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DECISION THEORY RESEARCH

DECISIONS AND DESIGNS INCORPORATED

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ADVANCED DECISION TECHNOLOGY PROGRAM

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The objective of the Advanced Decision Technology Program is to develop and transfer to users in the Department of Defense advanced management technologies for decision making. These technologies are based upon research in the areas of decision analysis, the behavioral sciences and interactive computer graphics. The program is sponsored by the Human Resources Research Office of the Defense Advanced Research Projects Agency and technical progress is monitored by the Office of Naval Research – Engineering Psychology Programs. Participants in the program are:

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DECISION THEORY RESEARCH

by

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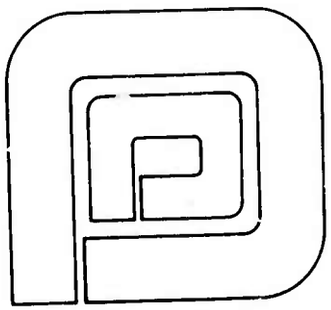

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DECISION THEORY RESEARCH

1.0 INTRODUCTION

The purpose of this report is to provide abstracts with suitable references reflecting significant accomplishments in each of nine decision theory research areas during the period October 1, 1972, through June 30, 1975. To this end, frequent references are made to four technical progress reports published by Decisions and Designs, Incorporated (DDI) during the foregoing period which more fully report the results of this research. For convenience and brevity, references throughout this report to any one of these four technical reports will be parenthetical, indicating volume number in Roman numerals, and section and sub-section numbers in Arabic numerals; e.g., (I, 3.2) refers to Technical Report Number I, Section 3, Sub-Section 2. A full description of these technical reports is provided in the Bibliography. Additional references are also identified in the text and fully described in the Bibliography.

The research reflected in this report had four primary tasks; namely, to

Task 1: Investigate procedures for improving human judgments of probabilities and utilities for decision-making;

Task 2: Conduct problem-oriented workshops for Department of Defense (DoD) personnel in which the potential value of decision analysis techniques is displayed to decision-makers by showing them how these techniques can be applied to real problems;

Task 3: Prepare a handbook on decision analysis designed for the manager or staff responsible for organizing and managing a decision analysis, rather than for the decision-analytic technician; and

Task 4: Conduct research on decision analysis procedures in connection with current intelligence analysis and with scientific and technical intelligence analysis in co-operation with the Defense Intelligence Agency (DIA) and the Naval Intelligence Support Center (NISC).

2.0 ASSESSMENT AND FORECASTING

This category of research includes the problem of assessing and expressing uncertainty, training and evaluating analysts in assessing probabilities, and developing techniques for modeling the current state of affairs, and forecasting the likelihood of future events.

2.1 Training Analysts in Probability Assessments and Techniques of Probability Analysis

Two experiments on probability assessment were conducted in 1972 at the Defense Intelligence School of the DIA using approximately one hundred student analysts as subjects. One experiment was designed to evaluate, in a static situation, whether odds are more extreme than probabilities, when individuals assess likelihood and also whether the odds mode is more accurate. The second experiment evaluated the relative merits of two different response modes that could be used for assessing the probability of events that lie along a continuum. Examples of continua used in intelligence estimates are the speed of an aircraft, the range of a missile, and the number of personnel in a division. (I, 1.2.3 and I, 2.3, and also References 11.2.2.12 and 11.2.2.13 in the Bibliography)

This early work led to a program to train analysts assigned to a division of the DIA in the use of probability assessments. (I, 2.3) After they were trained and had become experienced in probability assessments, data were collected for an 18-month analysis period to see how accurately the analysts were performing. The correlation between what the analysts estimated and what events actually occurred was exceedingly high and demonstrated that properly trained analysts can become highly proficient in assessing numerical probabilities. (II, 5.1.2)

Additional work with probability assessments led to the development of interactive computer programs to assist and train analysts. One program implements a proper scoring rule tool for calibrating analysts who assess probabilities and another implements a method for directly assessing probabilities of events that lie along a continuum. (V, 5.2, and also Reference 11.2.2.1 in the Bibliography)

Intelligence "order of battle" problems require rules and methods for obtaining and combining distributions. Research shows that intuitive approaches to target distributions are often inaccurate. A model reflecting this research is being developed for intelligence analysts to use in assessing uncertainty associated with personnel strength estimates.

2.2 Examples of Intelligence Assessments and Reports

Working with intelligence analysts in the Central Intelligence Agency (CIA) and the DIA, DDI personnel conducted a series of case studies involving actual intelligence analysis problems. These case studies, some of which are described below, illustrate the use of personal probabilities, both to quantify opinions of uncertainty and to describe linkages among data, events, and indicators and the hypotheses of interest. This work made it possible for analysts to construct quantitative models of their problems and to communicate their perceptions of the problems to others.

2.2.1 The Cyprus analysis - This analysis had two principal objectives: to present an analysis of the political situation on Cyprus and to display the analysis to the user in such a way as to provide a justification for the results. Employing probability diagrams and a Markov model, the analysis developed a specific probability and associated rationale for the hypothesis that there would be widespread hostilities during the next six months. (II, 2.2.2, and also Reference 11.2.1.1 in the Bibliography)

2.2.2 The Sino-Soviet border analysis - This analysis hypothesizes a number of attack scenarios and structures the relationships among such factors as the build-up of forces, political factors (internal and external), and border incidents, and each of six explicitly stated hypotheses concerning conflict between the two nations. Personal probabilities reflecting the state of knowledge of different specialists are generated by using structured procedures to encode the expert judgement of analysts and groups of analysts. (Reference 11.2.1.2 in the Bibliography)

2.2.3 The North Vietnamese (NVN) analysis - This analysis, which involved weekly forecasts, charted the impact of incoming evidence in the form of a numerical likelihood ratio that measured the degree to which a particular hypothesis concerning an NVN attack was favored. In this analysis, intelligence personnel learned to display the impact of new data on the prior odds through the use of a "log odds" chart. Working with analysts who had no previous experience in Bayesian techniques, DDI personnel confirmed the fact that the log odds procedure provided a viable approach for training analysts to assess likelihood ratios. (II, 5.1 and III, 5.1, and also Reference 11.2.1.7 in the Bibliography)

2.2.4 Other intelligence analysis projects - In the case of many complex, technical intelligence inference problems, it is unlikely that any one individual has the necessary experience to relate all of the detailed data concerning a nation's research and development programs to upper-level hypotheses. To solve this problem, a number of

complex technical assessments were decomposed along hierarchical lines so that each expert could apply his knowledge in a logically consistent manner. These hierarchical structures reflect the conceptual model that the intelligence analyst has of his problem. One of the studies evaluates the intent of a country to develop an independent nuclear weapons capability, and another evaluates a particular country's program to develop an advanced anti-submarine warfare capability. (References 11.2.2.10 and 11.2.1.3 in the Bibliography) Additional research performed on structuring inductive inference problems and linking data to hypotheses of interest has also been described. (References 11.2.2.4, 11.2.2.5, and 11.2.2.11 in the Bibliography)

2.3 Estimating the NATO Response to an Impending Attack

In this analysis, a rational decision analysis model was developed to provide military planners with new descriptive insights into the NATO decision process in the face of an impending Warsaw Pact attack. This project involved a quantitative model of the dynamic decision-making processes of the Supreme Allied Commander, Europe (SACEUR). The output of the model was an indication of a point in time when SACEUR would opt for NATO mobilization. The study provided a sound rationale for the estimated NATO delay and identified important areas for further research, most notably the modeling of bureaucratic decision processes. (IV, 3.3, and also Reference 11.2.2.6 in the Bibliography)

3.0 THE EVALUATION OF ALTERNATIVE SOLUTIONS

The major problem of evaluation is to assign a meaningful measure of benefit to alternatives. Procedures are needed for the development and application of scenarios and for going from broad goals to the specification of requirements and the selection of systems. This research led to the development of procedures that can be used to translate technical considerations into meaningful measures of user-oriented worth.

3.1 Operational Test and Evaluation (OT&E)

Design to cost procurement policies often require OT&E personnel to decide whether prototype testing is necessary to determine the acceptability of a proposed system and, if so, how much testing and whether or not subsequent testing is required before procurement, due to modifications which resulted from the initial testing. Such a complex decision has been systematized by a decision analytical model which incorporates a hierarchical evaluating mechanism within the framework of a value-of-information analytical model. A case study for the Commander, Naval Operational Test and Evaluation Force (OPTEVFOR) which explained the rationale for this decision analytical model was followed by a pilot project evaluating the suitability of the methodology for a specific weapon system (II, 2.2.4)

3.2 Allocation of Decision Analysis Resources

A system has been developed for allocating funds and evaluating proposals not only for decision analysis research, but also more generally for research in many other disciplines. The system divides the areas of research topically, establishes a standard allocation of resources and a corresponding benefit, and then varies the allocations to determine the changes in benefit along a "response curve". A computer program has been developed which permits specific evaluations and sensitivity analyses of research proposals in terms of the allocations of program funds. (III, 2.1 and IV, 3.7, and also Reference 11.2.2.7 in the Bibliography)

3.3 Design to Cost Contractor Selection

A multi-attribute utility model was developed to quantify user preferences and relate those preferences to technical system characteristics in the design to cost competitive acquisition of an Electronic Warfare (EW) Suite. The evaluation model was structured to decompose high-level operational requirements into more detailed performance requirements and to relate these to the degree of technical performance

proposed by each of the contractors. The results of operating the model in an iterative mode were used to select the most promising approaches and to reduce the number of contractors selected to build prototype EW systems to two.

4.0 POLICY FORMULATION AND IMPLEMENTATION

The policy analyst charged with making national policy recommendations is required to review a wide range of uncertain factors, examine costs and benefits, and choose among alternative courses of actions. Research conducted by DDI developed structured approaches that clarified reasoning and simplified presentation by using quantified decision models. Policy-making becomes more manageable for analyst and decision maker alike since all assumptions and judgments are made explicit, can be readily examined, and, if necessary, re-evaluated and revised.

4.1 Evaluating Foreign Policy Alternatives for A Mideast Oil Producer

Negotiating strategies to ensure a continuing and expanding supply of oil from a Mideast oil-producing country concerned staff members of the National Security Council (NSC). DDI developed a formal structure for incorporating data from economic, Mideast, oil, and CIA experts. Analysis of the problem led to an initial model for evaluating three quite different negotiating strategies. The first was a "base" option requiring no change in present U.S. policies toward the Mideast. The second was an extreme option requiring a radical change in current U.S. policies to accommodate the interests of the oil-producing country in every way possible. The third was an intermediate option requiring some changes in present policies. The model incorporated not only these options, but also their consequences; four, in particular: 1) the effect on balance of payments; 2) the impact on U.S. relations with Europe and Japan; 3) the impact on U.S. relations with Israel and on U.S. pro-Israeli sentiment; and 4) the effect on other oil producers. This study indicated that concern over the supply of oil required a change in present U.S. policy, but that an unfavorable impact on Allied relations and pro-Israel sentiment made the less extreme option more attractive to policy makers. A classified technical report (Reference 11.2.1.6 in the Bibliography) highlights a new technique for simplifying prediction of interrelated continuous variables. An unclassified version of this report was presented at the Decision Analysts' Conference in 1973 and during numerous briefings, such as one for the Senior Seminar at the Foreign Affairs Institute, have been given. (IV, 3.1)

4.2 Export Controls on Sales of Computers to the Soviet Bloc

The level of embargo that should be established for computers sold to the Soviet Bloc concerned the Assistant to the President on National Security Affairs. At his direction,

the Council on International Economic Policy (CIEP) directed an extensive study of this issue. At its conclusion, DDI developed a decision analytical model to help organize the accumulated data and expertise and to relate them to options available to the countries represented on the Coordinating Committee (COCOM). DDI researchers then elicited expert judgments in quantitative form from the business, intelligence, and policy-making communities on six representative options. The decision analytical model utilized these judgments to arrive at an expected value for each policy option, defined in terms of the relative ease of Soviet access to various levels of Western commerical computer equipment and technology. The various levels ranged from present policy, which generally limited "easy access", to those reflecting an extreme change of policy removing nearly all restrictions on access by the Soviet Bloc. The value to the U.S. of each option was based on four considerations; namely, 1) potential gains for Soviet Bloc trade; 2) COCOM response; 3) other economic, political, and technological gains or losses; and 4) the military threat to national security. The most highly valued option was an intermediate option allowing some relaxation of restrictions. Although the ordinal ranking of the values of the six options was not significantly affected by varying the data and expertise, the small differences in values among the options suggest that other options, such as a total embargo, are more critical to the U.S. The option recommended on the basis of utilizing the decision analytical model was consistent with, and apparently influenced, the ultimate CIEP recommendations to the President. A classified technical report addresses the methods used in dealing successfully with divers expertise and the implications of that expertise with respect to policy. (IV, 3.2 and also Reference 11.2.1.4 in the Bibliography)

5.0 VALUE-OF-INFORMATION PROBLEMS

Research in this area focused primarily on the problem of allocating resources for the collection of intelligence information. The technical approach was based upon a principle of decision theory which states that it is worthwhile to buy (collect) information only if it serves to change behavior, and that the value of the information is the difference between the expected values of the old and new behaviors. Some of the specific decision analytic techniques developed and applied to a variety of value-of-information problems are described below. The ultimate objective is to improve the utility of information collected and analyzed as part of the national decision-making process. (I, 1.2.2, and IV, 4.3)

5.1 Evaluating Reconnaissance Vehicles

This evaluation was designed to establish a functional relationship between the intelligence value of a given collection platform and the number of collection hours flown per month. The analysis was performed with DIA analysts and was based on the premise that information has value to the extent that it satisfies an important and valid intelligence production requirement. The analysis displayed the number of hours for which the value-to-cost ratio was greatest and least, and for which the number of hours flown, if doubled, would yield seven times the previous value of intelligence collected. The study also included a number of techinques for evaluating individual reconnaissance reports. (II, 2.2.3)

5.2 Evaluating Levels of Collection Effort

This evaluation resulted in the development of a decision diagram structuring an evacuation problem that could arise if hostilities broke out between Greek and Turkish Cypriots. The problem was whether or not gathering new information about the situation (and, if so, how much) would significantly improve decisions with regard to the evacuation of personnel. As part of the analysis, a perfect information model was constructed, and the output (a value expressed in dollars for perfect information about what will happen) placed an upper limit on expenses for increased collection of information. The results indicated that the cost of an increased collection effort for this scenario, even if it produced a perfect report, should not exceed $360,000. (II, 2.2.2, and also Reference 11.2.1.1 in the Bibliography)

5.3 Allocation of Intelligence Resources

The allocation of intelligence resources is based on the sequential judgments of expert budget and programming personnel at various levels within and among departments and agencies until the allocation is finally approved by the Executive and Legislative Branches. In general, the examination of alternative allocations during the normal budget cycle is made without a cost-to-benefit analysis.

This analysis described the national decision-making process in terms of the most important decisions that senior officials have to make and calculated the value of good intelligence in making those decisions. The model consists of standard decision-analytic procedures modified in a few important respects. For example, the model accounts for the fact that a decision-maker may act less on the basis of an accurate intelligence forecast than on the basis of political or budgetary considerations.

During the study, a workshop was conducted with analysts from DIA who were experts in both the collection and production areas of intelligence. Their inputs were important, since the model makes it possible to examine how changes in the mix of collection systems directly affect the quality of the finished intelligence product. Results from the model are expressed in terms of the expected dollar benefit of a good decision that results from having timely and accurate intelligence. Refinements also make it possible to compare the value of individual collection systems in terms of their respective cost-to-benefit ratios. (III,2.1)

5.4 Defense Attaché System Analysis

This case study involved an analysis of the impact on intelligence of changes in the budget of the Defense Attaché System. The problem was to assess the value of the information collected by each overseas attaché office and to relate it to the known cost of that office.

In order to obtain assessments of the importance of each country where an attaché office was located and of the value of different types of information obtainable in each country, a "boot-strapping" procedure was used. Intelligence and research analysts established the relative importance of each of several major areas of the world and the relative importance of countries within these areas. Multiple linear regression analysis was then used to obtain weights, and the fitted weights were used to generate a new set of values for each country. Once these values were obtained, they were weighted by the probability that the desired information would develop within the country and the probability that the attaché in the normal course of his duties would be in a position to collect and report it.

Results of the analysis revealed several high-value offices that cost very little and some low-value offices that were relatively expensive. The analysis also drew attention to less productive offices which management then examined in terms of other possible representational and political benefits that they contributed to the attache system. (II, 2.2.1)

5.5 Defense Intelligence Agency Intelligence Requirements Analysis

The collection of intelligence--always important, but also expensive--poses the following difficult question: What is the value of acquiring information beyond that already available? A corollary question is whether the value of acquiring additional information justifies the expenditure of funds and at what levels. The decision-maker often does not realize that, in making a particular decision, the difference between available and even perfect information is, in fact, a small one. Moreover, his uncertainty about the information that he does not have and about its value often exceeds the likelihood that such information would alter any decision he might make on the basis of presently available information. An on-going project has developed decision models to improve the identification of these differences and the evaluation of their impact on the decision-making process. Emphasis in these models is on the methods of identifying the decision-maker's needs in terms of the value of the intelligence to him. (IV, 4.3 and also References 11.2.1.5 and 11.2.2.9 in the Bibliography)

6.0 UTILITY ANALYSIS IN TREATY NEGOTIATIONS

Many believe that an issue-by-issue negotiation strategy on treaties dealing with complex international problems can result in nations concluding sub-optimal agreements. As an alternative, the application of utility analysis to negotiation problems permits simultaneous consideration of all issues in order to determine which of the possible treaties would result in each party's conceding least on the objectives it values the most. This research demonstrates how multi-attribute utilities make it possible to consider trade-offs among the issues and to reduce the sets of all possible outcomes to the Pareto-optimal set. (III, 2.2)

6.1 Arms Treaty Negotiations

A multi-attribute utility model was developed to handle the attributes of strategic weapon systems and related issues in negotiations. A major problem for analysis was whether or not the operational and technical characteristics of offensive and defensive systems equated to damage-causing and damage-limiting potential were adequate as determinants of utility. A preliminary conclusion is that more knowledge is needed with respect to how nations perceive the strategic balance and to its effect on utility. Two workshops were conducted which addressed perceptions of the military balance. (See Section 10.0)

6.2 Panama Treaty Negotiations

Since an issue-by-issue negotiating strategy often founders (or flounders) on legal and ethical-historical matters, intelligence analysts supporting the U.S. teams negotiating a new canal treaty with Panama proposed a better strategy. Moreover, on the assumption that a treaty has a better chance of winning acceptance and continuing compliance with its provisions if its value is maximized for both parties, a multi-attribute utility model was constructed. This model relates the separate utilities of each issue, weights the importance of each issue, and arrives at a Paretian optimal boundary which defines the maximum joint utilities of various possible treaties. Since the aggregate joint utilities are composed of the complementary utilities for both parties, a point which marks equal and unequal) utilities for both parties can be readily identified.

By distinguishing legal and ethical-historical matters from the utilities for the issues, the model helps negotiators avoid snags and reiterations in the negotiating process. For instance, although the present treaty gives the U.S. canal rights in perpetuity, the real utility of the duration

of the treaty is 100% for a period of no less than 50 years. However, since the utility over lesser periods declines gradually, it is possible to realize some benefits in terms of the duration of these rights for increased utilities of other issues. A multi-attribute utility model permits such trade-offs so as to assure each party that it will attain maximum realizable value. This study has served as a valuable tool for U.S. negotiating teams in formulating U.S. policies and has been accepted by senior authorities. New studies are being conducted to develop multi-attribute utility models for multi-national negotiations. (II, 2.1.1, and also References 11.2.1.8 and 11.2.1.9 in the Bibliography)

7.0 BASIC RESEARCH

Because decision analysis depends upon theoretical research undertaken in many fields, such as psychology, mathematical logic, systems analysis, and organizational behavior, further research must be conducted to make the findings in those fields applicable to Department of Defense (DoD) problems.

7.1 Multi-Attribute Utility (MAU) Analysis

Decision analysts have many options when faced with the problem of analyzing decisions whose consequences may be evaluated by multiple criteria. Research has helped clarify these options and provided guidance on when they should be exercised. Research began with a survey of the literature in the field and was continued with a systematic review of options for assigning values to multi-attributed objectives. Each analytical option was evaluated in the context of a limited number of problems in the areas of defense, foreign policy, and business. (Reference 11.2.2.3 in the Bibliography)

An initial finding of the foregoing study was that reference gambles to evaluate utility functions are not so promising as a direct rating procedure. Another finding indicated that the complexity of the utility scale is related to the length of time over which events are modeled; a short-time horizon typically involves complex MAU scales and a long-time horizon simple MAU scales. Conversely, in these instances, the probability relationships are simple and complex, respectively. Other findings indicated that certain problems with lists of dimensions combined by a formula (i.e., weighted sum) may be reduced by holistic assessment of undecomposed consequences and that precise definitions of individual scales and certain evaluation techniques require further study (IV, 2.1)

7.2 Modeling Subsequent Acts for Decision Analysis

Although standard decision theory operates on the assumption that acts subsequent to the initial choice are predictable, conditonal on explicitly modeled uncertainties, this assumption often distorts the evaluation of initial options, typically by undervaluing information-seeking strategies. A study attempted to avoid these difficulties by:

- Treating subsequent acts as events with probabilities based on partial information, or

- Not modeling them explicitly, but conditioning terminal events or value probabilities directly on partial information. (IV, 2.2 and also Reference 11.2.2.2 of the Bibliography)

7.3 Cross-Cultural Study of Uncertainty

A study to achieve better understanding of cross-cultural differences in the perception of probability aimed to identify those inter-personal differences that are based on culture and those that are not, and to explore the psychological mechanisms related to those differences. The study includes a review of the literature, discussions with experts, observational and clinical studies, development of measuring instruments using interactive computer graphics, formal experiments, reporting and feedback. (IV, 2.3)

7.4 Unilateral Disclosure

Because negotiating parties are uncertain about what information should and should not be divulged, the problem is to develop strategies for effectively witholding or disclosing information. The study undertook to categorize various negotiation conflicts in terms of their game-theoretic aspects and, within each category, to develop appropriate rules. The target of this research is the formulation of strategy for international negotiations and is based on a review of the literature, analysis of case studies, and a theoretical formulation and analysis of theories of games and decisions. (IV, 2.4)

8.0 INTERACTIVE COMPUTER GRAPHICS

Prospective users of new analytical techniques tend to consider their introduction into operational environments both unduly complex and time-consuming. Even when adapted to on-going undertakings, the departure of analysts experienced with the new techniques too often means a loss of expertise, which initially requires a repetition of the training process for their replacements. To facilitate the adaptation, training, and retention of expertise without loss of time, interactive graphic computers can be programmed to promote efficient operational use. Programs for structuring problems and making alternative computations have been developed and demonstrated.

8.1 General Tool Development

In the absence of any studies which categorize computer programs with respect to computational aspects of decision analysis problems, DDI undertook a study with the objectives of:

- Producing a guide for decision analysts wishing to use available computer programs.
- Providing an overview of the state-of-the-art computer applications of decision analysis techniques (Reference 11.2.2.14 in the Bibliography)

A technical report described each existing program and identified those representing the current state of the art. (Reference 11.2.2.1 in the Bibliography) The report also identified important areas of future technological improvements.

Two programs are concerned with probability assessments of categorical events, or events on a continuum. One interactive program involves a proper scoring rule tool for calibrating analysts engaged in assessing categorical events. Another program implements a method of directly assessing the probabilities of events lying along a continuum. Both involve computer feedback for faster and more meaningful results with CTREE--a general-purpose computer programming language for handling decision trees and similar structures. Moreover, in employing CTREE for the analysis of complex problems concerning the values to be placed on various kinds of intelligence, DDI is collaborating with Stanford Research Institute (SRI) to develop a method of automatically generating and analyzing decision diagrams by specifying an influence diagram. (IV, 5.1 and IV, 5.3)

A third program on the direct assessment of continuous probabilities involved the use of an interactive graphic computer program. (Reference 11.2.2.1 in the Bibliography) Previous research indicated that individuals more readily judge the point at which they are indifferent between two quantities than judge the relative magnitude of the two. Thus, rather than assessing the probability of an interval of the continuum directly, the analyst divides the continuum into two, three, or four intervals so that the probabilities of each are equal. The problem with sketching a cumulative probability distribution on graph paper is that the time involved delays feedback to the analyst. However, an interactive graphic computer program can provide far quicker feedback. By estimating tri-sections, quadri-sections, and credible intervals, the analyst can develop a graph representing the direct assessment of continuous probabilities. (II, 2.3.1)

8.2 Strategic Systems Analysis Technology

The decision-maker and analyst are often required to evaluate the effects of alternative assessments which may vary over a considerable range. The defensive and offensive capabilities of strategic weapon systems pose a multi-attribute problem in assessment--the analysis of which is greatly facilitated by using an interactive graphic computer.

In this application, the analyst operating the graphic display can vary the technical parameters of the strategic weapon systems belonging to one or both nations and note the overall impact upon their relative strengths. (Reference 11.2.2.1 in the Bibliography) This technique includes the capability to vary probabilities for offensive and defensive technical improvements and thereby provides assessments useful in establishing credibility over any desired distributions. The related development of a "virtual table" component facilitates programming, updating and display; it does so, in part, by reducing the programming effort by 90%. (IV, 5.2)

9.0 HANDBOOK FOR DECISION ANALYSIS

Although it is now winning recognition as a useful tool in dealing with a wide-ranging variety of management problems, decision analysis was for many years a fairly esoteric field of study. As a new and theoretical field, its development was piecemeal, its findings were scattered throughout a number of highly specialized journals, and its applicability was limited. Out of this disarray has emerged a well-integrated normative theory about the decision-making process which has permitted its increasing application to various kinds of problems. The coherence of the theory and its accumulated applications to military, and especially intelligence, problems have enabled the codification of its insights and techniques into a handbook serving the needs of military decision-makers.

A handbook designed for the decision-maker and his staff, rather than for decision analysts, was written, published, and widely distributed within the Defense Intelligence Community and other Government Agencies. The topics included in the handbook are, among others: decision tree models, assessment of value, utility analysis and attitude toward risk, probability assessments, Bayes Theorem, and the value of information. The handbook was used by the Defense Intelligence School in the training of intelligence specialists. It has also been used at the United States Air Force Academy in a course on management. Although a follow-up survey of users of the handbook indicates satisfaction with it, a revision incorporating recent developments and emphasizing even more strongly the applicability of decision analysis to a wide variety of problems, rather than the decision analytical techniques themselves, is being undertaken. (I, 1.2.5; I, 4.0; II, 4.0; III, 4.0; and IV, 7.0 and also Reference 11.2.2.8 in the Bibliography)

10.0 WORKSHOPS, BRIEFINGS, SEMINARS, AND CONFERENCES

Two workshops were held in November 1973 to introduce the methodology and application of decision theory--first to intelligence specialists and the second to budget and program personnel. Particular emphasis was placed upon the application of decision theory models to analyses of the:

- Effectiveness of strategic forces,
- Dependence of decision-making on intelligence information, and
- Relative cost of intelligence information to the intelligence needs of high-level decision-makers for improving strategic force effectiveness.

In January 1975, DDI conducted the second of two related workshops on the role of perceptions of the military balance in the DoD decision-making and planning processes. Although there was some divergence of opinion with respect to the degree to which something can/should be done about perceptions of the military balance in the decision-making and planning processes of DoD, there was also general concurrence that there is a need for additional research on the subject, and a number of likely areas were identified. There was also general concurrence on the need to develop an overview and general plan for making all of the perceptions-related research available to the senior decision-makers and planners in a form(s) that they can/will use.

Over thirty briefings, seminars, and conferences pertaining to decision analysis were conducted or attended during the period October 1, 1972, through June 30, 1975. Briefings on the methodology, applications, and results of decision analytic case studies were tailored to suit the needs and interests of various individuals and organizations, among which were the NSC staff, the Chairman of the CIEP, the Joint Chiefs of Staff (JCS), and the DIA staff. Seminars and conferences included, among others, the CIA Senior Seminar and the Defense Advanced Research Projects Agency (ARPA) summer study on Research Needs for Defense Decision Processes. The central focus of the latter seminar, to which DDI contributed on matters pertaining to decision theory, was upon developing through research, and then implementing, improved decision-making processes. A DDI review of a Soviet text on decision-making procedures reflects the Soviet belief that urgent improvements are needed in decision-making tools for the control of men and weapons. (I, 1.2.4; I, 3.0; II, 2.3.1; III, 2.3; III, 3.0; III, Appendix I; and IV, 6.3)

11.0 BIBLIOGRAPHY

This bibliography lists all documents referred to in the text of this report and categorizes them in three groups; namely, 1) the four technical reports by Decisions and Designs, Incorporated (DDI) on progress under Office of Naval Research (ONR) Contract N00014-73-C-0149; 2) unsigned reports listed alphabetically by title; and 3) signed reports listed by author.

The following abbreviations are used herein:

CIA - Central Intelligence Agency
CIEP - Council on International Economic Policy
ARPA - Defense Advanced Research Projects Agency
DDI - Decisions and Designs, Incorporated
DIA - Defense Intelligence Agency
ONR - Office of Naval Research
RADC - Rome Air Development Center

11.1 DDI Technical Reports under ARPA Order No. 2271 (7 August 1972).

11.1.1 [I] "First Quarterly Technical Report for Quarter ending 31 January 1973."

11.1.2 [II] "Technical Progress Report No. 2 for 1 February - 31 August 1973." (Classified)

11.1.3 [III] "Technical Progress Report No. 3 for 1 September 1973 - 28 February 1974."

11.1.4 [IV] "Technical Progress Report No. 4 for 1 March 1974 - 31 January 1975."

11.2 Technical Research, Studies, and Reports

11.2.1 Unsigned material

11.2.1.1 "An Appraisal of the Probability of an Outbreak of Hostilities on Cyprus, 1 November 1972 - 30 April 1973," Special Intelligence Project, for the Directorate of Intelligence DIA. (Classified)

11.2.1.2 "An Appraisal of the Probability of a Soviet Attack Across the Sino-Soviet Border, 1 November 1972 - 31 October 1973," Special Intelligence Project, for the Directorate of Intelligence, DIA. (Classified)

11.2.1.3 "A Bayesian Approach to Future Systems Assessment," CIA Scientific and Technical Intelligence Report (February 1974). (Classified)

11.2.1.4 "Computer Sale to the Soviet Bloc," DDI Technical Report 73-4 (October, 1973), to the CIEP. (Classified)

11.2.1.5 "Decision Analytic Assessment of the Value of Information," Part I, DDI Technical Report (August, 1975), for the Special Studies Branch, DIA, and ARPA. (Classified)

11.2.1.6 "Decision Theoretic Procedures for Intelligence," Section IV, RADC-TR-73-406 (February, 1974), for RADC. (Classified)

11.2.1.7 "An Intelligence Appraisal of the Probability of a General North Vietamese Military Offensive in South Vietnam, 1 March 1974 - 20 September 1974," Special Intelligence Project, for the Directorate of Intelligence, DIA. (Classified)

11.2.1.8 "Panama: 1973 - The Year of the Treaty?" (28 November 1972), for a CIA Directorate of Intelligence Memorandum. (Classified)

11.2.1.9 "The Panama Canal Negotiations - A Methodological Approach" (21 August 1974), a CIA Intelligence Report. (Classified)

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11.2.2.2 Brown, R. V., "Modeling Subsequent Acts for Decision Analysis," DDI Technical Report No. 75-1 (May 1975).

11.2.2.3 Brown, R. V. and Hatch, J. E., "Toward a Field-Tested Methodology for Multi-Attributed Decision Analysis, Part A - The Problem and Options," unpublished DDI paper (1974).

11.2.2.4 Kelly, C. W., III, and Barclay, S., "A General Bayesian Model for Hierarchical Inference," in Organization Behavior and Human Performance, Vol. 10, No. 3, (New York and London: Academic Press, December, 1973).

11.2.2.5 Kelly, C. W. III, and Barclay, S., "Improvement of Human Reliability Using Bayesian Hierarchical Inference," Proceedings of the 1974 Reliability and Maintainability Symposium, IEEE.

11.2.2.6 Kelly, C. W., III, Brown R. V., Stewart, R. R., and Ulvila, J. W., "The Timeliness of NATO Response to and Impending Warsaw Pact Attack," DDI Technical Report 74-1 (August 1974).

11.2.2.7 Peterson, C. R., Brown, R. V., and Gustafson, D., "Allocation of Decision Analysis Resources," DDI Technical Report 75-3 (c. January, 1976) for ARPA.

11.2.2.8 Peterson C. R., Kelly, C. W., III, Barclay, S., Brown, R. V., and Hazard, T. H., Handbook for Decision Analysis (16 chapters dated individually from June through October, 1973).

11.2.2.9 Peterson, C. R., et. al., "Inference from Evidence: Bayes' Theorem," Chapter 12, Handbook for Decision Analysis, (see 11.2.2.8 above).

11.2.2.10 Peterson, C. R., et. al., "Hierarchical Inference," Chapter 14, Handbook for Decision Analysis, (see 11.2.2.8 above).

11.2.2.11 Peterson, C. R., Kelly, C. W. III, et. al., "Multiple-Stage Probabilistic Information Processing," in Organizational Behavior and Human Performance, Vol. 10, No. 3, (New York and London: Academic Press, December, 1973).

11.2.2.12 Peterson, C. R. and Hazard T. H., "Odds Versus Probabilities for Categorical Events," DDI Technical Report 73-2 (July, 1973).

11.2.2.13 Peterson, C. R. and Barclay, S., "Two Methods for Assessing Probability Distribution," DDI Technical Report 73-1 (August, 1973).

11.2.2.14 Ulvila, J. W., "A Pilot Survey of Computer Programs for Decision Analysis," DDI Technical Report 75-2 (January, 1975).

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

This report summarizes research into and application of decision analytic techniques by Decisions and Designs, Incorporated (DDI) during the period October 1, 1975 through June 30, 1975. As such, this report provides a summary of those activities in terms of the following categories: -

- Assessment and forecasting,
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- Value-of-information analysis,

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- Utility analysis in treaty negotiations
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- Interactive computer graphics
- A handbook for decision analysis
- Decision analysis workshops, briefings, seminars and conferences

These summaries are keyed to four major Technical Progress Reports by DDI and to other relevant references.