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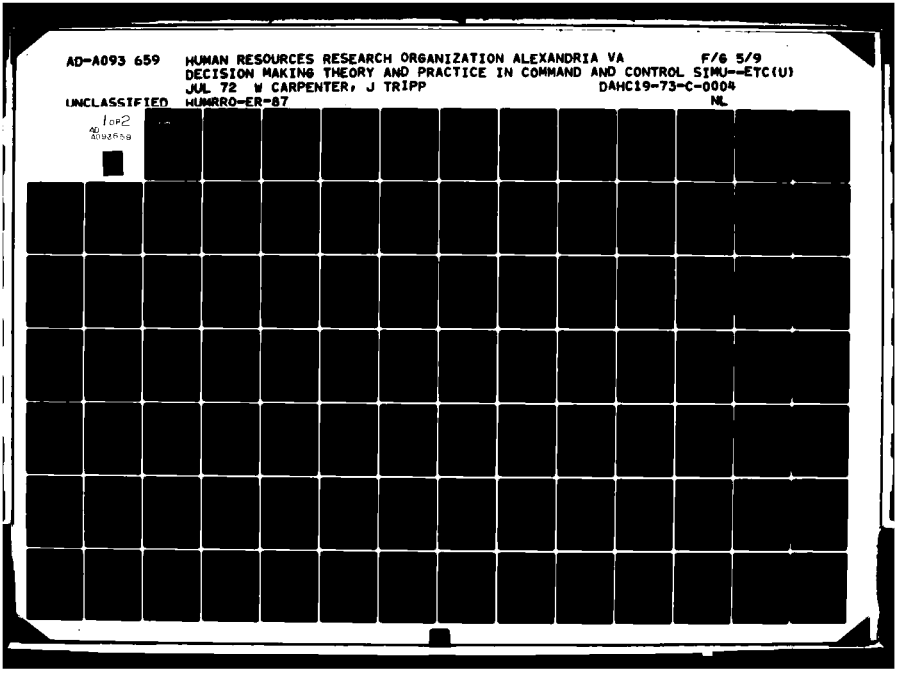

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD A093659 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DECISION MAKING THEORY AND PRACTICE IN COMMAND AND CONTROL SIMULATORS	5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Wayne Carpenter and James Tripp	8. CONTRACT OR GRANT NUMBER(s) DAHC 19-73-C-0004
9. PERFORMING ORGANIZATION NAME AND ADDRESS Human Resources Research Organization (HumRRO) 300 N. Washington Street Alexandria, Virginia 22314	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Army	12. REPORT DATE July 1972 13. NUMBER OF PAGES 115
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Research performed under Exploratory Research 87.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

decision-making
decision models

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper was prepared as background for a study decision-making in military command-and-control situations. It consists of an analytical review of some 600 books and other documents on the subject of decision-making. It discusses (1) the definitions and problems of current (up to 1972) decision theory; (2) the behavioral aspects of decision-making; and (3) the conditions necessary for development of a decision-making model for the Army's Combined Arms Tactical Training Simularot (CATTS).

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DECISION MAKING THEORY AND PRACTICE IN COMMAND AND CONTROL SIMULATORS

by

Wayne Carpenter and James Tripp

July 1972

ER-87

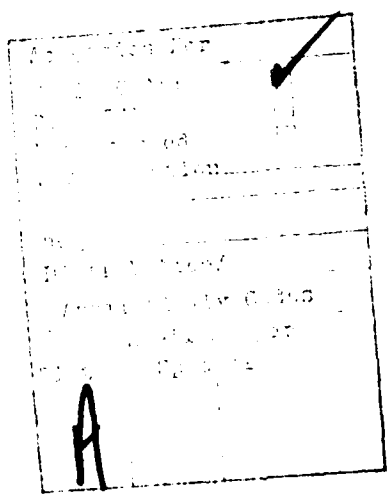
HumRRO Division #4
Fort Benning, Georgia

Preface

Exploratory Research 87 had as its objective the determination of software requirements for the Combined Arms Tactical Training Simulator (CATTS) project of the US Army Infantry School. This paper is one of the terminal products of that research.

The discussions presented in the paper are based on a literature survey of over 600 books and documents having to do with decision making concepts. The paper thoroughly discusses (1) the definitions and problems of current decision theory, (2) the behavioral aspects of decision making, and (3) the conditions necessary for the development of a decision model directly applicable to CATTS.

Exploratory Research 87 was terminated and Work Unit DECIDE was initiated to continue research in this general. Thus, this paper should be considered as a general guidance document for the further investigation of the command decision making area.



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Vocabulary

1. Analysis -- The process of separating or breaking up a whole into its parts for the purpose of finding out their nature, proportion, function, interrelationship, etc.
2. Conceptual -- Concerning the formulation of ideas or abstractions.
3. Criterion -- A standard, rule, or test which is used to judge the value of something.
4. Decision making -- The selection of an action from a number of alternative courses of action.
5. Descriptive -- The process of describing and classifying; that branch of science in which the data is described and classified.
6. Element -- A component part, a constituent group of a specified kind; or the term for the basic parts or principles of anything.
7. Empirical -- That which is based solely on observation and experiment rather than pure theory.
8. Extension -- The total number of objects to which a single term applies, i.e., the denotation of the term.
9. Intension -- The total number of characteristics which a thing must possess so that a particular term can be applied to it, i.e., the connotation of the term.
10. Isomorphic -- having identical structure, i.e., a one to one correspondence between the properties of two elements, structures, etc.
11. Logical -- This term is used in three ways: (1) correct reasoning, (2) the system of principles which underlies any science, and (3) necessary connection.

12. Method -- A regular, orderly, or definite procedure of doing anything.

13. Methodology -- The science of method; specifically, the branch of logic concerned with the application of principles of reasoning to scientific and philosophical inquiry.

14. Model -- A representation of something which serves (1) as the plan from which the final object is to be constructed or (2) as a representation of an already existing object, structive, or system.

15. Operational -- A method of defining a concept such that the meaning of the concept is the procedures which are used to measure it.

16. Paradigm -- A pattern or an example; a plan for the construction of an object, structure, or system or for the execution of an action.

17. Prescriptive -- That which prescribes, orders, or predicts.

18. Schema -- An outline, diagram, or plan for the construction of an objective, structure, or system.

19. Synthesis -- Either the putting together of the parts or elements to form a whole or the whole which is made of the parts or elements put together.

20. Theory -- This term is used in two ways: (1) the systematic statement of principles involved in the formulation of apparent relationships or underlying principles and (2) that branch of science which consists in a knowledge of its principles and methods rather than its practice, i.e., pure as opposed to applied science.

DECISION MAKING THEORY AND PRACTICE IN COMMAND AND CONTROL SIMULATORS

INTRODUCTION

DECISION MAKING THEORY AND PRACTICE IN COMMAND AND CONTROL SIMULATORS

INTRODUCTION

Background

The introduction and use of the helicopter in Vietnam, as a primary means of troop transportation and combat support, created an initial interest in an effective and economically feasible means of training potential airmobile commanders in the basic techniques of command and control. Again, as in every way, the hard lesson that training in combat situations is expensive both in economic and manpower resources had to be re-learned.

However, the problem of training airmobile commanders was different than most training requirements, in that even the training situation using real helicopters and appropriate troop support proved to be an excessive financial burden on a service school. The first decision, then, required that the operational environment be artificially created and in this vein, the concept of an airmobile simulator was originated.

It was quickly determined, however, that the development of successful simulation methods for one type of command and control situation (e.g. airmobile) would certainly have potential applications for other types of command and control aspects of tactical operations in a number of world-wide environments.

Research Approach

As support for the CATTS project, Exploratory Research (ER) 87 was established to determine the feasibility of contributing both to the development of CATTS specifically, and to the investigation of software technology in command and control simulators generally.

To approach this question, the research was carried out on several different levels. For the purpose of this paper, only the work in the area of decision making will be discussed.

As the initial effort in this area, an extensive survey was conducted in general decision making. The outcome of this survey was a 527 item bibliography[1] that serves as one of the bases for the research. This bibliography pointed to those publications which, by their titles, appeared to be of interest, and about 350 of these publications were obtained either by buying or borrowing.

The outcome of this work was an ER Research Paper[2] which discussed such factors as (1) decision under certainty, (2) decision under risk, (3) decision under uncertainty, (4) sequential decision making, and (5) the personality and environmental factors which influence decisions. This paper was followed by another ER research paper[3] which had as its central theme the delineation of various problems that confront current theory, particularly the reductionistic approach, and offered some logical approaches to avoiding current theory inadequacies.

During all this time, a number of abstracts were produced of some of the most important articles. However, the number of abstracts never

approached the number of articles surveyed due to various administrative and personnel problems. During the late winter, it was decided to go directly into the production of a "final" decision making paper. What follows, then, is not only the terminal product of the ER but also the charter that will be followed initially in Work Unit DECIDE.

Research Goals

A recent survey of decision theory states that "the most salient problem of human existence" is the problem of choice or decision making.[4] The prominence of this problem is reflected in the number of different disciplines which claim decision-making as a pivotal concept. For example, the concept of choice is interpreted in terms of preference theory, probability theory, game theory, learning theory, organization theory, information theory, statistical theory, and operations research theory. Moreover, proponents of operations research define their science as the science of making decisions.[5] The importance of decision making is paralleled by complexity and confusion in theory about decision problems. This complexity covers both the definition of decision theory, what it means to make a decision, and the application of decision theory to the actual decision situation. The burden of complexity, however, is overshadowed by the possibilities of the applications of future research in decisional analysis. Thus, the challenge of decision research is directed to both the theorist and the practitioner.

The purpose of this paper is to present a survey and summation of exploratory research on the problem of decision making. The aim of the

survey is problem review and problem analysis. The aim of the summation section is to provide methodological suggestions for better understanding the decision situation. Two questions serve as the basis for these two sections: (1) What does it mean to make a decision? and (2) What does it mean to make a good decision? These two questions reflect two methods which guide the research, (1) analysis and (2) synthesis. The first question is answered directly through conceptual and behavioral analysis of the decision situation. The second question is answered indirectly by proposing several means for increasing the clarity and depth of decision situations.

The emphasis of the research centers around two tasks: (1) analysis of the subject matter and (2) synthesis of the analyzed material. The term analysis refers to the process of breaking the subject matter down into its elements. The term synthesis refers to the process of combining the elements of the decision situation according to (1) a preconceived plan or (2) the demands of the actual situation. The analysis section focuses on methods which interpret the decision situation. The level of interpretation depends on the depth of analysis which precedes the synthesis of the material and the degree to which the synthesis method mirrors the structure of the decision environment. The final result of the synthesis of the decision material is a model which accurately portrays the actual decision making situation. The research on ER-87 has not achieved the decision model stage. However, the decision material has been analyzed and two schemas have been developed in an

effort to (1) increase the depth of the analysis and (2) investigate the structure of the situation which an eventual model will interpret.

The results of the exploratory research will be applied to the command decision situation, specifically to the CATTS decision situation. However, rather than focus on command decision making, the research began by focusing on the concept "decision making". The decision to focus on decision making in general was made for two reasons. One reason concerns the theoretical basis of the decision theory applicable to the CATTS situation and the other concerns the degree of applicability of decision theory which results from the research.

Firstly, this approach to command decision making should increase the scope and depth of the theory. Command decision making is one type of decision making. By analyzing theoretical and behavioral elements from the perspective of decision making in general, the boundaries of the theory are broadened, the richness of the theoretical elements is increased, the chances for logical error are reduced, and the chances for developing theory that is empirically testable are increased. Secondly, the approach should increase the applicability of decision models which result from the research. Theory developed from the perspective of command situations is limited by the perspective of these situations. Decision theory is formalized into decision models. Since decision models mirror the structure of the actual decision environment, the applicability of the model will increase as its ability to mirror the structure of the actual decision situation is increased. Therefore, the applicability of the model will be increased by basing the theory in the

wider perspective of the generalized decision situation.

There are four basic goals which guide the exploratory research. These goals were formalized as the decision literature was analyzed and as the significant problem areas in decisional analysis were recognized. These four goals are:

1. To isolate decision factors and elements.
2. To examine the logical structure of decision models.
3. To examine the literature in an effort to develop a critical perspective with respect to the subject matter.
4. To create (develop, identify, determine, etc.) a decision making model which is logically sound and, more important, applicable to the actual (CATTS) decision-making situation.[6]

As the research material was collected for the presentation of this paper, these four goals were generalized into three research purposes. The generalization was also a specification since the research purposes reflect what is accomplished at this state of ER-87. These three purposes are:

1. To provide a comprehensive background in decision literature in order to inculcate an awareness of the significant problem areas in decisional analysis.
2. To develop (1) a formal schema for the organization of the behavioral aspects of decision making and (2) a formal schema for the organization of the theoretical elements pertaining to decision models.

3. To investigate the logical and experimental conditions for a decision model which is (1) logically sound, (2) empirically testable, and (3) universally applicable.

The exposition of this paper is the materialization of these three purposes. The results of these purposes will serve as an indicator that there are patterns in decision situations and methods to making decisions which can be conceptually represented and applied to decision situations in general. The success of these results will determine whether the future research will be able to formalize these patterns and methods and transform them into an accurate representation of what decision making is, how decisions are made, and how decision making can be improved.

References

1. Carpenter, Wayne and Tripp, James, "A Tentative Bibliography for Decision-Making," Infantry HRU, January 18, 1972.

2. Tripp, James and Carpenter, Wayne, "Progress Report on the Survey of Decision Making Literature," Infantry HRU, January 21, 1972.

3. Carpenter, Wayne, "Problems in Decision Theory," Infantry HRU, February 16, 1972.

4. Rodgers, Dorothy L., Decision-Making, Human Factors and Training, Information Systems Operation, General Electric Company, 1960.

5. Smith, Nicholas M., et al, "The Theory of Value and the Science of Decision - A Summary," J. Operat. Res. Soc. Amer., 1953, 1, 103-113.

6. Fowers,Ted, "Monthly Written Report on ER-87 (CATTS)," HumRRO Division 4, March 7, 1972.

DEFINITIONS AND PROBLEMS OF DECISION-MAKING

DEFINITIONS AND PROBLEMS OF DECISION MAKING

Introduction

The complexity of decision problems and the variety of decisional analysis reflect the diversity of methods utilized by theories about decision making. Several excellent reviews reflect this diversity in their survey of research on decision problems. The purpose of this section of the paper is to survey decision making literature. However, rather than a general survey of decision literature, the aim of the survey is to present a conceptual analysis of decision making and a review of the significant problem areas in decision theory. This survey will provide the foundation for the development of conceptual tools. These conceptual tools will play a major role in the development of the end product of the research, i.e., a decision model applicable to the CATTS problem. Therefore, the survey of decision definitions and problems provides the background for the development of the decision model.

Definition of Decision Making

Parallel to the diversity of theories explaining decision making, there is a diversity of definitions of what it means to make a decision. These definitions differ not only with respect to the content of "decision making" but also with respect to the degree of application which they have to the actual decision situation. L. P. Schrenk recently noted that decision literature contains many statements as to what does or should constitute decision making and that "most of these tend to be

either very general or else so highly abstracted and limited as to be essentially irrelevant to most if not all decison problems."[1] There is an apparent need in decision theory, therefore, to clarify the problem of why definitions of decision making are irrelevant and why there is a lack of agreement between the diverse definitions of decision making. To satisfy this need, the following areas will be analyzed: (1) the concept of definition, (2) the types of definition of decision making, and (3) the deficiencies of these definitions. Furthermore, a new approach for defining decision making will be presented and the advantages of this approach will be investigated.

Analysis of the Concept "Definition"

A traditional characterization of the definition of a word is to assert that "the definition is a verbal formulation of its meaning."[2] The meaning of the word can be construed in at least two ways. According to the extensional (denotative) meaning, a general term means each individual thing to which it applies.[3] Thus, the totality of the things to which the general term applies is the "extension" of the term. For example, the extensional definition of a chair refers to an actual chair. According to the intensional (connotative) meaning, a general term means those characteristics which anything must possess in order that the term correctly apply to it.[4] Thus, the totality of the characteristics which anything must possess in order that the term correctly apply to it is the intension of the term. For example, the intensional definition of a chair refers to

the characteristics (legs, a back, a seat, material substance, etc.) which an object must possess in order that the term chair correctly apply to it.

These two types of meaning are paralleled by two types of defining in science, operational and conceptual. An operational definition relates a concept to "what would be observed if certain operations are performed under specified conditions or specified objects".[5] An operational definition provides the extensional meaning of a term, i.e., the object the term refers to is, in this case, a set of operations. The conceptual definition is the dictionary or lexical definition and relates the concept being defined to one or more other concepts. The conceptual definition provides the intensional meaning of the term, i.e., the characteristics, in this case the other concepts referred to, which an object must have in order that the term apply to it. The conceptual definition tells the scientist what to think about in relation to the concept, whereas, the operational definition tells the scientist what to do about answering questions involving the concept.[6]

The traditional definitions of decision making are operational definitions. Thus, the concept "decision making" is defined in terms of a set of operations. Which set of operations depends on the particular theory which sets the defining conditions of the concept. For example, the operational definition of decision making would vary from organization theory to operations research to descriptive learning theory. The argument of this paper is that these restrictions occur as the tradi-

tional definitions ignore the intensionality of the concept "decision making" in order to explore the extensionality of the concept. This operationalizing of decision making has restricting results on the depth of decision theory and on the scope of the applications of this theory. In order to investigate these restrictions, the diverse definitions will be explored. Finally, an alternative approach to avoid these restrictions will be examined.

Analysis of the Traditional Definitions of Decision Making

The traditional definitions of decision making can be arranged into three general classes. The definitions of the three classes differ as they focus on (1) the operations which define decision making, (2) the elements of decision situation, and (3) the alternative interpretations of the nature of decision making. The first class includes utility theory, game theory, operations research, preference theory, and statistical theory. The second class includes organization theory, information processing theory, and personalistic decision theories. The third class includes theories which identify decision making with rationality, theories which define decision making as process, theories which define decision making as product, and theories which translate decision theory into terms of descriptive learning theory. An examination of these classes will explicate the differences between the traditional definitions and set the stage for a critical analysis of these definitions.

The first class of definitions isolate decision making into a set of operations. The set of operations are interpreted as a set of quantities. There are two basic quantities which the members of this class utilize as a basis for decision making. These quantities are (1) the probability with which certain immediate outcomes may result if a given course of action is taken and (2) the value or worth of outcomes.[7] Each member of the class utilizes these two quantitites to define decision making. Differences among the members of this class result from the interplay between these two quantities. For example, one class stresses probability over value or vice versa. Or, one class may give a different interpretation of probability, value, or the relation between probability and value. These differences result in the inclusion of the following formal theories as members of this class: (1) operations research, (2) probability theory, (3) preference theory, (4) game theory, (5) utility theory, and (6) Savage's "new theory" of statistics.

Operations research combines these two quantities (probability and value) over all possible outcomes and describes the product of the two as "expectation". The course of action which leads to the highest expectation is the indicated choice of the decision.[8] The decisional problem, from this perspective, is the problem of establishing a set of values which will enable the ranking of preference of states or conditions. The set of values is, therefore, interpreted as a set of operations which lead to the highest expectation.

Variations of these two quantities yield probability theory on the one hand and preference theory on the other. From the perspective of probability theory decision theory investigates the relation of subjective probability to probability and subjective probability to utility. Subjective probability is defined as "a number that represents the extent to which an individual thinks a given event is likely."[9] Thus, the crucial concept for subjective probability is the "belief function" of the decision maker. One crucial problem for decision theory, therefore, is whether the subjective probabilities of a set of mutually exclusive events, each of which must happen, add up to 1.[10] This problem concerns the relation of subjective to objective probability. The other crucial problem for decision theory is how subject probability defined as "belief function" can be related to the utility of the decision. Both problems utilize the operationalized definition of decision making. In one case, the decision maker's belief that an outcome will occur appears as the probability of the occurrence of the outcome. In the other case, this belief function is interpreted as a combination of probability of occurrence and the utility of the occurrence of the outcome.

From the perspective of preference theory, decision making focuses on the problem of value which is placed on an outcome. The preference theorist directs his attention to developing methods of objectifying the value placed on an outcome. Decision theory interpreted as determining the value placed on an outcome differs from both operational theory and probability theory. With respect to decision making, the difference

between preference theory and operations research is that preference theory interprets decision making as "valuation" rather than as a combination of determining the probability and value of an outcome. The preference theorist considers the probability of an outcome; however, he stresses the methods which are utilized to objectify the standards of valuation. One aspect of this problem is the probability of an outcome. However, the emphasis is on the quantitative measurement of value.

Further variations of the relation of the two quantities, probability and value, yield game theory and utility theory. The history and interrelations of both theories has been varied and productive in terms of the number of interpretations of decision making. No history of either will be provided here. The significant point is that the two theories define decision making in terms of certain operations: (1) utility theory utilizes certain axioms which portray the rationality of the decision maker in choosing alternatives[12] and (2) game theory utilizes both utility and subjective probability to stress that in order to make a decision, one must be able to order the outcomes of alternative available responses on some preference scale and choose one of the responses on the basis of some decision criteria.[13] For utility theory, the rationality of the decision maker, and thus the rationality of what it means to make a decision, is interpreted as the ability to assign operational meanings and relations to the determination of the desirability of an outcome. For the game theorist, the rationality of the de-

cision maker, and again what it means to make a decision, is interpreted as the ability to formulate criteria which will assign operational meanings to the choosing of one alternative over another.

The final variation of this class is referred to as the "new theory" of statistics by L. J. Savage. He contends that "the whole design of a complicated statistical program can be regarded as a single decision to adopt one of an enormous number of possible acts."[14] The problem of this theory is statistical action rather than statistical inference, that is, the problem is "deciding on a reasonable course of action on the basis of incomplete information."[15] Both quantities, the probability of the occurrence of an outcome and the value of the outcome, are keys to the definition of decision making in this "new theory" of statistics. In Savage's words, "if in a given situation the actor assigns probabilities to the various unknown states of the world, he can calculate unambigiously the expected cash income associated with any action."[16] He then acts to maximize the expected cash income or the utility. The concept of decision making is defined in terms of the operations which interpret the adoption of one possible action.

The second class of definitions concentrate on the elements of the decision situation. A decision element is some factor, either logical or non-logical, of the decision environment. Examples of elements extracted from the decision situation include (1) the decision maker, (2) the results of choice, (3) the factors which influence the making of a decision, and (4) the information provided the decision maker. These

examples illustrate that the concept "element" has differing meanings for decision making. The meaning and also the purpose of the concept element, as it is utilized here, is to delineate one or more factors of the decision situation. The following examination will consider those theories which are defined in terms of the stress which they place on one or more decision elements.

Information processing is one example of this class of definitions. In this class, decision making is defined from the perspective of problems which occur with the proper utilization of information. Thus, one solution to the problem of what it means to make a decision implies "an understanding of how an individual collects, codes, stores and retrieves, and analyzes information for the purpose of making decisions and under what personal and environment conditions each of these functions is maximized."[17] What it means then to make a decision is determined by how one interprets the flow of information which the decision maker faces as he makes his choice. The key to defining decision making is shifted from a set of operations to the concept of information flow. The interpretation of information flow, however, may well be a set of operations.

Information processing is one aspect of organizational decision making. Thus, in the sense that organizational decision making concerns the flow of information, it is a member of this class. One example of an interpretation of organizational decision making as information flow is Schein's adaptive coping cycle.[18] Other theorists interpret information

utilization within an organization as a function of the allocation of responsibility and authority within the organization.[19] And, other theorists share the importance of information with such factors as the premises upon which a group operate in an organization or the penalty-reward structure of a particular organization.[20] Decision making within an organization obviously involves many complexities and no one theory is adequate for an accurate interpretation of what decision making means. One point can be safely made. The definition of organizational decision making, whether in terms of information flow or other factors, concerns the elements, both logical and non-logical, of the decision environment. Only from the perspective of the total decision environment can an accurate interpretation of decision making in organizations be made.

Personalistic decision theories provide a new perspective for the definitions of this class. These theories define decision making within the perspective of the individual decision maker. There are three variations of these theories which differ in their interpretation of the definitional relation between decision making and the decision maker. One variation of these theories offers a very general approach by defining decision making as "the complex of human associations, events and words leading to, and including, any conclusion for a program of policy or operations."[21] Within this perspective, the effects of the outside events are represented via the person making the decision. Thus, "it is suggested that decision making in concept include the

human events, associations and words involved in leading to a conclusion."[22] A second variation of decision making as decision maker concentrates on the decision maker as an agent of the situation. The premise of this interpretation is that "a decision must be that which is demanded by the situation."[23] As agent of the situation, the decision maker "must be conscious of the legitimate points of view of all who are interested in the matter, especially of those who are affected by the decision or who must contribute in some way to putting it into effect."[24] A third variation offers a definition of decision maker as a decision system. There are three basic components for this interpretation: (1) a prediction system, i.e., alternative futures, (2) a value system, i.e., the handling of the various conflicting purposes, and (3) a criterion, i.e., the integration of the other two components and the selection of an appropriate action.[25]

The third class of definitions define decision making in terms of alternative interpretations of the nature of the concept decision making. The previous two classes specified decision making in terms of a set of operations or in terms of the elements of the decision situation. The members of this third class seek to expand the concept of decision making by explaining the nature of decision making in terms of some other concept or set of concepts. The scope of the definition of decision making is altered to include the more general problem of what the nature of decision making entails. The change in scope results in a new theoretical approach to decision problems. Decision theory,

within this perspective, focuses on problems of development and justification of the theory which itself justifies the application of the concept "decision making" to a set of operations or to some element or elements of the decision situation. The definitional properties which the members of this class display are, therefore, meta-definitional properties of the decision concept. That is, these properties concern how the theory is going to be developed to meet logical and non-logical demands of the situation rather than the actual theory of how the decisions are to be made. The first member of this class focuses on the identification of decision making as "rational choice". The second class identifies decision making as process. The third member identifies decision making as product. The final member defines decision making in terms of descriptive learning theory.

The concept of rationality is a key concept in the explanation of choice behavior. In fact, Donald Taylor contends that a theory of organization "cannot exist without a theory of rational choice."[26] Patrick Suppes says that the normative theory of individual decision making has been concerned to explicate the notion of rationality.[27] However, he goes on to point out that just as "research in this century in the foundations of mathematics has shown that we do not yet know exactly what mathematics is, so the work in decision theory shows that we do not yet understand what we mean by rationality."[28] Thus, the concept of rational choice has undergone a series of revisions. These revisions begin with the "economic man" approach of the classical utility

theory, proceed to the concept of "bounded" rationality by H. A. Simon, and end with a critical appraisal of rationality by Patrick Suppes. An explication of this revision will indicate how the nature of decision theory, and thus what we mean by decision making, has evolved as the understanding of the implications of the concept of rationality has evolved.

The theory of economic man is a theory of rational choice. This theory has two forms (1) the classical concept and (2) the neo-classical concept. These two theories are both normative. That is, these decision theories prescribe what the decision maker should do rather than describe what he actually does. Within the perspective of the classical concept, economic man is assumed to have three properties: (1) he is completely informed, (2) he is infinitely sensitive, and (3) he is rational.[29] The focus of the paper is the rationality of the decision maker. Economic man is considered rational in the sense "that he can weakly order the states into which he can get and that he makes his choice so as to maximize something."[30] The rational decision maker must be able to (1) indicate preference or indifference and (2) make choices which will be transitive.[31] Thus, rationality entails that the decision maker can maximize values over a series of outcomes with complete knowledge of what the alternative outcomes are.

The neo-classical concept of economic man takes two forms: (1) decision making under risk and (2) decision making under uncertainty. The rationality of the decision maker is expanded to include those situ-

ations in which he is not completely informed of the consequences of this action.[32] Within this new perspective, the decision maker seeks, instead of maximizing value, to maximize the utility of the outcomes.[33] Furthermore, the assumption that the decision maker can order his outcomes according to the principle of transitivity is dropped.[34] The purpose of this expansion is to increase the applicability of the theory to the actual decision situation. However, both the classical and neo-classical concepts of decision making restrict the rationality of the decision maker to the fact that (1) the decision maker can order the possible states and (2) the decision maker can maximize whether on the basis of total knowledge or whether in terms of the probability of the occurrence of possible outcomes.

Therefore, although the neo-classical theory of rationality seeks to expand the concept "decision making", the scope of the theory is still restricted by the conditions which the decision maker must meet in order to be rational. H. A. Simon and Patrick Suppes seek to critically evaluate the restrictions which classical and neo-classical theories place on rationality. Their evaluations lead them to reject the older concepts of rational choice and introduce revisions into rational choice theory.

H. A. Simon rejects the classical conception of rationality. He refers to the classical concept as "objective rationality".[35] Simon seeks to counterbalance the classical conception with the concept of "bounded rationality". His argument is developed from the perspective of organizational decision making. Contrary to the principle of

"objective rationality", administrative man fails to meet the conditions of (1) complete knowledge and (2) ability to maximize. Simon suggests that the capacity of the human mind "for formulating and solving complex problems is very small compared with the size of the problems whose solutions is required for the objectively rational behavior in the real world - or even for a reasonable approximation to such objective rationality."[36] Therefore, he argues for the simplication of the choice process by replacing maximizing by satisfying.[37] The difference between these two methods concerns the constancy of utility over time. The theories which maximize utility or value assume that the utility or value is constant over time. In contrast, the decision maker, interpreted as satisfying, will modify the standards he seeks to obtain as experience warrants. The rational man cannot determine the utility of an outcome and apply this quantity to any and all possible decision situations. Each situation will command what standards must be met. Thus, the criterion for a rational decision maker must incorporate the flexibility of changing situations.

The difference between the concept of "objective" and "bounded" rationality is a difference in the nature of the theories defining decision making. The concept of "objective rationality" serves as the standard for one interpretation of decision making. Under this interpretation, decision theory is prescriptive. The concept of "bounded rationality" serves as the standard for another interpretation of decision making. Within this interpretation, decision theory is descriptive. Simon's goal is to expand the concept of decision making by

replacing the prescriptive nature of decision theory with a descriptive nature. The expansion of the theory concerns (1) the wider applicability of the theory and (2) the flexibility of the theory. That is, the concept of rational is stretched so that it applies to more situations and the standards which the decision maker must meet to be rational are made more flexible.

Patrick Suppes argues against both the classical and neo-classical interpretations of the concept of rational choice. His argument contends that recent work in decision theory shows that "there is no simple coherent set of principles capable of precise statement that corresponds to the naive ideas of rationality."[38] The naive ideas of rationality he refers to are the decision maker's ability (1) to order preferences and (2) to maximize over the possible outcomes. Suppes bases his argument on two sets of impossibility theorems. Firstly, John Milnor's set of axioms for any acceptable principle of choice have shown that no decision criterion satisfies all the axioms together. Secondly, Kenneth J. Arrow sketches an impossibility theorem which shows that no criterion results in an acceptable principle of social and individual choice (or preference). Suppes suggests that the paradoxes which these two sets of impossibility theorems reveal indicate that the "naive" conception of rationality which serves as the basis for normative decision theory cannot be counted upon to yield a coherent and consistent theory. He further suggests that a behavioristic approach would construct a more realistic framework for discuss-

ing the normative theory of choice. Suppes' argument, like Simon's argument, expands the concept of rationality in decision making by removing restrictions of purely prescriptive interpretations of decision making. The nature of decision making interpreted as "rational choice" is therefore expanded beyond the perspective of normative theory into the much wider perspective of a descriptive behavior theory. The theory of normative choice is not discarded, just as the theory of the rational decision maker is not discarded. Rather, normative choice has been placed in its proper perspective to the total problem of defining decision making; and thus, the concept of rationality has been expanded to meet the demands of the actual decision environment.

The problem of defining decision making has been explained in terms of a comparison of two procedures (1) defining the nature of decision making in terms of the product of the process of making a decision and (2) defining the nature of the decision making process itself. Interpreted in terms of "product", decision making is that which results in choice among alternative causes.[39] The problems of defining decision making in this perspective are the problems of the normative theories of choice. Decision theory based on this definition, therefore, has the same restrictions as the theories of the classical and neo-classical conceptions of rationality. Interpreted in terms of process, decision making "involves a decision maker, an environment in which the decision maker must operate, a set of actions available, and a set of goals to be accomplished."[40] The shift in emphasis from product to process

is a shift from a purely prescriptive theory of decision making to a descriptive analysis of the decision situation. The prescriptive power of the descriptive interpretations will depend on how accurately the theory interprets the actual process of decision making.

An analysis of the definitions of decision making which have been examined indicates that explanantions of the nature of decision making have shifted from a prescriptive to a descriptive interpretation of choice behavior. One result of this shift is the translation of the concept of decision making into the perspective of descriptive learning theory. In conjunction with this translation, experimental studies have shown that the behavior of experimental subjects "in many cases corresponds well with quantitative predictions derived from learning theory formulated in terms of stimulus sampling and conditioning."[41] Decision making in the terminology of learning theory, is defined in terms of the relationships between changes in choice tendencies.[42] These changes are translated into data which is interpreted in terms of various scaling methods. The problems of defining what it means to make a decision are, therefore, translated into problems of how to describe these changes in choice tendencies in a manner which can be interpreted using scaling methods.

Critical Analysis of the Traditional Definitions

The thrust of all three classes of definitions is to provide an operational meaning of decision making. The operational meaning occurs

explicitly in a set of quantities or implicitly in the research purpose which the meaning of the definition conveys. The first class of definitions define decision making explicitly in terms of a set of operations. The members of the second class implicitly define decision making operationally. The purpose which the definitions serve for the members of this class is to tell the scientist what to do about answering questions concerning the concept "decision making". For example, information processing theory defines decision making as information flow. The purpose of this definition is to provide a means of operationally defining decision making by defining the concept in terms of further concepts which themselves can be operationally defined. Thus, although this class focuses on one element of the intension of the concept, the purpose of the definition is not to explicate the intension of decision making but to translate the concept into terms which are operationally definable. This translation enables the decision theorist to focus on the extensional problem of how to define decision making by measuring information flow. The members of the third class of definitions both explicitly and implicitly define decision making operationally. Behavioral learning theory explicitly provides an operational definition of decision making. The aim of this theory is to reduce the concept of decision making into data which can be translated in terms of scaling methods. Decision making is reduced to a set of quantities, i.e., changes in choice, which are interpreted using scaling methods. The aim of defining decision making as product explicitly defines decision making in terms of the operations which result in the act of choice.

The aim of defining decision making as process implicitly defines decision making operationally. The purpose of the defnition is to reduce or translate decision making into terms which will provide a means for identifying an optimal decision. The identification of decision with rationality (1) explicitly defines decision making under the concept of "objective rationality", (2) implicitly defines decision making under the concept of "bounded rationality", and (3) explicitly defines decision making as the concept of rational choice entails the identification of the intension and extension of the concept.

In an effort to define decision making in measurable quantities, the traditional definitions of decision making have ignored the intensionality of this concept. The applicability of theories based on the operationalized definition of decision making is reduced. The purpose of the definitions is to translate the concept "decision making" into operational quantities or into concepts which can be handled operationally, i.e., translated into a set of operations. The theory which is based on such definitions is reduced to the perspective of the operational definition. Aspects of decision making (either logical or non-logical) are discarded unless they can be operationalized, i.e., unless they can be translated into operational terms. That is, aspects of decision making are reduced in an effort to make the concept measurable. As a result of this method, disagreements arise between decision theories about what decision making means. Conflicts over definition occur as these theories focus on different aspects of decision

making, operationalize the definition of decision making on the basis of these factors, and redefine all aspects of decision making in terms of the operational definition. Furthermore, as decision elements are reduced into the operationalized definition, the resulting theory is claimed as "the" theory of decision making. Thus, the scope of the reduction extends from the elements of decision theory to decision theories themselves.

The operationalizing by traditional definitions increases the scope of the concept decision making without increasing the depth of the concept. That is, the extension of decision making is increased without a corresponding increase in intension. The resulting concept resembles the concept "this". "This" has an infinite reference but no specification in relation to the number of properties which make up its intension. Thus, the traditional concept of "decision making" is applied to diverse theories without a corresponding increase in intension of the concept. The lack of expansion of the intension adversely affects the relation of the definition of decision making to the decision situation. The concept "decision making" should mirror the structure of the decision situation. Since the operationalized definitions of decision making do not allow for expansion of the intension of the concept, the resulting concepts of decision making do not mirror the actual decision situation. Instead, these concepts are restricted to the set of operations which define how decision making can be measured. The result is that the definitions are so abstract that they have no application to the actual de-

cision environment. Thus, instead of increasing the depth of meaning, such concepts increase the ambiguity of what it means to make a decision.

Proposed Definition of ER-87

The problems which occur with the traditional definitions result from the definitional method utilized by these theories. That is, the problem is the over-emphasis of the extension of the concept "decision making" and the under-emphasis of the intension of the concept. One result of the research of ER-87 is the development of a definitional method which will supersede the difficulties of ambiguity and irrelevance of the traditional definitions. The new definitional method reflects two changes: (1) one change concerns certain procedural measures which are guidelines for a better definition of decision making, and (2) another change concerns a revision of the nature of the definitional method itself.

The basic flaw noted in the traditional definitions of decision making is their reductionistic character. The procedural measures for a "better" definition of decision making seek to compensate for this flaw. The purpose of earlier definitions was to reduce the concept "decision making" into a set of quantities or operations or into a set of concepts which could be translated into a set of quantities or operations. The first measure for the proposed definitional method, therefore, changes the purpose of the definition. The definition of decision

making should reflect the variety and complexity of the decision situation. The purpose of the definition should, therefore, be the portrayal of all aspects of the decision making environment. That is, what the decision making concept means should reflect what the actual decision situation is. The second measure, therefore, is that no part of the intension of the concept "decision making" will be interpreted as an accurate reflection of the total decision situation. In other words, one cannot understand what it means to make a decision by focusing on one part of the concept of decision making. Thus, the perspective of the proposed definition of decision making is the total intension of the concept"decision making".

The proposed definition reflects two changes, one referring to the purpose of the definition and the other referring to the perspective of the definition. It is important to note, however, that these changes in procedure do not rule out the possibility that the proposed definition will be an operational definition or could be translated into an operational definition. What these changes do mean is that with respect to the definitions, the intension of the concept will be in direct proportion to the extension.[43] If the intension increases, the extension increases; and if the extension increases, the intension will increase. Thus, even in the case that decision making is translated into an operational definition, the intension of the operational set of quantities will be just as varied as the extension of the concept.

The method of the traditional definitions is to synthesize the elements of decision making into an operational definition. In contrast, the basic method of the proposed definition is analysis. The program of the analysis method is to discover the elements of decision making. Thus, the program involves a breakdown of the concept into its intensional properties. This breakdown involves a conceptual analysis of the concept and a descriptive analysis of the decision situation. The genesis of the method of analysis is (1) the established meaning of the concept, (2) a specialized or restricted meaning of one particular theory, or (3) a collection of the definitions which have been proposed. The method of analysis, therefore, does not stipulate a definition but expands the intension of already accepted definitions or an already accepted definition. The concept "decision making" is broken down into the concepts which compose its intension. Analysis of the relation of these intensional concepts reveals the logical structure of the concept. The decision situation is broken down into its elements, that is, the decision situation is described. In this context, analysis of the relation of the descriptive elements reveals the empirical (non-logical, descriptive) structure of the concept. The method of analysis reveals, via a conceptual and descriptive breakdown of the concept decision making, the structure of the decision situation which the concept "decision making" mirrors.

Whether decision making is interpreted as process or product, as information processing or organization theory, as preference theory or as probability theory, there is one core statement which is character-

istic of the concept. This statement asserts that decision making is the selection of an action from a number of alternative courses of action.[44] This core statement is the lexical definition of what it means to make a decision. For purposes of communication, this definition is what is usually meant when one thinks of the concept decision making. However, this statement is only one aspect of the content of scientific definitions. The other aspect is the purpose which the researcher intends the definition.[45] And furthermore, it is with the "purpose" of the definition of decison making that the proposed definition of ER-87 attempts to go beyond the traditional definitions.

The purpose of the "new" definition is to mirror the structure, both logical in terms of the concept and empirical in terms of the situation, of the decision situation. The method of analysis is, therefore, applied to the lexical definition in order to produce a conceptual and descriptive catalog of the intension of the concept decision making. The results of this analysis are (1) an analysis of the elements of decision making in terms of the classes or kinds of decision and (2) an analysis of the basic categories which order the elements or classes of definitions into certain types. These results point out two senses of the concept "element". In the first sense, element is used to refer to the properties or classes of decision making, i.e., the different parts of the intension of decision making. In the second sense, element is used to refer to certain boundaries between categories of decision properties.

In the first sense of element, the analysis of the concept "decision making" results in a variety of decision elements. These elements are grouped in classes. The content of each class depends on the perspective of the theorist who performed the analysis and the extent to which the analysis was developed. The different classes of decision elements which were found in the literature survey represent a catalog both of decision elements and of categories for these elements. Within the classes that were reviewed, decision making is analyzed in terms of (1) the elements common to all decisions, (2) the classes of decision, (3) the major components of decision making, (4) the factors of logical decision making and the non-logical influences of decision making, and (5) the focus of decision. The elements listed under these categories will be listed. This list will serve as an example of how the definition of decision making can be analyzed. Therefore, the list of elements is not intended as a final catalog of decision elements. No such catalog is possible. Different elements and classes of elements evolve as the perspective and purpose of the analysis changes.

According to Charles Wilson and Marcus Alexis, there are six elements common to all decision:

(1) the state of nature

(2) the decision maker

(3) the goals or ends to be served

(4) the relevant alternatives and the set of actions from which a choice will be made

(5) a relation which produces an ordering of alternatives in some arrangement

(6) the choice itself, the selection of one or some combination of alternatives.[46]

Marvin Adelson identifies four classes of the concept decision:

(1) the state of the world (information, time, future changes, environment, probabilities)

(2) available alternatives (as a function of time)

(3) predicted outcomes

(4) objectives and criteria.

These four classes result in the consequence of a decision action. The relevant aspects of these consequences "include the expected 'value' as a function of time; the new state of the world, expressible stochastically; and a new set of available consequences."[48] Dorothy Rodgers contends that there are seven major components in the decision situation and that each of these components requires a decision:

(1) Goal

(2) Criteria

(3) States of Nature

(4) Alternative Courses of Action

(5) Possible Outcomes

(6) Probabilities of States of Nature

(7) Probabilities of Each Outcome.[49]

Joseph O. Cooper defines three forces of decision and separates the factors of decision making into (1) the factors of logical decision making and (2) the non-logical influences. The three forces of decision are:

(1) The dynamics of the individual (self-image, etc.)

(2) The dynamics of the group self-image

(3) The dynamics of the environment[50]

These three forces of decision serve as one basis for the development of the behavioral schema for decision making. This schema will be explicated in the section of the paper devoted to the behavioral aspects of decision making. The factors of logical decision making are:

(1) Long- and short-range goals

(2) Recognition of an actual problem

(3) Understanding of one's operating environment and its impact upon oneself

(4) A set of identifiable personal values

(5) Knowledge of the pertinent facts in the situation and understanding of their meaning

(6) Recognition of the consequences of action

(7) Satisfaction of an expectation or outcome level which is higher than that which is exchanged for it whether in effort, materials, status, or money [51]

According to Cooper, the non-logical influences of decision making are:

(1) Fear and avoidance of the unknown

(2) Decision by indecision or default because of a lack of personal direction or a resistance to change

(3) Emulation, Conformism and Submission, sound implications of choice

(4) Conditions of acute stress for which the individual may not be adequately prepared

(5) Feeling one's way between pleasure and pain rather than reasoning one's way through

(6) Wishing that something were so and rationalizing its actuality; justification of a non-rational choice.[52]

These attempts to classify decision making into its various elements present a varied account of the intension of the concept. The problem now is to place some order among these properties by organizaing them into categories. These categories will respresent the types of properties which make up the concept "decision making".

In the second sense of element, the concept "element" does not mean the properties themselves of the intension of decision making. Rather, element means the categories which serve as boundaries between areas or classes of decision making properties. Within the perspective of this sense of element, the lexical definition of decision making is broken down into these elements: (1) factors which influence the selection, (2) the act of choosing, and (3) the consequences of choice.[53] These three elements are categories of decision properties. These categories are one means of ordering the properties of the decision making situation. Thus, element one refers to the factors, both logical and non-logical aspects. The non-logical aspect refers to the empirical act itself

and would, therefore, include all the descriptive properties of the decision situation encompassed by the intension of the concept. The logical aspect refers to the logical elements of action, e.g., preference or value elements and probability elements. The third element also has a logical and non-logical aspect. The non-logical aspect refers to the actual results in terms of empirical events in the history of the decision maker. The logical aspects refer to the logical structure of the resulting events.

These categories represent only one means of organizing the intensional properties of decision making. They are the categories which resulted from an analysis of (1) the lexical definition of decision making and (2) the various classifications of decision factors which other studies have yielded. In this sense, the decision categories are stipulative. The purpose of the categories is to organize the decision factors or properties. Thus, the categories are applied to the decision situation. This application serves two purposes, (1) identifying decision properties (or elements in the atomistic sense) and (2) ordering these properties along certain guidelines. The usefulness of the decision categories is dependent on how accurately their application mirrors the actual decision situation.

The new definitional method has four theoretical advantages that will be beneficial for the ER-87 research. Firstly, the scope of the definition is broadened. That is, the definition does not reduce the elements of decision making to any one element. Secondly, the richness of the definition is increased. The purpose of the definition is to explore the concept

of decision making. Thus, the number of intensional properties of the concept will be increased above those definitions which focused on merely one segment of these properties. Thirdly, the chances for logical error are reduced. The categories for analysis of the elements include the logical factors which influence the decision, the logical aspects of the act of choosing, and the logical aspects of the results of the decision. By applying these categories, the descriptive analysis which results should consider all logical conditions and problems of the decision making concept. Finally, the chances for developing a testable theory are increased. That is, by formulating the concept of decision making as a mirror (of both the logical and non-logical aspects) of the decision situation, the theory which is based on this definition should be a more accurate representation of the decision environment. Thus, this decision theory should be more conducive to empirical test to determine its applicability than theories based on definitions which do not mirror the actual decision environment.

The definitional method for ER-87 is a proposal. Thus, the total intension of the concept "decision making" nor the concept "command decision making" has been investigated. The definitional categories form the core of a definitional method which, when applied, will yield a new definition of decision making. At present, only a glimpse of the intensional properties of decision making has been provided. The intension of the concept will be analyzed as the definition is applied to the command decision situation. The proposed definitional method provides

the background for the future development of a decision model to be applied to the command decision problem. That is, the definitional analysis will eventually lead to a synthesis which will result in a model. Since the application of the definition should yield the intension of the concept "decision making" and since the synthesis depends on the level of interpretation of the intensional analysis, the depth and applicability of the resulting model should be increased.

Problems of Decision Making

In addition to the problem of how to define decision making, there are a host of other decisional problems. These problems concern both the methodology and the method of decision theory. These problems concern questions about the nature of decision theory and questions about application of the theory. The crucial point of all the problems is how to resolve the problem of inherent uncertainty.[54] Since the decision maker is the one who seeks to resolve this problem of uncertainty, the problem can be interpreted in terms of the question "what is a good decision maker?" The definitional problem is basically a descriptive problem, i.e., analysis of the intension of the concept decision making. The problems to be considered in this section are basically prescriptive. That is, the problems of what is a good decision maker prescribe what the correct decision action should be. The purpose of this section is to analyze the problems of method and methodology.

Problems of Methodology

There are two classes of methodological problems. One class concerns the nature of decision theory and the other class concerns decision models. A crucial problem for the decision theorist is the correlation of decision theory to the decision environment. This problem materializes into the problem of the criteria which are used to wager the outcomes of alternatives and to determine which alternative is best.[55] One aspect of the criterialogical problem is the determination of a method for deciding under what conditions a particular criterion should be used.[56] A general criticism of decision theories is that most experiments simply assume the correctness of one or another of the decision criteria at the beginning. Thus, what is needed is a method to judge the correctness of criteria for deciding among alternative courses of action. One method for determining the correctness of decision criteria is how effective these criteria relate the theory to the actual decision situation and how they relate theoretical elements of the decision criterion with the empirical elements to which the criterion is applied. This problem is one of abstraction to the point of irrelevance. In other words, in an effort to prescribe what action would lead to the best results, the theorist focuses on the aspects of the decision situation which are measurable, generalizes his theory on the basis of these measurable quantities, and formulates a criterion for action on the basis of these generalized measurable quantities. Thus, the theoretical elements of the decision criterion are based not directly on empirical elements of the decision situation but on generalized ele-

ments which are abstracted from the decision environment. This procedure is not necessarily unproductive. However, its productiveness depends on the degree to which the abstracted measurable quantities reflect the actual decision situation. With respect to decision theory, these measurable quantities have reflected only part of the intension of the actual decision situation. Thus, the criteria based on these quantities have had little relation to the decision environment or to one another.

The second class of methodological decision problems pertains to problems of model development. A model should mirror the structure of the decision environment. Thus, the basic problem in decision theory is how to construct a model which will mirror the structure of the decision environment. This basic problem can be reinterpreted as the problem of whether the decision model should be descriptive or prescriptive. The traditional theories of decision making have been concerned either explicitly or implicitly with prescriptive models. These models have been challenged on the basis that they are anchored in theory which is not empirically testable and that the theory does not reflect the actual conditions of the decision situation. Several theorists have suggested that descriptive approaches to decision theory should replace the prescriptive nature of theory. However, even their suggestions were cloaked behind the contention that the descriptive model serves as the basis for a prescriptive interpretation of decision making.[57] The proposal of research on ER-87 is that a descriptive model should be the

goal of theorists rather than a prescriptive model. However, the question which future research on this proposed descriptive model must face is whether a descriptive model merely catalogs the aspects of the decision situation;and if the result of descriptive models is simply to catalog, do these models produce significant results for the decision theorist? Since prescriptive decision models have no application to the actual decision environment and if descriptive models seem only to produce a catalog of the decision situation, the decision theorist will be caught on the horns of a dilemma. The resolution of this dilemma may result in a series of interrelated models each progressing toward (1) a more accurate interpretation of the decision environment and (2) a deeper conceptual level of interpretation of the decision situation. In other words, this series of models would begin with a descriptive interpretation of the decision environment and end with a prescriptive model. The prescriptive model would result in a direct relation between the intension of the concept decision making and its extension.

Problems of Method

There are three classes of decision problems which are problems of method. The first class concerns the basic question of how to resolve inherent uncertainty. One answer for this question is in terms of the probability of the occurrence of alternative courses of action. The second class concerns the universal applicability of decision theory; and the third class refers to the development of methods for training decision procedures.

The basic problem for decision making was earlier interpreted as the resolution of inherent uncertainty. The resolution of uncertainty may have many sources. The uncertainty may reflect ambiguity of the decision maker's part as to whether an event has actually happened or it may be the result of the occurrence of random events in the environment. The uncertainty may be caused by unreliability of information sources or it may further reflect the inability of the decision maker to predict the outcome of some course of action. Whatever the source of this uncertainty, it may be specified, in most cases, in terms of probability statements.[58] The problem of uncertainty for the decision maker may, therefore, be interpreted as the problem of how to figure the probability of the occurrence of alternative course of action.

According to one view of probability, it is the limit approached by some long-term relative frequency. Another view of probability is that it is the expression of the degree of belief regarding some uncertain event.[59] This second view is referred to as subjective probability. Decision problems concern unique events; and thus, people express opinions about the relative likelihoods of these events. This expression of opinion is a person's interpretation of the subjective probability of the occurrence of an event. The subjective probability refers to the degree of confirmation of evidence for a statement phrased in probability terms.[60] The basic problem of subjective probability is its relation to objective probability. There are a host of theories about the relation of these two types of probability. The major question which acts as the

cornerstone for these interpretive theories is "whether the calculus of probability can be applied only to frequency relations or whether it applies also to the inductive situation".[61] This latter question is complex. The complexity is increased by the fact that in some circumstances, the two types of probability tend to coincide and in others tend to diverge. Furthermore, within the perspective of the inductive situation, subjective probability is affected by the experience of the decision maker and by the number and value of alternatives.[62] A further problem with subjective probability is whether the concept refers to a measure of the actual psychological belief or whether the concept refers to a measure of the degree of belief one should consider as reasonable.[63] There is no one resolution to the problem of the relation of objective to subjective probability. There are, however, "resolutions"and these resolutions depend on what particular perspective one assumes. Whatever the outcome of theoretical and experimental discussions, the problem of determining the probability of an event by the decision maker continues to be a key problem for decisional analysis.

The second class of problems concerns the applicability of decision theory. The problems of applicability are basically problems of strategy. The problem of strategy is how to provide a method of stating a universal strategy for decisions which meets the criteria of adequacy when applied to specific decision events.[64] This problem is a further interpretation of the relation of decision theory to the actual decision environment. The decision theorist appears to rest on a dilemma with respect to this prob-

lem also. If decision strategies are developed for particular decisions, these strategies do not resolve issues beyond the perspective of the particular decision events. Thus, whereas criteria for adequacy for such strategies can be formulated with respect to the particular decision events, these strategies lack any universal application. If decision strategies are generalized so that they have universal application, there exists no criteria which justify their application to particular decision events. The resolution of the dilemma will occur, as in the case the question of descriptive or prescriptive models, when decision theorists construct a prescriptive model which will reflect both the variety of the intension of the concept "decision making" and the multiplicity of applications of this concept to the actual decision environment.

The third class of problems concerns the training of decision making techniques. The concern here is to develop appropriate systems designs and procedural aids to train decision makers (1) to be aware of what decision making means, (2) to be aware of the decisions that are to be made and the methods for making these decisions, and (3) therefore, to train people to be good decision makers. The problems of training for decision theory are therefore (1) problems of recognition, (2) problems of analysis, and (3) problems of resolution. That is, the decision maker must be aware of decision problems, and must learn to apply the analytical tools to decision problems in order to resolve these problems. The basic problem of training is, therefore, how to make the decision maker "aware". These problems will be the focus of the research as ER-87

moves out of the exploratory stage. The threefold problems of training (recognition, analysis, and resolution) will receive further examination in the section on the tentative decision making model. In this section, it will be shown how these three problems serve as three stages in a tentative decisional schema.

Conclusion

The analysis of the traditional definitions of decision making and the analysis of the basic problem areas combined with the proposed definition of decision making set the stage for two developments. One development is a behavioral paradigm or schema to be applied to the decision situation. The other development is a tentative schema which will serve as a preperatory device for the construction of a decision model. The analysis also substantiates the opening statement of this section that the complexity and variety of problems revealed by decisional analysis reflects the diversity of methods utilized by theories about decision making. The purpose of this analysis is to reduce the complexity of decision problems and to increase the variety of the intension of the concept decision making without reducing the application of theory about decision making.

References

1. Schrenk, L. P., "Aiding the Decision Maker - A Decision Process Model", Ergonomics, 1969, 12(4), 543-557.

2. Copi, Irving M., Introduction to Logic, New York: Macmillan, 1968.

3. Ibid.

4. Ibid.

5. Ackoff, Russell L., Scientific Method: Optimizing Applied Research Decisions, New York: Wiley and Sons, 1962.

6. Ibid.

7. Smith, Nicholas M., et al., "The Theory of Value and the Science of of Decision - A Summary", J. Operat. Res. Soc. Amer., 1953, 1, 103-113.

8. Ibid.

9. Edwards, W., "Behavioral Decision Theory", Annual Rev. Psychol., 1961, 12, 473-498.

10. Edwards, W., Subjective Probability in Decision Theories, Project Michigan Report No. 2144-361-T, Willow Run Laboratories, Univesity of Michigan, March 1959.

11. Churchman, C. W., Prediction and Optimal Decision, Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1961 (Also in Peter C. Fishburn, Decision and Value Theory, New York: John Wiley & Sons, 1964).

12. Wilson, Charles Z. and Alexis, Marcus, "Basic Frameworks for Decisions", J. of the Acad. of Management, 1962, Volume 5, 150-164.

13. Brody, Arthur L. and Weinstock, Solomon, Mathematical Theories in Performance Decision Making and Learning, A Literature Review. Final Rep., Contract AF 33 (616) 6179, Proj. 7183, MRL TDR 62-76, 1960, AD - 285-565.

14. Savage, L. J., "The Theory of Statistical Decisions", Journal of the American Statistical Association, March 1951, Volume 46, 55-67.

15. Ibid.

16. Ibid.

17. Rodgers, Dorothy L., Decision Making, Human Factors and Training, Information Systems Operation, General Electric Company, 1960.

18. Olmstead, Joseph A., et al., Components of Organizational Competence, Draft Technical Report, HumRRO Div No 4, 1972.

19. Mills, H. D., "Organized Decision Making", Naval Research Logistics Quarterly, Sep 1955, Volume 2, Number 3, 137-143.

20. Bonini, Charles P., Simulation of Information and Decision Systems in the Firm, Englewood Cliffs, N. J.: Prentice-Hall, 1963.

21. McCamy, J. L., "Analysis of the Process of Decision Making", Public Administration Review, 1947, Volume 7, 41-48.

22. Ibid.

23. Cooper, Joseph D., The Art of Decision Making, Garden City, New York: Doubleday, 1961.

24. Ibid.

25. Bross, I., Design for Decision, New York: McMillan Company, 1953.

26. Taylor, Donald W., Decision Making and Problem Solving, Yale University, Sep 1963.

27. Suppes, Patrick, "The Philosophical Relevance of Decision Theory", J. of Phil., 1961, 58, 605-614.

28. Ibid.

29. Taylor, Donald, Decision Making and Problem Solving.

30. Ibid.

31. Ibid.

32. Ibid.

33. Ibid.

34. Ibid.

35. Simon, H. A., Administrative Behavior: A Study of Decision Making Processes in Administrative Organization (2d Edition), New York: Free Press, 1965.

36. Ibid.

37. Ibid.

38. Suppes, Patrick, "The Philosophical Relevance of Decision Theory".

39. Taylor, Donald, Decision Making and Problem Solving.

40. Bates, J., "A Model for the Science of Decision", Phil. Sci., 1954, 21, 325-339.

41. Suppes, Patrick, "The Philosophical Relevance of Decision Theory".

42. Estes, W. K., "Of Models and Men", Amer. Psychologist, 1956, 12, 609-617 (Also, Estes, W. K., " A Descriptive Approach to the Dynamics of Choice Behavior ", Behavioral Science, 1961, Volume 6, 177-184).

43. For a discussion of the relation of intension and extension in the development of science, see Robert S. Hartman, The Structure of Value.

44. Bross, I., Design for Decision.

45. Ackoff, Russell L., Scientific Method: Optimizing Applied Research Decisions, New York: Wiley and Sons, 1962.

46. Wilson, Charles Z. and Alexis, Marcus, "Basic Framework for Decisions".

47. Adelson, Marvin, "Human Decisions in Command Control Centers", Annals of the N. Y. Acad. of Science, 1961, Volume 89, 726-731.

48. Ibid.

49. Rodgers, Dorothy, Decision Making.

50. Cooper, Joseph D., The Art of Decision Making.

51. Ibid.

52. Ibid.

53. Carpenter, Wayne, "Problems in Decision Theory", Infantry HRU, Feb 16, 1972.

54. Schrenk, L. P., "Aiding the Decision Maker - A Decision Process Model".

55. Rodgers, Dorothy, Decision Making .

56. Brody, Arthur L. and Weinstock, Solomon, Mathematical Theories in Performance Decision Making and Learning.

57. Reference here is to Suppes' article, "The Philosophical Relevance of Decision Theory" and Simon's book.

58. Schrenk, L. P., "Aiding the Decision Maker - A Decision Process Model".

59. Ibid.

60. Rodgers, Dorothy, Decision Making.

61. Ibid.

62. Edwards, Ward, "Behavioral Decision Theory".

63. Rodgers, Dorothy, Decision Making .

64. Bates, J., "A Model for the Science of Decision".

BEHAVIORAL ASPECTS OF DECISION MAKING

BEHAVIORAL ASPECTS OF DECISION MAKING

Rationale for the IOE Paradigm

An extensive review of the literature in the decision making field, focusing on environmental parameters and individual differences, revealed a logical need for a three factor paradigm which would adequately represent the decision making situation and identify those elements which may influence it.

Using the tentative organizational schema developed by Osborn and Goodman as a guideline, a three factor paradigm was developed.[1] The paradigm contained in Table 1, 2, and 3 at the end of this section, consists of the Individual or Group Decision Maker (I) those important Others (O) who may influence any decision, and the Environmental Parameters (E) directly or indirectly related to the decision making situation. Throughout our research, it became evident that the literature, dealing with the behavioral aspects of decision making, was divided into three general categories: (1) the individual decision maker in relation to the decision making situation; (2) the environment in relation to the decision making situation; and (3) the interaction of the individual decision maker and the environment in relation to the decision making situation. It was felt, for the sake of clarity if nothing else, that the environmental parameters should be separated into two categories, the physical environment (E) and the social setting (O).

Joseph D. Cooper described the decision making situation in terms of the forces of decision of which he established three: (1) the dynamics of the individual; (2) the dynamics of the group; and (3) the dynamics of the environment.[2] One might want to argue that you cannot logically separate the individual decision maker and the social setting from the environment. All three are highly interrelated and therefore a method of distinguishing one from the other is needed and the IOE paradigm seems to accomplish this task. It is acknowledged that none are separate entities in themselves.

Theoretical foundations for the IOE paradigm are based in Kurt Lewin's topological psychology or field theory. Lewin states that "every psychological event depends upon the state of the person and at the same time on the environment..."[3] From this assumption, Lewin developed the formula B = f(PE); where B = behavior; f = function; P = person; and E = environment. To put this in context with decision making and the IOE paradigm, it then follows that D = f(IOE); where D = the decision; f = function; I = the individual decision maker; O = aspects of the social setting that form the background of a decisional problem; and E = aspects of the physical setting that form the background of a decisional problem. Lewin uses the term "psychological life space" to indicate the totality of facts which determine the behavior of an individual at a certain moment , or in other words B = f(PE).[4] The decision situation is analogous to Lewin's psychological life space in that it represents the totality of facts which determine an individual's decision at a given moment in a given situation. Ac-

cording to Lewin, only those aspects of the physical world that affect the individual in his momentary state should be included within the psychological life space at any one given time. Therefore, it is readily seen that all of the elements in the IOE paradigm will not have an influential effect on the decision situation at any one given time and the decision maker need be concerned with only those elements that he recognizes are involved within a particular decision.

Lewin contends that "...only the present situation can influence present events."[5] Past and future events, according to Lewin, are not concrete because they do not exist in the present and only concrete events can have effects. A past event is viewed by Lewin as having "a position in the historical casual chains whose interweavings create the present situation."[6] Lewin views the attainment of a goal as being in the future, if it occurs at all, and the goal itself to exist psychologically in the present life space. The IOE paradigm, on the other hand, is based on the assumption that past, present, or future events or expectations of these events influence the present situation, i.e., a decision; and it is up to the logically thinking decision maker to consider these events when making a decision.

Research in the Area of Decision Making

The amount of experimental research in the area of decision making and problem solving is enormous and it is not in the scope of this section of the paper, nor the review of the literature to try to extensively

cover this material. Hopefully, a representative sample of the written material, in the field of decision making, was reviewed.

The research material reviewed covered four major areas: (1) decisional processes in relation to the individual; (2) decisional processes in relation to the social setting; (3) decisional processes in relation to the environment; and (4) military decision making.

Decision Processes and the Individual

There have been numerous attempts made to correlate personality and cognitive variables with decision making, but these attempts have met with little measurable success. Townsend and Smith conducted an experiment in which they tried to attempt to identify, measure, and predict from particular cognitive and personality variables certain scores on a criterion test of decision making ability.[7] The results were classified into four categories: (1) Goodness of Decision under Risk; (2) Goodness of Decision under Certainty; (3) Goodness of Decision under Uncertainty; and (4) Composite Goodness of Decision. The results indicate that the best predictors for predicting Goodness of Decision under Risk were Intellectual Efficiency, Unconventionality, and Ambitious Aggressiveness. The best predictors for predicting Goodness of Decision under Certainty were a mixture of low Dominance, low Patience, and good Imagination. A mixture of low Dominance and high Conscientiousness seems to be the best predictors for predicting Goodness of Decision under Uncertainty. Predicting composite Goodness of Decision seems to depend

on Conscientiousness and Cooperativeness with high Tolerance, Planfulness, Imaginativeness, and Patience coupled with low Dominance playing a predictive role. Townsend and Smith indicate that "the proper study of the prediction of decision from personality variables with normal Ss should be in a setting involving stress. It appears that normal people in normal settings tend to act in a rational, logical, goal oriented way and they make decisions which are little influenced by personality. However, when an individual must make a decision under stress or is maladjusted, his rational functions become clouded, and he must make decisions consistent with his personality and emotions."

The results of a study, conducted by Orville Brim, dealing with personality correlates and decision processes indicated that subjects high in dependency tend to be more optimistic over the outcomes of their actions, will consider fewer such outcomes in evaluating alternatives, and will be less rational in their preferential ranking of actions according to their prior evaluations, than subjects low in dependency.[8] Brim also found that intelligence correlated positively with the number of possible outcomes that may occur due to a subject's decision. The higher the subject's intelligence, the more alternatives he analyzes. Even in light of these results, Brim concluded that general values and orientations toward life (beliefs), together with the cultural background of the decision maker, seem to account for more variability in decision making than the more traditional personality traits.

Results obtained from other studies dealing with personality and decision making indicate that: (1) subjects who have a high motivation to achieve tend to prefer tasks with a moderate degree of difficulty as opposed to very easy or very difficult tasks. The stronger the motive to achieve, the greater the differential preference for tasks of moderate difficulty;[9] (2) subjects with high achievement needs tend to perceive their probability of success as being greater than the stated odds;[10] (3) stress seems to affect both attention and perception by enhancing attention and narrowing its focus in both time and space. Subjects tend to concentrate more on the task at hand and to ignore both previous events and peripheral stimuli;[11] (4) subjects, under extreme stress, tend to develop a cognitive defense, become less efficient in their use of the available information, and accept hypotheses recklessly;[12] (5) subjects high in the traits of exhibition, aggression, or dominance tend to prefer bets with high pay off and low probability of winning;[13] and (6) subjects high in the traits of autonomy or endurance tend to prefer bets with low pay off and high probability of winning.[14]

Decision Processes in Relation to the Social Setting

Previous studies of individual and group decision making by Wallach, Kogan, and Bem, found that group decisions tend to be more risky than decisions made by group members as individuals when these decisions were reached through discussion and consensus. They also found that groups were more likely to select more difficult, higher pay off problems than individuals in decision situations. Wallach and Kogan conducted a more

recent study dealing with group decision making under conditions of risk.[15] They found that: (1) unanimous group decisions concerning matters of risk show a shift toward greater risk taking when compared with individual decisions; (2) subjects tend to be more conservative when they knew that other members of their group would be advised as to how each individual decided; and (3) when one subject was expected to make a decision that was binding to a group, without the chance to discuss the decision with group members, a conservative approach was taken.

Higbee and Streufert conducted an experiment concerned with perceived control over the environment and risk taking behavior in complex decision making environment.[16] They found that those subjects who perceived that conditions in the simulated environment were due to their own decisions tended to take fewer risks than those subjects who perceived that the conditions were due to factors beyond their control.

William Jones believes that the main importance of the social setting, in respect to decision making, is the importance of the complex communications processes involved in decision making in groups.[17] Jones indicated that decision making in a large organization, like the military, is associated with a very complex communications process between individual decision makers, and this process is significantly different from the processes utilized by individual decision makers in non-group settings. Jones divides the communications process into three levels: the formal, the subformal, and the personal, with each level playing an important role in decision making. According to Jones, observable weaknesses of

organizational decision making can be attributed to weaknesses in the interorganization communications. In view of this, Jones suggests that higher echelon military command and control systems should be structured with a view toward enhancing communications between significant decision makers in order to avoid this weakness.

Decision Processes and the Environment

The majority of studies dealing with the environmental effects on decision making are concerned with information load and information relevance and this is reflected in the material that was analyzed in the literature review.

Streufert, in an experiment dealing with the effects of information relevance on decision making in complex environments, found that decision making quality was improved as information relevance increased.[12] Decision quantity was not affected by relevance variation. Streufert and Streufert found that as information relevance is increased subjects perceive an increase in both information relevance and importance.[19] These perceptions tended to be higher than actually induced levels of relevance. Streufert and Streufert concluded that an increase in irrelevant information is not detrimental to performance but instead an increase in the information load due to the addition of irrelevant information is what is detrimental. On the other hand, Hayes found that as the amount of relevant data increased, the time it took for subjects to make a decision increased and decision quality actually decreased slightly.[20] He attributed

this to: (1) subjects randomly selecting one alternative over another; (2) subjects giving more weight incorrectly, to some data as opposed to other data; and (3) an increase of confusion due to an increase of relevant data. In support of Hayes' findings, Peterson and DuCharme found that subjects place too much weight on early information and consider later information too lightly.[21] Rigney and Debow found that subjects seem to be unable to make full use of available information especially when placed in a multi-dimensional situation.[22]

Long discovered that as the problem or decision increased in complexity, more information was acquired by the subjects and more information was left unused at each higher level of complexity.[23] There also seems to be evidence to support the idea that more information is needed to change a decision than is originally needed to make the decision (Gibson and Nicol). Gibson and Nicol also found that subjects appear to be reluctant to change an erroneous commitment even in the light of new evidence.[24]

Other findings dealing with environmental parameters indicate that: (1) people tend to want too much information as opposed to too little information (Gibson and Nicol);[25] (2) people delay too long before arriving at decisions (Sidorsky and Houseman);[26] (3) people develop and consider too few courses of action (Kennedy and Schroder);[27] (4) people seem to show consistency in their decisions over time (Vaughan et al);[28] (5) voice communication is not a particularly effective means of compensating for information lost through adoption of all-or-none procedures

(Howell);[29] and (6) the value of experience in certain aspects of decision making does not generalize to conditions other than those under which the experience was acquired (Howell).[30]

These findings seem to indicate that the decision maker, when faced with an abundance of information, must: (1) consider the source; (2) evaluate each bit of information as it is received; (3) assign weights to each bit of information; (4) consider as many possible alternatives as time allows; and (5) continually reevaluate the situation as new information is received and be prepared to make corrections if the new information warrants it.

Military Decision Making

The present doctrine of decision used by the Armed Forces of the United States is based on enemy capabilities and is formally called the "Estimate of the Situation". An effort was made to trace the historical background of the "Estimate of the Situation" with little success and therefore, we concluded that this military doctrine of decision developed informally over the years. This approach is logically sound but has been criticized as being too conservative in view of the other alternatives open to a commander. The doctrine of estimate of the situation is based on the premise that "if a commander's evaluation of the situation is correct, he gains an assurance by basing his decision on the enemy's capabilities. If the enemy errored in his evaluation or makes a stupid decision, it cannot place the commander in a position less favorable than he had antici-

pated."[31] An alternative to the estimate of the situation, not generally accepted by the military, is a doctrine based on enemy intentions. Here, if the enemy commander makes a faulty decision then the decision maker may find himself facing disaster. If the commander guesses the enemy's intentions correctly then he is assured of an outcome at least as favorable and often more favorable than a decision based on enemy capabilities. Due to the element of risk, this doctrine is generally unacceptable to the military commander.

Von Newman suggests a course of action based on a weighted random choice from among all of the alternatives that a commander is capable of implementing. This involves assigning carefully chosen probabilities to each alternative and then basing decisions on some chance event such as flipping a coin or tossing a die. According to von Newman, the proper utilization of such doctrine would increase one's expectancy of gain over that obtainable by the doctrine of the estimate of the situation without accepting the risk involved in a doctrine based on estimating enemy intentions. Von Newman admits that this mixed strategy would work best in small unit decision making tasks. Difficulty can be seen in trying to implement a strategy based on chance events. Acceptance by commanders is questionable.

Complex decisions requiring an analysis of the future are categorized under the label operations analysis or systems analysis. An example of this type of decision would be the development of a system of strategic air bases. Both operations analysis and systems analysis have the same

essential elements:

(1) The objective

(2) The alternatives

(3) The costs

(4) A model

(5) A criterion

The analysis advances through various stages which are nothing more than an extension of the scientific method outside of the pure realms of science. The basic stages employed are:

(1) Formulation -- defining the issue of concern

(2) Search -- determining the relevant data and identifying the alternatives

(3) Explanation -- building a model and using it to explore the consequences of the different alternatives

(4) Interpretation -- deriving the conclusions and indicating a preferred alternative or course of action

(5) Verification -- testing the conclusion by experiment

Often it is not possible to carry out the last stage for either financial or practical reasons, but the first four stages are always a part of systems analysis.

Hendrickson, in an article dealing with the pros and cons of war gaming and simulation, criticizes war games and challenges their usefulness in providing a means to accurately describe what the game is supposed to interpret.[32] Hendrickson describes simulation and war gaming "...as an

effort to represent a system or organization in such a way that it can be studied precisely to yield data from which general relations can be declared or from which greater level of comprehension results." To date, few war games meet this requirement.

Other researchers reviewed provide data on scientific military decision making and game theory in relation ot military decision making.

Presentation of the IOE Paradigm

The purpose for the development of the IOE paradigm is to assist in the development of a decision making model that will adequately handle as many different aspects of the decision making process as possible.

As was stated earlier in this section, the IOE paradigm was developed by using the tentative organizational schema designed by Osborn and Goodman as a guideline. Both logical and theoretical aspects were also considered which led to what constitutes a revision and reworking of the Osborn and Goodman organizational schema.

The IOE paradigm, which is presented in tabular form at the end of this section, contains factors and elements that need qualification in order to ensure that the reader has a clear cut understanding of the IOE paradigm. Therefore, a list of definitions has been included in this section for the sake of interpretation.

Individual or Group Decision Maker: Those aspects of the decision maker which may influence the decision process.[33]

Others: Those aspects of the social setting that form the background of a decisional problem.[34]

Environmental Parameters: Those aspects of the physical setting that form the background of a decisional problem.[35]

Intellect: Those cognitive processes involved in thinking, reasoning, and judging.

Sensory: Those processes involved in the reception and transmission of sense impressions that are involved in decision making.

Physiological States: Those physical conditions of the organism which, as altered by drugs, fatigue, illness, stress, etc., have a potential influence on decision behavior.[36]

Behavior Patterns: Those patterns which are made up of individual recognizable components.

Experience: Knowledge or skill that results from training, observation, and personal participation.

Values: The social principles, goals, and standards held or accepted by an individual or a group.

Personality Correlates: Those traits, important to decision making, which make up the personality.

It is felt that all other factors and elements contained in the IOE paradigm are self explanatory and therefore are not defined in this paper.

TABLE 1

INDIVIDUAL OR GROUP DECISION MAKER

SENSORY	INTELLECT	PHYSIOLOGICAL STATES	BEHAVIOR PATTERNS	EXPERIENCE	VALUES	PERSONALITY CORRELATES
Visual	Cognition	Activation Level	Habits	Precedence	Attitudes	Degree of Dominance
Auditory	Memory	Biochemical States	Basic Drives		Preferences	Degree of Motivation
Olfactory	Evaluation	Endocrinological States	Acquired Drives		Beliefs	Degree of Aggressiveness
.	Divergent Production	.				Degree of Exhibitionism
.	Covergent Production	.				Confidence Level
.		.				Imagination
etc.		etc.				Conscientiousness
						Need for Achievement
						Risk Taking Behavior
						.
						.
						.
						etc.

TABLE 2

OTHERS

Cooperation Structure
Competition Structure
Authority Structure
Responsibility Structure
Reliability Structure

TABLE 3

ENVIRONMENTAL PARAMETERS

INDIRECT INFLUENCE	DIRECT INFLUENCE
Temperature	Resources Available
Noise	Resources Involved
Illumination	Weather Conditions
	Terrain Features
	Enemies Capabilities
	Time Available
	Costs
	Information: completeness
	amount
	difficulty
	order
	rate
	type and mode
	redundancy
	relevancy
	reliability

References

1. Osborn, William C. and Goodman, Barbara E., A Tentative Organization Schema for Decision Making Problems, HumRRO Technical Report, No. 66-14, vii, 1966.

2. Cooper, Joseph D., The Art of Decision Making, Garden City, New York: Doubleday, 1961.

3. Lewin, Kurt, Principles of Topological Psychology, New York: McGraw-Hill, 1936 (Paperback Edition 1966).

4. Ibid.

5. Ibid.

6. Ibid.

7. Townsend, John C. and Smith, Walter J., "Predicting Decision Making Behavior From Personality and Cognitive Variables", Technical Report No. ESD-TRD-64-619, November 1964.

8. Brim, Orville G., Jr., et al., Personality and Decision Processes: Studies in the Social Psychology of Thinking, Stanford University Press, Stanford, California, 1962.

9. Atkinson, J. W., "Motivation Determinents of Risk Taking Behavior", Psychol. Rev., 64, 359-372, 1957.

10. Ibid.

11. Block, Clifford H., Interrelation of Stress and Anxiety in Determining Problem Solving Performance, Technical Report No. 6, Contract Nonr - 60920, Proj. NR 150-166, 1962.

12. Ibid.

13. Cameron, P., and Meyers, J. L., "Some Personality Correlates of Risk Taking", J. Gen. Psychol., 1966, 74, 51-60.

14. Ibid.

15. Wallach, Michael A. and Kogan, Nathan, "Group Decision Making Under Risk of Aversive Consequences", J. Of Personality and Social Psychology, 1965, 1(5), 453-460.

16. Higbee, Kenneth L. and Streufert, Siegfried, "Perceived Control and Riskiness." Psychon. Sci., 1969, Volume 17(2), 105-106.

17. Jones, William M., "On Decision Making in Large Organizations", RM-3968-PR, AD No. 437492, March 1964.

18. Streufert, Susan C., Effects of Information Relevance on Decision Making in Complex Environments, Technical Report No. 24, ONR-Purdue, N 00014-67-A-0226-0007, NR 177-911 (Code 452), August 1969.

19. Streufert, Siegfried, and Struefert, Susan, The Perception of Information Relevance, Psychon. Sci., 1970, Volume 18(4), 199-200.

20. Hayes, J. R., Human Data Processing Limits in Decision Making, Project 2806, ESD TRD 62-48, 1962, AD 283384.

21. Peterson, C. R. and DuCharme, W. M., "A Primacy Effect in Subjective Probability Revision", J. Exp. Psychol., 1967, 73, 61-65.

22. Rigney, J. W., and DeBow, C. H., "Multidimensional Scaling Analysis of Decision Strategies in Threat Evaluation," J. Applied Psychol., 1967, 51, 305-310.

23. Long, B. H., "Predecisional Search in Concept Formation: The Effects of Problem Complexity", Psychol. Rec., 1965, 15, 197-202.

24. Gibson, R. S., and Nicol, E. H., "The Modification of Decisions Made in a Changing Environment", USAF, ESD-TR-No. 64-657, 1964.

25. Ibid.

26. Sidorsky, J. P. and Houseman, J. F., Research on Generalized Skills Related to Tactical Decision Making, Technical Report NAVTRADEVCEN-1392-2, Dec., 1966, US Naval Training Device Center, Port Washington, New York.

27. Kennedy, J. L. and Schroder, H. M., Decision Making Training in Tactical AAW Type Situations, Princeton University, Contract Nonr-1858 (42) Progress Report, 1964.

28. Vaughn, W. S., Jr., et al, Study of Functional Requirements of Training Equipment for Army Command Tactical Decision Making, USN NTDC Technical Report No. 1341-1, 1966.

29. Howell, W. C. and Gettys, C. F., Some Principles for Design of Decision Systems: A Review of the Final Phase of Research on a Command-Control System Simulation, USAF AMRL Technical Report 1968, No. 68-158-45.

30. Ibid.

31. Haywood, O. G., "Military Decision and Game Theory", Air University Quarterly Review, 1949, Volume 4, 17-30.

32. Hendrickson, R. G., Pros and Cons of War Gaming and Simulation, Technical Report RAC (ORO)-TP-49, Research Analysis Corporation, Bethesda, Maryland, October 1961.

33. Osborn, W. C., and Goodman, B. E., A Tentative Organizational Schema Decision Making Problems, HumRRO Technical Report No. 66-14, vii, 1966.

34. Ibid.

35. Ibid.

36. Ibid.

TENTATIVE DECISION MODEL

TENTATIVE DECISION MODEL

Introduction

One research goal of ER-87 is the construction of a model which is logically sound and applicable to the actual (CATTS) decision situation. This research goal was translated into a research purpose, "to investigate the logical and experimental conditions for a decision model which is (1) logically sound, (2) empirically testable, and (3) universally applicable." Due to the involved analysis under the research purpose, the goal was not achieved in the exploratory stage of the research. However, a tentative schema for model construction is proposed. This section of the paper will include an analysis of the conditions for a decision model and an analysis of a tentative schema for model construction. Furthermore, a series of steps for the construction of a decision model consistent with the research goal will be examined.

Analysis of Model Construction

The definition and problem analysis and the behavioral analysis of the decision situation provides an examination of the intensional properties of decision making. However, analysis of the total intension of the decision environment will not guarantee that the decision model will either be logically sound or will aplly to the decision situation. An additional analysis of model construction is needed. This analysis will have two purposes. One purpose is to examine the logical conditions of a decision

model via analysis of the nature of the model itself. Another purpose is to examine the conditions for model construction. This examination will result in the proposal of measures which will seek to insure that the decision model is an accurate representation of the actual decision data. By developing the analysis of decision models in both of these directions, the awkward situation of either producing a large amount of data from the decision situation without a satisfactory model or producing an elaborate, abstract model with little representation of the data will hopefully be avoided.

Analysis of the Nature of Decision Models

Examination of the nature of decision models begins with the definition of model. The analysis of the definition of a model will focus on the logical conditions which determine the nature of the model. The definition of the model will be applied to the research purpose to expand what is meant by the following three conditions of a model: (1) logical soundness, (2) empirical testability, and (3) universal applicability. This expansion will be narrowed to review the role of the model in terms of its purposes and to review the problems which occur with model development. The latter review will focus on the controversy in decision theory between descriptive and prescriptive models.

One definition of the word model is representation. The representation may be either physical, abstract, or symbolic.[1] The difference between these three senses of representation reflects a difference between the level of interpretation of the model and the data which the model rep-

resents. A physical model is an exact replica of what is being represented reduced to scale. An example of this type of model is an airplane in a wind tunnel. An abstract model may be (1) a set of concepts which are substitutes for the data represented or (2) a physical replica of the idea which these sets of concepts convey. Examples of these two types of abstract models are (1) the conceptual representation of the solar system and (2) a planetarium device with small spheres around a large ball. A symbolic model is a set of mathematical concepts which interpret (1) a mathematical system, (2) a conceptual representation of an abstract idea, or (3) an analogue of an abstract system. An example of these three types of symbolic models are (1) a set-theoretical; non-linguistic entity which satisfies a set of axioms, (2) a set of mathematical formulas for the relation of the planets to each other and to the sun, or (3) a set of axioms for a mathematical deductive system.

In all three senses of model, the model is a mirror of the structure of the data which it represents. Thus, a model mirrors (1) physical structure, (2) conceptual structure, and (3) mathematical structure. The mathematical structure divides into (1) that structure represented by mathematical formulas or theorems and (2) that structure represented by mathematical axioms. A further division occurs within the structure of the axiomatic structure between (1) the set of axioms and (2) a set-theoretical entity which satisfies these axioms. This latter distinction is a distinction between the system as it is interpreted in terms of its axioms and the system as it is interpreted as an expression of the axioms.

In short, a model describes the data whether in physical, conceptual, or symbolic terms. The model together withs its interpretations in the "real world" constitutes theory.[2] The "real world" may itself be an abstraction. The level of description then may itself be an abstraction. Thus, the level of description depends on the level of interpretation of the model. And, the level of interpretation depends on the nature of the data which the model represents. A model is a potential theory, and when the interpretation is added, i.e., when the "real world" is plugged into the model, it becomes a theory.[3] In the case that the model does become theory, it can be accepted or rejected on the basis of how well it works. That is, the model and its interpretations can be judged on the basis of how well the model represents the data of the "real world". The model qua model can be judged only on logical grounds.[4] Thus, the model, devoid of its interpretations, must satisfy only the internal criteria which determine, in fact, what kind of model it is. The logical criteria become more complex as the sense of representation shifts from the physical to the abstract to the symbolic level. Accordingly, the depth of the theory increases as the depth of the representation of the model increases.

The main goal of the model as representation of the data is to yield the greatest accuracy possible.[5] In other words, the goal of the model is to mirror its data such that the properties of the model which describe the properties of the "real world" are isomorphically related to these "real world" properties. The goal is achieved in a manner dependent on

the level of representation intended by the model. Thus, in the physical sense, physical properties are related to physical properties. In the abstract sense, physical properties are related to conceptual properties which are themselves compared to physical properties or conceptual properties are compared to physical properties. In the symbolic sense, mathematical properties are related to conceptual properties or to other mathematical properties or to total systems.

The criteria which judge the effectiveness of a model must judge (1) whether the model satisfies the logical criteria which determine what the level of representation is and (2) whether the model and its interpretation achieve "great accuracy". Judging the accuracy is dependent on experimentation with the model. Judging the logical criteria is dependent on what these criteria are. One basic criterion for all levels of interpretation is that the representation must mirror the data such that the representation and the data are isomorphically related. Other criteria must be formulated for judging when two properties are isomorphic. Other criteria are certainly possible not only with respect to the determination of the degree of isomorphic relation but to other logical conditions for defining the level of representation. An analysis is, therefore, needed to determine what the logical conditions for the definition of the model are, i.e., what the internal logical conditions for defining the model are, and to determine criteria which will be used to judge the effectiveness of the model in terms of these logical conditions.

One purpose of the research on ER-87 is to identify the conditions for a decision model which is (1) logically sound, (2) empirically testable, and (3) universally applicable. One perspective for the interpretation of these conditions is the definitional analysis of the concept "model". Within this perspective, the decision model is logically sound if it meets the standards for the definition of the level of representation characteristic of the model. The model is empirically testable if it is possible via empirical means to relate the properties of the representation, that is, the representation of the data, to the data of the situation which is being interpreted. The model is universally applicable if the interpretation of the model is applicable to the data in the multiplicity of configurations which these data may take in varied circumstances. To test the model under these conditions requires (1) logical criteria for the definition of the model, (2) empirical measures which will relate the properties of the model to the properties of the data, i.e., empirical measures to check the interpretation of the model against the actual situation which the model represents, and (3) a universal strategy which interprets the data of the individual situation without being restricted to the limits of the individual situation.

In general, to test the model under these conditions requires (1) that the interpretation of the model be logically consistent and (2) that the model result, via application to the actual decision situation, in actual decisions. The test of logical consistency decreases the possibility of the occurrence of logical error in the internal structure of the model. The

test of resulting in actual decisions is a check on the relevance of the model. The aim of this check is to prevent the model, at whatever level of interpretation, from applying merely to an abstraction, i.e., merely to an idealized concept of a decision.

If the interpretation of the model is faulty, the error could lie with the internal structure of the model or with the applicability of the model. Both of these possible problem areas define the boundary for the role of the model. That is, the role of the model is to accurately interpret the data which it represents. Interpreted theoretically, the role of the model concerns (1) the internal logical structure and (2) the external application. With respect to the external application, the role of the model concerns the multi-purposes for which the researcher utilizes the model. Thus, the model serves many purposes depending on the research demands of the application of the model to some environment. Phrased in terms of a decision model, the purposes of the model might be:

(1) to provide a framework for classifying and integrating research findings regarding decision behavior.

(2) to serve as a guide for future research by highlighting gaps in our knowledge.

(3) to guide system designers in structuring decision tasks and in allocating decision sub-tasks to man and machine.

(4) to specify sub-tasks in which human biases or limitations may degrade performance; thus, by providing guidance through the development of decision-aiding concepts.[6]

The importance of asserting "might be" instead of "are" is to suggest that the purposes of the model are determined by the purposes of the research. Although the four purposes mentioned are generalized and would have general application to the decision environment, the basic purposes of the model might become more general as the research aimed at the total decision environment or more specific as the research aimed at specific areas of the decision environment.

The problems concerning the logical conditions of the model are meta-problems. That is, these problems are problems about the structure of the model rather than problems within the structure. These problems have received little attention in decision research. Internal problems concerning the correlation of the data are problems that occur within the structure of the model. These problems have received much attention in decision research. Such problems concern (1) the subjective probability of the occurrence of an alternative course of action, (2) the nature and rate of information flow and how both affect the decision process, (3) the relation of successive decision events to the structure of the decision situation, (4) the nature and objectification of the value of alternative courses of actions, and (5) the effect of anxiety and stress on the decision process.

The external problems of model development relate directly to the research purposes of the model. These problems consider (1) the suitability of the model for the research purpose and (2) the applicability of the model to the actual decision situation. Both of these problems are problems of "control". That is, the purpose of the research is to describe

what goes on in the decision process or describe what should go on in this porcess. The researcher must experiment with the decision situation. That is, he must analyze the situation, formulate a model to apply to the situation (or formulate hypotheses about the situation) and empirically test the model (or hypotheses). In order to both formulate the model and to test its applicability, the scientist must determine (1) how much control of the environment is needed for his research purposes and (2) how much control, via predictive power, his model will have.

Problems of control reflect the controversy in decision theory between (1) descriptive models and (2) prescriptive models. The controversy has been described as a controversy between (1) closed and (2) open decision models.[7] That is, the problem has been described as a conflict between (1) rigid models which structure the decision situation in terms of certain prescribed rules and (2) flexible models which structure the decision situation by mirroring this structure itself. The controversy is between two methods for solving decision problems. One method controls the environment on the basis of principles which are determined outside the environment. The other method controls the environment via the controls which are characteristic of the environment itself.

The descriptive model is basically prescriptive. The aim of the descriptive model is to describe. However, the meaning of describe is to structure via natural controls. The aim of the descriptive model is to predict the structure, on the basis of what the actual situation demands.

Thus, the prescriptive nature of the descriptive model is implicit in the application of the model rather than explicit in the structure of the model itself. The prescriptive and descriptive model both represent an idealized decision process. The object of both models is to structure. Thus, the duplication of structure results in an idealization of the decision process in both the descriptive and prescriptive cases.

The natural step after a consideration of the nature of decision models is to analyze the steps which lead to development of these models and to a consideration of measures which will reduce the complexity of the problems inherent in any decisional analysis. This step is the next focus of the paper.

Analysis of the Steps for Model Construction

The standard for constructing models is successful prediction.[8] Formulated in terms of prediction, decision models are interpreted as decision systems. To formulate a model for a decision system usually involves three steps: (1) determination of the factors which are relevant for prediction, (2) determination of the actual relationship of the factors to the phenomena which the model predicts, and (3) construction of the prediction system based on the relationship of the prediction factors to the actual phenomena to be predicted.[9] These three steps are specified by relating them to (1) an intensional analysis of the decision situation and (2) the nature of decision models. Specification results in reformu-

lation of the three steps. Step one is interpreted as the application of methods to analyze the intension of the concept "decision making". Step two is interpreted as an analysis of the logical conditions or relations between the properties of the model and the properties of the data. Step three is interpreted as (1) the development of criteria to judge the internal logical structure of the model and (2) the development of criteria to judge the effectiveness of the model and its interpretation.

So far, in the paper, two tools have been provided for the analysis under Step 1, the definitional categories and the behavioral schema. A method is needed for the analysis under Step two. This method will review the theoretical elements of decision models. A tentative decision schema will be discussed later. This schema is one method for achieving the analysis under Step two. With respect to Step 3, one criterion for discovering logical structure has been proposed, i.e., isomorphic relationship. The justification of the adequacy of the criterion involves experimentation with a decision model. Since the research has not produced a decision model, this step is a projection for later research.

A new perspective is provided by interpreting decision models in terms of (1) the sub- or component models and (2) the whole model. Within the perspective, the steps for model construction begin with the analysis and development of the sub-models and end with the application of the total model. This interpretation is analogous to the relation of the parts of a system to the system itself. These steps are:

(1) To develop component parts which describe the parameters of interest in the analysis.

(2) To integrate or synthesize the component parts into a whole which is representative of the inner workings of the total system.

(3) To test the validity of the integration of Step 2 and return to Step 1 or Step 2 if the original sub-models are lacking in what is desired, or if the integration is incorrect.

(4) To use the model with actual data to generate parametric relations, that result from model integration which correspond to the test of hypotheses in the scientific method. During the step of model integration, the analyst relates the sub-models to his concept of parameter interactions.

(5) To formulate the results into data groups from which inferences may be drawn or laws may be formulated. [10]

These steps refer not just to construction of the model but to construction and justification of the applicability of the model. Step one refers to analysis of decision making into its intensional properties and arrangement of these properties in terms of special interest. Steps two and three refer to the analysis of the internal logical criteria and to the criteria which justify correlation of the model to its data. Steps four and five refer to experimentation with the model to justify it empirically.

Other interpretations of steps for model construction are possible. These interpretations would occur as one particular viewpoint is assumed and the process of developing the model is analyzed from this viewpoint.

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In the two examples cited, the process of model construction was analyzed with respect to a prediction system and with respect to the relation of the parts of a system to the total system. In both instances, the steps for model construction involve four distinct processes: (1) analysis of the decision situation, (2) synthesis of the analyzed situation, (3) validating both the analysis and the synthesis, and (4) application of the synthesized product to the environment which it interprets. The steps for developing a model depend on the nature of the model (i.e., the level of interpretation), on the nature of the data to be analyzed, on the procedures used to justify the soundness of the model, and on the procedures used to justify the applicability of the model. Two methods have been proposed to analyze the nature of the situation. A method will now be investigated for analyzing the theoretical elements of the model.

Tentative Decision Schema

The fist step in the construction of a decision model is to identify the elements of the decision situation. The next step is to identify the elements of the decision model, i.e., to decide what type of model will fit the demands of the research. The third step is to analyze the relationship between the elements of the model and the elements of the actual situation. The final step is to test (1) the validity of the structure of the model and to test (2) the applicability of the model to the decision situation. In this section of the paper, a method for accomplishing the

third step will be analyzed. This method is a tentative decision schema. The purpose of the schema is to (1) identify the theoretical elements and methods of the model and (2) show how these elements and methods represent the actual decision process.

The nature of the tentative schema is both conceptual and empirical. The composition of the schema is conceptual. The origin of the schema is the actual decision situation. Thus, the analysis which produces the schema is conceptual; however, the conceptual analysis is inseparably connected to the decision environment. The schema will not predict the occurrence of an action. It serves as a heuristic device, a guideline for analysis of decision making. The schema represents conceptually the order among the factors of the decision situation and the direction of the decision process. However, the process which the schema represents does not restrict the decision path to any one direction. Rather, the purpose is to show that some direction can be provided for the decision process which reflects the direction which the actual decision making process takes.

In short, the schema is not a model. It does not mirror the structure of the decision environment. That is, the schema does not represent the actual making of decisions but represents the order of the elements and methods which are utilized to interpret the making of decisions. The schema, therefore, serves as a means of revealing the multiplicity of the relations between the model and the situation. That the order which the schema reflects is a correct representation depends on

the application of the schema to the decision environment. At this point in the research, this application has not been performed. Hence, the schema is a proposal, a tentative analytical device. The application, if successful, will show that the schema is also a synthetical device.

The tentative decision schema originates with the perspective of the decision making situation. This perspective is narrowed to the individual decision maker. Thus, the schema is utilized to analyze the decision process from the viewpoint of the individual decision maker as he fits into the total perspective of the decision environment. The stages of analysis, elements, level of interpretation, and methods of interpretation compose the content of the schema. This content is broken down into four categories beginning with the process, moving on to the elements of the situation within the process, then moving to the level of the interpretation of the process, and finally, ending with the procedures which are utilized to interpret the elements within the process. The schema is, therefore, composed of stages, elements, levels and procedures.

The stages of the schema conceptually represent the direction of the decisional analysis in the decision making process. To the degree that the decision analysis is an accurate representation of the actual decision process, the stages represent the direction of the actual decision process. Three stages are identified: (1) recognition, (2) analysis, and (3) resolution. The decisional analysis begins with the recognition

of the process, moves to the analysis of the problem, and ends with the resolution of the problem. The actual decision process may not involve all three stages as separate stages. That is, there may be no distinction between stage 1 and stage 2 or between stage 2 and stage 3. The separation of the stages is for the purpose of clarification and analysis. Thus, to clarify what goes on in the actual decision process requires that the decisional analysis be separated into categories. In the case of the analysis of this paper, there are three categories, or stages. These stages represent the activities which the decision maker utilizes to make his decision. Thus, these stages may exist implicitly within the background of the decision maker's action or explicitly with the action itself. The key to analyzing the decision process in this manner is to make the decision maker "aware" of the direction and purpose of the analysis at different points within the decision process.

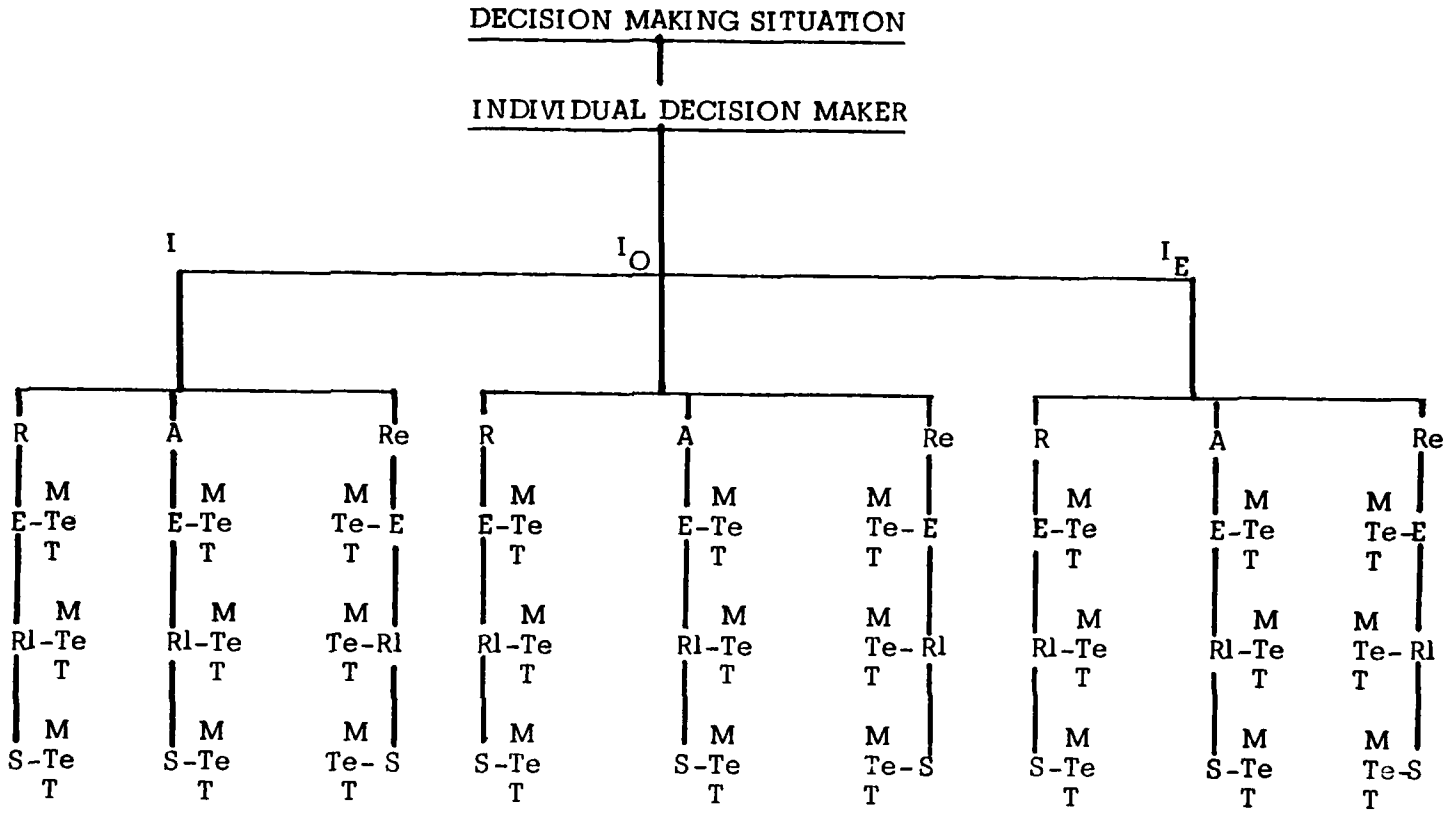
The decisional analysis progresses from the stages of the decision process to the elements of the decision situation. The survey of the literature in addition to an analysis of the decision situation indicated that there are three basic decision elements: (1) the individual, (2) the individual in relation to other individuals or to groups of individuals, and (3) the individual in relation to the physical environment. These elements reflect the IOE paradigm which resulted from the behavioral analysis of the decision situation. These elements are not totally separate classes. For example, a decision problem might involve an element which has both social and "other" implications. The purpose of

the schema is to provide representation of the elements in any combination. Thus, the schema allows for the involvement of one, any combination, or all three of the elements.

The three elements are interpreted on three levels: (1) the experiential, (2) the relational, and (3) the systemic. These three levels correspond to the three levels of interpretation of the model, (1) the physical, (2) the abstract, and (3) the symbolic. The levels of interpretation are performed through the utilization of three procedures, (1) the methods, (2) the techniques, and (3) the tools.[12] The three procedures may remain the same throughout the three stages of the decision process. Or with each stage, either one of the three or all three of the procedures may change. For example, the methods may remain the same for the whole process. However, the techniques and the tools may change with each stage. As an example of the application of these procedures, consider a problem in astronomy. Resolution of a decision problem with respect to an astronomical observation of a star could utilize the same procedures for the analysis of the decision process. In this case, the method would be direct observation, the techniques are the use of telescopes, and the tools are the actual telescopes themselves. This example is obviously a simple application of the procedures. The purpose of this example is simply to clarify what the procedures mean. The test of the three procedures, and of the whole schema, will be application to the actual command decision situation.

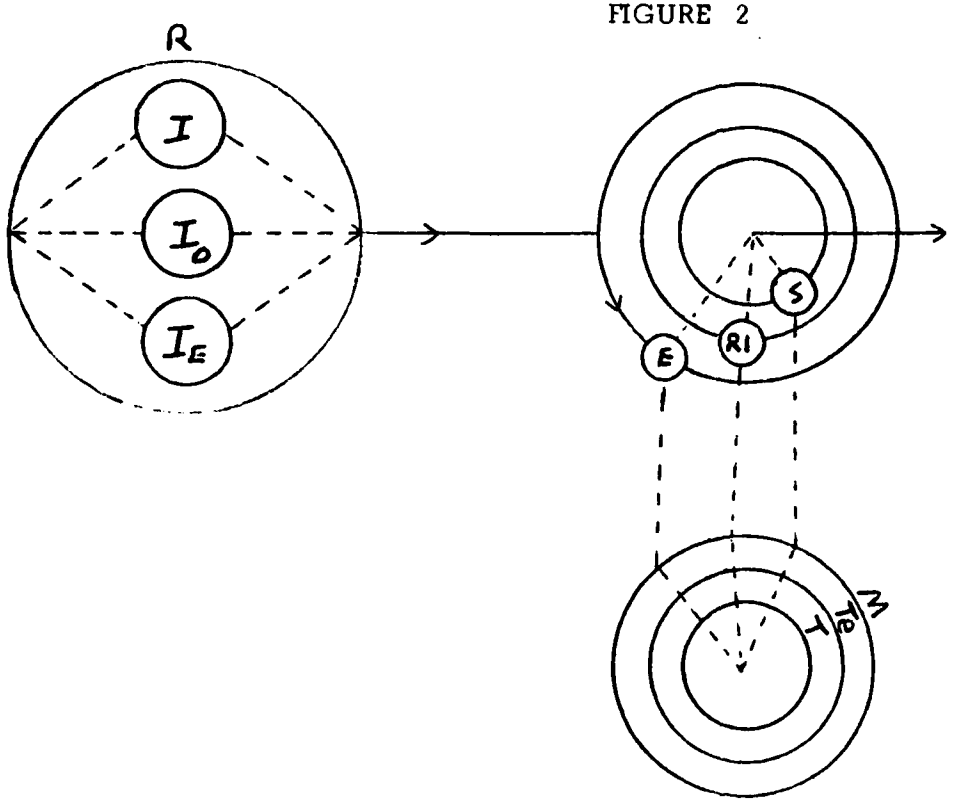
The schema is represented diagramatically in Figure 1. The key to the classification of the parts of the schema are as follows: (1) with respect to the elements, I refers to the individual decision maker, I_E refers to the individual in relation to the environment. and I_O refers to the individual in relation to other individuals or to groups of individuals; (2) with respect to the stages, R refers to the recognition stage, A refers to the analysis stage, and Re refers to the resolution stage; (3) with respect to the levels, E refers to the experiential level, R l refers to the relational level, and S refers to the systemic level; and (4) with respect to the procedures, M refers to the methods, Te refers to the techniques, and T refers to the tools. The focus of the diagram is the decision situation, thus, the perspective of the diagram is the three elements of the situation. The purpose of the diagram is to present a chart which will indicate the breakdown of the decisional analysis as the focus of the analysis shifts from the decision situation to the individual decision maker, to the elements of the situation interpreted from the perspective of the total environment, and then to the process of making the decision. The focus of the analysis within the process shifts to the levels of interpretation of the analysis and finally to the procedures which facilitate the interpretive analysis. The diagram is sufficient as a chart for the breakdown of the decisional analysis. However, a schematic diagram is needed to indicate how the parts of the schema fit within the decision making process and to indicate the direction of the flow of this analysis.

FIGURE 1


DECISION MAKING SITUATION
INDIVIDUAL DECISION MAKER
I
I_O
I_E
R
A
Re
M
E-Te
T
Rl-Te
S-Te
Te-E
Te-Rl
Te-S

A schematic diagram is presented in Figure 2 and Figure 3. The purpose of the diagram is to explore the relationship between the elements, levels, and procedures within the three stages of the decision process. A preliminary breakdown of the schematic chart is given in Figure 2. This preliminary breakdown focuses on the relation of one stage, the recognition stage, to the levels of interpretation and to the procedures of interpretation. The purpose of the preliminary chart is to aid in understanding the total diagram. An analysis of the preliminary chart shows that circles are used to indicate the stages, elements, levels, and procedures. The three elements are represented inside the circles which indicate the stage of the process. The three levels of interpretation are placed in concentric circles. The outer circle refers to the experiential level, the next circle refers to the relational level, and the inner circle represents the systemic level. The three procedures are placed in concentric circles outside the stages and the levels. The outer circle represents the methods, the next circle represents the techniques, and the final circle represents the tools. Dotted lines extend from each element and converge at one point on the circumference of the circle representing the stage. Dotted lines indicate that the decision process may extend in either direction. For example, the process may extend out of an element and return back into the element if analysis indicates that this measure is necessary. Dotted lines also extend from the miniature circles along the lines of the circles which represent the levels of interpretation. These dotted

FIGURE 2



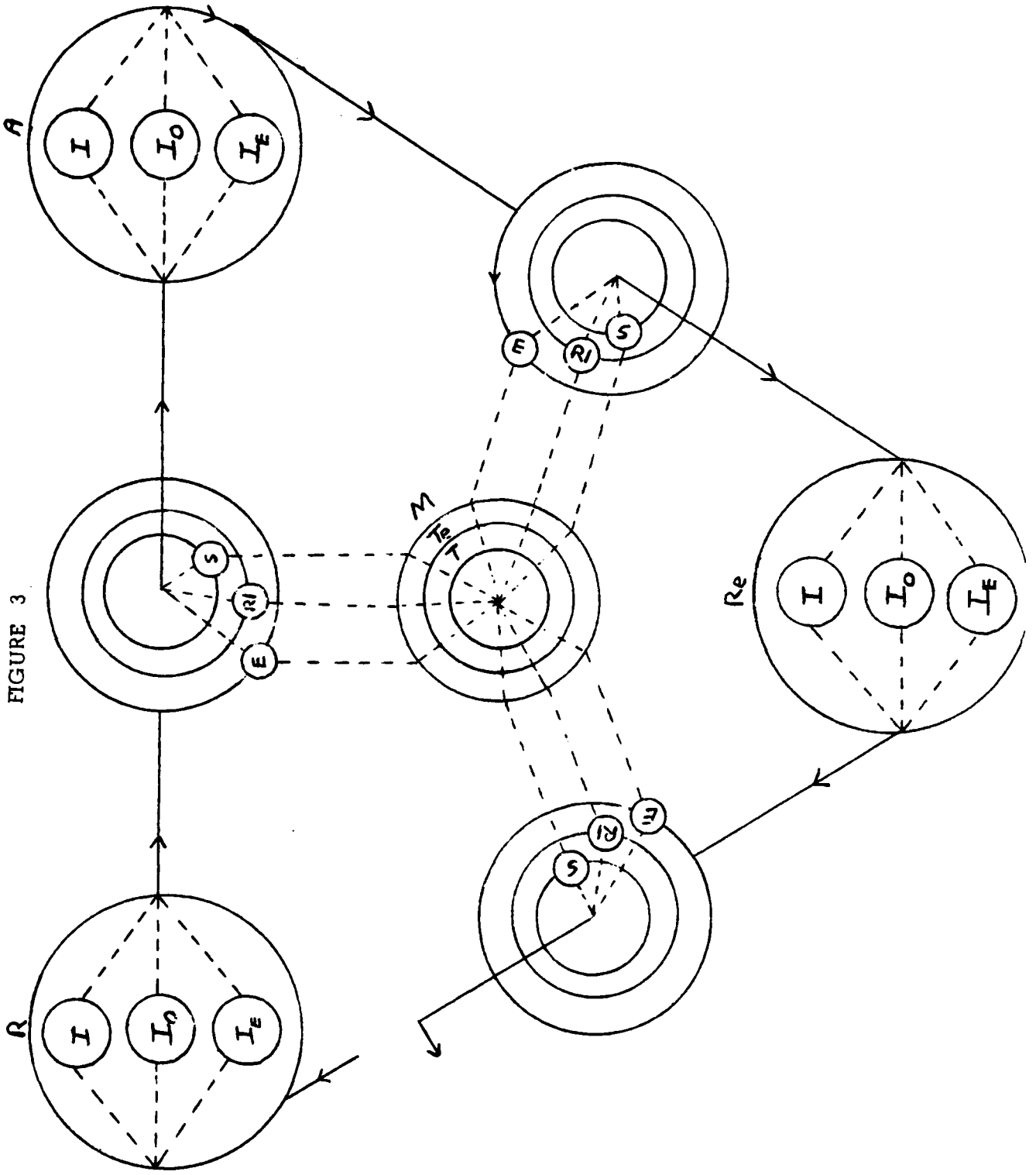


FIGURE 3

lines also indicate that the process may go in either direction. The miniature circles which represent the levels serve to allow passage of the process around one level or to indicate that one level has been collapsed into another. Solid lines indicate that the direction of the decision process extends from one stage to the next. The direction on the solid lines indicate where the process cannot be reversed. However, the solid lines do not mean that the process cannot be reversed or cut short. The placing of the procedure circles in the central position of the diagram will facilitate the reversible flow of the decision process. The centralized position of the procedures circles will be considered within the perspective of the total schematic diagram.

In the schematic diagram of Figure 3, the decision process begins with the analysis stage. The research purpose or the nature of the decision problem determines which element or combination of elements will be utilized. The process extends from each level of interpretation to the procedures which are utilized to facilitate the interpretation of the problem. The decision process may end at the recognition stage. That is, a sudden insight or hunch may solve the problem, i.e., resolve the decision. To indicate resolution prior to the resolution stage, the process must extend via the dotted lines of the procedures section around the circumference of the procedures circles, or from the center of the circles, if all three procedures are relevant, to the dotted lines which extend from the levels of interpretation of the resolution stage. The central importance of the procedures circles is, therefore, that they represent the pivotal point of the process. This central impor-

tance is reflected in two senses. Firstly, the same methods, techniques, and tools may be utilized in each stage of the process, or the same techniques (or even the same tools) may be utilized in each stage of the process. Secondly, the decision process may end at any point via a route through the procedures circles. The process extends through all three stages. If the decisional problem is not completely resolved; then, the process may begin again with the added information of the prior stages. Thus, on the schematic diagram, the possibility that the process may begin again is indicated by a solid line extending into the circumference of the recognition stage. Moreover, the level of the analysis may not be developed beyond the experiential interpretation. However, in some cases, it may include all three levels of interpretation.

The purpose of the schematic diagram is to provide a means of generating the possibilities of relations between elements and methods and the possibilities of the directions of the decisional process. To accomplish this aim, the diagram is constructed such that (1) at any point in the analysis, the process may end in a decision and (2) the process may utilize any three or all three of the elements, levels of interpretation, and procedures for interpretation. At this point, the schema is a proposal. Therefore, all of the possibilities of what the schema can reveal about decision making have not been investigated. Furthermore, the applicability of the schema has not been tested against the actual decision situation. The effectiveness of the tentative schema as a means

for generating the multiplicity of structure of the decision situation and of models representing the decision situations must wait for future research.

Although no application of the decision schema has been made, conceptual analysis does indicate what purposes the schema can serve if it is proved effective. The schema has the following applications in decisional analysis:

(1) The schema can be applied to a decision system or a decision environment in order to analyze the aspects, both logical and non-logical, of the system or environment.

(2) The schema can be applied to a specific problem to generate an analysis of the problem and a possible synthesis thus leading to a model for the interpretation of the problem.

(3) The schema can be applied to a decision environment in order to generate training objectives.

(4) The schema can be applied to a series of problems or situations in order to identify common ingredients.

(5) The schema can be used as a teaching aid to generate awareness of the theoretical aspects of decision making and awareness of the process of decision making.

The application of the tentative schema to decisional problems will verify these five purposes. If it is proved effective, the schema will be a major conceptual tool to be used in the construction of the decision model for the CATTS decision situation.

Remarks Concerning a Future Decision Model

The analysis of the concept "decision making" and the analysis of decision models provides the framework for the construction of a decision model. As a result of the research, procedures for avoiding the problems of prior decision models and plans for the construction of a model will be presented. The procedures serve as a heuristic device to guide future model contruction around the difficulties which plagued earlier models. The plans for the construction of a model will hopefully outline a pattern of research which will result in a decision model. The effectiveness of the steps, however, depend on the effectiveness of the three conceptual tools which have been presented in this paper, i.e., the Definitional Categories, the IOE Paradigm, and the Tentative Decision Schema. The effectiveness of these conceptual devices depend on their application to the actual decision environment. In the case of the research on ER-87, these devices will be applied to the CATTS Command Decision Situation.

The procedures for model development aim at two problems in decisional analysis: (1) the correlation of the model to the decision situation and (2) the universal applicability of decision models. These corrective procedures are:

(1) The theoretical foundations of the model will not reduce decision making to any one element of the decision situation.

(2) The direction of the research is toward a descriptive model which upon completion will have normative significance.

(3) The theoretical aspects of decision making will be identified and ordered using conceptual schemas which will serve as guidelines in the analysis of the actual situation.

(4) The model will not apply to any one particular type of decision situation.

(5) The model itself must have a multi-dimension character in order to incorporate theoretical soundness with total applicability.

The aim of the first measure is to reduce the complexity and confusion which resulted from the reductionistic character of traditional decision making definitions. The second measure identifies the nature of the model. The aim of the third measure is to insure that the total intension of the decision making concept has been analyzed and properly interpreted. The aim of the fourth measure is to insure that the model has universal application. And, the aim of the fifth measure is to insure that all levels of interpretation of the model will be explored. These measures will hopefully increase the logical soundness of the model and insure that the model is applicable to the actual decision situation.

The plan for construction of a future decision model applicable to the CATTS decision situation incorporates two methods: (1) the method of analysis and (2) the method of synthesis. These two methods provided the background for the exploratory research; and as these methods are explicated in terms of devices for model construction, they provide the frame for the application of the exploratory research. This plan is formulated in the following steps (the plan proposed here is in terms of the command decision environment).

Step 1. Utilize the definitional categories to analyze the intensional properties of the command decision situation.

Step 2. Utilize the behavioral paradigm to analyze and categorize the behavioral aspects of the command decision situation.

Step 3. Utilize the tentative schema to analyze and categorize the basic theoretical elements of the command situation.

Step 4. Validate the soundness of the theoretical interpretation provided by the tentative schema.

Step 5. Test the validity of the correlation between the decisional structure which results from the tentative schema with the actual command decision situation. (In other words, test the applicability of the structure.)

Step 6. Synthesize the analytical structure of Step 5 into a model which mirrors the actual structure of the decision situation.

Step 7. Test the effectiveness of the model by experimentation.

The future research which stems from this exploratory study will test the effectiveness of these conceptual devices for model construction. Moreover, this research will test the effectiveness of methods which seek to identify the order in the decisional process and to synthesize this "order" into a model which accurately portrays the actual process. The test of the conceptual devices is, therefore, a test of the basic problem of decision theory, i.e., to accurately portray the multiplicity and complexity

of decision making. The overall goal of this study was to reveal this multiplicity and complexity and to suggest that order can be discovered within the diversity and that this order can be conceptually represented in a model.

References

1. Bross, I., Design for Decision, New York: McMillan Company, 1953. (Also, this section was influenced by Donald Taylor, Decision Making and Problem Solving, Yale University, September 1963 and Donald Davidson and Patrick Suppes.)

2. Davis, Robert L., "Introduction to 'Decision Processes'", In Decision Processes, Thrall, R. M., et al (eds), New York: John Wiley and Sons, Inc., 1954.

3. Coombs, C. H., et al, "Some Views on Mathematical Models and Measurement", In Decision Processes, Thrall, R. M., et al (eds), New York: John Wiley and Sons, Inc., 1954.

4. Ibid.

5. Hendrickson, Robert G., Pros and Cons of War Gaming and Simulation, Technical Paper RAC (ORO)-TP-49, Research Analysis Corporation, Bethesda, Maryland, October 1961.

6. Schrenk, L. P., "Aiding the Decision Maker - A Decision Process Model", Ergonomics, 1969, 12 (4), 543-557.

7. Wilson, Charles Z. and Alexis, Marcus, "Basic Frameworks for Decisions", J. of the Academy of Mangement, 1960, Volume 5, 150-164.

8. Bross, I., Design for Decision.

9. Ibid.

10. Hendrickson, Robert G., Pros and Cons of War Gaming and Simulation.

11. Schrenk, L. P., "Aiding the Decision Maker - A Decision Process Model".

12. Ackoff, Russell L., Scientific Method: Optimizing Applied Research Decisions, New York: Wiley and Sons, 1962.

DIRECTION AND APPLICATIONS OF FUTURE RESEARCH

DIRECTION AND APPLICATION OF FUTURE RESEARCH

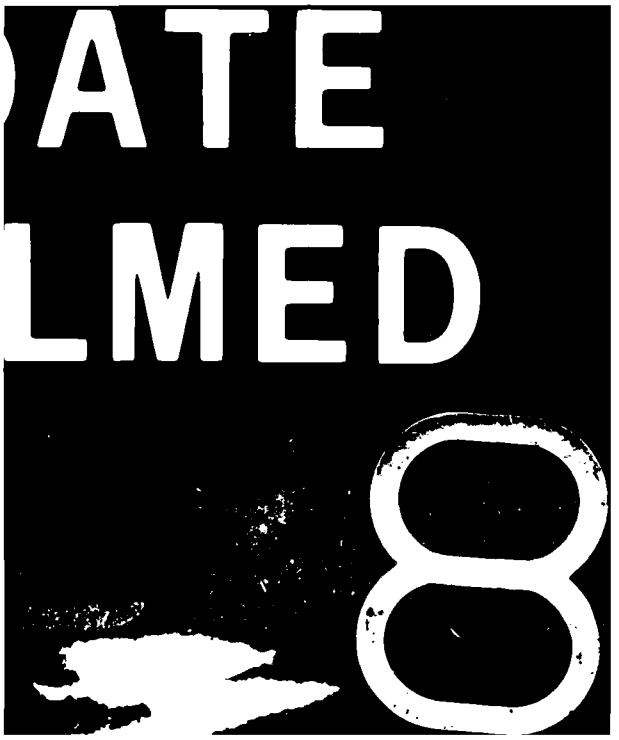
The overall goal of the exploratory research on decision making was to create (develop, identify, determine, etc.) a decision making model which would be applicable to the actual (CATTS) decision making situation. The achievement of this goal will play a major role in future research. One purpose of the literature survey was to identify the factors and elements of the decision situation and examine the logical conditions for the development of models which apply to decision situations. This approach resulted in the development of decisional categories, development of the IOE paradigm, and development of the tentative decision making schema or shell. During future research, our interest will turn from an analysis of the formal and empirical elements of decision situations to an application of these elements to command decision situations of the Army via the CATTS project.

It is during this application stage that the IOE paradigm and the tentative decision making schema will be tested and hopefully validated, via the CATTS project, ultimately resulting in the development of the actual decision making model. An analysis of decision making skills required in command and control situations is an essential part of the testing and validating procedure. It will be necessary to determine if those elements contained in the IOE paradigm are a part of, or influence, the decision making processes utilized in the CATTS situation and if so, how they com-

bine with decision making skills in command and control situations to form the decision making model.

While the final decision making model will have direct applicability to the CATTS situation, it is hoped that a model that has applicability to decision making situations in general will be produced, therefore, enabling other organizations along with the military to profit from its development.

The goal of Work Unit DECIDE is not limited to the development of a decision making model which is logically sound and applicable to the CATTS decision situation. Just as important will be the development of task inventories, performance objectives, and performance standards for those personnel who are to be trained with the CATTS device resulting in training procedures that can be used to increase decision making skills through the use of command and control simulators. Those components that have impact on training objectives, such as leadership and organizational effectiveness, tactics, communications, etc., will have to be identified and studied in order to provide basic information useful for wide application in command and control simulation efforts. The direction and application of future research will be the focus of a new research paper. The new research paper will follow this literature survey of decision making.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