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ABSTRACT

As part of the Design of Training Systems project, the Naval Postgraduate School, Monterey, California, was assigned a sixfold task by the Training Analysis and Evaluation Group: (1) analyse the functional description of the Naval Education Training and Command (NAVEDTRACOM) from the standpoint of how decisions are made; (2) review the literature bearing on decision theory as applied to large-scale organizations; (3) develop a taxonomy of the types of decisions made by managers within the NAVEDTRACOM; (4) develop criteria for evaluating decisions within the NAVEDTRACOM; (5) develop recommendations for improving the present decision-making process; and (6) develop a description of the optimum method of decision-making. Findings on each point are summarized, along with recommendations for future decision-making policies and implementation strategies. (SK)

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The Naval Postgraduate School, Monterey, California, was tasked by the Training Analysis and Evaluation Group to (1) analyze the functional description of the NAVEDTRACOM from the standpoint of how decisions are made, (2) review the literature bearing on decision theory as applied to large-scale organizations, (3) develop a taxonomy of the types of decisions made by managers within the NAVEDTRACOM, (4) develop criteria for evaluating decisions within the NAVEDTRACOM, (5) develop recommendations for improving the present decision making process, and (6) develop a description of the optimum method of decision making. This study was accomplished as a part of the "Design of Training Systems" project in response to ZPN07 (formerly P4303), "Education and Training Development."

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William C. Giauque, D.B.A.

This Study Was Performed by the

Naval Postgraduate School
Monterey, California

for the

Training Analysis and Evaluation Group

July 1975

Alfred F. Smode

ALFRED F. SMODE, Ph.D., Director
Training Analysis and Evaluation Group

TAEG Report No. 27

FOREWORD

This report prepared in partial fulfillment of the requirement of Technical Development Plan (TDP) P43-03 (P01A), considers decision making at the top management levels of the Naval Education and Training Command. Traditionally top management decision making relies heavily on informal techniques--intuitive judgments by experienced managers, traditions and "rules of thumb" peculiar to each organization, or informal consensus among a group of managers. Currently, however, the training command must do a job which is unprecedented in its complexity and must do it despite declining resources. These considerations indicate the desirability of increased effectiveness in decision making. This report surveys the potential role of and desirability of more formal approaches to some top management decision problems.

Appreciation is expressed to the staffs of the organizations studied for their cooperation. Special thanks are due to Mr. E. Riley (Chief of Naval Education and Training Staff) and Mr. T. McNaney of the Training Analysis and Evaluation Group who coordinated the field research effort.

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INTRODUCTION

A. BACKGROUND

In 1966 the Chief of Naval Operations promulgated the Advanced Development Objective (ADO) 43-03X, "Education and Training Development." This document recognized both the importance of the education and training methods and management techniques in making training more effective. Subsequently, Technical Development Plan (TDP) P43-03X was prepared in response to the ADO. Part 01A of the TDP, "Design of Training Systems," addressed the management of the training effort, with the goal of providing training managers at all levels with an effective decision making capability. Implementation of this subproject is the responsibility of the Training Analysis and Evaluation Group (TAEG), Orlando, Florida.

The TAEG has contracted with the Federal Systems Division of International Business Machines (IBM) to conduct a study in support of this work. IBM has, among other things, conducted a broad survey of management functions within the Naval Education and Training System, and proposed a number of areas in which computerized decision aids would be useful to training managers. Initially, three computer models were designed and developed, all of which address problems of managing student flows, course and resource planning, and system requirements. A fuller discussion of this background can be found in a series of reports prepared by TAEG, particularly TAEG Reports No. 11-1 (Lindahl, et al., 1973), 11-2 (Lindahl and Gardner, 1974), 12-1 (Volumes I and II), and 12-2 (Volumes I, II and III).

B. PURPOSE

The purposes of this report are:

(1) to provide training managers basic but pertinent reference material on the subject of decision analysis, (2) to stimulate interest in decision analysis for the purpose of adopting the concepts in problem solving, and (3) to present a consultant's observation and recommendation for improving decision making within the Naval Education and Training Command (NAVEDTRACOM).

C. REPORT ORGANIZATION

In section II the process of decision making in large organizations is discussed. Included are some notes on the decision making mechanisms observed in large organizations, a taxonomy of decision making, an introduction to the field of decision theory, and a summary of the use of decision theory in organizations. In section III the background and responsibilities of the Chief of Naval Education and Training (CNET)

organization are presented preparatory to a discussion of the decision making process observed in CNET, Chief of Naval Education and Training Support (CNETS), and Chief of Naval Technical Training (CNTECHTRA). Finally, section IV consists of a summary and recommendations for improvement in the NAVEDTRACOM decision making process.

SECTION II

DECISION MAKING IN LARGE ORGANIZATIONS

One of the purposes of this report is to suggest improvements to the decision making process within the NAVEDTRACOM. It is worth noting that formal techniques, whether they go under the guise of computerized management information systems, operations research, decision theory, etc., have a disappointing track record in general management, although there have been some outstanding successes. Part of the reason for this may lie in the way decisions tend to get made in organizations, whether the methods used be formal or informal.

A. ORGANIZATIONAL GOAL SETTING AND DECISION MAKING

In traditional economic theory, business firms act in such a way as to maximize profits, given that there are behavioral constraints imposed by the competition, the marketplace, government, and society. The picture of decision making in this theory is that of managers and organizational forces together working to pull together information, assess uncertainty, and make rational choices to maximize profit under uncertainty. One would predict, under these assumptions, a number of behavioral patterns which do not seem to exist in real organizations; further, the traditional theory does not provide for a good many important behavioral patterns observable in actual firms. Traditional theory doesn't allow, for example, for complex organizations, problems of control, standard practices and operating procedures, budgets, politics, entrenched "bosses" or aspiring "middle managers." In short, the traditional theory of the firm does not address the mechanism by which managerial decisions are made. It is precisely this mechanism, however, which is the focus of this research. Thus, it is vital to have a good understanding of organizational decision making. This would not only give a basis for analyzing NAVEDTRACOM, but also provide a realistic background for evaluating suggested improvements. A standard reference in the descriptive theory of organizational decision making is Cyert and March (1963). This work has "an explicit emphasis on the actual process of organizational decision making as its basic research commitment." The remainder of this section draws heavily upon the framework and observations made in this book. Although the Cyert and March research was done specifically on large, multiproduct, profit-making firms in oligopolistic markets, the major observations on organizational decision mechanisms seem to be valid, for any large organization, including public sector not-for-profit organizations.

ORGANIZATIONAL GOALS

Any organization is a coalition of individuals, each with his own set of goals. These individuals are, in turn, organized into groups, the groups into larger groups, and so on, with each level adding a new set of goals.

How then does one manage to set goals for the entire organization without causing fatal conflict? There are two answers to this question: first, the goals themselves are structured in such a way as to avoid conflict; and second, the goal setting mechanism allows for conflict resolution.

Goals are rarely structured in precise, unambiguous terms. On the contrary, studies of organizational objectives suggest that agreement on objectives usually exists only when objectives are highly ambiguous, and that behind this agreement lies considerable uncertainty and disagreement on subgoals. To a large extent critical areas of conflict are never brought into the open, and agreeing, in essence, to disagree is usually a semipermanent way of life. Goals which are set usually take the form of aspiration levels, which are subject to change over time, rather than imperatives to "maximize" or "minimize." This tends to make conflict resolution less urgent, as organizational units are judged by the degree to which they attain the aspiration levels, which are largely set according to past experience, rather than by what is theoretically possible.

The goal setting mechanism is also an important stabilizing influence. Organizational goals are not, as a rule, set through a process of analytic determination of optimal procedures, but through a bargaining process. The parties to the goal-setting reach agreements through sharing rewards, not only such monetary rewards as budgets, salaries, and contracts, but nonmonetary rewards as well: promotions, citations, policies, personal treatments, private commitments, etc. This process allows parties to settle conflicts through relatively non-disruptive mechanisms. The objectives resulting from this process have a number of important attributes (Cyert and March, 1963, p. 32):

1. They are imperfectly rationalized. The exact forms of the agreements will depend at least as much on the bargaining skills of the leaders, the history of the bargaining session, and the particular resource scarcities faced as on the merits of the issues themselves.

2. Some objectives are stated in the form of aspiration-level commitments, such as "We must allocate ten percent of our total budget to research." The determination of the "ten percent" undoubtedly has little to do with cost/benefit analyses of the particular research projects available, but a good deal to do with the prestige, power, and persuasiveness of the research director.

3. Some objectives are stated in a nonoperational form. Such objectives have the advantage of being consistent with virtually any set of operational objectives. For example, nonoperational goals are evidenced in such political rhetoric as "We must 'crack down' on crime, while simultaneously protecting citizens rights and eliminating police brutality." This can be cited in favor of such diverse operational goals as increasing the use of wiretapping and eliminating the use of wiretapping.

Once organizational objectives have been established, a number of stabilizing mechanisms tend to make them permanent. Budgets are based partly on past budgets. Allocations of functions and other precedents are remembered and followed, sometimes taking the form of "rules of thumb" or "the usual way we do things," and occasionally becoming part of the standard operating procedure. Thus accidents of organizational geneology tend to become perpetuated, to be abandoned only under pressure. Further, organizations tend to build up a certain amount of "fat" (termed "organizational slack" by Cyert and March, 1963). In case of adversity, this provides a cushion so that business as usual can continue, perhaps indefinitely or at least until a new bargaining cycle can be completed.

It is worth contrasting the preceding description of organizational goal setting with an objective, or "rational" procedure, which would require the firm to predict the environment, survey all possible actions, then pick a set of goals which would result in the best actions. It is not at all clear that the objective procedure, even if it were possible to implement it, would be the better way to choose goals. Clearly the actual process contains valuable mechanisms for keeping the organization stable and viable, and substituting the "rational" procedure could easily result in the surfacing of chaotic conflict.

ORGANIZATIONAL EXPECTATIONS

Expectations are seen as the result of drawing inferences from available information. Thus, while goal setting might be seen as both a way of stating what considerations are important in an organization and of setting up evaluation standards, expectations might be thought of as projections of what will happen. One can study expectations, then, both from the standpoint of how inferences are drawn and of how information is made available in the organization.

On the subject of inference drawing, two general observations can be made. First, expectations are biased, both consciously and unconsciously, by hopes, wishes, goals, and internal bargaining. The manipulation is usually subtle, but is occasionally overt. A classic case of the latter occurred in a major Naval weapons system acquisition procurement project, which suffered a budget cut severely limiting the number of units to be purchased for the fleet. The cut was justified by a study showing that the new lower number of weapons (less than half the number originally planned) was adequate to meet the needs of the fleet; however, the study was in response to, rather than in anticipation of, the budget cut. Second, it appears that the computational power and precision available in organizations are limited. One observes that only on a few of the potentially relevant variables are data gathered and projections made. Also, the projections that are made tend to be very simplistic, requiring a minimum of calculation. There is, of course, nothing wrong with simplicity, but by and large the capacity for more sophisticated methods seems to be lacking, even when such methods may be justified.

Information availability within an organization is strongly affected by the nature of the data gathering system. Information becomes available in a fragmented, sporadic fashion at different organizational and geographic locations. Communication of the information is subject to severe bias, delay, and filtering effects; internal communication is, in fact, a significant competitive weapon within the organization. Thus the communication system introduces significant distortion into the system; over the long run, however, systematic bias seems to be at least partially detected and accounted for.

Most significant decisions require information which is not readily available, thus implying the need for a search procedure. In rational economic theory, a firm would have a portfolio of potential investments, against which new proposals would be continually evaluated. Information search should, in theory, be treated just like any other proposal, as a potential investment of resources which is expected to yield a benefit. An information search project, if accepted, would be analogous to a prospecting expedition; the world is searched in a systematic way with particular data needs in mind, and any nuggets of information found are brought back and assayed. In reality, this ideal picture is inaccurate on a number of counts. First, project evaluation and information search do not occur continually, but only as a result of fairly obvious problems. Organizations do not plan nearly as much as they fight fires, reacting to current crises. Second, search activity is not itself treated as an investment. Rather, there are various levels of search activity that are called into play, so that for a given situation there is a standard search procedure. Further, the criterion of search activity is feasibility rather than optimality. As soon as something is found that seems to (more or less) solve the problem, the search stops; the only questions asked are "Is it feasible?" and "Is it better than what we have now?," rather than "Is this the best possible way of handling the problem?" Finally, the search procedure is not nearly so much a prospecting expedition as a "mating dance." The direction of the search is largely determined by the conspicuousness of the alternatives, and as various people, both inside and outside the organization, have their own interests tied up in the decision they naturally try to make their preferred alternatives the most conspicuous ones. Thus, the organization is not only in search of information, but interest groups are trying to make at least parts of the information known to the organization.

ORGANIZATIONAL CHOICE

There are three basic principles in decision making: (1) avoid consideration of uncertainty, (2) maintain organizational rules and precedents, and (3) keep decision rules simple.

It seems paradoxical to speak of firms avoiding the consideration of uncertainty. After all, the world is uncertain. There are procedures,

however, which minimize the need to predict uncertain events. First, firms do very little meaningful long range planning, moving instead from one crisis to the next. Second, firms rely heavily upon standard rules for doing things, whether these be traditional methods, general industry practice, or standard operating procedures. These not only influence (and in many cases dictate) the decisions which are made, but provide stability and predictability to the organization. Thus, when Department A is working on a problem, it is already known what the responses of Departments B and C to their parts of the same problem are going to be. In addition, planning records made within the organization act to fix commitments and expectations. "Plans, like other standard operating procedures, reduce a complex world to a somewhat simpler one. Within rather large limits, the organization substitutes the plan for the world--partly by making the world conform to the plan, partly by pretending it does" (Cyert and March, 1963, p. 111). When possible, organizations arrange a negotiated environment.

The stabilizing influence of standard procedures would largely be lost if the procedures were to change frequently. The procedures build up around themselves a myriad of precedents, understandings, and unspoken connotations, thus becoming entrenched. When procedures are changed there is always a period of uncertainty and unsettlement until things "get worked out" again. The second principle of decision making, then, is to maintain the organizational procedures and precedents.

The third and final principle is to keep decision rules simple. Generally one searches for feasible alternatives (rather than optimal ones) and implements the first one encountered. Thus the search procedures strongly affect the decision making process. There are, of course, problems which come up which are not adequately covered by standard procedures. Rather than elaborate procedures to cover a wider variety of problems, organizations opt to keep the rule simple and rely on individual judgment to provide flexibility.

SUMMARY

It is important to recognize the potential of analytic techniques. First, on problems that are reasonably complex, particularly when uncertainty is involved, formal techniques can, if used properly, nearly always result in better decisions. Second, effective use of formal techniques does not require replacement of the entire corporate decision making apparatus. An individual manager can make effective use of such techniques on problems falling within his own area, or in broader problems, to yield results for his own evaluation of alternatives, or as ammunition in corporate give and take. The techniques themselves are useful for broad or narrow problems, or for top or lower level decisions; however, due to the fact that at some levels, for some problems, explicit rationality would be a positive hinderance rather than a help, one should pick the problems to be analyzed rather carefully.

B. DECISION MAKING - A TAXONOMY

There are any number of ways of classifying decisions--by subject area (inventory decisions, personnel decisions, etc.), by managerial level (top level decisions, middle level decisions, lower level decisions), by importance (critical, major, minor, etc.), and so on. A taxonomy should, though, be an aid to good decision making, not simply an arbitrary classification scheme. Ideally a decision maker could use a taxonomy not only to attach a classification label to a given decision problem, but to find an approach useful in solving his problem. Thus, the starting point in constructing a decision taxonomy is to consider the decision making process itself.

THE DECISION MAKING PROCESS

Decision making involves four steps: forecasting or projecting, identifying alternatives, determining measures of effectiveness of possible outcomes, then making the choice. The first step, forecasting or projecting the needs of the organization, the outside environment, future constraints upon the organization, and so forth, defines the context against which any decision must be evaluated. In some decisions this step is critical; determination of capacity needs in training facilities depends on forecasts of training volume and methodology, for example. There are other cases where this step is less important, as in choosing among methods to present a standard block of training. In forecasting, it seems useful to distinguish two extreme situations. The first extreme, called in this paper a "well defined" situation, is one where the objectives, the constraints, the structure, and the relationships among variables in the problem are relatively well understood. A good example of this is an inventory policy decision. Demand is well understood and, though uncertain, amenable to analysis. Costs of carrying a given inventory level can be defined and calculated. Costs of a stockout, though harder to calculate, can still be understood and approximated. Relationships among supply, demand, stock level, lead times, etc., can be easily specified. Contrast this with the other extreme, an "ill defined" situation, such as a decision problem like "what should CNET's policy toward enlisted personnel training be over the next five years?" Here a good deal of effort must be expended simply in defining the critical questions, the alternatives, and relevant considerations before the problem can be meaningfully discussed. Initially, at least, the ill defined problem would seem to call for a different type of approach than the well defined problem.

Another characteristic of decision problems which can be observed during the forecasting phase is the importance of uncertainty. Occasionally the uncertainty in a problem is relatively minor, so one can act as if all relevant factors were known. Many resource allocation problems and scheduling problems, for example, are of this type. Most real problems, however, involve uncertainty to a major degree, and decisions made under

the assumption of certainty may be grossly misleading. Thus, one must adopt different techniques for dealing with these two types of problems.

The second step in decision making involves specifying alternatives. In well defined problems these are usually readily apparent; in the inventory policy decision, alternatives are defined by all possible stock levels and reordering policies, and the choice of the inventory control mechanism itself. In ill defined problems a major effort may be needed to define a set of reasonable alternatives. If uncertainty is a consideration, then it may be necessary to specify contingent, as well as immediate alternatives. Thus, techniques for dealing with decision problems under uncertainty must include methods of identifying and describing contingent decision structures.

In the third step in the decision process, measures of effectiveness are specified. This involves considering the job to be done and identifying considerations relevant in evaluating alternatives. Sometimes a single measure can be identified as an overriding consideration, but more often one must deal with multiple criteria, some of which may not be measurable. Suppose, for example, that the job is to train pilots. Some relevant considerations are the length and cost of training, final pilot proficiency, capacity of the training pipeline, and a number of others. Only some of these considerations are directly measurable, so it is necessary to specify ways of estimating nonmeasurable outcomes. An approximate measure of pilot proficiency, for example, can be constructed by use of subjective evaluations, such as instructor comments, and results of quantitative tests, such as proficiency exams. Finally, these various measures are combined into a single measure of effectiveness. As a rule this last step is not performed explicitly; it is unusual to find a manager who has specified in any coherent manner the kinds of trade offs he is willing to make among effectiveness measures. Usually decisions are made on a case-by-case basis by consensus or "common sense"; these intuitive decisions do, however, define implicit trade off structures.

The final step in decision making is to select the best alternative among those specified. A variety of techniques, ranging from snap judgments to sophisticated and expensive computerized models are available to aid in this step. A major purpose of this taxonomy is to wed the decision problem with the appropriate technique.

THE TAXONOMY

The taxonomy developed in this research is outlined in figure 1. Branches on the breakdown tree in the figure are numbered, so that the discussion can be keyed to the appropriate part of the breakdown structure. A breakdown, between problems not requiring thought (branch [1]) and those requiring thought (branch [2]), is introduced at the top of the breakdown structure. This is introduced, somewhat facetiously, as a

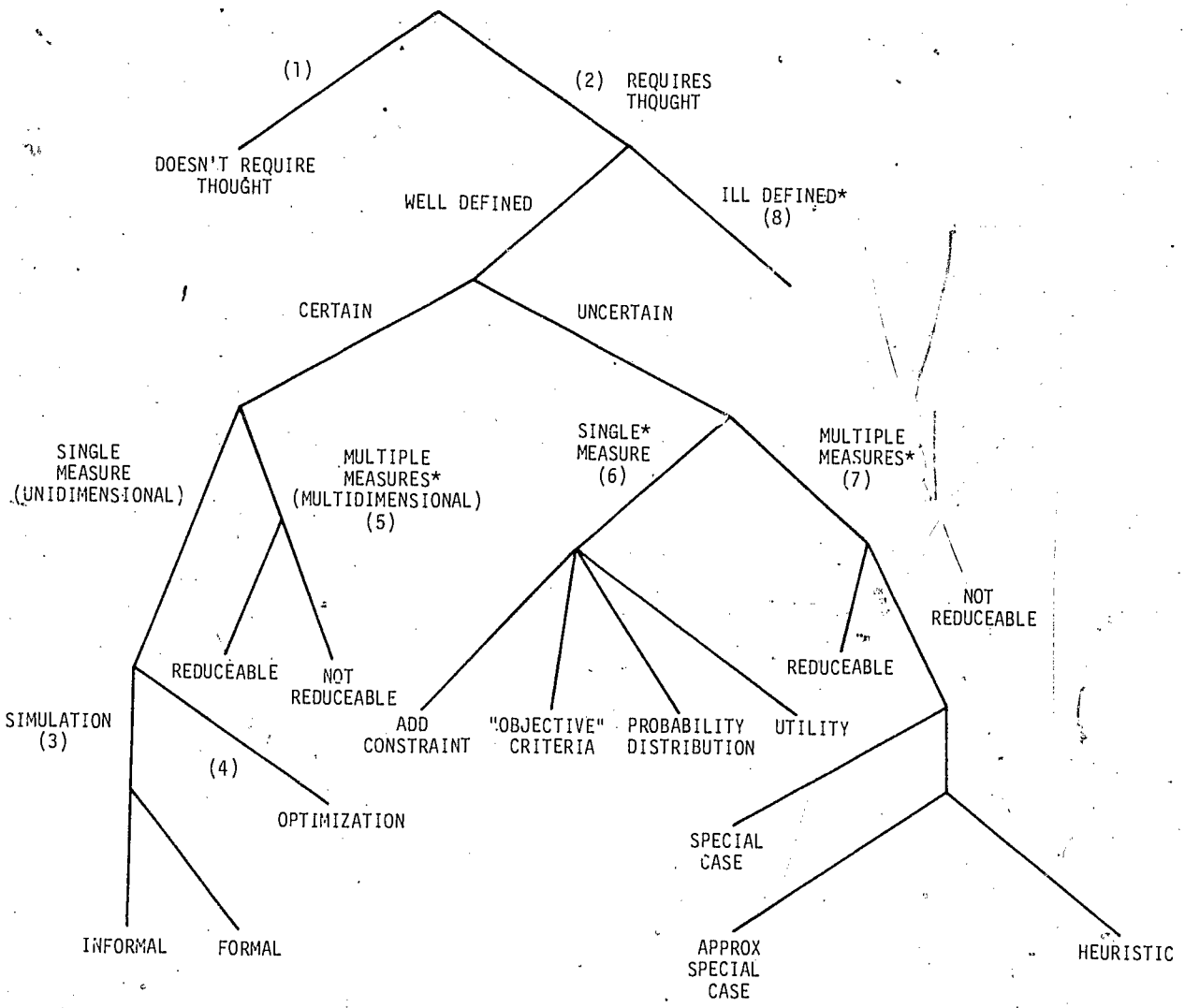


FIGURE 1. A DECISION TAXONOMY

reminder that many problems are too trivial, too obvious, or too constrained to justify detailed analysis. It is important to remember that the scope and expense of the analysis and the magnitude of the original problem must be kept in proportion. Most of the solution methods discussed below can be applied in either relatively simple or relatively complex manners, depending on the demands of the problem.

WELL DEFINED, CERTAIN, UNIDIMENSIONAL PROBLEMS (BRANCHES [3] and [4]). In discussing the taxonomy, consider first a problem which (1) requires thought, (2) is well defined, (3) can be treated as certain, and (4) has a single measure of effectiveness. Most real problems aren't this uncomplicated, but this simplest case is important as an approximation for many real problems and as an introduction to the more complex situations. Nearly all solution techniques for more complex problems consist of ways to reduce them to this simplest case, then using the techniques for this case to solve the problem. An enormous variety of techniques suited for such problems is known; here they are classified broadly as simulation techniques (branch [3]) and optimization techniques (branch [4]). Some of these solution techniques require computers for useful implementation.

Simulation techniques are projection techniques. Given a particular decision, the simulation method predicts the outcome. In order to determine the best decision, one must redo the simulation many times, trying all possible decisions in order to find the best one. Informal, "seat-of-the-pants" judgments are classified as simulation techniques in this report, as judgments consist of projecting the consequences of an action, then choosing among the actions. Simulation techniques can be extremely straightforward. Every manager who has projected a cash flow, forecasted expenses, or set up a budget has, in effect, performed a simulation. The idea in simulation is to formulate a set of rules which govern the behavior of a system, then apply those rules to see how the system acts. The more complex the simulation becomes, the more expensive, time consuming, and error prone it becomes, but the more potential usefulness it has. There have been many cases where complex simulations yield insights impossible to obtain in any other way.

Optimization techniques differ from simulation techniques in that optimization techniques are designed to not only predict outputs, but to determine automatically the best possible decision. The price one pays for this additional feature is usually a good deal of additional complexity. There are a number of "standard" types of problems (such as linear programming models) which can be relatively easily solved. If a particular problem fits one of these types, then optimizing may be straightforward, although perhaps expensive.

A complete discussion of optimization is well beyond the scope of this report. An introduction to this field can be found in Wagner (1969). A good, elementary, managerial-oriented discussion of optimization and simulation, with examples of how each can be applied, is contained in Springer, Herlihy and Beggs (1965).

WELL DEFINED, CERTAIN, MULTIDIMENSIONAL PROBLEMS (BRANCH [5]). There are two approaches to this situation. First, one might try to express all the measures in terms of some common measure, such as dollars. Suppose, for example, one must decide whether or not to install an expensive computer system to individually manage student instruction, and that tests have shown a decrease in the average length of training time under the computerized system. There are multiple measures in this decision, dollar cost and average training time. These could, however, be reduced to a single measure, dollars, if one could express the worth, in dollars, of having a student complete training earlier. There are a number of other techniques, some fairly simplistic and some quite elegant, for reducing multiple criteria to a single criterion. These will be discussed somewhat further in section C, under "Determining Preferences for Outcome". Once a single criterion is established, then either simulation or optimization techniques can be used to solve the problem.

Second, in some problems it is easier to work directly with multiple criteria than to try to reduce them to a single criterion. If the problem is solved by a simulation technique, this is no particular problem; outcomes projected by the simulation technique are characterized by many measures of effectiveness rather than one, and in the end the decision maker must choose among them. Thus, although he may be able to avoid an explicit specification of the trade offs he is willing to make among objectives, he cannot avoid striking some kind of balance among them in the final analysis. If one wishes to use an optimization technique to solve the problem then working with multiple criteria becomes very difficult. It is possible to make some use of optimization; for example, one might do a number of optimization calculations, each time using a different measure of effectiveness as the optimized criterion. With some luck, this would narrow the choices down enough to effectively solve the problem. In the more general case, though, it is difficult to make good use of optimization.

WELL DEFINED, UNCERTAIN, UNIDIMENSIONAL PROBLEMS (BRANCH [6]). This has been an extremely important special case, particularly in the financial literature, and has given rise to a number of ideas, all of which are designed to translate this problem to an equivalent problem under certainty, so that the usual simulation and optimization solution techniques can be used. Before discussing these approaches, a bit of terminology must be introduced. In an uncertain problem one does not, by definition, know in advance the exact value of the outcome for any decision. One always knows, though, that for a given decision some results are more likely than others. It is possible to express this knowledge by describing, or assessing, a probability distribution for the outcome. Given the probability distribution one can calculate a number of data, the most important of which are the mean or expected value (a measure of the average value of the outcome) and the standard deviation (a measure of the spread, or variability, in the outcome). It is also possible to calculate the chances of any given value of the output being exceeded.

The first approach to solving these problems ignores uncertainty as long as it stays within predefined limits. In setting up the problem, the decision maker can specify such constraints as his maximum allowable loss, or the probability that costs, for example, exceed a given figure. Within these bounds he uses some simple measure of outcome, usually the expected value, to solve his problem. In this way he translates the uncertain problem into a constrained problem under certainty, which is readily solved by certain optimization techniques.

A second approach does not utilize the probability distribution as such, but embodies such ideas as "Let's assume that the worst (or best) possible event will occur, then maximize our gain under that assumption." It has been pointed out that this approach can lead to overly pessimistic (or optimistic) decisions, so a variation has been developed which allows the decision maker to express his personal attitudes toward risk by picking a value for a "pessimism factor," which is then used to balance the best and worst cases. Still another variation assumes that all uncertain events are equally likely, then maximizes the expected value of the criterion.

The third approach consists of defining a new, certain measure of effectiveness, most commonly by subtracting a constant times the standard deviation from the expected value of the outcome. The rationale is that, variations being equal, one would choose the alternative with the higher expected value. If variations are not equal, then one must have a higher expected value to offset the additional risk of the larger variation. One is allowed to set the degree of offsetting required by picking the value of the constant referred to above.

All these approaches are useful in certain circumstances, but can be shown to lead to irrational decisions in other cases. A more general approach, known as utility theory, can be shown to be valid for all problems, given that one believes some basic assumptions about the meaning of the term "rationality." In the utility approach, the decision maker expresses his attitudes toward risk in the form of a curve, called a utility curve. The utility curve is then used along with the probability distribution mentioned above to calculate a measure of "goodness" which accounts automatically for the uncertainty in the results. This utility measure can then be used with any of the techniques discussed under branch [3] to solve the problem. This approach, although unfamiliar to many managers, is straightforward.

WELL DEFINED, UNCERTAIN, MULTIDIMENSIONAL PROBLEMS (BRANCH [7]). Sometimes the criteria can all be expressed in terms of a common measure, as was discussed for problems with multiple criteria with no uncertainty (Branch [5]). To take the same example, it might be possible to approximate the worth, in dollars, of shortening training by one day, then express the uncertainty both in the cost of the computer system and in the number of days by which training would be shortened in terms of a single, uncertain, total

dollar figure. The problem could now be solved by methods discussed under branch [6].

In many problems it is impossible to express the criteria in terms of a single criterion. Another approach exploits the ideas of utility theory, discussed briefly above. In the case where a single criterion exists in an uncertain problem, one expresses his attitudes toward risk in the form of a utility curve. In this case, where multiple criteria exist, one can, in theory, do the same thing, except that the utility curve becomes a 3-dimensional or higher dimensional curve, a utility hyperplane. Because of practical difficulties, it is possible to determine what this hyperplane looks like only for certain special cases. Fortunately most real problems can be treated as one of the special cases, so the multidimensional utility approach can be an extremely useful analytical tool. Even if a problem is one which doesn't fit the "special case" category, one can usually get a good approximate solution by treating it as if it were, then seeing how sensitive the results are to the utility assumptions.

A third approach to this class of problems consists of using heuristic approximation techniques, or in more everyday language, using reasonable ideas that seem more-or-less to work. One might, for example, select what he considers the most important outcome measure, get a rough idea of the probability distribution of that outcome, then make a tentative decision based on that; he would then check the other outcome measures to make sure that his solution wasn't ridiculous before making the decision final. Another commonly used approach has been to set "aspiration levels" on all the criteria, then to search for a decision alternative which has a reasonable chance of attaining all the aspiration levels. In choosing training methods, for example, one may set limits on the cost and the length of training, the physical facilities needed, and the prerequisites on the student input, then choose the method which seems to have the best chance of meeting the limits. The major problem with such heuristic methods is that they depend heavily on the ingenuity and judgment of the human decision maker, and humans can be shown to be notoriously poor processors of uncertain, multidimensional information. Both the methods mentioned above, plus many others one could conceive of, can lead to bad decisions at times. Somewhat more structured approaches can usefully supplement, though not supplant, the capacities of human judgment.

ILL DEFINED PROBLEMS (BRANCH [8]). Solving an ill defined problem requires first shaping it into a well defined problem; doing this requires a different type of effort than discussed so far. Any real situation is infinitely complex in detail, so the first step in analysis is to identify the major issues and constraints in a problem. Next, the major action alternatives should be outlined, and some thought given to the impact of each possible action upon the major issues. Third, the most promising alternatives are selected for further study, then this process is repeated.

Thus, the process of analysis is cyclical rather than linear. With each cycle the problem and the issues become successively better defined until the problem can finally be effectively defined and solved. In the early stages of problem definition formal approaches are of limited use, as the problem is mainly one of encoding impressions, knowledge, and attitudes. Even at this stage, however, systematic methods of thinking can pay dividends. A systematic approach to decision making, both in ill defined and well defined situations, is outlined in the next section.

ROLE OF COMPUTER-BASED METHODS

Computers have the capacity of processing enormous amounts of data at staggering speeds with excellent accuracy. In addition, it is possible to build a good deal of sophistication into computer programs. This can, under the proper circumstances, allow a manager to supplement his own expertise with the intelligence which went into designing the computer program. For these and other reasons piles of computer printouts, and occasionally computer time sharing terminals, are becoming increasingly common sights in managers' offices. The precise role played by the computer in the decision making process can, however, vary a good deal. One critical dimension to the computer's role, namely the relative involvement of the computer versus the manager in making decisions can be depicted as shown in figure 2.

At one extreme, the computer can be used simply as a data gathering and summarizing tool. The manager retains not only all decision making prerogatives, but the bulk of the analytical workload. The computer may do a minimal amount of computing (summarizing, calculating ratios, computing variances, etc.), but the primary use of the computer in this mode is to feed data to managers for their analysis and interpretation, and to handle routine paperwork. The bulk of current applications is of this type. Managerial and cost accounting systems, payroll systems, and many production control systems, to name a few examples, can be classified in this category.

The prevalence of such data gathering and file maintenance systems has led to the creation of sizeable and reasonably complete data bases. These data bases are, in most cases, potentially valuable for a variety of managerial purposes. Data gathered and stored as part of a payroll system, for example, is frequently useful in the analysis of productivity and the projection of employee expenses. Data from a billing and invoicing system can be used in inventory control. The Navy maintains extensive records on equipment maintenance and failure histories as part of the 3-M system; these data are potentially useful to the training command in indicating problem areas and possible training deficiencies. The usefulness of a given data base for a new purpose is limited, however, by the organization and scope of the data. Usefulness of 3-M data to the training command, for example, is limited by the fact that the training record of the man responsible for given equipment is not recorded.

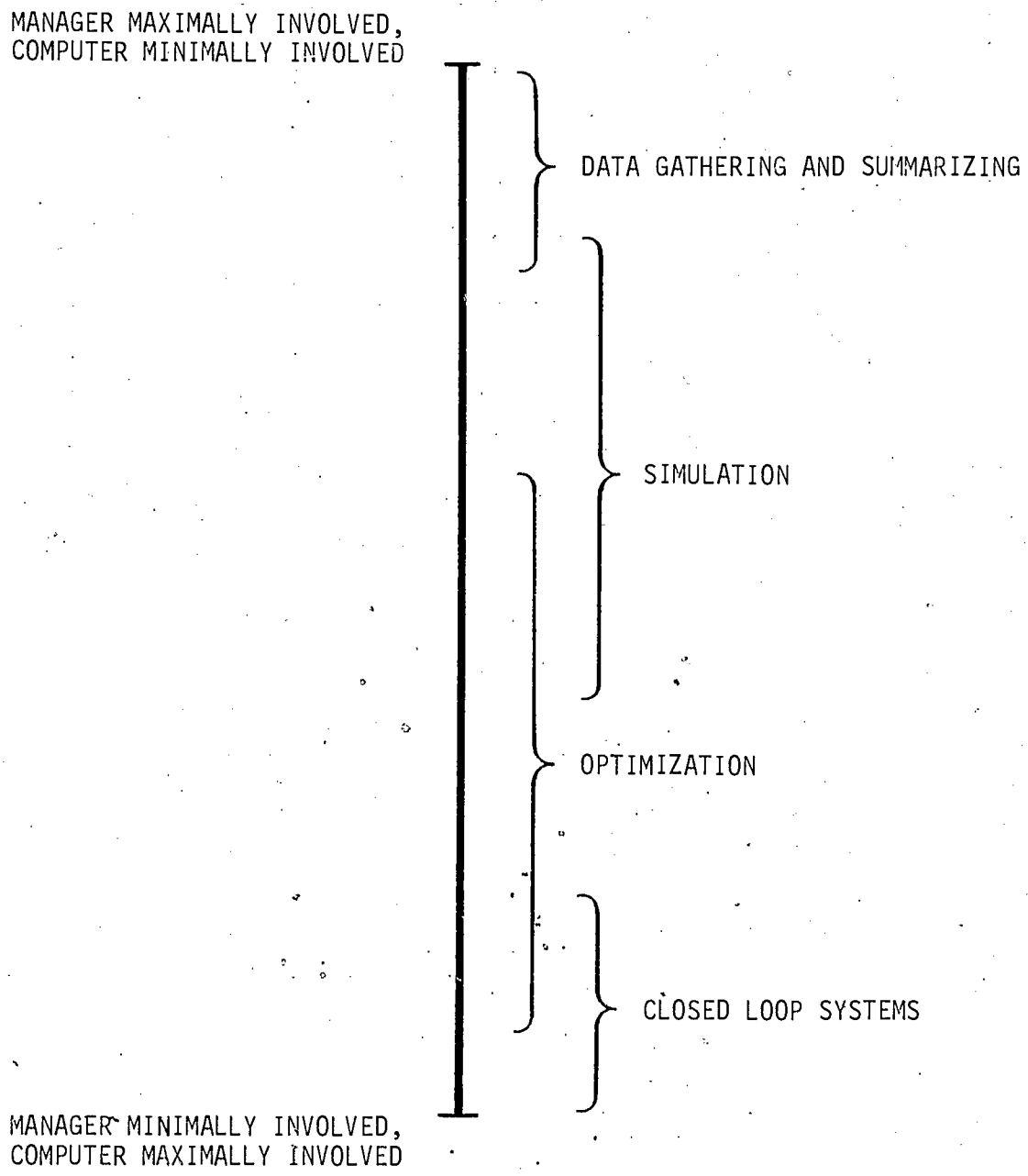


FIGURE 2. INVOLVEMENT OF THE COMPUTER VS THE MANAGER IN DECISION MAKING

A more complex category of applications involves using the computer to analyze data through simulation models. As explained earlier, simulation techniques involve representing a system in a mathematical form. Consider, for example, a simulation model to predict student throughput in a training program. There are a number of factors which clearly affect throughput, such as the nature of the training to be performed and the skill level desired, instructor availability and skill, the amount and type of training equipment available, student intelligence and motivation, and so on. The builder of the simulation model attempts to determine which of these factors are most important in determining throughput, and just how the critical factors interrelate to determine the throughput. He then puts these relationships into a mathematical form which can be used in a computerized model. Once this is done, the manager can use the simulation model in a number of ways--to forecast some figure of interest, such as the budget required to produce a given student throughput, to perform "what if" analyses, to plan and design a new system or a change to the present system, or in many other ways. A feature shared by all simulation models is that the human, the manager, remains in the decision loop. The computer simply projects the effects of a set of assumptions, and it is up to the manager to examine the results and either change the assumptions and perform additional analysis, or to make a final decision.

The next level of computer application involves the use of computerized optimization techniques. Optimization techniques, being designed to automatically determine the best possible decisions in a given situation, have the capability of removing the manager from direct involvement in the decision process. Usually, however, the manager is involved in interpreting and implementing the analytical results. Most optimization techniques are designed to yield information not only about the optimal decision, but information on the sensitivity of the result to various data and assumptions used in the model. The purpose of this is to allow the manager to estimate the impact of factors not included in the model, and to explore the feasibility of alternatives other than those derived by the optimization technique. Thus, the manager and the computer usually supplement one another in the decision process.

Finally, there are some cases when it has been shown useful to eliminate the manager from the decision process altogether. In many inventory systems, a computer not only sets reorder points and quantities, but places the order as well. The only impact the manager has on this process is to occasionally review the system performance and to adjust the rules by which the computer makes its decisions. Production scheduling and process control are other areas where this "closed loop" approach has been applied. All these applications occur in situations which are repetitive, and where the major variables in the decision process are known.

C. OUTLINE OF FORMAL DECISION ANALYSIS

The decision aids outlined in the previous section, although useful, do not provide a general method of attacking most managerial decision problems. In these other areas, nearly all decisions are made intuitively, and there are some circumstances when some better method than intuition is desired. Perhaps the decision is of major importance, or the complexities and uncertainties of the problem are such that there is a need to integrate the expertise and knowledge of a number of people in the organization; or perhaps there is a need to explain the issues and trade offs in the problem to someone else, either a superior or an ally. In any event, there are circumstances when a rational, systematic method of outlining the decision process is needed. The bag of techniques for doing this is known collectively as "decision analysis" or sometimes "decision theory." Very briefly, use of these techniques allows one to:

1. Outline all alternatives and to consider all possible consequences of each alternative in a systematic way,

2. Break a large, complex problem down into a series of smaller, simpler problems so that different experts or organizational units can contribute to the solution of the problem in their particular areas,

3. Specify and quantify uncertainty, and determine how critical the uncertain variables are,

4. Specify, in a logical manner, the trade offs one is willing to make among outcomes,

5. Determine the worth of gathering further information, and finally a measure of how much better that decision is than any other alternative. This last point is useful in deciding, for example, whether factors ignored in the formal part of the analysis could possibly change the decision.

Basically there are four steps to decision analysis: (1) structuring the problem, (2) determining uncertainty, (3) determining preferences for outcomes, and (4) obtaining results.

STRUCTURING THE PROBLEM

Consider, for the purpose of illustration, a highly simplified decision problem. Suppose you are trying to decide whether to invest $1000 of your money in a bank, where you are assured a 6 percent annual return, or in a business venture. If the business is successful, you would receive a 100 percent return over the next year, while if it went broke you would lose everything. You will cash in your investment at the end of one year in any case. To keep the problem simple, assume these are the only two possibilities, and that there are no other uses of your money that you wish

to consider. Finally, suppose it is possible to buy some information concerning your problem. A business expert of your acquaintance has heard of two other business ventures of the type you are interested in; for a $100 fee he would research the problem for you to find out if the two were successful. This problem can be diagrammed in the form of a decision tree, as shown in figure 3. Note that the decision tree lays out, in chronological order, all possible decisions and uncertain events; by convention, the decision points are represented by squares and the uncertain events by circles. If you invest in the bank, then the decision tree shows a sure return of $1060 (the original $1000 plus the 6 percent interest) at the end of the year. Similarly if you invest in the business you will have either $2000 or nothing at the end of the year. If you purchase the information, then you will find out that none, one, or two of the other ventures were successful. This is treated as an uncertain event since you do not know in advance which of these is the true case. After receiving this information, you can decide on the bank or the business investment, with the possibilities of gain or loss as shown. Note that the $100 cost of the information has been taken into account in calculating the payoffs.

Even for this simple problem, the decision tree is an extremely useful device for organizing one's thinking, for decomposing a large problem into a series of smaller ones, and for gathering information. A decision tree also serves as a good communication tool in outlining a problem to someone else. Decision trees have the advantage of being easy to draw and manipulate, making them useful even when high-powered analysis is not warranted.

DETERMINING UNCERTAINTY

A critical factor in the investment problem outlined above is the probability of the business being successful. One rarely knows in advance, of course, what the odds are, but usually there is at least a vague impression of some kind (the business "looks promising" or perhaps "seems risky"). It is possible to quantify these impressions by interviewing the decision maker, or better yet, an expert in the field, to determine a probability distribution of the odds. The probability distribution can then be used to determine the attractiveness of the business venture. The probability data can also be combined with objective data, such as is obtained on the "purchase information" option, to determine whether the venture still looks good after the information comes in, and to determine whether or not the information is worth the $100 cost.

DETERMINING PREFERENCES FOR OUTCOMES

In our example a single measure of effectiveness, namely the amount of money at the end of the first year, is used. Even in this case, it is not clear how to proceed; for one thing, people's attitudes towards risks differ. It may well be optimal, for example, for a poor man to pass up an otherwise attractive investment because the chances of loss are too great.

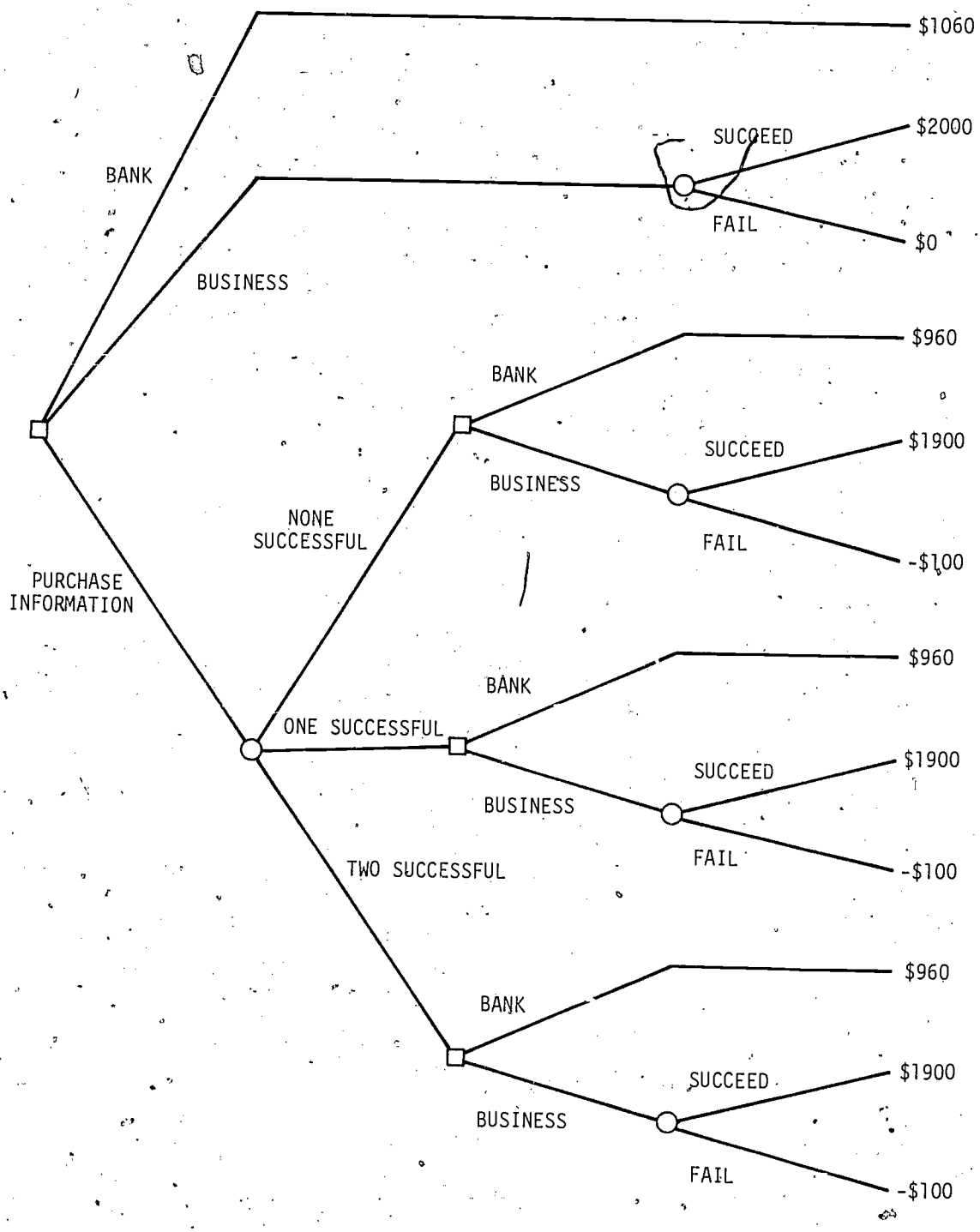


FIGURE 3. DECISION TREE

Even when two individuals have the same wealth, one person may be more willing to take chances than the other. A method for dealing with these considerations was first suggested by von Neumann and Morganstern (1944). Their idea was to pick a "best" outcome and a "worst" outcome which are at least as good and bad, respectively, as any outcome you expect to get. In the investment example, the best and worst possible outcomes are $2000 and -$100. Then for each possible intermediate outcome, one must assess a probability such that the intermediate outcome is exactly as attractive as a gamble between the best and worst outcomes. This probability is called the "utility" of the outcome. For example, consider the $1060 which we would receive by investing in the bank. We assess the utility of $1060 by determining a probability, which we will call p, so that the gamble in figure 4 is neither more nor less attractive than $1060 for sure. If p were nearly one then the gamble would be more attractive, while if p were nearly zero the $1060 would be more attractive, indicating that there must be some value of p between zero and one where the choices are equally attractive. Note that the value of p chosen would vary from individual to individual, depending on the decision maker's personal attitudes toward risk.

Finally, von Neumann and Morganstern (1944) point out that the value of p (or the utility) is a measure of the relative attractiveness of the $1060 consequence, and prove that the expected value of the utilities of end points is a valid decision criterion under uncertainty. To solve the investment problem, then it is necessary only to assess the utility for each end point, calculate the expected utility for each decision, which is easily done, then choose the action with the highest utility.

The validity of the utility approach depends upon certain behavioral axioms, or observations on rational behavior. The major ones are:

1. Given two consequences A and B, then either A is preferred to B, B is preferred to A, or both A and B are equally attractive;

2. If A is preferred to (indifferent to) B and B is preferred to (indifferent to) consequence C, then A is preferred to (indifferent to) C;

3. Given a utility assessment problem such as is outlined in figure 4, it is always possible to find a value p such that the gamble and the "for sure" amount are equally attractive;

4. If consequence A is preferred to consequence B then of two different gambles between A and B, the one offering the larger chance at A is preferred.

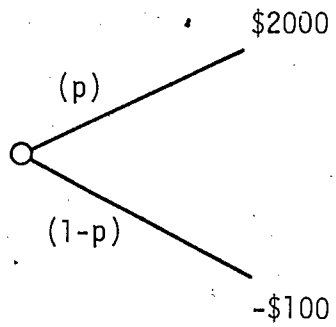
These seem to be reasonable assumptions, but it has been observed that people do not always act according to the axioms. This fact indicates that utility theory may not be a good descriptive theory, but emphasizes its

YOU MAY HAVE EITHER

Ⓐ $1060 FOR SURE

OR

Ⓑ THE GAMBLE



WHICH GIVES A PAYOFF OF $2000
WITH PROBABILITY p AND A PAYOFF
OF -$100 WITH PROBABILITY (1-p)

YOU MUST SET THE VALUE OF p SO THAT Ⓐ AND Ⓑ ARE EQUALLY ATTRACTIVE.

FIGURE 4. UTILITY ASSESSMENT EXAMPLE

potential usefulness as a prescriptive theory; i.e., one which indicates improved decision methods.

In the case where multiple measures of effectiveness must be used, the same basic ideas of utility theory hold. Due to practical problems, however, it is possible to assess a multidimensional utility function only if certain assumptions about one's preferences hold. For most problems the assumptions are valid, making it possible to use the utility approach.

OBTAINING RESULTS

Once the problem has been structured and the probabilities and preferences assessed, obtaining results is a straightforward computational matter. Simple problems can be solved by hand, while for more complex analyses a number of computer methods can be used. The hardest part, by far, in a decision analysis is in structuring the problem and gathering data, rather than in calculating the solution. A good deal of "art" is required in selecting the portions of a problem to explicitly represent, since a decision tree can rapidly become overly complex if too much detail is included. Analysis is generally a cyclical, rather than a linear process. This comment applies particularly to this type of analysis. The first cut at a problem should outline major alternatives and outcomes only roughly. After "lopping-off" the least promising branches of the initial tree, the remaining part can be elaborated, and this process continued as long as is necessary.

D. USE OF FORMAL DECISION THEORY IN ORGANIZATIONS

In section II.A some questions were raised concerning the role of formal analysis in real organizations, indicating that it is important to identify the types of problems for which formal techniques would be useful. One way of approaching this issue is to summarize successful applications of the method.

APPLICATIONS OF DECISION ANALYSIS

Decision analysis, in its present form, resulted from a marriage between a particular school of thought concerning statistical analysis (the so-called "Bayesian" approach) and the von Neumann-Morganstern theory of utilities. Von Neumann and Morganstern were interested primarily in applications in economics, giving that side of the union a strongly business oriented bent, and as the union was consummated largely in graduate schools of business, most of the applications work has been in a business setting. Reinforcing this propensity has been the fact that business problems have a natural, easily measured, common measure of effectiveness, namely profit.

BUSINESS APPLICATIONS. An important early application of decision theory is Markowitz (1959). Markowitz was concerned with the rational investment of funds in a portfolio of potential investments, each characterized by an expected monetary return and a degree of riskiness. The portfolio problem is how to determine the investment, or mix of investments, which optimizes the return/risk trade off.

The portfolio selection process has a direct analogue in business decisions involving capital investment. Matheson (1969) discusses an analysis of new product development alternatives. Briefly, a major manufacturing research company has developed two compounds for a particular market, and the decision must be made to do final development on neither, both, or only one of them, and if the latter, to decide which one.

Cook (1968) presents another analysis of a product development, this time, in the atomic power field. Four different product development alternatives for atomic electric generating stations were analyzed. A complex computer model of the market, costs, demands, and sales aspects of the problem was constructed and evaluated by decision analytic techniques.

Additional analyses of a similar nature are described by Laessig & Silverman (1974) and by Frederick (1973) who describes a product pricing problem for butadiene, a petrochemical product, in which multiple criteria were considered. Huber (1974) reviewed a number of field studies, primarily business oriented, in which multidimensional utility models were used. A more complete and general discussion of risk analysis in capital projects is contained in Spetzler (1968). Spetzler interviewed a number of executives of a company, then used the resultant utility assessments to formulate a corporate risk policy.

Decision analysis has also been shown to be useful in settings other than investment problems. Keeney (1969) discusses an application of multidimensional utility theory to determine the optimal organization of a telephone network. The object was to maximize the degree of service, as determined by the percentage of time the lines are available to two different customer groups.

In Brown (1970) the results of a survey among firms using, or who have used, decision analysis are reported. The firms surveyed included organizations with several years of active experience in decision analysis, some where the method is fairly new but is in active use, some where there is interest, but little application, one or two where decision analysis has been a disappointment, and two consulting firms with expertise in the area. Brown found that general decision making procedures are not radically affected by the presence of decision analysis, but that individual decisions are often profoundly affected to the good. The consensus among the survey participants was that the methods had enormous potential which is not yet realized. Major problems seen in using the method are: (1) management

education, (2) communications between the analysts and the managers for whom the analysis is done, (3) the difficulty in many organizations in identifying who is responsible for specific decisions, and (4) organizational obstacles. Brown concludes that "If there is one dominant feature that distinguishes the successful from the less successful applications of DTA (Decision Theory Analysis), judging from the findings of this survey, it is the organizational arrangements. . . . The most successful appears to be the 'vest pocket' approach, where the analyst works intimately with the executive and typically reports to him...."

MEDICAL APPLICATIONS. A rich literature has grown up describing applications of decision theory to medical problems. Among the reasons for this are: medical decisions have important consequences in cost, suffering, and death; medical problems are complex and involve uncertainty; the volume and fragmentation of knowledge requires an effective integrating structure; data are widely available and relatively easily obtainable; and public interest in medicine is high. Although medical decisions per se are not of interest in this research, the methodology of applying decision analysis which is demonstrated in this field is. In particular, medical decisions typically require consideration of multiple objective criteria, and a number of techniques for dealing with this problem are described in this literature.

A number of articles describe the application of decision theory to specific medical diagnostic or treatment problems. Giauque and Peebles (1974) discuss analysis of the treatment of strep throat and rheumatic fever, developing in the process a scheme for evaluating consequences with as many as 10 attributes. Ginsberg (1971) performs a similar analysis for the pleural-effusion syndrome (which involves fluid in the lung cavity), while Ginsberg and Offensend (1968) discuss a diagnostic problem in spinal bone disease. The approach to the multidimensional consequence evaluation in both these cases was somewhat simpler. Thomas et al (1973) analyze the diagnosis of heart disease, while Schwartz et al (1973) discuss hypertension (high blood pressure). Some of the papers [particularly Giauque and Peebles (1974), Ginsberg (1971), and Schwartz et al (1973)] contain general discussions of decision analysis in addition to the specific studies.

More general approaches to broad problems are contained in Giauque (not yet published) and Lusted (1971). Giauque discusses a utility approach to measuring the quality of health care, with a particular application in the treatment of hypertension. Lusted discusses the use of decision theory in interpreting X-rays. Lusted (1968) contains an extensive bibliography of other medical analyses.

PUBLIC SECTOR APPLICATIONS. Public sector applications are particularly difficult to analyze since they have neither the natural measurement criterion of profit found in business applications nor the data availability of medical applications. Decision analysis offers methods both for dealing

with the multiple criteria required in public sector analysis and the uncertainties caused by lack of data, leading to a significant volume of literature on public sector applications.

Howard, Matheson, and North (1972) discuss the problem of deciding whether or not to seed hurricanes with silver iodide. Experiments with seeding have shown promising results, but a decision to seed a hurricane bearing down on populated areas carries legal and moral consequences. Howard et al used decision analysis to examine the problem and to explore other decision alternatives besides the "seed" and "don't seed" alternatives. In Giauque (not yet published - II) a scheme to determine an optimal method of oil spill cleanup in harbors, depending on the geographic and climatic conditions at the harbor, is presented. Keeney (1969) explores blood bank inventory control and cost/benefit relationships of depth surveying in the Cape Cod Ship Canal through use of a multidimensional utility analysis.

A second group of papers are broader in scope, but still deal with well defined problems and priorities. Gear (1974) and Roche (1972) present analyses of planning in education. Gear, after discussing approaches to a number of common educational decision problems, presents an analysis of secondary school pupil allocations between adjacent geographical areas. Roche discusses an extensive investigation into the problem of resource allocation among different subject areas in a secondary school. This involved determining the trade offs the school board and school administration are willing to make among proficiency levels in the various subjects. Other application areas include space and military planning. Matheson (1969) presents a method for planning payloads on unmanned Martian exploration vehicles. Power (1973) discusses an interactive system, utilizing decision analytic concepts, to plan cost and schedule estimates for anti-ballistic missile programs.

Stanford Research Institute (1968) conducted a study for the Mexican Government, in which a strategy for electrical power system expansion for the entire country over the next 30 years was derived. This involved forecasting a complex array of power needs, technical advancements, price movements of various fuels, and so forth, over this time frame. In addition, a number of social trade offs had to be considered. For example, the impact on employment, self-sufficiency, side benefits, and technical expertise required are very different for say, nuclear versus hydroelectric generating plants. This study is referred to and discussed in Matheson (1969) and Howard (1971).

In a separate study, Keeney and Nair (1974) discuss the complex issues and trade offs involved in licensing nuclear power plants within the United States, and propose a decision analytic based approach to solving these issues. Hammond (1971) and Ellis & Keeney (1972) derive methods to analyze

problems of strategic military planning and air pollution control, respectively. Finally, deNeufville and Keeney (1972) consider the possibilities for future development of the Mexico City, Mexico, airport. A number of effectiveness measures were used, specifically, noise problems, cost, capacity, safety, transportation time, and the number of people displaced by the airport expansion.

APPLICABILITY OF DECISION ANALYSIS

The overriding impression one gets from reading the applications literature is the importance of the relationship between the analyst and the decision maker. What is studied does not seem to be nearly as critical as how the study is performed. In the words of Keeney and Raiffa (1972), "The metadecision of whether or not to do formal analysis cannot be divorced from the questions of organizational structure, of the personal incentives for the people involved, and of the quality of the analysts." Brown (1970) also emphasizes the quality of the analyst-client relationship. The above amounts to saying "Get a good analyst and a motivated manager, get them working well together, and no matter what the problem is you'll get a good analysis." This is the same thing that operations researchers have been saying for years, and it seems to be true in decision analysis as well.

Some additional light on this issue can be obtained by referencing figure 1. Branches of the taxonomy tree marked with an asterisk are those where decision analysis is most likely to be useful. If problems are well defined, certain, and have a single decision criterion (measure of effectiveness), the particular strengths of decision analysis are not really called into play. In other types of problems, though, the usefulness of the method can be dramatic, either alone or in conjunction with other techniques. The structural aspects of decision analysis are helpful in defining problems, specifying the magnitude of uncertainty, providing for contingent decisions, and determining the sensitivity of results to assessments and assumptions. The utility formulation allows one to specify objective criteria valid under risk, and to reduce multiple criteria to a single criterion.

SECTION III

DECISION MAKING IN THE NAVAL EDUCATION AND TRAINING COMMAND

In the previous section a number of general observations concerning decision making in large organizations were summarized. With this background, decision making in the NAVEDTRACOM is now discussed. Source material for this section was gathered both during field interviews with NAVEDTRACOM staff personnel and from written material. A particularly useful discussion of the functions performed by the NAVEDTRACOM, including specifically the decision-making functions, is found in TAEG Report 12-1.

A. HISTORICAL AND ORGANIZATIONAL SUMMARY OF THE NAVEDTRACOM

The NAVEDTRACOM was organized in August 1971. Prior to that time the training function in the Navy was allocated among a number of agencies. Due to the difficulties of coordinating efforts it was decided to consolidate the responsibility for all naval training under the newly formed office of the CNET. The CNET and his staff, located in Pensacola, Florida, have responsibility for all naval education and training programs, except medical training and some training done in the Fleet (source: TAEG Report 12-1, p. III-7). Included in his duties are the responsibilities for organizing, staffing, and running the training function, submitting and administering training budgets, determining optimal training methods given the budgeting and congressional constraints faced by the Navy, advising the remainder of the naval organizations on training matters, and other related duties. The position of CNET is currently filled by a Vice Admiral.

An organization chart for the major divisions of the NAVEDTRACOM is given in figure 5. Five major entities report to the CNET. The CNETS is tasked with providing to CNET and other assigned claimants support in the areas of, first, material evaluation, development, production, support, and validation; and, second, educational and library services, general military training, and international logistics. The CNTECHTRA is assigned the responsibility of administering, staffing, supervising, and running the Navy's technical training schools. The Chief of Naval Air Training (CNATRA) performs the same functions for schools involved with air training. The final two organizational entities reporting to CNET are the Commanders of Training in the Atlantic and Pacific Fleets (COMTRALANT and COMTRAPAC). These organizations are tasked to work with CNET and their respective fleet commanders to implement and supervise fleet training.

Currently over 50 percent of all training dollars are spent on recruit and advanced enlisted training, falling under CNTECHTRA, COMTRALANT, and COMTRAPAC, and an additional 25 percent on flight training, falling under CNATRA.

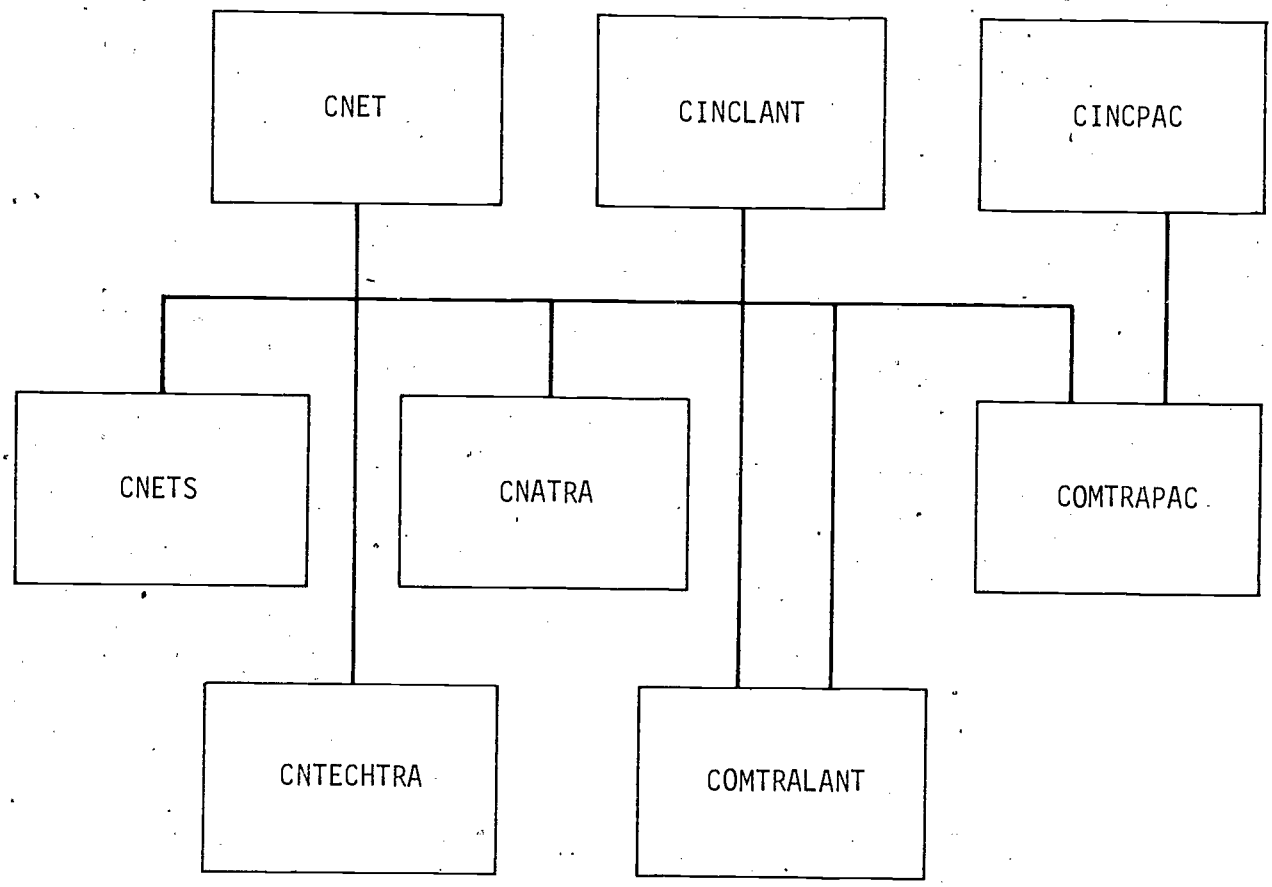


FIGURE 5. NAVEDTRACOM ORGANIZATION

B. MAJOR DECISION MAKING FUNCTIONS OF THE NAVEDTRACOM

The responsibilities of the NAVEDTRACOM can be classified into 10 major areas. These are:

1. develop training requirements,
2. analyze and plan training,
3. coordinate and control training,
4. implement training,
5. evaluate performance,
6. manage resources,
7. perform research,
8. support training,
9. administration and internal control, and
10. miscellaneous functions.

DEVELOP TRAINING REQUIREMENTS

New training needs arise from two types of situations. First, as the hardware and systems used by the Navy change there is a need to modify the corresponding training packages for incoming personnel and, in most cases, to retrain current operating personnel. Second, the requirements for ongoing training are modified due to changes in such things as personnel requirements, characteristics, input rates, etc.; changes in operational demands; or changes in policy. In general, a training need is defined as a need for a particular number of personnel with a given skill. The need requirement first goes to BUPERS, where an inventory of Naval personnel with given skills is maintained, to determine whether the requirement can be satisfied out of the existing skill inventory. If the requisite number of qualified people is lacking, then the CNET is requested (or required) to provide training to meet the need.

As can be seen, training requirements originate outside the NAVEDTRACOM, as it is up to the operating Navy to determine needs and the responsibility of the training system to fill those needs. Training needs can come to NAVEDTRACOM via four major interfaces:

1. the Chief of Naval Operations,
2. the Naval Material Command,
3. the Bureau of Naval Personnel, and/or
4. the Fleet Commands.

These interfaces are not clearly defined, however, in that requirements given to CNET are usually ambiguous (TAEG Report 12-1, op. cit.). In addition certain types of changes, particularly policy changes, may affect the requirement for training greatly, but the changed requirements may never be formally submitted to CNET in the form of a training task requirement; in such cases CNET generates the requirements internally. An example of such a policy change is the decision to implement the all volunteer force. For these reasons, and since the determination of requirements is critical to the effective functioning of CNET, this function is handled as if it were an integral part of the training system.

DESCRIPTION OF EXISTING SYSTEM[1]. The problems of developing training requirements can be seen to be both important and ill defined. The first step in solving an ill defined problem is to make it into a well defined problem. In the CNET organization this is accomplished as follows. Each year CNET is faced with a "base load" of continuing training requirements; resource levels needed to support such training are routinely estimated and factored into the budget. New requirements, on the other hand, go through the justification process outlined in figure 6. This procedure begins with the submission of new training requests, which are then analyzed and prioritized by CNET. A request for new training generally, but not always, is originated outside CNET. The first step in processing the request is to make an estimate of the resources required to implement the request. The form used to document the estimates (CNET Form 1500/8, see figure 7) requires estimates of funding requirements and known sources, classroom and laboratory space requirements, instructor requirements, and other pertinent data.

It is currently the case, and it is reasonable to expect that it will continue to be the case, that resources for training are less than desired resources. This necessitates a continual ordering of desired activities into a priority sequence. Currently, prioritization involves two phases, a fairly mechanical scheme which assigns a numerical "priority designator" to each project, and project review by either one or two committees, depending on the particular project.

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[1]Refer to TAEG Report 12-1, Vol 1 (op. cit.). Prioritization is discussed under the "Coordination and Control," the "Analysis and Planning," and, more extensively, under the "Manage Resources" functions.

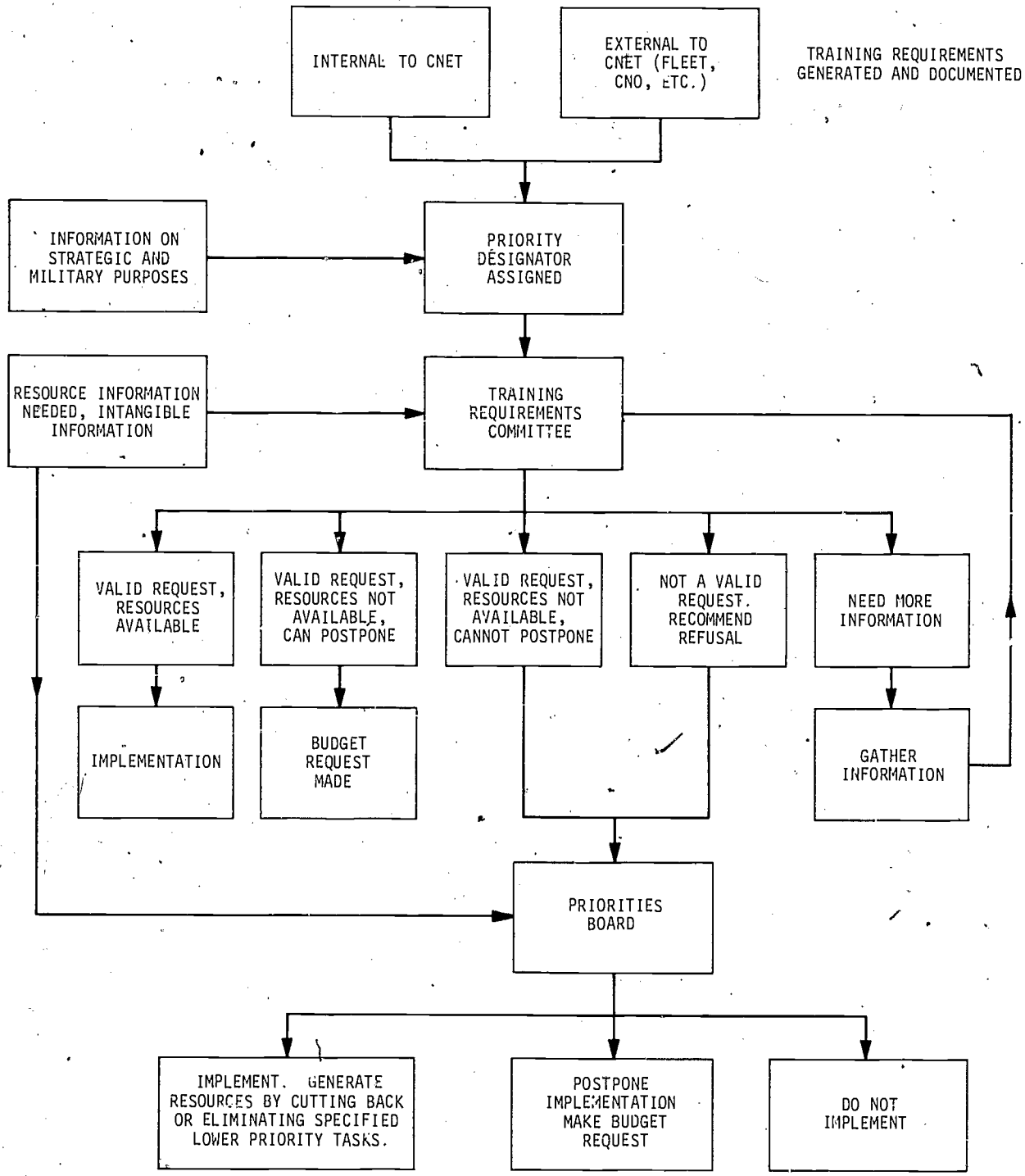

FIGURE 6. ESTABLISHING NEW TRAINING REQUIREMENTS

RESOURCE REQUIREMENTS REQUEST
NEW EXPANDED TRAINING PROGRAMS
CNET Form 1500/8 (Rev. 4-74)

* As a minimum, identify source of available billets and funds and purpose of funds.
* If additional space needed, continue on separate sheet.

CNET Report 1500-2

CNET PLAN NO.

PROGRAM TITLE

DATE RECEIVED

SPONSOR

CNET PRIORITY

DATE REQUIRED

REFERENCES

CNET GOG

COURSE LENGTH	ANNUAL CONVENINGS	MAX CLASS SIZE	AWARDS: ☐ NEC ☐ NOBS	TYPE COURSE	LOCATION

REQUIREMENTS

RESOURCES		FY ____			FY ____			FY ____			FY ____			FY ____		
		OFF.	ENL	OTHER	OFF.	ENL	OTHER	OFF.	ENL	OTHER	OFF.	ENL	OTHER	OFF.	ENL	OTHER
BILLETS – STUDENTS – ANNUAL INPUT	Chargeable															
	Non-chargeable															
	TOTAL															
BILLETS – STUDENTS – AVG ON BOARD	Chargeable															
	Non-chargeable															
	TOTAL															
BILLETS – INSTRUCTOR	Total required															
	* Available															
	Balance required															
BILLETS – SUPPORT	Total required															
	* Available															
	Balance required															
GRAND TOTAL	Student															
	Instructor and support															

FUNDS	AVAIL	BAL REQ	AVAIL	BAL REQ	AVAIL	BAL REQ	AVAIL	BAL REQ	AVAIL	BAL REQ
* O&MN										
* OPN										
* OTHER (Specify)										

REMARKS

Figure 7. CNET Form 1500/8

Clearly, the priority of any particular program should be determined by a number of factors, including usefulness to the fleet, urgency of the training, length and cost of the training, projected cost savings (if any) anticipated, etc., plus any number of such intangible but critical issues as who the program sponsor is, and the "political" effects of the training both inside and outside the Navy. The prioritization scheme currently used addresses some of the issues in a formal manner and others in an informal manner or not at all. The formal phase consists of the use of the scheme outlined in figure 8 to assign a "priority designator." This procedure is used for all projects except those relating to air training; it is expected that the air training command will develop a similar scheme appropriate for their needs. A complete description of the prioritization scheme is contained in CNET Instruction 1500.10 (11 June 1974).

The factors considered in the formal scheme and how they affect the priority designator are summarized below:

1. The military purpose of the training. Possible categories, in general order of priority, are special, strategic, sea control, projection forces, logistic support, and general and non-warfare. Special projects are those which, due to their impact on the Navy or their urgency as defined by higher authority, must receive special consideration. These projects always have the highest priority. Although strategic programs generally have the highest priorities, and logistic support and general non-warfare training the lowest priorities, there are some exceptions to this rule.

2. Operational function served by the training. Possible categories are:

- propulsion and auxiliaries
- communications
- navigation and seamanship
- life support, including damage control and safety
- surveillance (search and detection), electronic warfare, security and intelligence, operational security, and cover and deception
- command and control, weapons control, and tactical data processing
- weapons (offense or defense), missile and gun systems, and specific primary functions of non-combatants, and
- administration, planning, and personnel.

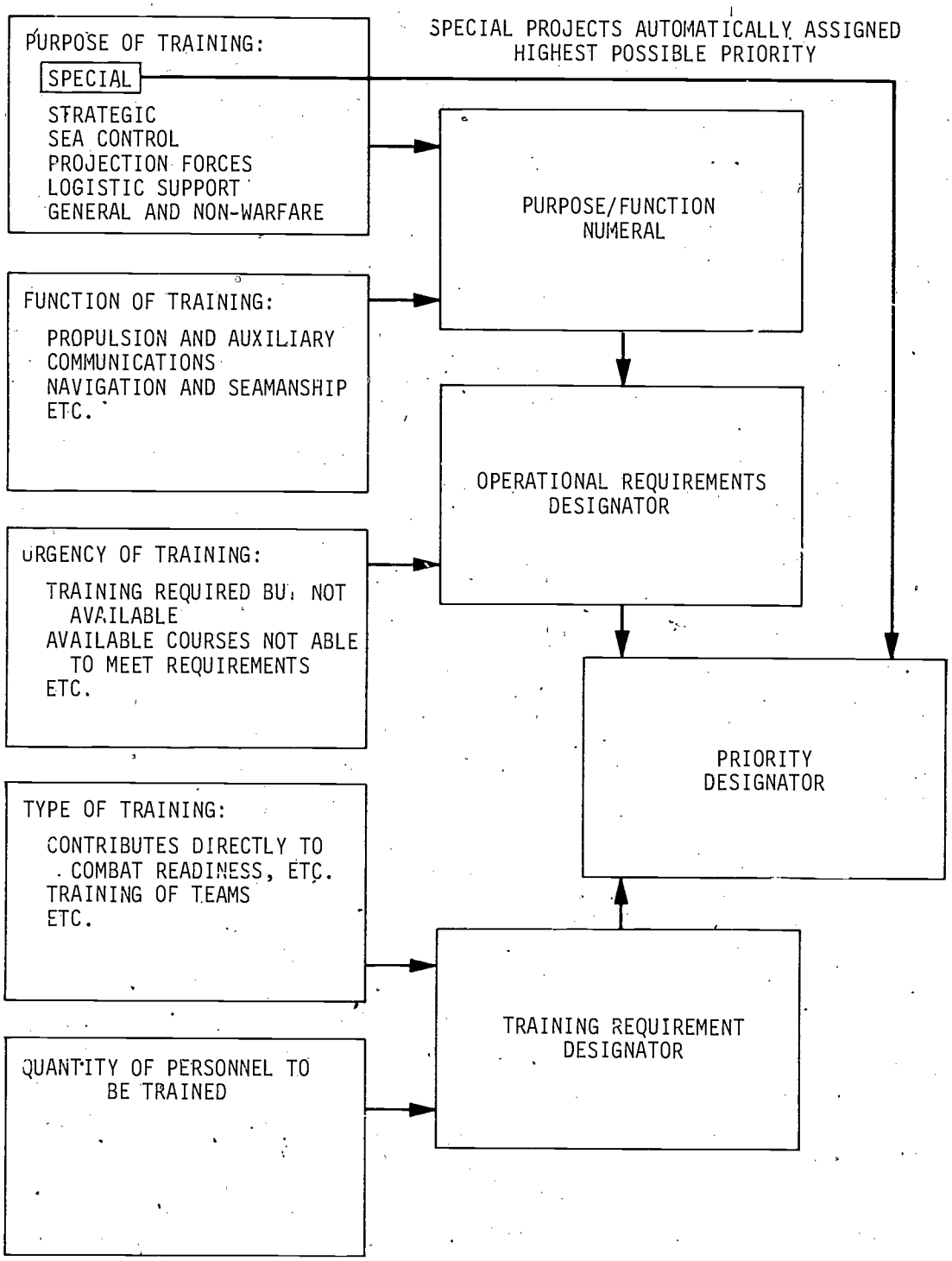

FIGURE 8. PRIORITY DESIGNATOR ASSIGNMENT SCHEME

Higher priorities are associated with combat related categories (propulsion and auxiliaries, communications, etc.) and the lowest priority with administration, planning, and personnel.

3. Urgency of the training. The highest priority is assigned to tasks required to maintain operational effectiveness in the fleet or to implement CNO-directed programs. Other categories, in decreasing order of priority, are:

- major training objectives to which this course contributes significantly cannot be met by alternate means
- most major training objectives to which this course contributes significantly can be met by alternate means, but some major objectives cannot be met completely, and
- all major training objectives to which this course contributes significantly can be met by alternate means, but minor training objectives will not be accomplished.

4. Type of training. In order of decreasing priority, the possible types of training are:

- training conducted on board the duty station or operational site in functions which contribute directly to combat readiness, operational capability, or technical maintenance,
- training of teams of personnel to perform functions within units of the operating forces,
- training which qualifies for assignment of an existing or planned NEC or NOBC in units of the operating forces, or training, which awards certification of a skill upon successful completion of the course,
- training which earns an NEC or NOBC of a billet ashore, or training in operational or technical skills similar to NEC or NOBC awarding courses, or is designated as a Class C or F course, or is designated for achievement of journeyman level,
- training in initial skills, or is designated as a Class A course, or is designated for achievement of apprentice level, or training for advancement in rating to pay-grade E-4,
- advanced training of career-development nature or designed for supervisory or management skills, or training for advancement in rating to pay-grades E-5 and above, and
- all other types of training.

5. Quantity of personnel to be trained. Categories of annual inputs range from over 10,000 to less than 50 trainees per year.

In order to assign a priority designator to any project, one works through a series of tables, reading off the categories appropriate for each of the items summarized above to determine priority codes which are combined in the tables to yield a priority designator, a number varying from 00 to 32, with lower numbers designating higher priority.

Once a project has been assigned the priority designator, it comes before the Training Requirements Committee. This committee, which meets at least monthly, examines each proposal and delivers a recommendation for CNET action. Members of the Training Requirements Committee are drawn from each of the CNET Sections, from administrative levels directly below the Deputy Chiefs of Staff. Detailed descriptions of the composition of the committee and duties of committee members are found in CNET Staff Instruction 1500.5, 22 April 1974.

As shown in figure 6, the Training Requirements Committee normally issues one of five possible recommendations for each project. In some cases the recommendation is implemented directly, and in some cases it is referred to a Priorities Board for further review. The Priorities Board, consisting of the Deputy Chiefs of Staff of CNET, has the final authority within CNET on training decisions. Possible recommendations of the Training Requirements Committee, and the action required by the Priorities Board, are as follow (source: CNETSTAFFINST 1500.4):

1. The training requirement is considered valid and can be met within existing resources and training limitations. These actions are passed to the appropriate operations division for implementation.

2. The training requirement is considered valid but implementation should be postponed until the budget or subsequent year. In these cases a budget request is made, and when funding is made available the program is implemented.

3. The training requirement is considered valid and the training program needs to be implemented during the current fiscal year, but resources or Congressional training authorization are not readily available. Such recommendations are forwarded to the Priorities Board, along with a summary of specific deficiencies, recommended lower priority source of compensation, and possible recommendation for consideration at a later date. The Priorities Board then decides whether or not to implement the program and if implementation is directed, what sources will be used for the funds. Generating funds may require discontinuance of a lower priority project.

4. The training request is not considered valid and implementation is not recommended. In these instances the committee recommendation and the reasons therefore are recorded and forwarded for decision by the Priorities Board. If the Priorities Board concurs, the originator of the requirement is notified.

5. The request cannot be processed since quantified data are lacking. In these cases, the cognizant staff code is requested to provide the missing data, and the request form is recycled for consideration at a subsequent meeting.

In summary, the process of deciding which programs to implement consists of two major phases. The first phase, assigning a priority designator, is a fairly mechanical means of measuring the overall usefulness of the program to the Navy, while the second phase, consisting of reviews by the Training Requirements Committee and the Priorities Board allows for input of some of the intangible considerations.

COMMENT ON EXISTING TRAINING REQUIREMENTS SYSTEM. The general problem of developing training requirements, one must recognize, is ill defined. Most organizations deal with such situations by avoiding meaningful long range planning (instead, they react to crises as they arise) and by relying on standard rules for making decisions. Both of these modes of action basically ignore the existence and importance of uncertainty. The plan becomes a substitute for reality. The process described for developing training requirements is in agreement with this observation. Ideally the role and composition of the Navy over at least the near future would be translated into lists of specific required skills, which would in turn be used, along with skill inventory projections, to determine training requirements. This process would intimately involve CNET as both the repository of training expertise and the coordinating agency for all training. To some extent this process is followed but only imperfectly. The operating Navy often is unsure of its future requirements and of the impact of broad level policy and force changes upon training requirements; thus it is unable to give the training command precise definitions of its needs (TAEG Report 12-1, Vol I, p. VI-340). Instead of actively participating with the operating Navy in designing training programs, the process described in the previous section has CNET responding to requests for specific programs. As individual training requests are submitted, it may be difficult to build an integrated and complete training program, thus the current system is rather piecemeal. The CNET staff, in order to at least partially overcome this problem, does do some requirement definition. It must also be recognized that the above description understates the amount of cooperative interaction between CNET and the operating Navy by ignoring some of CNET's other functions, specifically in feedback and evaluation tasks and in training advisory roles. Nevertheless, it must be remembered that the ideal is continued close cooperation between the training and outside commands in these matters.

The essence of prioritization in any organization is the determination of optimal trade offs among multiple objectives. The formal phase of the current prioritization scheme recognizes trade offs to some extent by making the priority designator depend on a number of factors--the purpose of the training, the function of the personnel to be trained, the quantity of personnel to be trained, and so forth. A number of other factors, however, such as the estimated resources needed to accomplish the training, are ignored in the formal prioritization scheme. These are brought informally to the Training Requirements Committee and Priorities Board. In addition, although the current scheme has trade offs built into it, they are, in a sense, hidden in the tables. The person who constructed the tables may have had a good intuition for quantifying trade offs, but if these were more explicit it would be easier to correct the scheme for possible oversights and to update the tables as the Navy's role and needs change. The techniques associated with multidimensional utility theory are ideally suited to this task, and allow a much more explicit and logical specification than is possible strictly by use of tables. There are also a number of other benefits which would result from a multidimensional utility approach to this problem. It would identify the measures of effectiveness for training and separate these from process considerations, that is considerations of how the means are to be obtained. To illustrate, measures of effectiveness include costs, throughput, skill level attained by the trainee, etc., while process considerations include some aspects of the type of training given, location and setting of the training, training aids used, and so forth. The current scheme contains some elements of both purpose and process. Also, there are some legitimate purposes of training, such as cost reduction, and highly relevant considerations, such as estimated resources needed for the new program, which are not formally addressed by the current scheme but which could easily be included in a multidimensional utility formulation. Finally, a new scheme could yield a priority designator which could be calibrated in terms of some measure, such as dollars. It would then be easy to judge the impact of adding or dropping any given project. The precise manner in which multidimensional utility theory could be used to construct a new scheme is too technical to describe here, but the technique is moderately straightforward.

The final steps of the prioritization process, review and final prioritization by the Training Requirements Committee and Priorities Board, allows for a broad based review and negotiation process by the managers involved. Every successful manager has learned that there are some facets of any problem which are difficult to work into a formal analytic structure but which are critical to any decision. For example, factors involving morale or humanitarian issues are difficult to quantify. In addition, the opinions and desires of some people in an organization carry more weight than those of others. Thus, the best formal prioritization scheme possible would fail unless there were some informal mechanism for working the intangible considerations into the priority ranking. The two committees allow for such an input, thus their existence and continued functioning are critical. It

has been repeatedly demonstrated, however, that although the human mind is extremely good at some kinds of complex synthesis tasks, it is very bad at systematically processing complex data. In particular, humans are poor at consistently choosing optimal combinations of factors, especially when many factors must be considered simultaneously. Since prioritization requires this kind of thinking, it is advantageous to include as many factors as possible in a formal prioritization scheme, and then use managerial judgement to adjust the results to allow for the factors which were omitted. To do this job well, the committees require a formal scheme which (1) considers all quantifiable factors in deriving a priority ranking, and (2) yields not only a priority ranking, but a measure of the strength of the priority differences as well, so the committees can determine the "cost" of altering selected priorities. The multidimensional utility approach discussed above does precisely that.

RECOMMENDATIONS FOR MODIFYING THE TRAINING REQUIREMENTS SCHEME. Specific recommendations for modifying the existing training requirements system are as follows:

1. As far as possible, encourage close and continual cooperation between CNET and the operating Navy (including the chief of naval material) in defining long range training requirements. It would be useful to set up a permanent committee to make such projections on a regular basis.

2. Develop a new formal prioritization scheme to allow the consideration of all quantifiable factors including resource requirements, in determining priority scores. The technique of multidimensional utility theory is ideally suited to developing this scheme.

3. Slightly redefine the role of the Training Requirements Committee and the Priorities Board so as to include quantifiable factors in the formal prioritization scheme, rather than in the factors considered explicitly by the committees.

ANALYZE AND PLAN TRAINING

The "analyze and plan training" function determines the what, how, where, when, and who of training, and yields an estimate of how much it would cost. The first step is to determine the performance requirement to be met, or the "what" of training. The performance requirement defines the job to be done by the person receiving the training and identifies the qualifications required to do it. The differences between required qualifications and available qualifications then determine the specific training goals and tasks, which are further broken-down into specific elements to be taught. These elements form the basis of the training course.

The next step determines the "how" and "where" of training. Any given course can, generally, be taught by any of a variety of techniques. The most obvious method of presenting training is to start a new course, task a shore school with providing the manpower and space to teach it, develop an outline, provide equipment, then plan a regular schedule of presentations. This can be a major undertaking with high costs, and sometimes considerable savings can be realized by alternate methods, particularly when the proposed training involves a relatively small number of people or when demand is sporadic. Often an existing course can be modified or extended so that the new requirement could be attached to a related course. This may be particularly attractive if courses were constructed in a "modular" fashion, with modules constructed to cover single subject elements. A training requirement can sometimes be contracted out to a manufacturer or conducted on board a duty station rather than in a school. Courses can be taught in a number of different locations, or students can all be brought to a central location. Historically, training in the Navy has been dispersed among a number of locations. Currently there is an effort underway to centralize training as much as possible, to restructure training classes to support a new classification of enlisted personnel, and to reallocate specific training tasks among A schools, B schools, and on-the-job training. Even when the decision has been made on how and where to teach a course, decisions are still required on what types of training equipment should be provided, what kinds of audio and visual aids will be used, when programmed instruction texts are appropriate, etc.

The final steps of the analysis and planning of training are to determine a training schedule (the "when" of training) and to specify the rates or ratings to receive the training (the "who" of training). These factors, once determined, finally yield an estimate of the resources required, in terms of manpower, equipment, facilities, and money, and indicate when they would be required.

DESCRIPTION OF AND COMMENT ON THE EXISTING SYSTEM. Analysis and planning decisions are made in a wide variety of locations within the NAVEDTRACOM, by a wide variety of techniques. Broadly speaking, the "what" decisions are based on task analyses, conducted partly by the Bureau of Naval Personnel (BUPERS) and partly by the training command. Task analyses are concerned with describing skills required in existing ratings classifications, rather than with analyzing the broader question of whether the ratings classification itself is optimal. (This latter issue has recently been addressed in a larger study concerning a new Naval enlisted personnel occupational classification scheme.) Once a task analysis is available, the "what" of training is determined by noting the required skills identified in the analysis.

"How" and "where" questions are decided at a number of levels within the NAVEDTRACOM, generally by informal means. There is currently work underway to develop decision aids, in the form of computerized planning

models, for detailed planning of school work loads and for student scheduling, but by and large the personnel involved in these problems rely on their intuition and experience, on the opinions of professional educators attached to the staff, and the costing analyses developed as part of the individual training proposals. Special studies are made on issues which involve significant and semipermanent policy changes, such as the issues of central versus decentralized training locations, and still other issues form the focus of long range research efforts, such as the question of the optimal design of training aids. Some of the decisions discussed here are relatively well defined. In determining how many classrooms and instructors are needed to instruct a given number of students in a well understood subject, for example, there is a good consensus about what is needed. For overall planning and analysis purposes, then, one or many of the techniques discussed for well defined problems may be helpful, depending on the particular situation. Simulation models (e.g., TAEG Report 11-2 [Lindahl and Gardner, 1974]) should be extremely useful in scheduling student throughput and resource requirements for particular training courses. Optimization models of different types could yield useful insights in facilities planning and scheduling decisions. In some of the other problems discussed above, however, a real difficulty is that the issues are poorly defined and understood. In the choice of training equipment, for example, there is general agreement that the training equipment should simulate the actual field situation as closely as possible, but the real question is "how close is close enough?" Is it worth $10,000, for example, to add a sixth degree of freedom to a flight simulator? These are issues in which there is a good deal of disagreement and in which experimental data are hard to come by and difficult to interpret. Decision analysis allows one to determine just which sources of uncertainty are the most critical for any problem, and thus to indicate what studies or research efforts are most likely to yield useful results.

"Who" and "when" decisions are not, in general, made within the NAVEDTRACOM. Entrance requirements for the schools are set largely by BUPERS, but valid predictive work on student performance would be useful to the NAVEDTRACOM in planning, in monitoring staff performance, and in assessing the effectiveness of training methodologies. Such knowledge could also be useful in recommending entrance criteria to those groups which do make admittance decisions. The current separation of admitting and scheduling responsibilities from the training responsibility seems to conflict both with the general management principle of consolidating authority and responsibility, and with a good deal of civilian educational practices. In training contexts, however, particularly in the military, this separation may perform a useful function. Training in the Navy is regarded as a service to the fleet rather than an end in itself, and the fleet must have a great deal of control if it is to be well serviced. That does not mean, though, that the impact of training decisions upon the training command cannot be communicated. Indeed, in order to make intelligent "who" and "when" decisions such impact information is vital. Thus the planning information developed by the NAVEDTRACOM should be readily available to outside forces. As in the

case of the "how" and "where" decisions, formal predictive models of both the decision analytic type and the conventional operations research type can be extremely helpful, and their use should be investigated. There is currently little evidence of use of these techniques.

RECOMMENDATIONS FOR MODIFYING THE ANALYSIS AND PLANNING SYSTEM. Specific recommendations to improve decision making in analyzing and planning training are:

1. Implement computerized simulation models in planning and forecasting resource requirements for training operations

2. Disseminate knowledge of decision analytic techniques to those working with ill defined planning problems, and analyze specific planning problems with these techniques to illustrate the applicability of the method

3. Investigate the possibility of using simulation techniques to project student performance as a function of student characteristics and the type of training being performed, and

4. Disseminate, as widely as possible, information concerning the impact of student characteristics on the training process to those who make training admission decisions.

COORDINATE AND CONTROL TRAINING

As is the case with any large organization, the NAVEDTRACOM consists of a number of organizational entities whose individual efforts must be monitored and coordinated. The coordination and control prerogatives of management are exercised to some extent by all headquarters and staff groups, though the depth and span of control differ greatly, of course, from level to level. Some members of the NAVEDTRACOM have been assigned, as their major responsibilities, a coordination and control function. The largest single group doing this work is the staff of Training Program Coordinators in CNTECHTRA. More commonly, however, the coordination and control function is exercised as part of general management responsibilities.

DESCRIPTION OF THE PRESENT SYSTEM. At the CNET level is a staff who are, in effect, the duty officers in charge of the actual training effort. All training actually implemented by the NAVEDTRACOM is funnelled through CNET for endorsement, budgeting and funding, and operational review and control at the headquarters level. Most of the problems faced by this staff are day-to-day issues; a lot of "firefighting" goes on, with little time for detailed analysis of the issues. A good many of the decisions which have to be made don't require detailed analyses since the proper course of action is fairly obvious. In cases where this is not so, the staff generally finds some sort of workable compromise between conflicting viewpoints, generally

with the aid of the staff's collective judgement and experience, but rarely with the aid of formal analytic techniques. The long range issues that do exist relate to design of reporting and control systems for the groups which actually do the training, and determining methods of implementing certain directives relating to priority setting and training methods. For example, the CNO has directed that a substantial part of the training load now being performed in shore-based schools be moved to the shipboard environment. A number of problems in implementing this directive are foreseen by the operational fleet, who feel that they have neither the time nor the resources to effectively increase their current training load. The CNET staff is concerned with determining which portions of the training can be effectively moved to the ships and how to make the training work in that environment.

At the CNTECHTRA level is a group tasked with planning for and allocating resources to the training locations. This staff works out contingency plans, such as what would be done by CNTECHTRA in case of mobilization, and operational plans, such as how training should be relocated in the event of a facilities shutdown, for approval by CNET. This branch is also heavily involved in planning interservice training and in determining how portions of the training process could be moved to the shipboard environment. The staff also has responsibility for resource allocation, including the allocation of instructor and support billets in CNTECHTRA, and providing physical facilities to support training. The branch utilizes various rules of thumb on student/teacher ratios, etc., in making these allocations.

Other groups in CNTECHTRA have responsibilities for the direct supervision of training activities. These staffs decide how a course will be run, what type of instruction will be used, what facilities will be used, what the pace of the instruction will be, and so forth. The CNTECHTRA groups rely heavily on advice and directives from CNET, CNETS, and the CNTECHTRA research groups, but there remains sufficient latitude to significantly affect the efficiency of the training process.

Most of the detailed design of a course is done by a Training Program Coordinator (TPC), an officer or chief petty officer with expertise either in the subject area of the training or in the training process itself. The CNTECHTRA staffs are responsible for training the TPC in his job and supervising his efforts, but he usually has a good deal of latitude in determining the details of the course. His suggested curriculum, course length, etc., are subject to review and correction by CNTECHTRA or CNET.

COMMENTS AND RECOMMENDATIONS. Managers rely heavily on historical methods and rules of thumb, so examination and rationalization of those rules would be desirable. In determining optimal resource allocations, training schedules, or type of instruction, to take some specific examples, research efforts are worthwhile if results can be communicated to operating managers in a useful way. Such communication can take place in at least three ways:

- through training and seminar programs and written material, where results can be summarized and the effects upon training decisions discussed

- through directives, where results are not discussed but the implications are encoded in formal procedures and control mechanisms, and

- through decision aids, from simple decision rules (e.g., optimal instructor to student ratios) to computerized decision models, where the manager specifies some parameters of his problem and the computer determines the optimal action.

Which combination of means is chosen depends strongly upon the nature of the particular problems being addressed.

IMPLEMENT TRAINING

This function includes all efforts directly involved with the actual conduct of training. A number of activities are involved in the running of the classroom, such as the preparation and distribution of instructional materials, the conduct of class sessions, and the evaluation of students; these are all included in the training implementation function. This function also includes such preliminary activities as the preparation of the detailed course outline and presentation sequence, determination of specific behavioral and knowledge objectives, and training the administrative and instructional personnel, and such post-training activities as training evaluation and evaluation of testing methods. These activities tie in closely with the course requirements as developed in the "analyze and plan training" function discussed above. Finally the "implement training" function includes some data management and administrative efforts, such as student enrollment, student record maintenance, staff administration, etc.

The types of decisions made in this area are detailed, nonquantifiable, and generally of too small a scope to warrant must individual analysis. In running a classroom it is not possible to explicitly analyze the effect of each possible way of teaching a class. There is, or course, a difference between good and bad instruction, but good instruction results not entirely from good administrative decisions but from good teaching techniques as well. A number of broader, analyzable issues are, however, raised in the implementation function. Such issues as good general approaches to course material, optimal class sizes, and reasonable methods of training evaluation become relevant only in a classroom situation.

EVALUATE PERFORMANCE

This function deals with the determination of how well training prepares the individual to perform his job assignment. Thus, it is a post-training

feedback related to the relevancy of the training itself, as opposed to the intra-training feedback conducted under the "implement training" function, which is designed to indicate how well individual students are doing in the course. Post-training feedback is critical to the overall effectiveness of the training effort, since the absence of effective feedback from the functional Navy could result in training which is inefficient, ineffective, or irrelevant. There is no widely accepted "best" way of evaluating training, however, as all evaluation techniques are highly subject to bias and incomplete, superficial, and irrelevant data. Overcoming these problems completely is impossible, and even lessening them to a significant degree is costly and time consuming. Due to the importance of the problem, there is nevertheless a continuing effort to refine the techniques and to gather feedback information.

DESCRIPTION OF AND COMMENT ON THE PRESENT SYSTEM. Feedback information is broken into two major types, summative feedback, which generally indicates that a problem exists but which gives little information on how the problem could be corrected, and formative feedback, which yields information on the particular problem and indicates how the problem could be solved. Examples of summative feedback are unsolicited letters, material inspections, fleet exercise reports, operational and technical evaluation reports, some 3-M reports, etc. These documents can indicate problems in the operation and maintenance of equipment which can sometimes be traced back to inadequacies in the training courses. Formative feedback, which is designed around the evaluation of a specific course, involves a determination of the objectives of a course then an assessment of whether or not these objectives are being met. To be effective a course must cover the objective material, the training must be done in such a way that behavior in field situations will be positively affected (i.e., there must be a transfer of the training), and the exam criteria used in the course must be relevant to field situations. The technique usually used to obtain this feedback is to ask the man and his supervisor for comments after he is back on the job. This can be done via a questionnaire or during visits to the duty station by a NAVEDTRACOM staff member. Evaluation methods of possible use to the NAVEDTRACOM, other than those mentioned above, are interviews with rotating fleet and training personnel, experimental methods, use of performance diaries, and formal, structured visits to duty stations. Each of these methods, along with their advantages and disadvantages, are mentioned briefly below. A fuller discussion can be found in TAEG Report 12-1, Vol 1, pp. VI-190 and 191.

In evaluating the results of any feedback method it must be remembered that the fleet often does not understand the purpose of a given training course, thus is prone to giving erroneous feedback, and that the NAVEDTRACOM has little control over the qualifications of incoming trainees. The seeming inadequacy of a training course may not be due to the course design or implementation at all, but due to the lack of qualifications of the trainee.

From a theoretical point of view the evaluation picture is not tidy. Efforts are fragmented and tend to be superficial. Before discussing ways of improving this, however, it is worth considering how much effort the evaluation function is worth. Evaluation can be extremely demanding of money, time, and personnel. Specialized skills, which are generally scarce, are required.. Clearly some reasonable level of evaluation effort must be determined, and that level may well be less than the theoretical "best that money can buy." In addition, one must recognize that training does not occur in a vacuum. Training goals and course objectives are set in response to requests from and in conjunction with the operating Navy. The NAVEDTRACOM staff is generally familiar with Naval needs and procedures; trainees do go out to duty stations and occasionally word on performance does get back to the training command, all without too much effort on the part of the NAVEDTRACOM. Biased, sporadic, and distorted as these informal means are, they sum to a fairly large amount of useful information flow. The next level of effort, which involves such active but relatively simplistic information search techniques as mail out questionnaires, informal visits to duty stations, and screening of existing data banks, is also in wide use in the NAVEDTRACOM. Again the total amount of information gained through such means is consequential. Such techniques would be grossly inadequate for a research oriented institution, but for an organization providing more-or-less standard kinds of training in more-or-less standard ways they may suffice. This is not to say that present methods could not be improved. Present questionnaire design leaves much to be desired, and the timing of the questionnaire mailings may not be optimal. The limitations of informal feedback tend to be ignored. There are a number of cases where cooperation and information exchange among different schools would be useful, but there is no integrated effort to obtain feedback. (See TAEG Report 12-1, Vol 1, pp. VI-224 and 225 for a discussion of these points.) Finally, there appears to be a legitimate, though limited role for the more sophisticated techniques of evaluation, namely use of professionally designed and evaluated experiments, use of performance diaries and other structured performance records, and use of structured interviews. A capacity in this area would enable in-depth analysis of new teaching methods, evaluations of problem courses, and be a good source of knowledge for the educational process in general.

Once a system for gathering feedback information in an effective manner is established, one must be concerned with how to determine measures of training effectiveness. This again is an extremely difficult research area as there is little agreement on what, specifically, constitutes effective training. It is possible to gather experimental data on, say, how often given tasks can be performed successfully, how quickly students can respond to simulated emergency conditions, how well students have mastered factual data, etc. Further, such data can be gathered and compared for different training methods, enabling one to obtain some relatively objective effectiveness comparisons among the methods. With proper experimental design, the effects of inherent differences among students could also be negated. Unresolved problems, though, exist in the following areas:

1. The above approach yields many measures of effectiveness in different tasks, while a single overall measure is desired,

2. The individual data items gathered must relate directly to effectiveness in operations, and there are difficulties in establishing this relationship,

3. Experimental data are often difficult to gather and subjective in nature (what, for example, constitutes successful performance of a task?), and

4. Experimentation is expensive, and it is not clear that experimental establishment of measures of effectiveness is always an effective use of funds.

Although these problems must, to a large extent, be dealt with through informal techniques (experimental ingenuity, understanding of job requirements, experience), formal techniques could be very useful, particularly in combining multiple measures into a single measure of effectiveness, in clarifying assumptions, and in evaluating the potential worth of experimentation.

RECOMMENDATIONS FOR CHANGING THE PRESENT SYSTEM. What is needed is first, an improved method of collecting data and, second, better ways of determining total measures of effectiveness. Consider first an improved data collection system. Such a system should involve a series of effort levels; first the "no effort" methods can generate rough information on many areas; second, the "moderate effort" methods can be used to generate data on specific courses and identify problem areas; and third, "high effort" methods can be used to study problem areas in depth and perform research in the learning process. A number of specific suggestions are included in TAEG Report 12-1, pages VI-224 to VI-235. The "measures of effectiveness" problem is basically a problem involving multiple measures of effectiveness under uncertainty. As discussed in section II.B, page 17, multidimensional utility theory can sometimes be used to determine a single measure of effectiveness and expected utility used as a decision criterion under uncertainty. This approach also indicates promising areas for further research. It is recommended that those persons involved in research in these problems be familiarized with these techniques.

MANAGE RESOURCES

This function encompasses the management techniques which are associated with resource control in any organization. Some of these are: (1) forecasting expenses and constructing and defending budgets; (2) monitoring expenditures of resources vs budgeted amounts, then correcting and updating budgets, and implementing corrective action to control budget variances; (3) material management, including providing, maintaining, supporting, and controlling material and equipment, quality control, maintenance and logistic support; and (4) the allocation, utilization, and record keeping of personnel within the training command. In the NAVEDTRACOM these actions take place within the context of the standard government planning and budgeting cycles,

which enable the CNET budgeting system to interface with Navy, DOD, and Congressional budgeting data. Procedures for these efforts are spelled out and documented in some detail in standard government directives. Some parameters of the organizational design are also fixed by outside authority, and CNET must operate within those limits.

DESCRIPTION OF AND COMMENT ON THE EXISTING SYSTEM. Some of the decisions categorized under resource management are highly routine. Some of these, such as determining inventory policies for spare parts, are highly amenable to formal analysis; industrial experience has shown that careful analytical design of inventory systems, to remain with this particular case, can be most rewarding. A number of other routine functions, such as record maintenance, are primarily administrative rather than decision oriented in nature.

Other decisions may seem routine, but are critical to the success of the training effort. Allocation of people within the staff, for example, is an important determinate of effectiveness, efficiency, and morale. Selection of a material control system can be critical in the success of an effort. The NAVEDTRACOM staffs rely heavily on experience and other informal mechanisms for making these decisions. There are also groups tasked with providing budgeting and financial expertise, acting primarily in advisory roles to the rest of the command, projecting the resource needs of various proposals, outlining funding alternatives and interpreting budgetary constraints for the other groups. These staffs are generally represented in decision making groups, but in the role of defining feasible alternatives and performing economic analyses of decision alternatives, rather than in the role of advocating particular projects. Such practices are in agreement with usual management techniques, and cannot, in general, be faulted. Detailed investigation of specific decision practices in this area was not undertaken in this research.

RECOMMENDATIONS FOR IMPROVING THE CURRENT SYSTEM. In those areas of resource management which involve well defined, routine functions, such as inventory management, production control, quality control, forecasting demand, and other areas, use should be made of the wide variety of analytic techniques commonly used in modern management. Industrial practice has demonstrated that substantial operating improvements can result from proper application of such analysis.

PERFORM RESEARCH

The "perform research" function includes all activities concerned with the acquisition of knowledge relating to the training, learning, and evaluative processes. As used here, then, the term "research" includes not only research in the sense of conducting formalized experimental situations, but field studies and surveys, statistical analyses, and monitoring ongoing research in other locations as well. "Research" can mean either basic or

applied studies. The NAVEDTRACOM conducts some research in-house, sponsors some research performed by outside contractors, and reviews a good deal of work performed by the research community at large.

DESCRIPTION OF AND COMMENT ON THE PRESENT SYSTEM. Research groups within the training command have the responsibility of identifying current and future needs of CNET, then insuring that research needed to satisfy those needs is performed. This involves: first, monitoring all relevant research and development efforts, both within and outside the Navy, and identifying results of interest to CNET; second, coordinating efforts among research groups whenever appropriate; third, determining priorities among potential research efforts which CNET could encourage or sponsor; and fourth, designing and conducting or sponsoring specific research projects. The first two efforts are administrative rather than decision oriented. Some groups are tasked with the role of being a research broker. Researchers and possible funding sources are brought together. In return the NAVEDTRACOM asks for support for its own research goals. The third effort involves the need for a powerful decision making capacity, and being a prioritization function, it shares many of the needs of prioritization schemes as discussed in section III.B. The research prioritization function differs from the training prioritization function in that uncertainties are even greater and objectives less well defined in the research prioritization. Finally, a good deal of research is done in-house by the training command. Some of this is very specific, such as research into the teaching process. Task analyses are performed for given jobs, alternate methods of teaching tasks are considered, human factors analyses are performed to determine the most promising teaching methods, and programs are evaluated. For example, such research at the CNTECHTRA level is oriented toward very specific criteria, such as lowering student attrition rate, optimizing use of instructor time, or minimizing costs. Other efforts are directed towards more general problems, such as methods of determining optimal equipment designs, ways of measuring the transfer of training, and so forth.

RECOMMENDATIONS FOR IMPROVEMENT. Comments on optimal experimental design are not made as that is too large a subject to address here. The subject of choosing which data are most worth experimental pursuit is, however, essentially a prioritization problem. The techniques discussed earlier should be just as beneficial in this setting as in project prioritization, thus it is recommended that managers charged with prioritizing research projects investigate the possibility of developing, through decision analytic techniques, a formal ranking scheme to account for quantifiable factors. Nonquantifiable factors could be handled through prioritization committees and individual judgement, as is being done now.

SUPPORT TRAINING.

This function includes all activities directly relating to the support of training operations. Among the specific items accomplished are:

1. Development, procurement, and maintenance of training equipment, ranging in scope from small inexpensive items to room-sized simulators,

2. Development and dissemination of self-instruction materials and training packages for use in on board training,

3. Procurement and dissemination of books for libraries,

4. Development, administration, and scoring of tests for advancements in rating, and

5. Recommending course structures and training media.

DESCRIPTION OF AND COMMENTS ON THE PRESENT SYSTEM. The first area of responsibility of the support staff concerns equipment design and selection. There are two types of decision tasks falling in this area. First, in designing new equipment, trade offs must be made among cost, schedule, and various performance parameters. The second, related task involves both monitoring and evaluating new developments, both technical and educational, and determining when to "freeze" equipment design. Sometimes these tasks are identical, such as in determining the design for a new one-of-a-kind, high cost simulator. In other cases these are distinct types of decisions. In providing operating units with such standard equipment as projectors and tape recorders, for example, CNETS must continually balance the benefits of standardizing on newer, improved equipment versus the extra costs of obsoleting present inventories and spares and restocking a logistics system for the new unit. Decisions in this field are difficult to make, but both these types of issues can be approached more systematically through decision analysis than is done traditionally.

To illustrate the general approach to analyzing these problems, consider an example in equipment design. This example is grossly over simplified, but it should serve to outline the technique.

Suppose a large one-of-a-kind simulator is being designed, and it is unclear whether or not a particular feature, costing $D, is worth including. The key issues, clearly are (1) how much better, or faster, or cheaper, will training be with the feature, and (2) how much, in dollar terms, is it worth to have better, faster, or cheaper training. Let us first discuss the dollars issue. Sometimes, as is the case when the feature leads to cheaper training, any theoretical difficulties go away. A severe practical problem may exist in estimating the magnitude and duration of the savings, but one could easily use a simulation model to determine how much time and effort is warranted in collecting that data. Likewise, if the feature leads to faster training it should be possible to simplify the problem by estimating the cost per day of training, then translating the time savings to a cost savings and analyzing as above. If the feature leads to an improvement

in training (i.e., an increase in skill level), it would be necessary to quantify skill level in terms of one or more measures, then determine trade offs among cost and skill levels. This can be done through multidimensional utility theory.

A more difficult datum to establish is the degree to which training will be improved by the feature. Not only is the training mechanism poorly understood, but results should vary from student to student. One can, however, use decision analysis to quantify the degree of this uncertainty. People expert in the field could be asked to assess probability distributions over the range of possible improvements, then this data can be used to determine whether a decision can be made immediately or whether experimental evidence of various kinds should be gathered. Even in highly uncertain areas it is usually remarkable how closely experts will agree on the limits of their uncertainty.

The second area of responsibility in training support includes writing and updating training manuals and texts. In writing manuals the selection and structuring of materials is clearly of major importance, and careful coordination between the support staff and outside groups is necessary to insure an effective product.

The third area of responsibility, supporting general libraries afloat and ashore, is not so much an issue in itself, but does raise once more the problem of project prioritization since library support functions must compete with other areas for funding, and it is difficult to quantify the benefits of supporting libraries. As is generally the case within the training command, there are more projects coming to the support groups than can be handled, so some method of prioritization is needed. It was found that support groups rely exclusively on informal schemes, such as the priorities board. A number of precedents exist to guide funding decisions on various types of efforts; these are supplemented by staff studies on project validity, benefits, and costs, and the collective experience of the board. Also, data from the field is generally collected on the projected impact of funding alterations. In determining the effect of investing a given amount of money into simulators versus libraries, for example, both internal and external opinions are solicited on the probable effects on the quality of the training effort, but no attempt is made to formally measure or trade off those effects. If all relevant issues in these decisions are indeed nonquantifiable, this may be the only possible way to proceed. Almost always, however, it is possible to systematize at least part of this process and to improve the quality of decision making.

The fourth area of responsibility, relating to testing training course graduates, is a significant aspect of the support function, but is not a significant decision activity. Thus, it is not discussed in this report.

The final area of responsibility concerns training structure and organization. The support staff supports this effort with task and course analysis, and is responsible for making recommendations on optimal ways of restructuring training. A good deal of work is also done on recommending training media and equipment appropriate for given courses.

RECOMMENDATIONS FOR IMPROVEMENT. It is difficult to make blanket recommendations in an area as diverse as this one. Formal decision techniques, including decision analysis, seem to have potential usefulness, but it seems difficult to set up a system to use such techniques on a routine basis. Perhaps the best way of introducing support groups to the potential of formal techniques is to train a relatively small group then let them act as internal consultants. If such a counsulting group were already established, it would facilitate such a move.

ADMINISTRATION AND INTERNAL CONTROL

This function includes personnel administration; a number of human resources, equal opportunity, and drug/alcohol programs; such management services as management analysis, computer systems administration, and management information systems design and administration; and a number of routine accounting and budgetary functions. Decision making in these areas was not analyzed in this report.

MISCELLANEOUS FUNCTIONS

The training command performs a variety of miscellaneous missions. Some of these areas, a few of which are quite sizable, are educational programs, equipment design, and budget advice. The educational programs area includes administration of, curricula development for, and selection of students for the Navy Campus for Achievement, the NROTC and Junior NROTC programs, the Naval Postgraduate School, the Naval Academy, special or graduate education in universities, officer enlistment programs, those overseas dependent schools for which the Navy has been assigned responsibility, and internal management training. The equipment design area arises from the recognition that the initial design of a piece of equipment clearly has a bearing on the amount and type of training later required to qualify personnel to operate and maintain it. The training command tries to establish an effective dialogue with the equipment design office as early as possible so that training considerations can be anticipated. In this relationship CNET does not act as a decision maker, but as an advisor. The budget advisory role relates to the governmental budgeting and accounting cycle as it affects training. The training command works with the operating Navy in projecting training needs and including required resources in training budget requests. In addition, cooperation and advice is given in arranging funding for items submitted too late to include in budget estimates.

C. GENERAL OBSERVATIONS ON DECISION MAKING IN THE NAVEDTRACOM

Decision making within the NAVEDTRACOM relies heavily upon informal judgements, group consensus, rules of thumb, and traditional practice. This is a common mode of decision making in large organizations and is rather to be expected. In the NAVEDTRACOM, in fact, pressures toward such behavior appear to be even greater than in corporations.

THE NAVEDTRACOM DECISION ENVIRONMENT

Decision problems which are easiest to solve through analysis are those which are well defined, where uncertainty is negligible, and where a single decision criterion (measure of effectiveness) exists. Most problems in the business world are not this tidy, and in the NAVEDTRACOM the vast majority of decisions are even more complex than in business. While a business can usually use financial gain criteria at least as the starting point of an analysis, in the training command this common measure is lacking. The "cost" side of training is readily apparent, but the "benefit" side is nearly unmeasurable. One cannot easily put a dollar value on the benefits of training, so the best one can hope to do is to determine the minimum cost of meeting preset training criteria. When it comes to deciding what those criteria should be, however, a subjective evaluation must be made. In addition, one must recognize that the NAVEDTRACOM decision maker is not only a part of the training command, but a member of the Navy. The tightness of the Naval community, the importance of personal influence and contacts, the permanence and importance of the fitness reporting system, and the ever present concern with one's career all combine to give "political" considerations extraordinary importance. One always considers not only how good or bad a program looks on paper, but who is pushing it and how much weight he carries. Such pressures exist, of course, in every large organization, but in the military they seem to be particularly evident. This tends to confuse the effectiveness measurement picture even more, as a whole list of new factors are brought into every decision.

Another critical factor in the decision environment is the fact that the military manager is a highly transient individual. The frequent rotation cycle encourages a certain shortsightedness in Naval management methods, one consequence of which is that out-of-the-ordinary things, especially if they are complicated, do not get done. In industry a good many analytic efforts start with the "conversion" of a manager, who then uses the method in his own department, on his own problems. He builds up an expertise and a staff familiar with the method and produces, eventually, some concrete benefits. In the Navy it is difficult to do this, as both the manager and the staff are continually shifted. There is little incentive to try something new, no matter how promising, unless the payback is immediate.

SUMMARY OF RECOMMENDATIONS FOR IMPROVING DECISIONS IN THE NAVEDTRACOM

Given the limits of this environment there still appear to be promising areas for improving the decisions made by the NAVEDTRACOM. Further, the magnitude, importance, and complexity of the problems being faced make better decision making techniques imperative. In this research a number of opportunities for improving decision making have been identified and discussed. Suggestions can be classified as being improvements in organization, in data gathering procedures, in decision rules, in analytic capability, and in analytic techniques.

Organizational improvements refer both to formal organizational changes and to changes in formal communication mechanisms. If separate groups each possess only portions of the information necessary to make rational decisions, then cooperation and information exchange among the groups will often improve the quality of decisions made. This does not happen automatically, since proper reward structures and task definitions must also exist, but complete discussion of these issues would go beyond the limits of this report. Specific organizational improvements that can be suggested are:

- the role of prioritization committees and other management groups in project prioritization be modified to emphasize only the non-quantitative factors, with quantifiable factors being included in a formalized scheme,
- in developing training requirements, the NAVEDTRACOM and the operating forces should set up a joint, continuing effort to define and project requirements,
- CNET should disseminate projections of training costs and success rates as a function of student characteristics, and
- in training support, continuous communication between the staffs involved in writing training manuals and texts and the schools is essential.

The professional background of the researcher precluded an exhaustive examination of organizational issues; undoubtedly, much more could be said in these areas.

Data gathering procedures can be improved particularly in the training evaluation function. A range of feedback techniques should be used to determine weaknesses in the current training system. In addition, techniques of applying some of the methods currently used can be improved, as discussed in TAEG Report 12-1, pp. VI-224 to VI-235.

Decision rules are defined as the specific guidelines and procedures by which organizations make decisions. Often these are very informal, being expressed as general rules of thumb, or they can be formalized as standard procedures. Sometimes there is a good deal of wisdom built into these rules, but sometimes they lead to non-optimal decisions. Thus, a systematic, rational redefinition of decision rules may pay dividends, particularly since it is usually possible for an operating manager to apply the rules without understanding the details of the analysis behind the derivation of them. Decision rules can be expressed in the form of simple "if-then" statements ("If anticipated training load is greater than 100 students per year then set up a new course"), in the form of tables and charts which are used in scoring possible actions, or in the form of computer models. Some areas where rationalization of decision rules seem particularly appropriate are:

- in the formal phases of project prioritization, whereby project characteristics can be used to derive a priority ranking much as is now done in the training requirements area, but with the tables being more systematically derived,

- in the analysis and planning area, where computerized planning and forecasting models can usefully capture a good part of the complexity inherent in such situations, and

- in the coordination and control area, where many day-to-day decisions on training administration must be made on an ad hoc basis, but where a systematic examination of such issues as optimal student/instructor ratios, optimal methods of presenting various types of material, etc., could be beneficial.

Improvements in the analytic capability of an organization can be brought about by increasing the level of analysis which underlies standard decision rules, as discussed above, by using outside specialists in the analysis of particular problems, by establishing groups of analytical specialists to be used as internal consultants, and by increasing the general managers' understanding of and use of analytic techniques. Each of these approaches has its particular strengths. Through improving the decision rules one can parsimoniously improve the mass of decisions, but unusual or extremely important decisions cannot be handled with standard rules. Outside experts can bring particularly needed expertise to bear and can be hired only as long as needed, but they can be expensive; they must become educated in the organization's problems and must be found and identified. Internal consultant groups are invaluable for longer term expertise and are usually familiar with the organization, its problems, and often its personnel, but may lack expertise in specialized areas. Increasing the analytical sophistication of the general manager is difficult and expensive, particularly in highly transient organizations, but some education is necessary before the manager

even recognizes the possiblity of formal analysis. All four approaches are thus appropriate for different circumstances, and a balanced program is necessary to derive maximum benefits from formal analysis.

A few of the specific areas in which an enhanced analytic capability would be useful are in the determination of the relationship of student characteristics to length, proficiency attained, and dropout rate in training; in the planning of training, where a number of recurring decision problems regarding training structure occur; and in the resource management function, which is an area where formal techniques have returned substantial benefits in industrial settings.

The final suggestion involves improving analytic techniques. As outlined briefly in the taxonomy, a number of analytic approaches have been developed for dealing with decision problems. A fairly new and extremely powerful series of techniques, decision and utility analyses, promise an approach to solving problems which are intractable by any other means. Analytic expertise in this field is valuable in determining measures of effectiveness, in dealing with problems involving uncertainty, in working with ill defined problems, and in working with problems where results are difficult to estimate or quantify.

A specific suggestion arising from the last two paragraphs is to establish an internal consultant group familiar with formal analysis, particularly decision analysis. Some consultant type groups already exist in the NAVEDTRACOM. Since these groups already exist as operational entities and already have a good deal of analytical expertise and experience, adding a decision analytic capability would not be too difficult. This could be done in a variety of ways. The Naval Postgraduate School is able to offer educational programs, from brief introductory courses to accredited short courses at field sites. If there is interest in doing this, a program tailored to the NAVEDTRACOM's needs and desires can be arranged. Self-education is a second possibility. The classic introductory text in decision analysis is Decision Analysis by Howard Raiffa, Addison-Wesley, Reading, Mass., 1968. A newer text, perhaps more appropriate for the generalist, is Decision Analysis for the Manager by Brown, Kahr, and Peterson, published by Holt, Rhinehart and Winston, New York, 1974. The Naval Postgraduate School has a capability in developing programmed learning material, and could be tasked with providing such a course in decision analysis. A third possibility is to educate CNET personnel in university courses in decision analysis. A number of schools offer such courses. The two most well known being the graduate schools of business administration of Harvard and Stanford Universities. A fourth possibility is an expert in decision analysis could be hired directly to an internal consulting group. This is clearly the most direct way of gaining expertise. A final suggestion is to hire outside consultants for selected analysis projects. This would not only allow members of the training command to see the techniques in practice, but to appraise the usefulness of the approach. External consultants can also be used directly in educational roles.

SECTION IV

SUMMARY AND RECOMMENDATIONS

In this section, the major points and conclusions reached throughout this report are summarized, some suggestions for implementing change given, and recommendations for further research and development work made.

A. SUMMARY OF THE REPORT

In section II, the background of the research is presented. Organizational decision making is discussed in section II.A, the major observation being that organizations typically rely heavily on "irrational" techniques for decision making, but that there are very rational reasons for doing so. Then in sections II.B and II.C, some background in formal, rational techniques of decision making is given, with section II.B containing a taxonomy of decision techniques and section II.C an outline of formal decision theory. These two lines of thought are brought together in section II.D, where the actual and potential use of rational decision techniques in primarily irrational decision environments is discussed. It is pointed out that decision analysis not only shows great promise on paper, but has demonstrated significant benefits in actual situations. The attitude of the manager and the competence of the analyst, however, are critical to the success of any analysis.

In section III, a broad overview of the functions performed by the NAVEDTRACOM is given, then the types of decisions made within the command are discussed in some detail. Section III.C summarizes observations of NAVEDTRACOM decision making, pointing out the extraordinarily heavy reliance on informal techniques for critical decisions and indicating some reasons for this. A number of potential areas for improving decisions are identified and the reasons for considering these areas are discussed.

B. IMPLEMENTATION STRATEGIES

There are two routes to be considered in improving decisions in an organization--a "cookbook" approach and an "educational/consulting" approach. In the "cookbook" approach the decision maker is given a set of instructions which he more or less blindly follows in order to reach his decisions. This method has a number of advantages: a good deal of effort and intelligence can go into designing the instructions, insuring a well thought out and complete decision making procedure; the effects of personnel rotations on decision making are minimal; the instructions can be gradually improved as experience is gained; the instructions can be expressed in many different forms, such as directives, standard operating procedures, decision tables, computer models, or informal recommendations; and use of standard instructions leads to consistent, predictable decision making. In some situations, such as in computerized systems, some simple instructions may by necessity be built-in. Even in situations where

computers are not involved, the "cookbook" approach has merit. The priority setting scheme used in the training analysis and planning area is an example of this situation. Whenever a "cookbook" approach is appropriate, decision analysis can be used to analyze the problems and construct the decision rules. As long as the "book" is used, implementation of the results of the analysis is assured.

The "cookbook" approach is useful only in repetitive, predictable types of problems where the major variables and considerations are known in advance. In other situations, individual analysis of the actual problems is required. This indicates that if analysis is used, either the manager himself must be familiar with the analytical technique or a consultant (perhaps internal to the NAVEDTRACOM) be used. Even in this latter case, some exposure of managers to the rudiments of analytical techniques is helpful. Some possible methods of introducing general management to this subject are:

1. Use of supporting relationships: This is exemplified by a consultant who uses analysis to solve a problem arising in the normal consulting relationship. During the presentation and discussion of the results, some educational work takes place.

2. Short presentations: A short one- or two-hour management briefing would suffice to outline some of the ideas and advantages of analytical techniques.

3. Articles and written summaries: a good deal of written material summarizing various analytical techniques exists, some of which is quite basic. In the field of decision analysis, for example, the Harvard Business Review has printed a number of articles discussing not only the theory but the practice of decision analysis.

4. Textbooks: A number of books, including some programmed texts, go deeper into analytical techniques than an article could do.

5. Seminar: Seminars, ranging in length from a half day to two or three days could be useful in giving a fairly broad introduction to a group of limited size.

6. Short course: The Naval Postgraduate School is currently offering short courses in a number of subject areas. If sufficient interest exists, a course could easily be offered in this format.

7. Other educational efforts: Many schools offer courses in analysis either separately or as part of degree programs.

C. RECOMMENDATIONS FOR FURTHER WORK

There are a number of areas in which further work in analysis, particularly in decision analysis, appears promising.

First, in working toward effective implementation, it is recommended that a group (like TAEG) which is already involved in analysis and consulting within the NAVEDTRACOM be identified and given expertise in decision analytic techniques. The group is likely to be more receptive to new techniques than general management, and having already established relationships within the command, be more effective as an ongoing educational agent than an outsider could be. An internal group would also be aware of outstanding problems, and be able to demonstrate concrete benefits of decision analysis on those problems on which it consults. The expertise could be most readily developed through training seminars or short courses, either of which the Naval Postgraduate School could offer.

A second recommendation, which could be accomplished in conjunction with the first, is to identify and analyze a "cookbook" type project, such as developing a prioritization rating scheme or formulating decision rules of a computerized system.

Implementation of the results of such an analysis is less dependent on the manager than for less structured problems. Ideally, this would be done by an internal consultant enrolled in the training program mentioned above in conjunction with an outside expert.

The major area of potential improvement lies in educating the general manager. As discussed above, there are a number of methods of reaching him. Such an effort should be undertaken in conjunction with establishing expertise in an internal group, so the managers could obtain help on problems when necessary. General management education should be tied in with concrete results on a real problem in order to lend credibility to the technique.

Further research in decision making within NAVEDTRACOM should be more narrow and more intensive in nature than was this work. One particular organizational unit or function area should be selected and studied in depth. Such a study should focus on the (1) types of problems faced, (2) frequency of occurrence of each type, (3) decision methods used, (4) pressures and influences which limit decision alternatives, (5) impact of the decisions made on the rest of the organization, and (6) formal and informal roles of the organizational unit in the total organization. Alternatively a single type of problem (e.g., prioritization) could be chosen for intensive study, with the same types of questions being asked.

The NAVEDTRACOM, like any large organization, is complex and unwieldy. Its members are subject to human frailties and prejudices, and in the face of a complicated and uncertain world make mistakes in judgment. Decision analysis and other formal techniques cannot overcome human frailty, but they do allow one to examine his thinking and assumptions in a way which minimizes the faults attendant to being human.

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