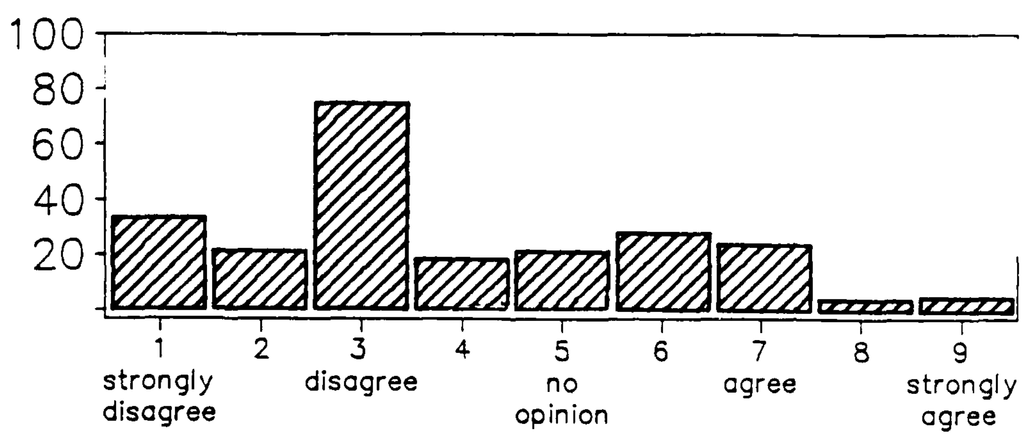



Figure 27. (Q24) Adoption of AI technology may undermine my decision-making authority.

Officers who were not concerned about the possible undermining of authority expressed views such as the following:

> "As long as I am experienced and knowledgeable about the situation, AI will help, not undermine my authority."

> "Overrule authority should be built into AI technology."

> "AI will recommend, not decide."

> "Authority will still rest with the Commander."

> "Depends upon the personalities involved."

> "Only if the machine is designed to directly run systems normally under the control of a person."

But on the other hand,

> "AI eliminates the gut feeling. Many military engagements are won or lost on the Commander's gut feelings."

> "If you make a decision contrary to the AI output, and the mission fails you will hang!"

> "(It will) make justification of an alternate decision difficult."

One officer pointed out that it will be a function of the experience level of the user:

> "...if you are an uncertain user of that machine, then you may in fact be unduly led by what it tells you to do. I think it's going to have you cast doubts on your own decisions if you aren't sure why you are making them, you are just following the machine. So it's going to take somebody who in fact, use it as a tool, recognizes how it is functioning, and can essentially look at it with a kind of jaundiced eye and say 'well it is doing it's job before I do my job,' and then I am going to base my decisions on what it says if I can believe what it is saying. So you could be swayed by it unduly I think."

"I think you have got to (take into account) at what level you are using this tool. I don't expect to find this down at the lower officer levels where I would expect people to be 90 day Lieutenants and very inexperienced Captains. I would expect that something as sophisticated as this would be used at a level where someone is commanding a ship, commanding a group of ships, commanding a brigade or division ... I don't think that these people will be that green because they will have gained (experience) working with large organizations before."

"While I think everyone agrees that even if you have AI you are not going to have your decisions taken away from you, it's just going to assist and provide information for your decision making process. No way is the machine going to have the ultimate decision."

"...It's nice to say it should be an aid, but invariably it's going to be used as strong justification for a decision somebody wants. Maybe one of your subordinates will be using the aid, the people working for you will be using the aid, he'll bring the information to you and he'll say 'the aid says', 'but sir, look here it says ... you know this is the way we should go'. It could have a tendency to cause problems in that situation."

"That goes back to what we were talking about earlier, where you used to make decisions based on the raw data input... Now, you introduce the machine, now you have two sources of data to analyze and if you decide something different, now you have to justify why you changed the decision of the machine. I don't think most people want to be put in that position. There may be an interim process or transition ... until it becomes more widely accepted, but that's a real thing to consider."

"I think the thing that all of us are saying is that we would like to see the system implemented in such a manner that the human is, in fact, the decision maker and does not lose that authority. ...What we are all afraid of is that if they put this 'wally kazam' piece of technology in there, that the ultimate decision maker somehow is going to get lost in this 'wally kazam' technology. But the ultimate decision maker can only be the human. You can't do it in any other way."

"I think the Commander might ...not tend to follow background information as much as he would if he didn't have that (AI) system available. He says, 'well as long as I have Frank (the AI decision aid) over here, he's going to be able to follow all this information for me (and) I won't have to worry about it. I'll do the other things that I need to spend my time on,' And when it comes time to make the decision, he doesn't know all the information, as much as he would if he didn't have an AI system available. And then he really doesn't make a good decision or (is) taken out of the process entirely."

In addition to these concerns, there was a frequently mentioned theme to the effect that there could be a problem if the decision maker chose to disregard or lightly weight an output of the AI device that later proved to be correct:

"I think that it comes down to how your boss, if you are out there on a ship and the machine says do something, and I or my Captain look at the thing and say 'no we are going to do something else.' If that decision is right then you are in great shape, but if you screw up ...at the Board of Inquiry they say 'well the machine said you should have done that and you did something else.' ...You might as well hand in your shoulder boards and go home because the machine said you should have done something and you didn't do it. So I think you are going to be influenced to do what the machine says out of fear. It depends on how the support is, or the superiors above you perceive, and what kind of guidance they give you on your ability to override. And it needs to be written policy saying at all times the CO is totally in charge. That might be o.k.."

But:

"If you look at the black box as staff, as the Commander would use a staff officer, then I think you are in good shape. If you look at it as a source of recommendations, I don't see where it could undermine your decision making authority. Commanders overrule staff officers every day of the week."

"I think the bottom line is, I'd never let any damn machine make the decision for me. That's it. No machine ever makes my decision, but, on the other hand, I see the machine as a facilitator because a lot of times I make crappy decisions because I am under stress, I don't have a lot of time to analyze the data, or there is a lot of different things going on and so, it depends on how you look at the machine. If you look at it like a staff officer, something that's going to take this data, process it, and make recommendations, it's not going to undermine your decisions because if you don't like it, you turn it off and you walk away from it."

## Summary

The four items in this group reflect a number of vital concerns for the innovation introduction process. Among the potential users there are serious concerns about the use of AI decision aids by inexperienced personnel, with their possible inability to critically weigh the output of the device against a broad background of operational experience. It seems to us that there is a distinct possibility of consumer resistance by virtue of the fact that the data base and decision rules may not be fully understood, a problem perhaps faced less often with strictly mathematical algorithms. Finally, although most officers contend that an AI decision aid would be treated as just that, an aid, (or staff officer), there is concern about post-hoc analysis and retrospective evaluations of decisions that were made that might appear to have ignored good advice from the AI device. Curiously, a decision maker might make a mistake of ignoring or discounting the suggestions of a staff officer and this might never become known to the rest of the world. But if it's a matter of record with a machine the situation may be more career threatening. This is a particularly thorny acceptance issue in the domain of decision making.

## DESIGN AND USER INTERFACE CONSIDERATIONS AFFECTING THE ACCEPTANCE OF AI DECISION AIDS

In previous sections of this report we have discussed current beliefs of military officers on a wide variety of technical issues that may affect ultimate acceptance of AI technology in the decision making domain. It was clear from the commentary that in many instances the seriousness of a particular concern depended upon how the system would be implemented in practice. Since the survey did not address any particular application, it was sometimes difficult to know how serious a particular concern might be in a specific operational context. For example, the criticality of the relaxed time versus real time issue could well be application specific. It might also vary considerably depending on how well the man-machine interface enables the user to cope with peak information loads under high stress conditions.

The next portion of the survey addressed some of the interface design issues. We could only deal with these issues in general terms but we nevertheless sought to identify design criteria that military officers felt were important in decision aiding devices, whatever the operational context. The results of this "design" portion of the survey are presented next.

## Nature of Recommendation/Situation Assessment Outputs

The survey participants were provided with four alternatives with respect to how an AI decision aid should display what it "knows" with respect to decision alternatives and/or situation alternatives. The resulting distributions of officer opinions with respect to these four approaches are shown in Figure 28 through 31 which summarize responses to four alternative output styles. The survey participants were asked to consider all four alternatives before expressing their opinion on each.

It is clear from these data that one alternative, namely that the decision aid should show only the alternative it considers best, was rejected out of hand (Figure 30). It is also clear that the officers could not agree, a priori, on the number of decision or situation alternatives that should be displayed under any given circumstance (see Figures 28 and 29). Rather, the clearly preferred alternative was for the decision aid to automatically tailor the number of decision alternatives displayed based on the time available for making the decision. However it should be noted that this alternative (Figure 31) leaves the decision as to how many alternatives should be displayed to the user, who can adjust it to present more or fewer recommendations/assessments at his discretion. The great majority of the officers endorsed this as the best option although there was a minority (15%) who did not agree.

There were no differences in the pattern of results as a function of rank, military specialty or current assignment. In regard to computer experience, officers with extensive computer backgrounds were more positive toward the alternative described in Item 31 ($p < .05$) than officers with lesser computer experience, although all groups were basically positive toward this alternative.

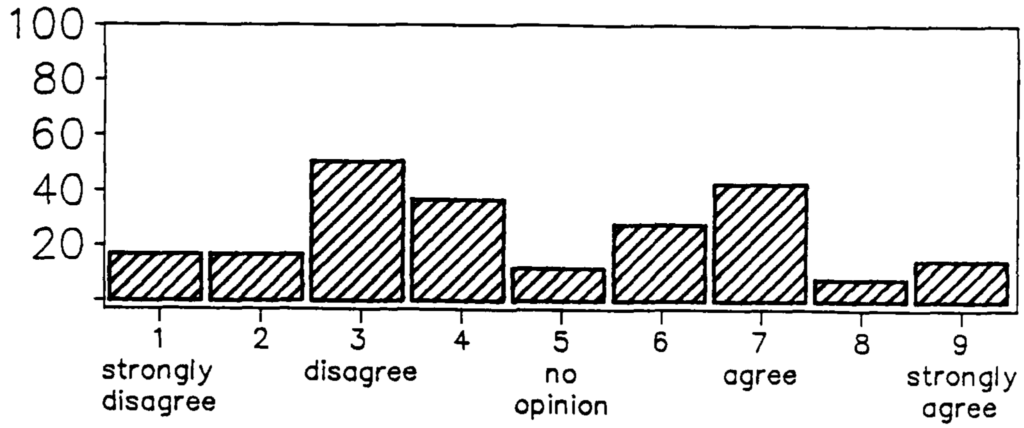



Figure 28. (Q28) The decision aid should always show me <u>all</u> the decision or situation alternatives it knows about.

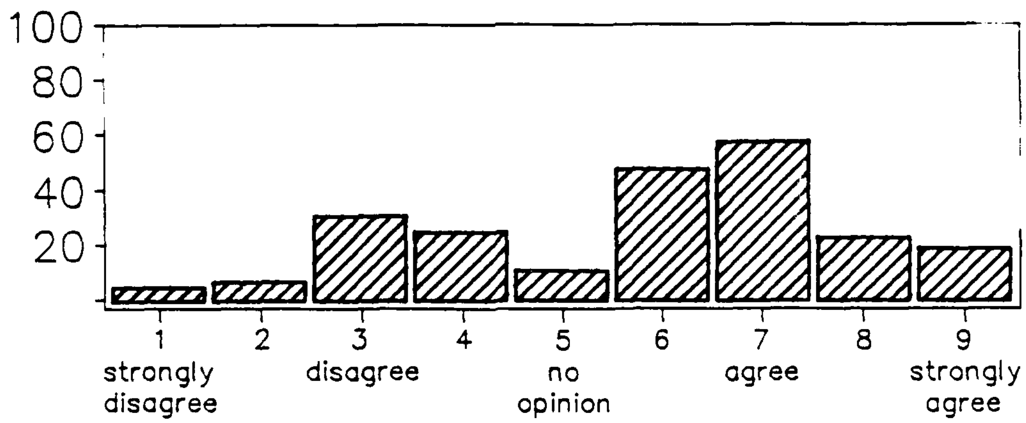



Figure 29. (Q29) The decision aid should show me a limited, user-selectable number of "good" alternatives for each decision.

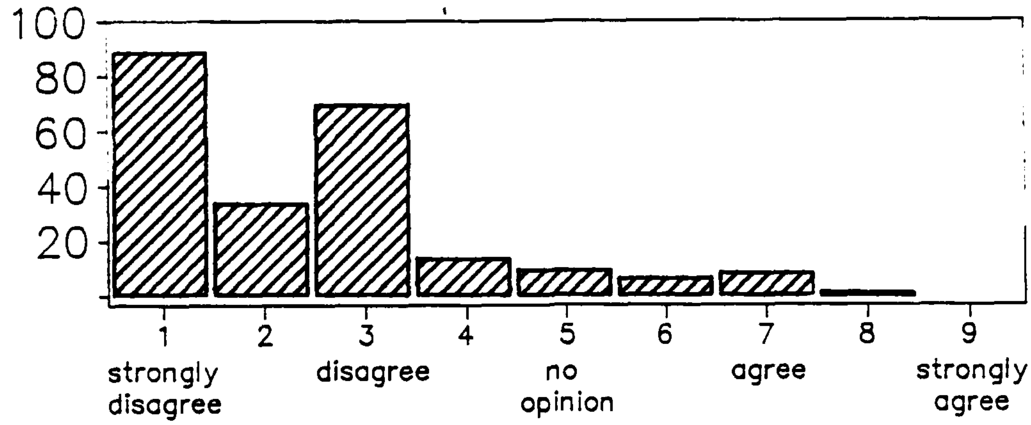



Figure 30. (Q30) The decision aid should always show me only the one alternative it considers best.

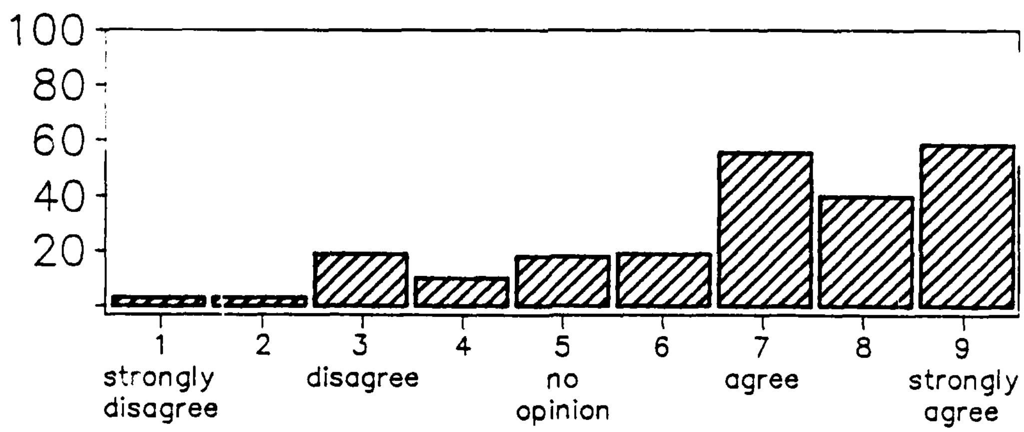



Figure 31. (Q31) The decision aid should automatically tailor the number of decision alternatives it shows me, based on how much time is available to make a decision (But I can adjust it to present fewer or more).

With regard to the alternative described in Item 28 (Figure 28) the principal consideration appeared to be time limitations. Some officers commented that this type of output would be desirable when time permitted. One should be able to request all the alternatives, preferably prioritized from best to worst. Similar comments were made with respect to Item 29.

The output described in Item 30 was considered too limiting and, "since working with probabilities only, this could be disastrous." Comments with respect to Item 31 also emphasized that the alternatives should be prioritized. One officer who endorsed this option did so with the qualification, "but operator must understand his own limitation, (i.e., people demand more information than they can use)."

The following quotes reflect some of the considerations:

> "(If) it's a large data base and it gives you everything it knows, you may be just totally inundated and you'd not be any better off than you were when you started. It depends on the size of the data base."

> "I think I looked at it more as the situation driving how many alternatives you want. So if it's not a high stress situation then I want the time to sit back and look at alternative number 3 and say '... how did it choose 2 over 3?' If they were real close, maybe I want to go with 3 over 2, but on the other hand, if it's high stress, I just want the top 1 or 2 and go with that."

> "I am on the side of getting me the best and giving me the option to call up all of the alternatives that it looked at or all the possibilities, because if I am in a time constrained situation I want it now and I want the best one and I will make the decision whether or not I like that one, whether or not I am going to go that route. But if I've got more time, give me more data and let me evaluate the alternatives in how you went about getting it ..."

"Well it depends on what you are thinking about as far as your alternatives and the data base. If you are looking at a system where there are maybe 5 alternatives and you want to see all 5, that is certainly reasonable, but if you are looking at a decision that maybe had 100 alternatives, there is no way that you would want to look at every one of those."

"...Some people like 20 alternatives (for) every decision they make, and some people want 1 or 2, and then they want to make the decision ... Decision style (of the) individual (is a factor)."

"The way I envision the AI is it's supposed to help you make the better decision faster, that's the goal I imagine. And I think we do tend to want more information than we can perhaps assimilate rapidly sometimes. And I hadn't really thought about that when I responded to that question. I was thinking more along the lines, it would be good to have the options. If I got lots of time then sure, show me how you came up with that decision. And if I am being shot at right now and I have got to make a quick decision and select one answer and it better be right. But after talking with a few people and listening to this, maybe a single answer or just a couple of bright alternatives and let the machine throw out the ones that are probably not important for you. But it just depends on the situation a lot of times."

"...Because of the nature of the (range of applications) from a relaxed time to a stress time scenario, if you can have the luxury particularly for training, for understanding where the computer got its information and how it developed its answers (it would be desirable)."

"...In a relaxed time situation, being able to get more information, being able to get in-depth, but then also having the capability for, under certain say defense conditions, this is the only information the computer is going to give you, and that's what you will have."

"I looked at the computer assistant there the same way you would a staff officer. A good staff officer never comes and greets the Commander and starts out saying 'I have 322 courses of action.' That's dumb. You try to get it down to like 3 or 4 courses of action and you make the recommendation of the best one ... but you present those 4 because you have already boiled out all of the rest."

"I guess I answered ...based on distrust of the machine. I want to know what the machine's considering, so I said, I always want to know what it is going to put out. I want to know all the rules it's using. It doesn't mean that I can't turn it off at a certain point and say 'o.k., I am tired of looking at these' ...I want to see what the machine recommends and then I want to be able to evaluate the recommendations. And I also want to be able to go back and say 'these look like good recommendations, why do they look like good recommendations?' It's almost like a teaching thing, if the machine's evaluating these things, why is it? I'd like to be able to go back and look at it."

## Understanding Basis for Recommendation

Survey items 33, 34 and 35 were also considered as a group by the survey participants before each was rated in terms of preference. Figures 32, 33, and 34 show the results with respect to the desirability of the decision aid showing the user what steps it went through in deriving each recommendation.

It is clear that most officers viewed as undesirable an option in which the decision aid always showed a summary of steps it went through in deriving each recommendation (Figure 32). A minority group (about 10%) felt this to be desirable. There were no differences in pattern of response to this item in regard to the officer's rank, military specialty, current assignment or computer backgrounds.

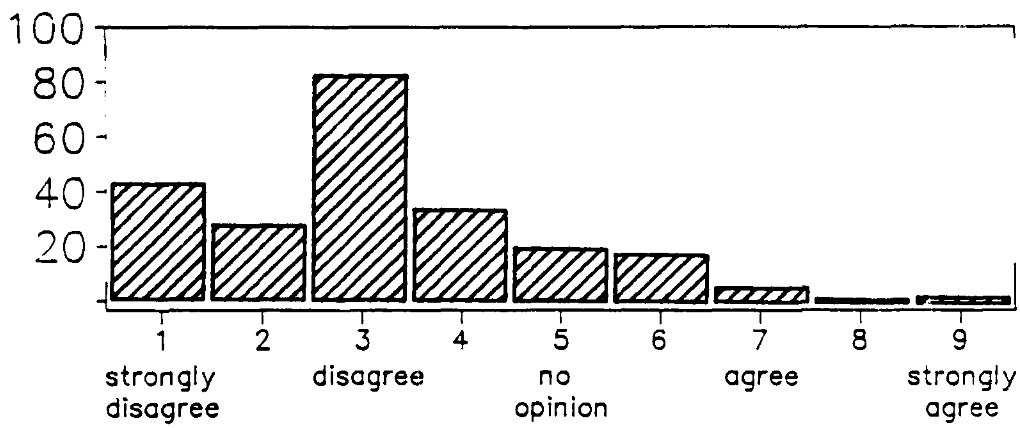



Figure 32. (Q33) The decision aid should always show me a summary of the steps it went through in deriving each recommendation.

The patterns of response to Items 34 and 35 (Figures 33 and 34) were highly similar although 35 received a somewhat stronger endorsement. Of course, these two design features are not mutually exclusive. The former will result in the decision aid displaying a summary of steps it went through in deriving any recommendation only if it is requested by the user. The latter permits the user to interact with the decision aid to get an increasingly detailed description of the steps it went through in deriving the recommendation. Generally, there were no differences among different groups of officers with respect to their endorsement of these 2 operational features, rank, military specialty, and computer experience having no effect. However, officers at the Naval Postgraduate School agreed significantly more strongly ($p < .01$) on the desirability of the option described in Item 35 than did the other officers (although all groups were positive).

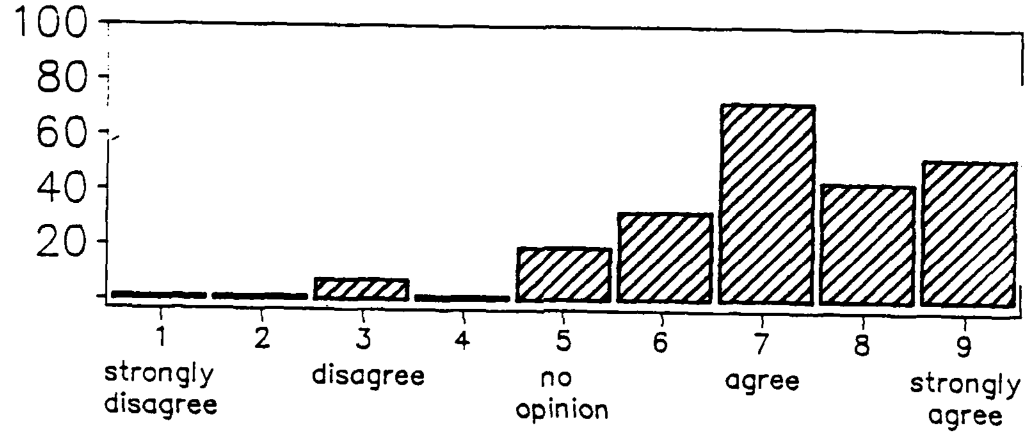



Figure 33. (Q34) The decision aid should display only if I request it a summary of the steps it went through in deriving any recommendation.

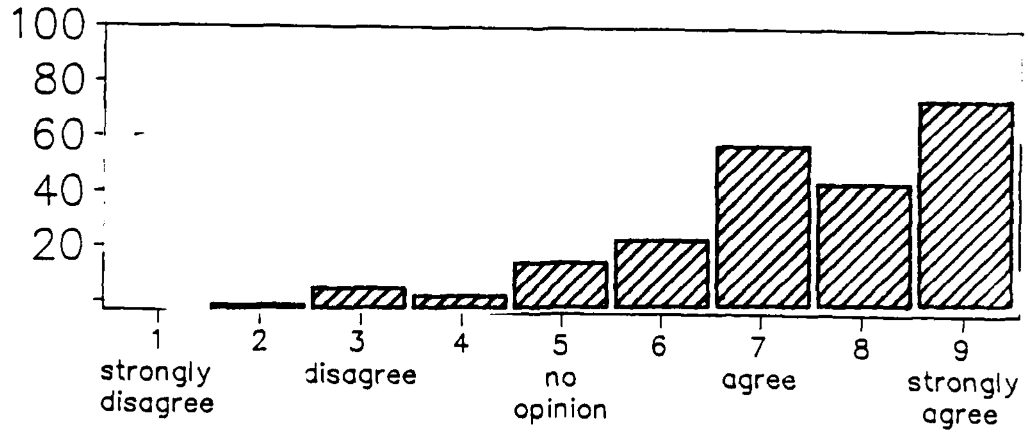



Figure 34. (Q35) The decision aid should permit me to interact with it to get an increasingly detailed description of the steps it went through in deriving any recommendation.

The fundamental objection to the decision aid always showing a summary of the steps it went through (Item 33) was strictly a time consideration. This supports many of the observations made throughout this report on the potential user's concern with available time for putting the decision aid to good use.

## Display of Historical Data

There was near unanimity of opinion on the desirability of the decision aid showing, on request, a summary of all historical data bearing on the decision at hand (Figure 35). There were no significant differences in opinion as a function of officer rank, military specialty, current assignment or computer background.

## Summary

A general conclusion to be drawn from the results of the above items seems clear. Potential users of AI decision aids strongly desire the opportunity, at their own option, to determine the basis for recommendations made by the device. This includes access to historical data in the data base and, although we did not address the issue directly, they undoubtedly also desire the option of querying the system in regard to applicable decision rules.

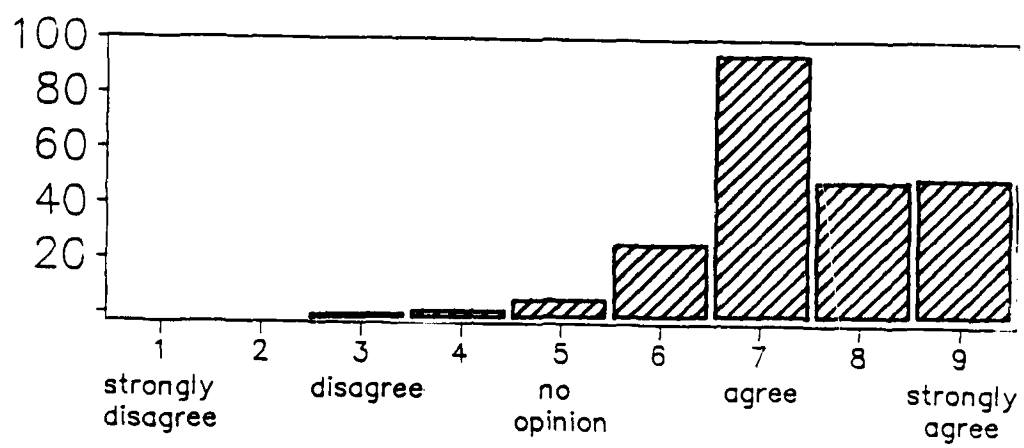



Figure 35. (Q38) The decision aid should show me on request a summary of any historical facts (operational data, intelligence data, performance data, etc.) it has bearing on the decision at hand.

## Probability or Confidence Estimates

Survey participants were asked to state their level of agreement with the proposition that the decision aid should provide a numerical probability or confidence estimate for each alternative recommendation. The results are shown in Figure 36. The great majority of officers agreed with this proposition, many of them very strongly. There were no differences in response pattern as a function of rank, military specialty, or current assignment, but officers with extensive computer experience were even more positive in this regard than those with lesser experience. The group with little or no computer experience had the greatest number of "no opinions."

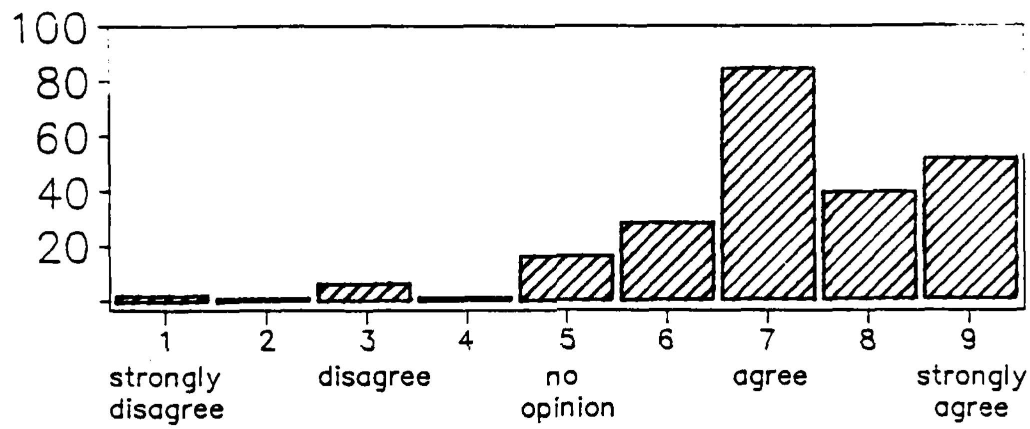



Figure 36. (Q32) The decision aid should provide a numerical probability or confidence estimate for each alternative.

Despite this very positive reaction, a few officers raised caution flags:

"NTDS does this and it is hokey."

"In real time decisions this unnecessarily confuses the issue."

"If this is possible. Don't build a more sophisticated machine just to incorporate this."

In the way of a positive suggestion, one officer urged that if probabilities are displayed they should be presented in order of magnitude.

## Minimum Knowledge of Computers Required

The officers were asked to respond to the proposition that for a military AI decision aid to be acceptable, it must not require extensive knowledge of computers. This statement was strongly endorsed by all officers in the survey; there were no significant differences in response pattern as a function of rank, military specialty, present assignment, or computer background. A very small minority (6%) disagreed (see Figure 37).

One comment offered in support of this design objective was that many senior users are not computer literate, so systems must be user friendly. Others stated that it would probably initially be necessary for this condition to be met but in the longer term a better solution is to educate the potential user community.

Given the wide diversity of backgrounds in computers represented in this sample of officers, and the unanimity of opinion on this issue, it would seem that minimizing required computer background for users of AI decision aids should, for the foreseeable future, remain a general design objective. This of course does not obviate the need for system-specific training, a matter that is discussed next.

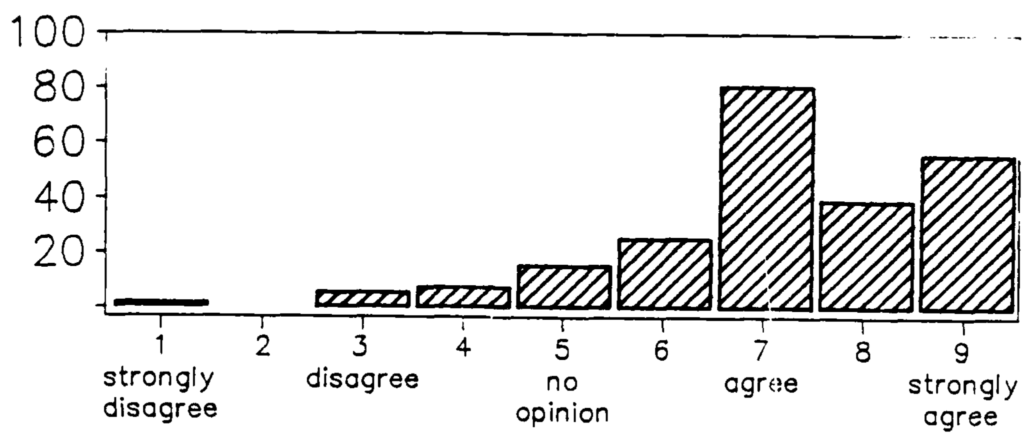



Figure 37. (Q26) A military AI decision aid must be usable without requiring extensive knowledge of computers.

## Embedded Training Capabilities Desired

The survey participants were asked whether they viewed training embedded in the AI device itself as preferable to independent text book approaches. The results are shown in Figure 38, and it is clear that there was a strong preference for embedded training. There were no differences of opinion as a function of officer rank, military specialty, current assignment, or computer background.

Quite a few officers felt that whether or not training is embedded in the AI system, textbooks should be available and perhaps should "come first." One officer was concerned that an embedded training capability would be a substitute for formal training and suggested that similar programs on board ship with NTDS systems had proved impractical because of interference with operations. With respect to the tutorial feature, one officer suggested that this would be very valuable during relaxed time usage. Another important observation was that the embedded training feature would encourage the updating of training whenever the expert system itself was updated.

A second training issue concerned the desirability of the AI system providing tutorial assistance on request when the users need help during system operation. Figure 39 reveals that this was regarded as an even more desirable design feature than embedded training. Once again there was no difference as a function of degree of computer background, rank, military specialty, or current assignment.

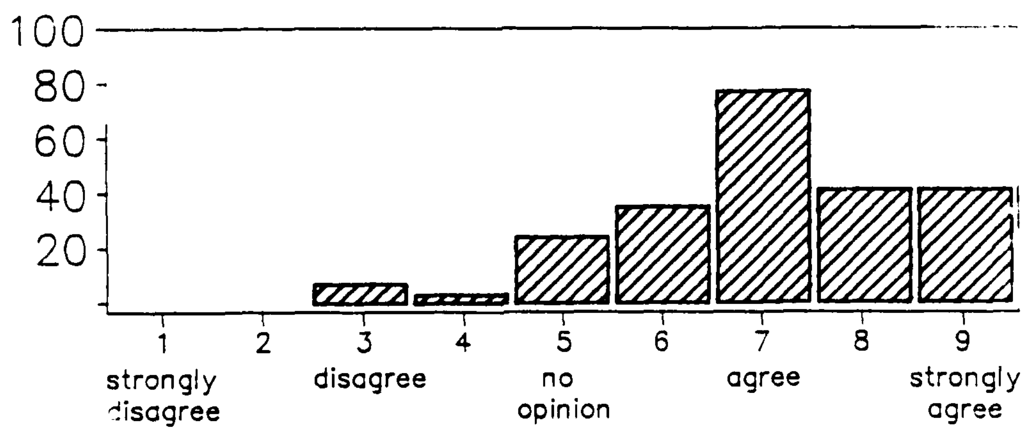



Figure 38. (Q42) Interactive user training embedded in the AI device itself is preferable to independent textbook approaches.

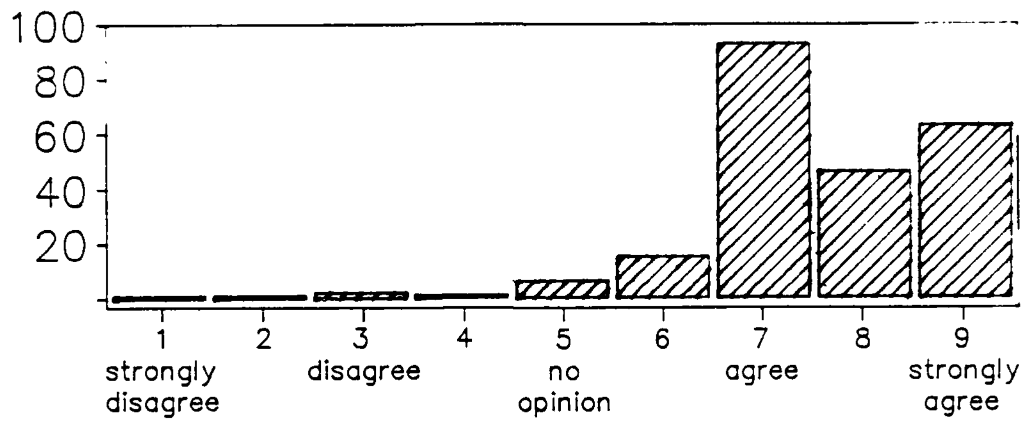



Figure 39. (Q43) The AI system should be able to provide tutorial assistance on request when users need help during system operation.

## Setting Operating Modes

A question was asked concerning the desirability of the AI decision aid being designed to automatically set its own operating modes, amount of output and so on, both when first turned on and during changing conditions. Figure 40 shows that a *majority* of the survey participants agree with the desirability of this feature, although many had no opinion. About 10% disagreed. There were no differences as a function of rank, military specialty, current assignment or computer background.

The following specific comments were offered:

> "(Yes), with some way of indicating to the user wha' it has set/changed and, upon request, why."

> "How about an initial screen output stating these settings and their alternatives."

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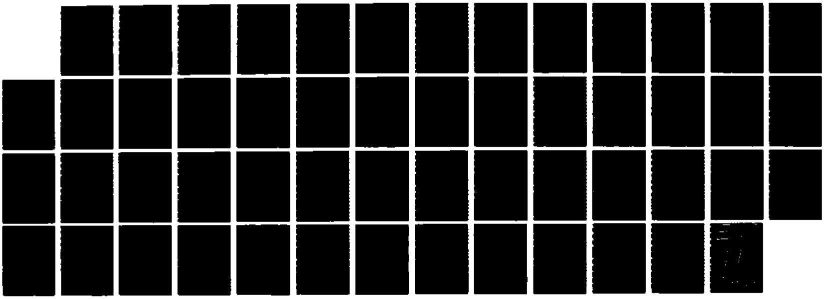

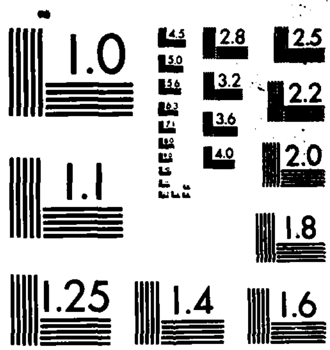


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

"Must have default values, but operator must be able to set desired parameters."

"You could pull down menus and use a mouse to facilitate data entry."

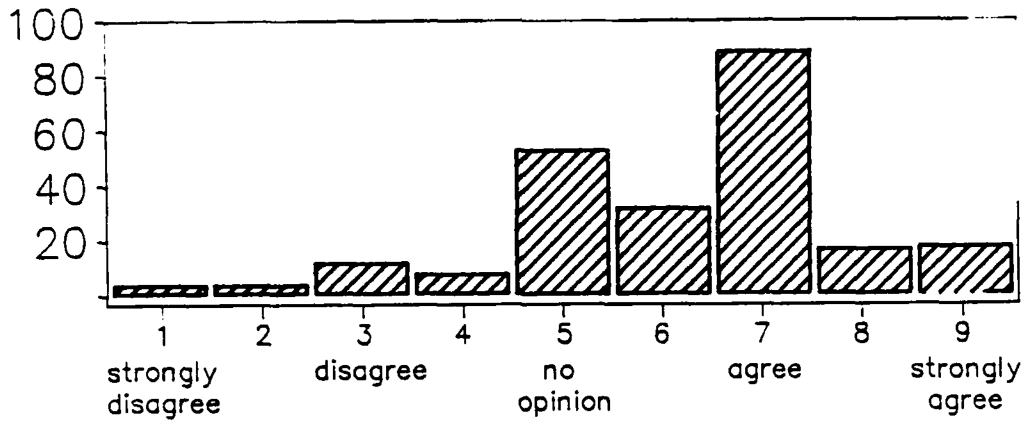


Figure 40. (Q39) To minimize user input requirements (but user can override), the decision aid should be designed to automatically set its operating modes, amount of output, etc., when first turned on and during changing conditions.

## User Communication With AI Decision Aids

Because of the importance of easy interaction between the military decision maker and any decision aid, the survey participants were asked whether they thought AI technology would make communication between computers and human being easier. The results are shown in Figure 41. It is evident that a majority of the officers felt that this would be true although a substantial number had no opinion. About 10% disagreed. There were no differences in the pattern of responses as a function of rank, military specialty, current assignment or computer background.

Most officers viewed this as a fundamental problem in design of the user interface which faced the same kinds of human factor problems that other systems do. However a few suggested that in an AI system the computer will be able to answer the human's questions more quickly and accurately, that the natural language feature and speech generation/recognition capabilities would help. One commented that "AI programs will make machines more friendly; that should help, but good ones seem to be a long way off in the future."

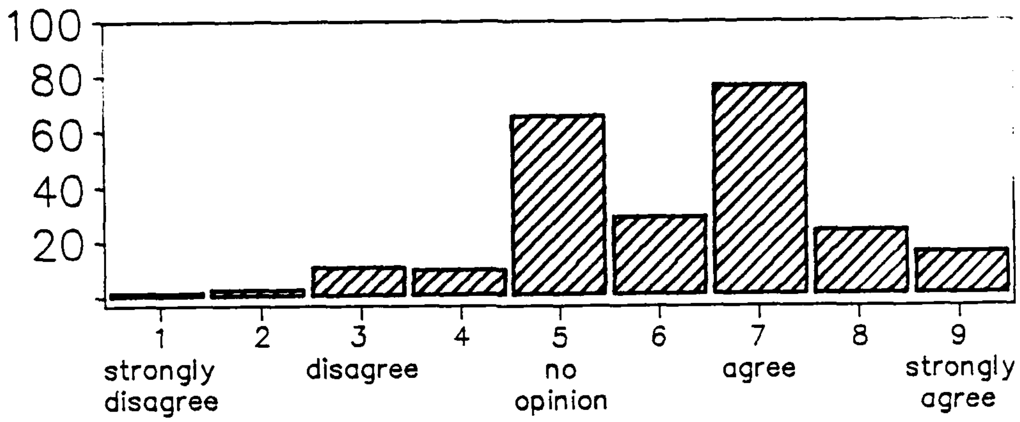


Figure 41. (Q14) AI will make communication between computers and human beings easier.

## Acknowledgement of User Inputs

We have seen that in any real time application of an AI decision aid, the potential users view speed of response as a critical system characteristic. Item 40 in the survey raised the specific issue of whether a 1-2 second acknowledgement time to user inputs was acceptable. The great majority of officers agreed but about 10% disagreed (see Figure 42). There were no differences in response pattern as a function of rank, military specialty, current assignment, or computer background. Numerous officers qualified their response by indicating that it depends on the situation. Some again expressed the concern that AI systems may not respond fast enough to meet urgent requirements. One officer commented that a keyboard would tie the decision maker down too much. Voice should be the preferred method of entry.

> "Again, it all depends on the situation. If you are in some kind of tactical situation where you need to use it, ...you don't want to wait even 1 or 2 seconds. But if you are in say a supply mode where you can wait 10 minutes, or 15 minutes, or 1/2 hour or whatever, there is a big difference there."

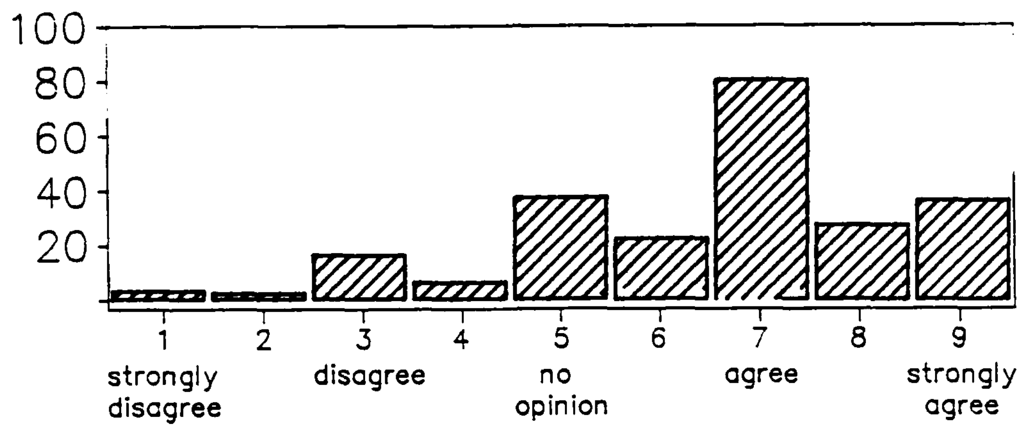


Figure 42. (Q40) An AI system should acknowledge a keyboard or other user input within 1 or 2 seconds in order to be acceptable.

## Addition/Deletion of Decision Rules

The survey participants were asked to respond to the proposition that the user should be able to add or delete decision making rules and data that are used by the decision aid to derive recommendations. There were wide differences of opinion regarding the desirability of this provision, although more officers agreed than disagreed (see Figure 43). The disagreement group was large enough however for this to raise an acceptance issue. There were no differences in response pattern as a function of rank, military specialty or current assignment. However, officers with more extensive computer backgrounds were significantly more often in disagreement ($p < .005$) than officers with lesser computer experience.

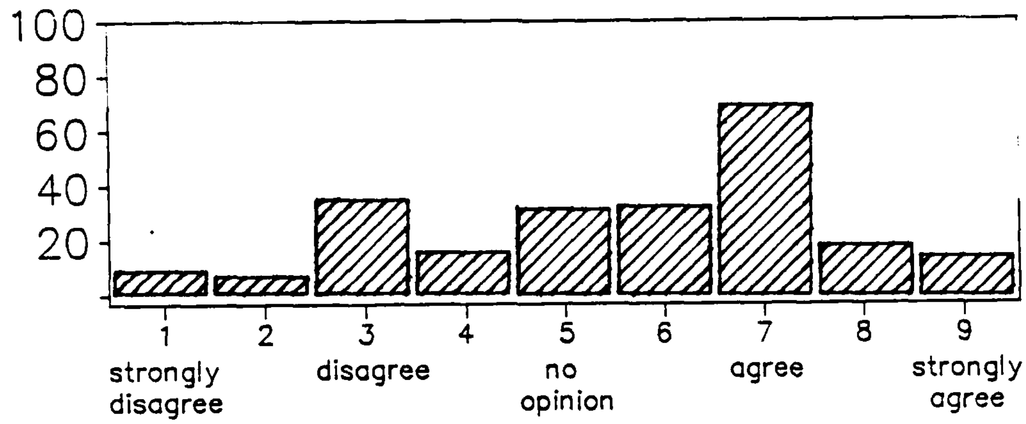


Figure 43. (Q41) The AI system user should be able to add or delete decision-making rules or data in the "expert data base" that is used by the decision aid to derive recommendations.

Some of the considerations surrounding this issue are reflected in the following quotations:

> "I think it came up earlier ... that if you change the input data, you can't be assured the system that you have is quite the same as it was before, and we may not want to have so many variations in these things out in the field. It may be that you would like to control the change in the data base centrally and not give the user the ability to change this thing..."

"On the other side of the issue, I kind of like to have the ability out there to say 'yeh I know what you just told me, but what if this happens, what if something was not quite as we thought it was? Let me change this bit of data and see what difference it makes in the response'. Maybe you don't have the time available to do that but to eliminate that capability kind of restricts the way in which the tool can be used. So it gives the ability for sensitivity analysis. Whatever change you make will perhaps be only a temporary change and it will, next time you boot the system or something, it will disappear. But it gives you the opportunity to run that through and say 'what happens if I do that?'"

"...That (rule modification) could easily be abused but if you want me to have confidence in the machine then you need my input into the data base. That will put my confidence into the machine. But the other side to that is that, that will be abused. If there is any way to abuse it, we will."

"With the high turnover in the military, what are you going to do when you get transferred? After they implement it and when you transfer you are going to pull all your data base out and take it with you in your duffle bag ... and let the next guy put in his stuff? He may not, the next person in the job, may not like the way you went about making the decision."

"(It's) not a problem of somebody's not liking it, there is a tendency in whether you've got (with) a data base like this, (a situation where people will) tailor programs to their personalities so much, then leave it, the next guy doesn't understand it. You can make some very serious mistakes with it (and the next guy) comes in and thinks 'oh, we've got a great system here,' but because of the personal quirks that the guy before him put into it, he could get some bad outputs from it."

"The initial presumption is that the experts are the people (whose) knowledge is being programmed into a computer, then to have somebody in the field add to the thinking process I don't think is valid. Certainly that AI should be updated with all the sensory information - radar, troop movements, intelligence and all that stuff. But those are just factors that will go into the decision model... So to have somebody out there ...saying 'well the experts are wrong and I'm right,' I think that would (subvert) the whole idea of this."

"I think you have to be able to tailor to the tactical environment that you are in. I mean there can't be one standard for all over the world, no matter what it is, especially in aviation where I'm in."

"I think it's highly dependent on the implementation that you are dealing with. A body of knowledge such as law, for instance, if you are taking yourself through a legal problem, that body of law doesn't change very fast and obviously you are not going to want to get in and twiddle the data base. But if you are dealing with the activities of an opponent or something like that, that's liable to change on an hourly basis."

"...You can get somebody who doesn't really know what's going on and (he will) delete something really important. That's what scared me on that question. Someone who wasn't really sure of something, deleting something that couldn't come back into the system."

"...It would be nice if there was some way that, (for) a given battle group or a given situation, you could tailor a portion of it to be your ship, your plane, your crew ..., but by the same token, the overall data base - you can't be screwing with it all the time or you would lose validity very quickly."

"... Ron made the point earlier that you shouldn't be able to change the expert data base and I sort of agree with that. But on the other hand there is time when, if this thing's applying a body of rules and you can look at those rules and say, well in this case, for some exceptional reason that rule doesn't apply. You've got to be able to override a rule or a set of rules and ask it to generate another decision based on what you (perceive to be happening). That would be helpful I think, in some cases."

## Amendment of AI Knowledge Base

In view of the potential user's likely interest in amending the AI knowledge base, the survey participants were asked whether they thought this could be easily accomplished. Although this is a technical question, we thought it appropriate to secure the opinion of military decision makers on this point to see whether or not there was a possible problem relating to acceptance of this new technology.

The results in Figure 44 show that most of the officers surveyed had no opinion on this matter. Of those who did, about equal numbers agreed and disagreed. There were no differences in response pattern as a function of rank, military specialty, or current assignment. However, officers with relatively greater computer experience were significantly ($p < .01$) more skeptical than the others regarding how easily this could be done.

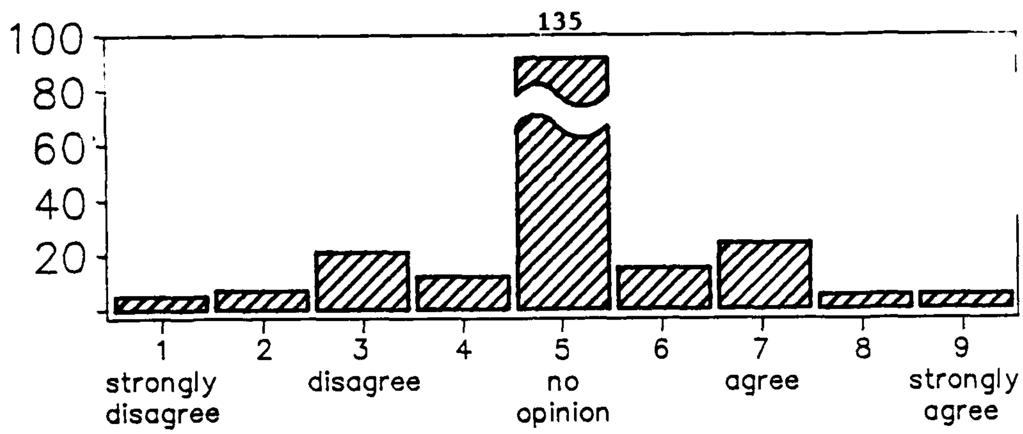


Figure 44. (Q25) AI knowledge bases are easily amended.

## Output Tone of AI Decision Aids

Because of the unique role of an expert system in support of decision making, an interesting design question concerns the style in which the recommendations are output to the user. Some have suggested that since the AI system incorporates the opinions of experts, it's output statements should be highly authoritative in tone. Others have suggested a more personalized human-like conversational tone, embodying perhaps some of the incidental remarks that often accompany mutual problem solving.

This is not a trivial issue in regard to innovation acceptance. A potential user may be unnecessarily antagonized if he finds the output tone unacceptable. This can be true whether the output mode is in the form of a message on a screen or whether it is presented by voice. Of course, the use of voice adds yet another dimension in regard to tone that is acceptable.

These issues were addressed by two survey items, the results of which are shown in Figures 45 and 46. It can be seen that the majority of the survey participants rejected output that is authoritative in tone. However, there was a substantial number of "no opinions", and about 10% thought an authoritative tone desirable. There were no differences in pattern of response as a function of rank, military specialty, current assignment, or computer experience.

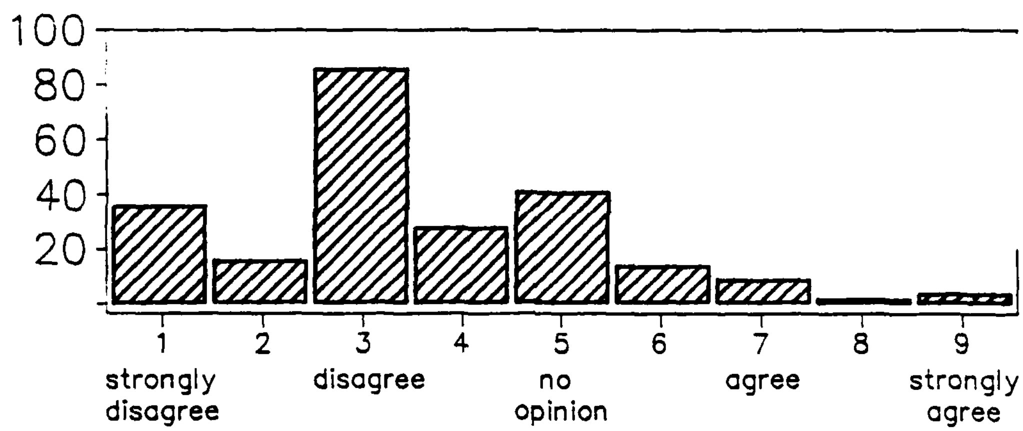


Figure 45. (Q36) Since an AI system incorporates the opinions of experts, its output statements should be highly authoritative in tone.

Figure 46 shows that there was a wide disparity of opinion concerning the desirability of employing a human-like conversational tone. While a substantial number of officers agreed with this, there were many "no opinions" as well as a significant percentage who disagreed. Interestingly, officers of lower rank were significantly more inclined to endorse this proposition ($p < .05$) while higher ranking officers were more neutral. There were no significant differences in response pattern as a function of military specialty, current assignment, or computer experience.

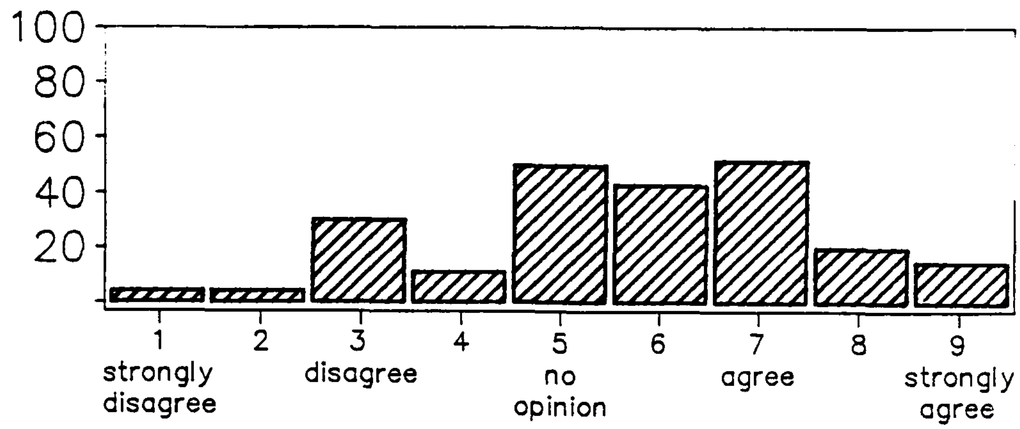


Figure 46. (Q37) It is desireable for the output of a decision aid to use a human-like conversational tone (e.g., "I am working on the problem"; "I recommend this solution..."; "I can't figure it out, because...").

The following quotes reflect some of the diversity of viewpoints on these two issues:

> "Just straightforward. I'll decide what's authoritative!"

> "These are recommendations and options and <u>nothing</u> more!!"

> "Even experts, when teaching inexperienced pupils, do not always use highly authoritative tones. They would be much less acceptable coming from a computer."

> "I like the probabilities approach better."

> "No one likes to be ordered what to do by a machine."

"Cryptologists are conservative in stating their conclusions. So should the machines be."

"They should be authoritative in the interest of brevity - too much time wasted with the 'I recommend' or 'maybe you should try ...'"

"(This conversational tone) would enhance user friendliness."

"I wouldn't care about this (conversational tone) but I know many others that would."

"Skip needless verbage."

"It's as if you are trying to give this thing a personality. It's a tool, like a 3/4" drill or a waffle iron. Why waste your time?"

With respect to desirability of conversational tone:

"...I think it needs to be pointed out (that) to do something like that is great, but it eats up a heck of a lot of machine overhead... You can get the job done with the same degree of efficiency overall, more or less, without doing that, and you can save a heck of a lot of machine overhead. So if something's got to go because of budget, size, capacity or whatever, I would think that would be the first thing I would cut out. ...If you can get the idea across in a more concise way, without using a conversational tone and use less overhead, do it."

"I don't think it (should be) artsy, cutesy. There's times when I have worked some software type programs that puts out these real cute little statements, and they are fun the first 2 or 3 times you look at it, and then you are ready to reach in and rip its face off."

With respect to authoritative tone,

> "I'd like to offer one thing, and this happened to me. In a stress situation with a machine whose language had been designed in a very authoritative tone, being under pressure and having a machine come up and tell you something that you are already doing in an authoritative tone was an emotionally, there was a negative reaction in response, and I think that may happen to other people. Having a machine, and you know it's a machine, tell you what to do especially if you are already doing it, can have a negative reaction."

> "I think AI is supposed to help the decision maker make a decision, so I think therefore that your machine should make suggestions to the decision maker, and that's why I didn't like 'authoritative.'"

> "This goes back to that other highly authoritative type question that you had further back, where you would take away the authority of the decision maker. I mean you get a highly authoritative tone and you get a very authoritative type Commander, and he's not going to want to hear this. You've got to put it in a tone that's almost neutral, I think neutral."

Though many of these comments were s newhat facetious, they reflect important considerations in regard to the innovation acceptance issue. Military personnel, particularly when working in time critical circumstances, develop a kind of shorthand communication that minimizes word usage and capitalizes upon esoteric terms that are rich in meaning in the context of operations. Perhaps this kind of formula will be preferable in AI decision aiding systems. At the moment it is easier (from the survey results) to describe what people will not want rather than what they will.

## System Adaptation to the User

In perhaps the most sophisticated interface issue to be addressed, the survey participants were asked whether they considered it desirable for an AI system to be able to recognize individual differences among decision makers and automatically adjust its outputs to compensate for those differences, in order to achieve more uniform man-machine system performance.

Figure 47 shows that there were wide differences of opinion on the desirability of this feature. There are in fact three major subgroups: those who agreed, those who disagreed, and those who had no opinion. In all likelihood this was the first time that most of these officers had ever thought about this kind of issue.

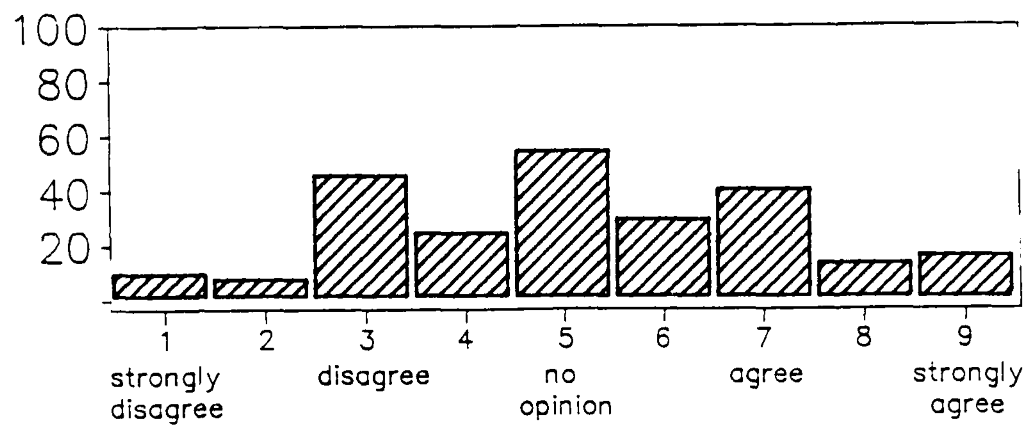


Figure 47. (Q44) An AI system may be able to recognize individual differences among decision makers and automatically adjust its outputs to compensate for those differences, in order to achieve more uniform man-machine system performance. Designers should include this feature in AI systems.

Opinions varied somewhat for different officer subgroups. Lower ranking officers tended to be significantly more positive ($p < .01$) than senior officers. Officers at the Naval Postgraduate School were significantly more opinionated, in both directions, than officers attached to the Tactical Training Group. ($p < .05$). Finally, officers with relatively more computer experience were somewhat more positive ($p < .05$) than those with lesser experience, although all groups registered considerable uncertainty.

Some illustrative comments follow:

> "If they could recognize the level of experience a certain individual has, i.e., in ASW, AAW, the system could compensate for how much explanation and decision alternatives it would need. Sounds like a very good idea."

> "If the user had no experience in tactical decision making, perhaps the system might need an 'automatic' feature, but standard training in decision making among experienced people should result in standard decisions for the most part."

> "A set of selectable modes of operation would be nice, if the differences could be identified."

> "Pretty ideal but how realistic?"

> "It would be helpful to be able to identify yourself to the machine and then it would automatically 'know' what your preferences are. This is not a crucial feature however. Just make it fast, user friendly, reliable, and as easy to fix as possible."

> "Nice goal. (But,) don't let this one stop attempts to develop system now."

> "I think in a system that is used on an airplane where that system happened to be used by the same user all the time, it would help if it could grow somewhat so that you didn't get in there and it was just back to the base line, the same basic idea. It could be sort of human."

But, in a more negative vein:

> "Absolutely not! You want information, not a 'yes man' machine!"

"Then humans will play games with the system."

"Tends to limit the number of alternatives."

"I think then the machine or the tool is responding to the decision maker and not the situation... 'here's what the boss wants to hear, let's put this one up first'."

"Another thing to consider, ...if you tailor it more to be more user friendly or extremely friendly to the point where you could develop a certain reliance and you feel very comfortable with it, well maybe we don't want to get that comfortable with it. Maybe we always want to ...create a system that's not so friendly so we always remember it's still a machine and it has some limitations and it's still our responsibility to make the decisions. It seems like if I have an extremely friendly system you may lose that perspective."

## Summary

The several rather diverse considerations presented in the paragraphs above have identified a number of issues that can be highly important in the innovation acceptance process.

First, the officers in this survey agreed that ease and rapidity of communication between the decision maker and the AI decision aid is critical to acceptance in many operating circumstances. There is considerable uncertainty in the minds of these officers concerning whether communication between computers and human beings is made easier by AI technology. To the extent that it is, this message should be conveyed.

More specifically, the whole issue of ease of input by the user is a significant one. The system's response to the decision maker's inputs/queries should be as rapid as possible. To the extent that the input technique makes use of advanced technologies, as opposed to relatively slow and cumbersome keyboard entries, acceptance will be enhanced.

For the most part, military officers do not know whether AI knowledge bases can be easily amended. A more important issue is under what circumstances, if any, the user is to be permitted to add or delete from the expert data base, and to modify decision rules. Since this is a capability that could be incorporated into AI decision aids, and since the Navy usually has very formal procedures for modifying computer systems software, this is a capability that requires very careful introduction. The optimum solution may very well involve a combination of relatively permanent expert data and decision rules, and an adjunctive system that is modifiable by the local user as he perceives it to be necessary in order to deal properly with special circumstances or changes in the situation.

The superficially simple question of the authoritative/conversational tone of the AI system output is a potentially important acceptance issue. Certainly the present survey has raised caution flags about either highly authoritarian assessments/recommendations, and conversational features that may be regarded as "cutesy" or otherwise unnecessary. Either of these features could create resistance to a device that otherwise had great utility.

Finally, there is considerable uncertainty among many officers as to the desirability of having an AI system adapt to the idiosyncracies of a particular user. While some officers see merit in this approach, others have quite strong reservations. If this feature is to be included, it must be handled very carefully in the introductional strategy.

## SECTION 5
## A PLAN FOR TECHNOLOGY TRANSFER

One of the objectives of this study was to develop a plan for enhancing user acceptance of innovative technology, with particular emphasis on the application of artificial intelligence to decision aids. Section 4, "Results and Discussion," provides details of the perceptions of military officers regarding the application of AI technology to the decision making process, and their preferences regarding man-machine interface design; numerous issues are discussed and recommendations made regarding general and specific user considerations. However, we felt it would be useful to also address the process of innovation acceptance and how that, in turn, leads to the formulation of a plan for technology transfer. Figure 1 (which is repeated on the next page for convenience) presents the key steps required in a program to achieve user acceptance and beneficial application of new technology. Each of these steps will be discussed in turn.

### COMMUNICATE WITH POTENTIAL USERS

An essential but often overlooked step in the process of developing new technology for application is that of early communication with potential users. As Fundingsland (1984) noted, "a common problem with mission-targeted R&D programs is the failure to adequately consult the proposed users of the technology in the planning process. GAO [United States General Accounting Office] evaluations of R&D activities often uncover this missing link." It is essential to communicate with users in order to gather information in regard to critical operational issues, and to feed back to them how these issues are addressed in the development plan. The top row of blocks in Figure 1 relate to these requirements, and each is discussed below.

#### Identify Critical Issues

The population of potential users should be identified as accurately as possible, and a representative sample of users should be selected from which to gather information by means of interviews and surveys.

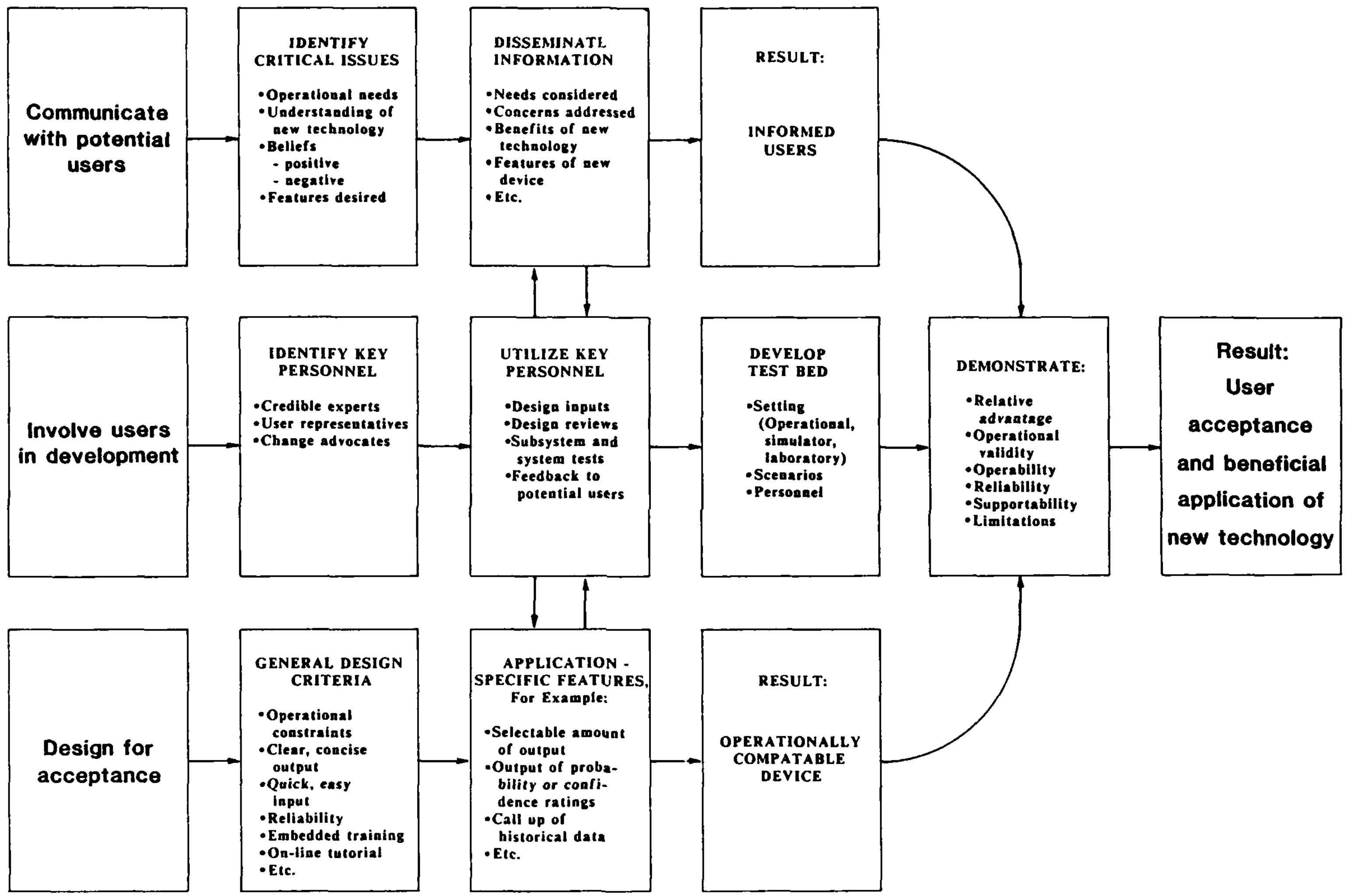


Figure 48. A Technology Transfer Plan: (Identical to Figure 1)

This population may be diverse in military rank and specialty; all important sources of influence should be identified. The present study represents an example of this process, but the information gathering and feedback process should be periodically conducted throughout development. The objective of the information gathering should be to identify critical issues, including those discussed below.

Operational needs. It is important to learn from users what they perceive their operational problems to be in the area addressed by the new development, and the extent of their felt need for improvement. If the innovation "scratches where the users do not itch," a critical acceptance problem may be posed. If they do not forsee valid future needs, information in this regard should be disseminated (see below).

Understanding of new technology. The users' awareness of the innovative technology at issue should be gaged, because user misperceptions of innovations often lead to an acceptance problem. Likewise, it should be determined whether users have had experience with devices which they think are "similar" to the innovation. Such experiences (positive or negative) may have an impact on acceptance, and may be based on "similarities" that are misperceived. Such potential problems, if discovered, can often be countered by the dissemination of accurate technical information.

Beliefs. The users' beliefs concerning the application of the new technology should be examined, including positive attitudes and beliefs, and particularly, doubts, concerns, and skepticism. The latter should be defined as clearly as possible in order to respond to them during design and during information dissemination and device demonstration.

Features desired. Carefully worded rating scales may be used to determine user preferences for alternative design features that are identified a priori, and discussions with users can be conducted to identify preferred features which may not have been anticipated in designing the survey questionnaire. Identification of user preferences for design features provides an input to design trade-offs, and provides an important basis for feedback to users regarding both features that are and are not incorporated in the final design.

## Disseminate Information

The potential user's initial attitude toward a new development is strongly determined by whatever information he receives, accurate or not, concerning the various characteristics of the innovation. It is particularly important that the developer of the innovation control this information process. There are at least four methods by which valid information should be disseminated. First, a selected summary of the results of the "critical issues" study (discussed in the preceding block) should be prepared for distribution to all potential user commands, particularly those that participated in the survey. (The present report constitutes the output of such a study; a convenient short summary should be prepared and returned to the survey participants and other potential users.) Secondly, because considerable time can elapse during system development, a periodic bulletin might be prepared for distribution to all potential user commands which could keep appropriate personnel updated and invite feedback and commentary. A one-shot dissemination of information will not meet the need. Officer (and perhaps senior enlisted) personnel are vitally concerned with the issues which AI decision aids may address. They need to know that something is being done, but most of all they need to know that their own inputs and concerns are being considered. In the absence of periodic communications, and with the characteristic turn-over of military personnel, there is continuing risk that the innovative development will lose its visibility. Worse, there is risk that invalid information and rumor will fill the information void. Thirdly, there is no substitute for face-to-face meetings if they can be arranged. Finally, a fourth channel of communication involves the use of a "change advocate" within each user community who can serve as a focus of the regular information exchange between the developers and the user community. These last two methods will be dealt with in greater detail under the heading "involve users in development."

Using such methods, the following kinds of information need to be communicated:

User needs considered. Users should be informed that their felt needs, as determined by surveys and interviews with key user personnel, are being considered in the development of the innovation.

User concerns addressed. To counter user concerns and skepticisms identified during the user survey, users need to be told that their concerns are being taken into account through direct involvement of professional peers in the design process.

Benefits of the new technology. Users will need valid information regarding the new technology underlying the innovative device, even if it is as popular as artificial intelligence currently is. It is important to convey the particular aspects of the new technology which apply, and how it is that they are expected to benefit the user.

Features of the new device. Potential users need to be updated periodically regarding the features and characteristics of the new device. A concerted effort should be made to point out how user inputs influenced the choice of features and how the features of the new device will permit it to address operational needs while meeting the standards of operability desired by the user community.

**Result: Informed Potential Users**

A *successful program of communication* will result in informed potential users who will have valid knowledge about the innovation and some positive attitudes and beliefs concerning it (which the developer will know of and be able to utilize). The users may also have some negative attitudes and beliefs, or at least a healthy skepticism regarding certain aspects of the innovation. If communication has been effective, however, these will not be based on misinformation, and the nature of the users' concerns will be known to the developer, so he can plan effectively to deal with them. At this point, the users - and the developer - are well prepared to have the innovative device demonstrated, which is the next step shown in Figure 1. This step will be discussed in detail later, but first the remaining processes in Figure 1 which also precede demonstration need to be described.

## DESIGN FOR ACCEPTANCE

The bottom row of blocks in Figure 1 relate to the engineering design of the innovative device. Here, we are concerned chiefly with general design criteria for user acceptance, and specific criteria derived from direct user involvement in the development. Each of these will be discussed in turn.

## General Design Criteria

In this and in earlier studies of user acceptance of decision aids in the Navy, certain general design considerations emerged as being very important to users:

Operational needs and constraints. It is very important to users that the design of the innovation reflect not only what users perceive to be operational needs, but also the constraints placed upon the user by his operational environment. Achieving this must be a fundamental goal of any plan for technology transfer.

Operability and Reliability. In a rank ordering of 10 general decision aid design criteria by 203 Naval personnel (Mackie, 1980), the following group of items was clearly set apart as the most important: (1) ease of information assimilation and interpretation; (2) speed of operation and ease of information call-up; (3) ease of obtaining and entering needed inputs; and (4) reliability. Mackie pointed out that "the unanimity of opinion among all survey participants concerning the importance of [these design criteria] was impressive. ... Agreement was strong on the ordering of all criteria regardless of whether the participant was from the Altantic or Pacific Fleet, was a senior officer, middle grade officer, or petty officer, and whether he brought to the task the perspective of ASW as performed aboard patrol aircraft, carrier based aircraft, tactical support centers, destroyers, or submarines. Such high agreement in the domain of human judgment about anything is indeed exceptional."

Embedded training and on-line tutorial. Adequate and convenient training support is invariably a concern of the recipients of systems employing new technology. The results of the present survey showed that there was a strong preference for embedded training over independent textbook approaches. There were no differences of opinion as a function of officer rank, military specialty, current assignment, or computer experience. Even more strongly endorsed (nearly unanimously) was the proposition that tutorial assistance should be available upon request when users need help during system operation. User acceptance of new technology will be enhanced by evidence that the system developers have adequately addressed the training requirement issue.

## Application-Specific Features

During design, key users should be involved in the development of application-specific design criteria. Identifying and incorporating user inputs in the form of widely-endorsed design features can lead to improved user acceptance and beneficial application.

Obviously, it is premature to specify examples of application-specific features here; that must await the more complete definition of an application. However, several items can be cited as examples specific to AI decision aiding as identified in this study. A number of these are listed below, together with page number references where additional details may be found.

- There should be user control of the number of situation/decision alternatives the AI device should display under a given circumstance. (Page 73)
- The display of probability or confidence estimates for each alternative recommendation is strongly desired, and alternatives should be listed according to these estimates from highest to lowest. (Page 81)
- There should be user control of the call-up and display of any historical data in the AI system that bears on the decision at hand. (Page 80)
- The user should have the ability to determine the basis of recommendations made by the AI device, in increasing levels of detail. (Page 78)
- A suggestive, rather than authoritative output tone is desired. (Page 91)
- A conversational (human-like) output tone is less preferred than brevity of output. (Page 91)

## Result: Operationally Compatible Device

A successful program of design for acceptance, which incorporates both general design criteria for acceptance and application-specific features identified by users themselves, should result in an operationally compatible device. Clearly, this in itself does not ensure operational validity or sufficient relative advantage to guarantee adoption of the innovation; other aspects of engineering must contribute as well to develop an inherently "good" device. However, responsiveness to the several design criteria outlined above will ensure a much higher likelihood of successful adoption and continued use than simply expecting a "good" device to succeed on its own merits.

## INVOLVE USERS DURING DEVELOPMENT

The middle row of boxes in Figure 1 describes a more intimate and detailed level of user involvement that that so far described. The importance of user involvement in design has been recognized for some time. Mecherikoff and Mackie (1970), in a study of attitudinal factors in the acceptance of innovations in the Navy, concluded that "opportunity should be provided for the users (or representatives of the users) to 'invent it here' - provide inputs about operating procedures, constraints, and environment to the designers." They further noted that "In the case where the users themselves had no input into the design of the innovation, care should be taken to explain to them how inputs from individuals like themselves were considered in the design of the innovation. (This assumes, of course, that such inputs were, in fact, made and considered seriously.)" Each of the processes in the middle row of Figure 1 will be discussed in turn.

### Identify Key Personnel

Credible Experts. Obviously, any development program employing the AI methodology of "expert systems" must identify subject matter experts whose knowledge can be extracted and used to build a "knowledge base" for the system. However, there is an attitude which was frequently expressed during the survey, which is epitomized by the comment of one officer: "There could be a major (maybe fatal) difficulty in deciding who are the experts - choose the wrong ones, and you curse us all!" The credibility of the experts chosen to provide the knowledge base is likely to be a key issue in acceptance.

User Representatives. Most innovative systems are aimed at relatively large numbers of potential users and it will be feasible to involve only a small sample of them in the development process. It is critical that the selected sample be representative of the user population in terms of background, responsibility, and beliefs germane to the innovation. For example, in conducting surveys to identify critical issues, a comparatively small but representative sample of the user population will need to be identified in order to make the survey and interview technique economically feasible. An even more restrictive step concerns face-to-face user involvement in design; clearly, only a limited number of user representatives can be consistently involved in in-depth interaction with the project design team. Thus, it becomes critically important that persons selected for this role be carefully chosen for their credentials in providing representative inputs on behalf of users and, equally important, be perceived by the user community as credibly representative.

Change Advocates. A change advocate is defined in acceptance theory as a representative of the developing organization who directly interacts with potential users in the interest of promoting acceptance. The role of the change advocate is vital because he constitutes an informed link between the development agencies and the user. The change advocate serves as a personal linkage between the user and the developer of the system. Because of his continuous presence, as opposed to the other intermittent communications that may filter down, he is a particularly significant link. Mecherikoff and Mackie (1970) observed that:

> A qualified change advocate must be explicitly provided at all the crucial stages in the introduction of the innovation. The following should be resisted: (1) the assumption of advocacy by an unqualified person; (2) dependence upon documentation to carry the advocacy function; (3) the expectation that (an innovation) will explain itself and sell itself without any explicit documentation or advocacy.

The change advocate must be a technical expert whose viewpoints are widely respected by those he would influence. In the present context, the advocacy functions should logically rest with a respected official whose credentials in the subject matter area are widely respected. There are at least three practical considerations in the assumption of the change advocate's role by Naval officers: (1) they must, themselves, be convinced that the innovation represents a significant solution to recognized needs; (2) because their role as advocate is likely to an ancillary duty, they must be highly motivated to serve in that capacity; and (3) the rapid turnover in Naval billets may mean that a strong advocate will drop out of the information circuit before his role is finished.

Utilize Key Personnel

It is crucial for acceptance that the selected experts, user representatives, and change advocates are formally made a part of the development team. The Navy has officially recognized this, for example, in one area of innovation, as reflected by OPNAV instruction 1551.7, "Fleet Participation in Development, Acquisition, and Acceptance of Major Training Devices." In that instruction, the Fleet Project Team (FPT) is defined to be "a group of knowledgeable representatives from the fleet or other user and interested non-user activities, consisting of qualified military and/or civilian personnel designated by cognizant commands. The Fleet Project Team will assist and advise the training device development and acquisition activity in development, acquisition, and acceptance of specifically designed training devices." The Fleet Project Team's role, functions, and duties are defined such that it can play a very important role in training device development, acquisition, and introduction, depending upon how many of the duties listed are actually assigned to the FPT and whether the FPT has made available to it the resources to properly discharge these duties.

By whatever name, key user personnel involvement in the development must be facilitated by the developer in a variety of areas, some of which will be discussed briefly in turn.

Design inputs. Key user personnel should be given the opportunity to interact with others in the design team in the typically dynamic, iterative trade-off process that is typical of system design. Key user personnel will consequently not only have the opportunity to make potentially beneficial inputs to design, but will come to understand the constraints of the design process and the limitations of the technology. Such information will prove valuable in discharging their function of disseminating information to the broader population of potential users.

Design reviews. User involvement in design reviews should be ensured by formal process in order to continue the involvement of key personnel and to foster a detailed understanding of the system configuration and its underlying design trade-offs.

Subsystem and system tests. Since the validity, operability, and reliability of an innovative device are crucial factors in its acceptance, the key user personnel involved in development should also participate in subsystem and system tests, to help in assuring that operational needs and constraints are considered, and to learn first hand the performance characteristics of the system. Subsystem and system tests may reveal design problems, of course, but if key user personnel see, or even participate in, a systematic effort to correct such problems, knowledge of this fact can enhance rather than hinder user acceptance.

Feedback to potential users. One of the most important results of involving experts, user representatives, and change advocates in the development process is credible feedback of valid technical information to potential users. Because of their direct involvement in development, on the one hand, and their respected standing within the user community on the other, properly-selected key user personnel are in a unique position to be advocates for the new development.

**Develop Test Bed**

Subsystem and system testing is an inherent part of any new development, regardless of whether that development includes any formal consideration of a technology transfer plan. However, because demonstration of an innovative device to users is a crucial step in achieving user acceptance, special consideration should be given to ensure that the test bed meets the requirements of a sound plan for technology transfer. In many cases it will likely be found that the test and evaluation required by the ordinary development process will meet most of these requirements, and the objectives of the technology transfer plan can be achieved by "piggybacking." In some instances, however, to maximize the likelihood of user acceptance it may be necessary to conduct additional tests and demonstrations with settings, scenarios, and personnel specifically selected to achieve the goals of the technology transfer plan.

Setting. While it is convenient and necessary to conduct testing of innovative devices in the laboratory setting, users ultimately demand proof of performance in the operational setting. In some cases, it may be impractical or prohibitively expensive to demonstrate a device in all its intended applications in an actual operational setting. In such cases, it may be necessary to simulate the operational setting in some degree. The fidelity of any simulator, or simulated environment, that is employed must be sufficient to convince potential users that the innovative device will behave similarly in the intended operational setting. The question of whether a particular simulated environment is adequate to demonstrate the validity and reliability of a newly developed device is a fundamental concern in system development today.

Scenarios. If a realistic setting is provided, but the scenarios used in demonstration are regarded by potential users as inadequate representations of the operational problem, the demonstration will not help, and may even hinder, the likelihood of user acceptance. It was stated early in this plan for technology transfer that operational needs and constraints need to be considered, and an awareness of these should follow through to the test bed scenarios. If some scenarios are unfamiliar to users because they involve, for example, anticipated future threat capabilities, this should be clearly and carefully explained to potential users.

Personnel. Users will not very likely be convinced of the operability of an innovative device if during demonstration it is operated by the highly practiced engineers who designed it in the first place. It is very important that representative personnel be involved in the test bed situation, both in its design, in the conduct of testing, in the operation of the device, and in instructing potential users. Thus, it is important to carry the involvement of the key user personnel (experts, user representatives, and change advocates) through the entire course of system development, including operational demonstration.

**Demonstrate**

When a suitable test bed has been identified or developed, it may be seen from Figure 1 that the next step in the technology transfer plan is to bring (hopefully) informed users and the (hopefully) operationally compatible device together. If the demonstration can show relative advantage, operational validity, operability, reliability and supportability, the likelihood of user acceptance will be high. Each of these requirements will be briefly discussed in turn.

Relative advantage. Relative advantage is the degree which an innovation is judged by the user to be better than the idea or device it supersedes. Perceived relative advantage is a function not only of the technical performance of the device, but many other variables related to its use and supportability in the operating environment (as previously discussed). The greater the relative advantage, the more rapidly an innovation is adopted. This is not only intuitively clear, it has in fact been demonstrated.

Operational validity. One of the strongest themes to come out of the present study is the user's "show me" attitude concerning innovative devices. Many officers have encountered innovations in aircraft, surface ships, submarines, or shore stations that fell short in the operational environment. Particularly in the case of decision aiding, where "artificial intelligence" may appear to encroach upon what traditionally has been a human activity, demonstration of operational validity is absolutely essential.

Operability. The present study has reinforced Mackie's 1980 finding that fleet users put great emphasis on operability. Repeatedly, officers emphasize that to be of utility in the operational environment, any decision aid must provide quick, easy input and clear, concise output.

Reliability and supportability. Potential users frequently expressed concerns regarding the reliability of innovative equipment in the operational environment. Concern was also often expressed regarding the supportability of decision-aiding innovations, particularly with respect to whether the software and data bases would be updated frequently enough to remain current and operationally valid in a changing tactical environment. Reliability and supportability cannot be conclusively demonstrated over a short period of time, but as much evidence as possible should be presented, together with plans for life-cycle support.

Limitations. The limitations of an innovation should be openly discussed throughout the development, and they should be made clear to users during the demonstration phase. If the reasons for the limitations (e.g., reasonable design trade-offs and inherent limitations of technology) are clearly understood by the users, the implications will be far better for user acceptance than if users must discover limitations of the innovations themselves (especially in an operational environment).

## RESULTS: USER ACCEPTANCE AND BENEFICIAL APPLICATION OF NEW TECHNOLOGY

Figure 1 presents a plan for technology transfer that we believe has a sound basis both in terms of the scientific literature of innovation acceptance and from the perspective we have achieved in interviewing over 400 Naval personnel. We believe that if a technology transfer plan similar to that described in this section is effectively incorporated in a research and development program, the probability of user acceptance and the beneficial application of new technology will be greatly enhanced.

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## APPENDIX A
## FACTORS INFLUENCING INNOVATION ACCEPTANCE IN THE MILITARY

(An Elaboration on Figure 2 in the Text)

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(An Elaboration on Figure 2 in the Text)

The acceptance process has been described as the mental process through which an individual passes, starting with his first knowledge of an innovation, to an eventual decision to adopt or reject the innovation. The stages in this process (which have been described by many researchers) include: awareness (first knowledge of the new idea), interest (gaining further knowledge about the innovation), small scale trial, and the decision to adopt or reject. In subsequent paragraphs we discuss a number of factors of the innovation process. We have borrowed heavily from earlier investigators, but we have added to the description based upon our own observations, particularly as they reflect certain uniqueness of military organizations.

### INITIAL AWARENESS

Initial awareness of an innovation comes about in the Navy through a variety of *channels and media*, both formal and informal. It is important to recognize that if the system is truly innovative (i.e., it is not simply an improved version of an older system) the way in which this initial communication in the past where Navy personnel first became aware of an innovation on the day it was delivered on the dock for installation aboard ship. Since the advent of any new system is to some degree disruptive, this approach is certain to create initial resistance.

Whatever the nature of the initial communication, it is not important that it be accurate and reasonably comprehensive. In any organization, remarkable inaccuracies can quickly creep into communications conducted by word of mouth. Such inaccuracies do not serve the interest of acceptance. A key role in communicating initial awareness can be played by what we call a "change advocate." A change advocate is a professional who influences innovation decisions by means of direct interactions with user personnel. Though the change advocate has a long and historically important role in promoting the adoption of innovations in other contexts, he is rarely, if ever, evident during the process of introducing new systems to military organizations. However, some of his functions may be performed in military organizations in an incidental fashion by individuals who are particularly enthusiastic about new systems. The role of the change advocate is not to by confused with that of the undisguised "salesman," whose motives often do not coincide with those of the potential user.

## IMMEDIATE PERCEPTION OF NEED

Whatever the source of the initial communication, the user's feeling of need for the innovation will be affected by his operational experiences. It is unlikely that all potential users will have the same appreciation for the operational problem. (There is also some risk that a development agency will not fully perceive the operational problem.)

One of the complicating factors is that because the innovation is being developed in anticipation of future needs, the intended users may not be aware that a requirement for the innovation has developed. In the Navy, personnel in development groups and in test and evaluation groups are more likely to be aware of future needs than are fleet personnel in general. Here we encounter two major roles for the change advocate: 1) he should provide information about current and future operational problems, and 2) he should provide information concerning how the innovation is expected to aid in solving those problems. Of course if there is disagreement on the nature of the problem (or its existence), there is not likely to be much interest in an innovation designed to solve it.

## LEVEL OF INTEREST

Initial level of interest is affected by the user's feeling of need for improvement and general awareness of the purpose of innovation. If he personally identifies with the operational problems the innovation is designed to address (or if the change advocate has done his job in making users aware of the problems) his initial level of interest should be high enough that he will be receptive to further information. On the other hand, if his level of interest is low, he likely will not be receptive. The following describes this tendency aptly:

> "Generally, individuals tend to expose themselves to those ideas which are in accord with their interests, needs or existing attitudes. We consciously avoid messages which are in conflict with our predisposition. This tendency is called selective exposure. It has been argued that individuals will seldom expose themselves to messages about an innovation unless they first feel the need for an innovation."

> "However, an individual may develop a need when he learns that an improved method, an innovation, exists. Therefore, innovations can lead to needs, as well as vice versa. Some change agents use this approach to change by creating needs among their clients through pointing out the desirable consequences of new ideas." (Rogers and Shoemaker, 1971)

## INFORMATION ACQUISITION

Military personnel who are aware of an innovative system that promises to meet their need will likely seek additional information about it. However, the degree of this information seeking will depend on the intensity of their felt need and the ease with which information can be obtained. Sources of information can vary widely in their authoritativeness and persuasiveness. The important point to consider is that, in the absence of authoritative messages, the user's general perception of the innovative system may be influenced mostly by informal channels that may contain a good deal of "noise." For some systems, the primary source of information may well be manufacturer's salesmen or advertisements that appear in various trade journals or military periodicals. There is no assurance that authoritative information will be provided in the absence of controlled presentations by the development agency or the change advocate. However, such authoritative sources are important to prevent misconceptions concerning the innovative system.

## PERCEIVED FEATURES AND PERCEIVED NEED

The information which the user first gains is responsible for his initial perception of the features of the innovation. There follows an immediate favorable or unfavorable reaction depending upon whether this perception is in harmony or disharmony with the user's view of the operational problem and the strength of his feelings of need for improvement. This initial reaction may change as further information is acquired about the detailed characteristics of the innovation. The process is interactive and additional information can result in either increasing or decreasing the match between perceived need and various perceived features of the innovation.

## EXPERIENCE WITH SIMILAR DEVELOPMENTS

The intended user may have had experience with prior developments that he feels, correctly or not, are similar to the proposed innovation. If so, his subjective evaluation of the new development will likely be influenced by that experience. If there have been prior negative experiences, an important requirement of the introduction process is to provide information that will offset feelings that the new development won't be any better than the last. The role of the change advocate can be critical in this regard, and he should be well aware of the deficiencies of early systems that are viewed as belonging to the same category as the proposed innovation. This may be a particularly important consideration in the introduction of AI decision augmentation, since some earlier computer based decision aids have gained a reputation as being inadequate.

A related consideration has to do with the technical reputation of the system developer. (It should be noted that the developer, from the user's point of view, may be the project office, the Navy laboratory involved, or the actual manufacturer of the equipment.) If the developer is viewed as having a history of product development that is not well matched to operational needs, additional negative bias in the evaluation of the innovation can be expected. The opposite effect can also occur, of course, if that reputation is generally favorable.

## USER PARTICIPATION IN DESIGN

A strong source of negative bias stems from the "not invented here" syndrome. Such a bias is particularly likely if the innovation is seen as an intrusion into the user's own area of expertise. If neither he nor other personnel with similar qualifications has been consulted with respect to design, an initial negative attitude toward the innovation is frequently the result. Navy personnel assigned to development groups may be a particular source of this type of resistance. As noted in other studies of innovation acceptance in the Navy, highly qualified users should be involved in the design process if at all possible. If they are not, the change advocate may have to make an effort to secure the endorsements of a recognized group of expert Fleet representatives.

## PERSONAL RISK

All innovations carry some degree of subjective risk to the potential user. Initially he may be uncertain as to how the innovation will affect his operational responsibilities or those of his subordinates. He is likely to seek reinforcement of his concerns through communication with his peers. Clearly, exchange of information through the "grape vine" is inevitable in a military organization. It is all the more important, therefore, that accurate information be readily available concerning all significant design characteristics of the innovation, in order to minimize inaccuracies or misunderstandings.

## AVAILABILITY OF SUPPORT

It is obvious that new Navy systems require proper documentation, maintenance support, and operational training. The user's prior experience with the adequacy of these support functions can lead to early formation of attitudes of acceptance or rejection. Unfortunately, in the case of computer based aids, there have sometimes been significant deficiencies in one or more of these support areas. If the potential user carries forward an expectation of similar deficiencies for the new system, he is likely to be less than enthusiastic about its adoption. In the longer run, after the system is actually implemented, continuing support is absolutely essential. Otherwise, temporary adoption of the innovation may be followed by subsequent disuse and rejection. It is unfortunate that some innovative Navy systems have fallen into disuse because of poor support despite the fact they were developed to meet a widely recognized need.

## SUBJECTIVE EVALUATION

The degree of harmony that a user sees between the operational need and features of an innovation can vary over a considerable range and depends upon what information becomes available to the user as the system development continues. The degree of judged harmony (consonance) or disharmony (disconsonance) reflects a process of subjective evaluation that is critically dependent on the information provided concerning the innovation. The role played by the change advocate in providing inputs to the user may therefore be critical to initial acceptance distinguishes several different aspect of the subjective evaluation process.

## Relative Advantage

Relative advantage is the degree to which an innovation seems to the user better than the idea it supersedes. The greater the relative advantage, the more rapidly an innovation is adopted. This is not only intuitively clear, it has in fact been demonstrated.

However, even where there is clear relative advantage, adoption of an innovation is not certain because many other considerations enter into the acceptance-rejection decision. These are discussed below.

## Compatibility

Compatibility is defined in innovation acceptance theory as the degree to which an innovation is seen by users to be consistent with their existing values, past experience, and needs. However, Navy personnel are also concerned with compatibility in the sense that an innovation must be operationally compatible with other systems with which it must work. The compatibility of an innovation has been shown to be positively related to its rate of adoption.

## Complexity

Complexity is the degree to which an innovation is perceived as relatively difficult to understand and use. Complexity has been shown to be negatively related to its rate of adoption. This may be particularly true of computer based systems. (However, there are some subtleties involved. An innovative system may experience rejection is it is seen as over simplifying a problem that is known to be inherently complex.)

## Observability

Observability is the degree to which the results of an innovation are visible to others. The observability of an innovation has been shown to be positively related to its rate of adoption. (This of course assumes that relative advantage, compatibility, and complexity are viewed favorably.) Observability is likely to be particularly important in acceptance of computer based products about which there is some initial skepticism.

## Trialability

Trialability is the degree to which an innovation may be experimented with by users. The trialability of an innovation has been shown to be positively related to its rate of adoption. It should be noted that trialability may involve hands-on experimentation; however, it may also be vicarious. · That is, the user may simply visualize how the innovation might be used in his own operating environment by himself or others.

## Summary of Subjective Evaluation

The first three aspects of subjective evaluation as outlined above (relative advantage, compatibility, complexity) pertain primarily to the design of an innovation. The latter two (observability, and trialability) relate to how the innovation is introduced and/or demonstrated on a trial basis. The importance of the change advocate in providing information and demonstrations cannot be overestimated for innovative systems where user personnel will have the option as to whether or not to adopt the system. (There is an important distinction in this respect between systems that must be used, such as sensor systems, weapons systems, navigation systems, etc., and innovations such as decision augmentation devices whose use may, rightly or wrongly, be regarded as optional.)

## ORGANIZATIONAL CLIMATE

Some organizations provide a more receptive climate than others for the introduction and acceptance of innovations. It is very likely that individual commanding officers will vary widely in their receptiveness, and this will strongly influence acceptance at the unit level.

The Navy has development groups whose charter it is to work with innovative systems. These groups should serve to bridge the gap between operational needs and proposed solutions. It might be supposed that such groups would be particularly receptive to innovative developments, but they are also potentially a source of resistance via the "not invented here" syndrome. Direct involvement of the development groups in innovative programs seems essential if product endorsement by these key groups is desired. We feel this should be a significant element of any effective acceptance program.

## ADOPTION OF AUTHORITY

Authority innovation decisions are those forced upon the user. The individual is ordered by someone in a position of higher authority to adopt or reject an innovation. Obviously, in a military organization, authority innovation decisions are commonplace. However, no matter what the source of the decision, the users inevitably evaluate the innovation in terms of their personal operational needs. This is not to say they won't comply with the order. The authority decision may be accepted--on the surface. However, compliance is very different from adoption. In the case of compliance, the change in behavior is usually temporary. Continued surveillance and reinforcement are required to avoid gradual disuse and rejection. There is particular vulnerability to this outcome in the case of computer aided systems where the extent of use may be a matter of individual discretion.

## SUMMARY

A potential user's initial positive or negative attitude toward an innovative system is the result of a large number of variables associated with his perception of the operational problem, perceived features of the innovation, prior experiences with similar developments, subjective estimates of relative advantage, compatibility and complexity, perceived personal risk, etc. The process of adoption or rejection may take place over days, weeks or even months. Initial inclinations toward adoption or rejection will be modified as further information is received during the course of system development, and subjective evaluations will be revised. In the case of systems that relate to human decision processes, it is particularly important that system information be comprehensive and factual; that misperceptions be recognized and corrected; that problems associated with similar systems be addressed; that design inputs from users be considered; and that endorsements of Fleet personnel in the development circuit be secured.

## APPENDIX B
## SURVEY QUESTIONNAIRE

Group I.D.:

# ARTIFICIAL INTELLIGENCE DECISION AID SURVEY

The Naval Electronics Systems Command (NAVELEX) and the Naval Air Development Center (NADC) are investigating the transfer of artificial intelligence (AI) technology into operational environments to provide new tools for military decision makers. NAVELEX and NADC believe it is important to involve eventual users in the development of such innovations. Therefore, NADC has contracted with the Human Factors Research division of Essex Corporation to prepare, conduct, and analyze the results of this survey as an early step to take account of user considerations in this area. Essex conducted a similar survey for NADC about 5 years ago regarding a number of "conventional" computer-based decision aids. The focus of the present survey is on AI-based decision aids.

## Artificial Intelligence

Artificial intelligence (AI) is not a new field, but recent developments in micro-electronics and computer architecture have given AI (as well as other computer applications) a boost. Also, AI seems recently to have attracted a great deal of commercial interest -- to the point where some computer scientists believe the current capabilities of AI are being over-promoted. However, most specialists agree that a significant potential exists for AI to aid humans in several areas.

It is remarkably difficult to find consistent definitions of AI in the literature. Some consider AI a minor variation on the general themes of computer science, others feel AI consists of attempting to give a computer a "real" conscious mind. Most middle-of-the-road definitions pragmatically define AI as modelling some of the processes of human thought. A sense of this is implied by the names of the various sub-fields of AI. Some generally agreed-upon subdivisions include robotics and vision, natural language recognition, logical reasoning (theorem proving), and "expert systems" (systems that are "expert" in limited areas of medical diagnosis, interpreting geological data in oil prospecting, etc.). These subdivisions represent functions which humans routinely perform, but which by nature cannot (presently) be described by formal mathematical models that would permit solutions using "ordinary" (ie, numerically-oriented) computing. There seems to be general agreement that where "formal" mathematics does apply, conventional numerical computing is to be preferred to AI. AI does not compete with "conventional" methods, but attacks areas where they cannot be applied.

## Knowledge-based Systems

The subfield of AI most pertinent to military decision aiding is that of "expert systems," also called knowledge-based systems or rule-based systems. In the late 1960s, Allan Newell and Herbert Simon of Carnegie-Mellon University showed that a great deal of human knowledge could be represented by rather simple "if-then" rules. It soon became apparent that the key in making knowledge-based systems perform was not to develop more sophisticated processing algorithms, but to add more rules (ie, more knowledge). New programming languages (LISP, PROLOG) facilitated the development of rule-based systems.

One of the first useful knowledge-based systems was developed by Edward Feigenbaum and his colleagues at Stanford. Called MYCIN, the system incorporated hundreds of rules obtained from physicians expert in diagnosing certain types of infectious diseases. MYCIN proved in many instances to be able to diagnose diseases just about as well as the human specialists could, and it sometimes generated alternatives that the specialists didn't expect, but which they found useful or interesting. MYCIN was structured so that the user could ask the system (by entering the word "RULE") to state the rule it was currently trying to employ, or (by entering the word "WHY") to provide an explanation of how it arrived at its current "reasoning." It was (and any knowledge-based system can be) designed to express numerically the uncertainty in its conclusions, based on the uncertainty expressed in the underlying rules. The following is an example of MYCIN dialogue which may give you some feeling for this early knowledge-based system. In the example, MYCIN's statements are in lower-case letters and the physician's entries (following MYCIN's "**" prompting symbol) are capitalized.

22) Was any chemotherapy recently begun specifically to combat organism-1? ** NO 23) Is Jeremiah Sample (patient-1) a burn patient? ** RULE

rule 047
If:

1) The site of the culture is blood, and

2) The identity of the organism is not known with certainty, and

3) The stain of the organism is gramneg, and

4) The morphology of the organism is rod, and

5) The patient has been seriously burned

Then:

There is weakly suggestive evidence (.4) that the identity of the organism is pseudomonas

** NO 24) Is the patient's illness with organism-1 a hospital-acquired infection? ** YES 25) Do you consider Jeremiah Sample (patient-1) to be a compromised host? (alcoholic, immunosuppressed, etc.): ** NO 26) Has Jeremiah Sample (patient-1) had any GU surgery or manipulation of the urinary tract? (e.g., indwelling catheter, cystoscopy, etc.) ** WHY

I am trying to find out about the identity of the organism. I already know that: the portal of entry of the organism is upper-GU the morphology of the organism is rod the stain of the organism is gramneg the site of the culture is blood therefore, if: 1) the patient has not had a genito-urinary manipulative procedure, and 2) urinary-tract-infection is not a problem for which the patient has been treated then: there is suggestive evidence (.6) that the identity of the organism is E.COLI (rule156) etc.

It is estimated that a chess master uses the equivalent of about 50,000 rules, whereas current knowledge-based systems are limited to a few thousand rules at most. However, new technology is expected to increase this number significantly, which would improve performance. However, one of the most challenging aspects of knowledge-based systems is eliciting rules from human experts in the first place, and incorporating them into an

AI system. Typically, this is done by having so-called "knowledge engineers" and subject matter experts interact, solving example problems and codifying rules. This phase of development can require thousands of man-hours. However, it may well be worth the effort if useable military situation assessment or decision-aiding tools can be developed.

## Objective of this Survey

The objective of this survey is to obtain initial inputs from potential users of future AI-based decision aids. Please respond from the perspective of military operations you are most familiar with. At this early stage the details of specific decision-aiding applications cannot be provided, which in some cases may make it difficult for you to respond to the questions. Please do the best you can; space is provided for written comments as you feel appropriate. Also, you may feel you don't have sufficient knowledge of AI to be very certain in responding to some of the questions. That is expected; one useful finding of this survey will be an indication of how much uncertainty does exist, and in what areas, among potential AI users.

The biographical data requested will be used to determine whether officers with different areas of expertise have consistently different inputs regarding AI decision aiding. The results will be reported as statistical averages, etc. Survey respondents will not be identified individually.

Now, please proceed to fill out the biographical data sheets, then read the survey questions and mark the rating scales. Feel free to make written comments in the spaces provided. Also, we look forward to discussing with you the overall results and specific points of interest.

# BIOGRAPHICAL DATA

Rank: 0-1 = 5%  0-4 = 28%  0-2 = 5%  0-5 = 7%  0-3 = 52%  0-6 = 1%

Name TOTAL SAMPLE

Branch of service 76% Navy  4% USAF  10% ARMY  4% USMC  6% USCG  1% Civ.

Country 229 USA, 20 foreign (foreign offic omitted from following analysis)

Designator or other occupational code

Years of active duty mean=9.7, S.D.=4.8, lowest-0.3, highest=25

Current billet and duty station 69% Naval Postgraduate School, 31% San Diego area

Kinds of military operations, systems, or departments you are most experienced in:

surf ship=29%, pilot=11%, NFO=10%, sub=2%, land combat=6%,

engineering=15%, admin.=24%, $C^3$=3%

College degree(s), institution, and year awarded

Bach=85%, Master's=13%, Ph.D.=1%, no entry=1%

Field of major emphasis in undergraduate study Liberal Arts=28%  Sci,Math,Eng=44%  Admin. =26%  Comp.Sci. = 2%

Field of major emphasis in postgraduate study Liberal Arts=4%  Sci,Math,Eng=36%  Admin. =51%  Comp.Sci. =9%

Computer experience (check all items that apply to you):

6% I have little interest in computers.

14% I have little or no experience directly interacting with computers.

71% I have used specific applications programs (eg, spreadsheet, word processor, etc.).

46% I own or have extensively used a "personal computer."

83% I have written computer programs, using these languages:

| | | |
|---|---|---|
| 52% BASIC | 15% PASCAL | 64% FORTRAN |
| 1% FORTH | 4% C | 14% assembler |
| 3% LISP | 7% PROLOG | others: 28% responded |

81% I have taken computer science courses (please list):

0 = 19%, 1 = 18%, 2 = 25%, 3 = 18%, 4 or more courses = 20%

12% I have written/designed computer software/hardware for the following professional or operational applications:

0 = 88%, 1 = 10%, >1 = 2%

Experience in Artificial Intelligence (AI) (please check all items that apply to you):

42% I am unfamiliar with AI.

50% I have read "popular" articles about AI.

13% I have read technical articles about AI in professional journals.

5% I have read technical reports about AI.

6% I have read books about AI.

10% I have taken courses in AI (please list):

0 = 90%, 1 = 10%

Please list any courses you have taken in cognitive science or behavioral science as it relates to decision making:

0 = 45%, 1 = 27%, 2 = 16%, 3 = 7%, 4 = 3%, 5 or more = 2%

Please describe any computer-based operational decision aids you may have used in your military occupation:

0 = 60%, 1 = 29%, 2 = 10%, 3 = 1%

Whether or not you have had prior experience with computer-based decision aids, from what you presently know how do you feel about their potential value to the military decision maker? (Place a check mark above any number on the scale below.)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 6 | 10 | 30 | 71 | 40 | 36 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| I am extremely pessimistic | | | | I am maximally uncertain | | | | I am extremely optimistic |

## PART 1: AI DECISION AUGMENTATION BELIEFS

In this section, we want to determine your beliefs regarding various aspects of the application of artificial intelligence to assist military decision makers. Please read each statement below, then place a check mark on the "agreement" scale associated with the statement, indicating the extent to which you personally agree or disagree with the statement.

1. There exists, in my military specialty, a group of experts whose knowledge and decision making rules, if encoded into a computer program, would greatly aid my own decision making.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| strongly disagree | | disagree | | no opinion | | agree | | strongly agree |

Comments:

2. The decision-making rules used in my area of expertise can be incorporated into an AI knowledge-based system.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| strongly disagree | | disagree | | no opinion | | agree | | strongly agree |

Comments:

3. AI systems can be made to emulate the thinking of the best decision makers in my area of technical expertise.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| strongly disagree | | disagree | | no opinion | | agree | | strongly agree |

Comments:

4. AI systems can be made to emulate the knowledge of the best decision makers in my area of technical expertise.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| strongly disagree | | disagree | | no opinion | | agree | | strongly agree |

Comments:

rev 1

## APPENDIX C
## STATISTICAL ANALYSIS

## APPENDIX C
### Statistical Analysis

All data analyses were done employing the statistical analysis system developed by SAS Institute, Inc. The biographical data from the survey forms were coded and keyed to disc along with the numerical values (1-9) representing the rating responses for each of the 44 statements in each questionnaire. Then a variety of statistical procedures were performed.

### UNIVARIATE ANALYSES

Univariate analyses were done on all numerical data to obtain common descriptive statistics (e.g., mean, median, quantities) and frequency distributions. The results for the biographical data are discussed in Section 3, "Survey Participants," and summarized in the biographical data section of Appendix B. The results for the rating scale responses are presented in histograms and text in Section 4, "Results and Discussion."

### EFFECTS OF OCCUPATIONAL SPECIALTY, SITE, AND SENIORITY ON RATING RESPONSES

The SAS procedure FREQ was used to produce 2-way cross-tabulation tables with a chi-square test of independence between the rating responses and occupational specialty (surface warfare, air warfare, administration, engineering, land combat, submarine), site (San Diego, Monterey), and seniority ("junior"=Ens, Ltjg, Lt; "senior"=Lcdr, Cdr, Capt). The results are discussed for each of the 44 statements in Section 3, "Survey Participants," and Section 4, "Results and Discussion."

### EFFECTS OF COMPUTER EXPERIENCE

It was hypothesized that the responses of the officers to the rating scale statements might be influenced by the degree of computer experience they possessed. There were several questions in the biographical data part of the questionnaire which provided information on computer experience. However, it was not evident a priori how to combine the scores on these items to yield a variable that would best relate to attitudes towards AI decision aids. Consequently, we employed an empirical approach, namely to use the statistical technique of canonical correlation to obtain weights for the linear combination of computer experience responses that would correlate most highly with a linear combination of the attitude responses.

In order to facilitate the canonical correlation, 9 new variables representing various aspects of computer experience were formed from the biographical data responses for each officer, as follows:

1. Negatives. This variable was given a value equal to the sum of the number of check marks the following statements received: "I have little interest in computers," "I have little or no experience directly interacting with computers," "I am unfamiliar with AI."

2. Use/own. This variable was comprised of the total number of check marks given to these two statements: "I have used specific applications programs," and "I own or have extensively used a 'personal computer.'"

3. Languages. This variable was comprised of the total number of computer languages a respondent indicated he had used.

4. Computer Science Courses. This variable was comprised of the total number of computer science courses the respondent indicated he had taken.

5. Programs. This variable was comprised of the number of professional or operational applications programs the respondent indicated he had written.

6. Readings. This variable was comprised of the sum of the check marks given to the 4 statements: "I have read 'popular' articles about AI; technical articles about AI in professional journals, technical reports about AI, and books about AI."

7. AI Courses. This variable was comprised of the number of AI courses the respondent indicated he had taken.

8. Decision-making Courses. This variable was comprised of the number of courses the respondent indicated he had taken in cognitive science or behavioral science as they relate to decision making.

9. Decision Aids Used. This variable was comprised of the number of computer-based operational decision aids the respondent indicated he had used in his military occupation.

A canonical correlation was performed between the attitudes and beliefs rating responses (statements 1-27 in the questionnaire) and the responses to the 9 computer experience variables discussed above. The canonical correlation procedure finds, from 2 sets of input variables, linear combinations (i.e., new variables) that are most highly correlated. The first canonical computer experience variable was found to be significantly correlated with the first attitudes and beliefs canonical variable ($r=.600$, $p=.006$). The distribution of the computer experience variable is shown in Figure 49.

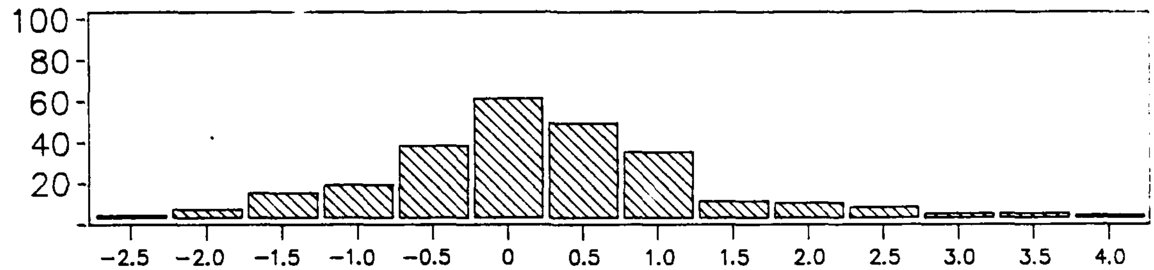


Figure 49. Normalized distribution of computer experience scores.

The canonical correlation provided a single computer experience variable and indicated that it was significantly correlated with the attitudes and beliefs variables, but did not indicate how it might be related to specific attitudes and beliefs, nor to the ratings of user interface considerations reflected in questionnaire statements 28-44. In order to facilitate this analysis, a categorical computer experience variable was derived based on dividing the distribution of the continuous canonical variable into three categories, representing "low," "medium," and "high" levels of computer experience comprised of approximately equal numbers of respondents. Thus, each survey respondent could be categorized as having one of these three levels of computer experience, and this categorization was employed to develop two-way cross-tabulation tables with a chi-square test of independence between the rating responses and the level of computer experience. There proved in many instances to be a statistically significant relationship, and these are discussed in Section 4, "Results and Discussion." Generally speaking, computer experience usually related more to the strength of conviction about a particular issue rather than to a fundamentally different viewpoint. No significant relationship between computer experience and seniority was found.

END

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