AD A121846

DOCUMENTATION OF DECISION-AIDING SOFTWARE:

OPINT USERS MANUAL

DECISIONS AND DESIGNS INC.

Dorothy M. Amey
Phillip H. Feuerwerger
Roy M. Gulick

April 1979

N00014-79-C-0069

DTIC
NOV 2 0 1982
H

DTIC FILE COPY

ADVANCED DECISION TECHNOLOGY PROGRAM

CYBERNETICS TECHNOLOGY OFFICE
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
Office of Naval Research • Engineering Psychology Programs

DISTRIBUTION STATEMENT A
Approved for public release;

82 11 26 188

DOCUMENTATION OF DECISION-AIDING SOFTWARE:

OPINT USERS MANUAL

by

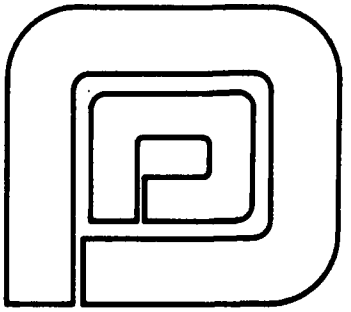
Dorothy M. Ämey, Phillip H. Feuerwerger, and Roy M. Gulick

Sponsored by

Defense Advanced Research Projects Agency
ARPA Order 3469

April 1979

DTIC
NOV 2 9 1982
H



DECISIONS and DESIGNS, INC.
Suite 600, 8400 Westpark Drive
P.O.Box 907
McLean, Virginia 22101
(703) 821-2828

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

CONTENTS

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A

CONTENTS (Continued)

FIGURES

FIGURES (Continued)

OPINT USERS MANUAL

1.0 INTRODUCTION

1.1 Purpose of the Users Manual

The purpose of this manual is to provide users of the OPINT system with the background material and the detailed instructions necessary to use and interpret the various functions that OPINT provides. The manual also presents the decision-analytic concepts inherent in the OPINT approach, including the assumptions and restrictions concerning its use. The manual includes case study applications.

Because the manual must serve users both skilled and unskilled in the use of decision-analytic methodology, it is prepared in a modular fashion. Thus, whereas the initial sections provide detailed information for the naive user, the last section is direct and unelaborated for those users knowledgeable in the approach.

1.2 References

1.2.1 Barclay, Scott, et al. Handbook for Decision Analysis. Technical Report 77-6-30. McLean, Virginia: Decisions and Designs, September 1977.

1.2.2 Gulick, Roy M. Documentation of Decision-Aiding Software: Introductory Guide. Technical Report TR 79-1-93. McLean, Virginia: Decisions and Designs, Inc., in press.

1.2.3 Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: OPINT Functional Description. McLean, Virginia: Decisions and Designs, Inc., April 1979.

1.2.4 Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: OPINT System Specification. McLean, Virginia: Decisions and Designs, Inc., April 1979.

1.2.5 Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: INFER Users Manual. McLean, Virginia: Decisions and Designs, Inc., in press.

1.3 Terms

1.3.1 OPINT - OPINT is an abbreviation for Operations and Intelligence, reflecting the system's major area of applicability.

2.0 SYSTEM SUMMARY

2.1 Background

During crisis situations, military decision makers and their staffs strive to react swiftly, decide wisely, and communicate accurately. However, by its very definition, a crisis situation inherently creates significant obstacles to the successful attainment of those three worthwhile objectives.

Some of the obstacles occur because during a crisis decision makers must necessarily abandon their routine day-to-day working relationships, information channels, and standard, familiar procedures. Other obstacles arise from the increased tension and anxiety introduced by the enormity of the stakes at hand and the attendant risks, uncertainities, and intricate value trade-offs. Still other obstacles stem from the pressures of time constraints and the ambiguity of goals.

In addition, crisis decision making is usually attended by extraordinary demands for, and the production of, information. The tasks of information collection, processing, and distribution may well dominate the workflow and unduly monopolize the time and attention of the decision maker. Indeed, crisis decision makers are often inundated with a vast and diverse collection of both hard objective data and soft subjective data in the form of expert advice and opinion. Both kinds of data may be of highly varying quality and relevance.

The high premium placed on information collection and processing, coupled with the significant obstacles imposed by the crisis situation, greatly enhance the always-present

opportunities for misperception, misunderstanding, and miscommunication among decision makers and their staffs. To prevent those opportunities from arising, decision makers need effective decision strategies that impose rigor and provide a logical, structural framework to assist them in the process of choosing an optimal decision alternative in the face of voluminous and often inconclusive evidence.

OPINT is a decision strategy that provides just such a framework for deliberation, reasoning, and analysis. OPINT aids decision makers by prescribing a straightforward normative procedure for organizing and analyzing difficult decision problems involving both uncertainty about the outcome of future events and perplexity about the complex value trade-offs involved in the choice of a course of action.

OPINT has its roots in *decision analysis*, a management discipline that emerged in the 1960's. As described in Reference 1.2.1, decision analysis has proven enormously effective in aiding military decision-making processes across a broad spectrum of applications. OPINT, in particular, has been employed in several actual crises, military exercises, and in the development of contingency plans.

2.2 Objective

OPINT is a decision-analytic based, computer-assisted decision strategy. Its primary objective is to provide decision makers a procedural framework, or decision template, that will ensure that their ultimate decision choice is a coherent one: a choice consistent with their own value structures and beliefs about the relative likelihoods of future events that will impact the decision outcome.

The fundamental product of OPINT is a computer-stored conceptual representation, or decision model, of the decision problem at hand. Whereas decision analysis provides the theoretical background and procedural guidance, the OPINT decision model provides the specific methodological tool for processing information and evaluating the various decision alternatives open to the decision maker.

It must be emphasized that the use of decision analysis and OPINT does not replace human judgment; it aids human judgment.

The objective of the OPINT software system is to provide decision makers with the capability to construct, store, retrieve, exercise, and modify OPINT decision models. The user who is inexperienced in decision analysis is cautioned that the OPINT model should not be applied indiscriminately, nor should its results be interpreted blindly. In particular, the prospective user must understand that the OPINT framework fits only those decision situations that meet all of the following characteristics.

- The decision problem is well formed; i.e., alternative courses of action and key uncertainities have been identified.
- A simple structural problem representation will suffice.
- A single decision is under consideration.
- A single key uncertainty confounds the choice of the decision alternative.
- The probability of the uncertain event is not dependent on which decision alternative is chosen.
- Several criteria will apply to the ultimate evaluation of the decision outcome.

- o The decision maker is working under a short time constraint.
- o An ad hoc solution is appropriate.

2.3 Procedural Overview

The first step in problem solving using OPINT is to construct a conceptual decision model of the problem at hand. The OPINT software is not used during the development of the model; rather, the modelling process is a learning process that involves many trial constructions using paper and pencil methods. The computer is used only when the model has reached an advanced state of refinement.

The OPINT decision model is a specialized decision-tree diagram which always takes the same form. The OPINT model accommodates only one decision and one uncertainty, as shown in Figure 2-1.

The decision flow begins at the left of the diagram with the decision block. The flow then branches outward to the right into the various decision alternatives open to the decision maker. Each decision alternative leads to a node representing the key uncertainty faced by the decision maker. Since there is only one key uncertainty, the nodes are identical for each decision alternative. Continuing the flow to the right, each of the key uncertainty nodes branches outward into event outcomes which, taken together, define all of the various ways in which the key uncertainty could unfold.

The flow terminates at the far right of the diagram with decision outcomes. Each decision outcome is a paired combination of one decision alternative with one event outcome.

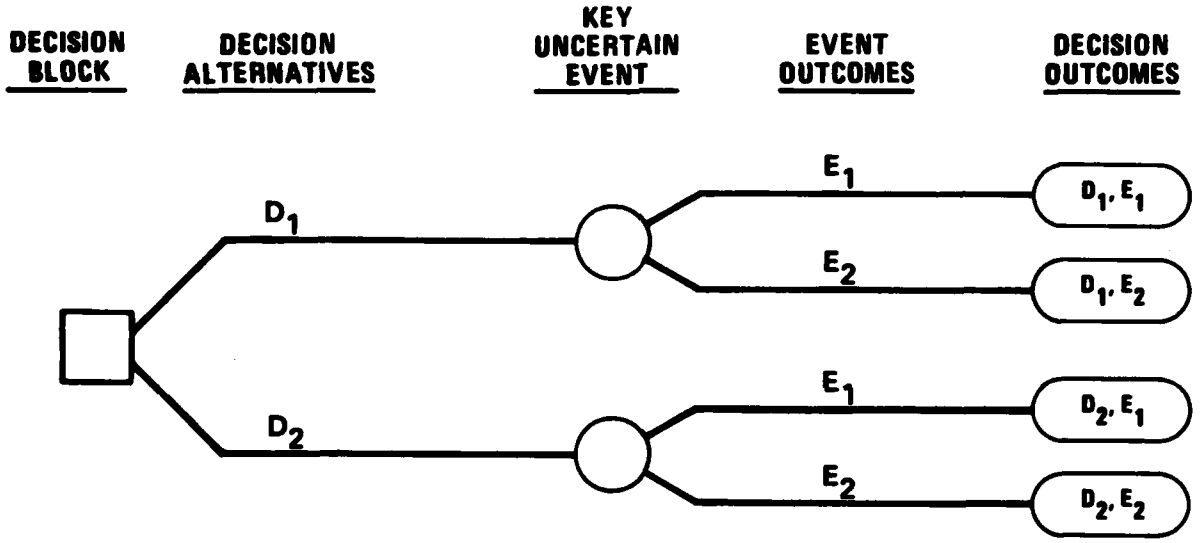


Figure 2-1
AN OPINT MODEL

Figure 2-1 represents the simplest form of an OPINT model, one that contains just two decision alternatives (D_1 and D_2), an uncertain event having just two event outcomes (E_1 and E_2), and terminates in four decision outcomes.

Once the model is structured, the decision maker must provide two distinct value judgments: the probabilities of occurrence of each of the event outcomes, and a value of regret, or loss of opportunity, associated with each decision outcome. Neither task is easy. The first is complicated by the various relationships among unfolding events that will influence the outcome of the key uncertainty; and the latter is complicated by the multiple dimensions, usually subjective, that comprise the decision maker's expression of the total regret associated with a decision outcome. For ease of assessment, the OPINT model requires that total regret be determined by decomposing it into several specific regret criteria, each having an associated relative importance weight.

Once the model has been completely specified, it can be exercised by the user to produce the value of expected regret associated with each of the decision alternatives. The rational user should choose that alternative having the least expected regret.

The model can be analyzed with respect to the sensitivity of the implied decision choice to variations in either the event outcome probabilities or the weights assigned to the regret criteria.

2.4 Purpose of the Model

At this point it must be noted that the purpose of an OPINT model is not to capture reality, but rather to approximate it. Structuring a decision model is an art, and the

practice of that art is attended by great difficulties in selecting a representative set of viable decision alternatives and a representative set of uncertain event outcomes. Ideally, a professional experienced decision analyst would work closely with the decision maker in structuring an OPINT model.

The ultimate tests of an OPINT model should be:

a. Is the model free of obvious inconsistencies?
b. Does the model approximate the reality of the situation?
c. Is the model practical and useful to the decision maker?
d. Does the model provide insight to the decision maker and the staff?

3.0 STRUCTURING THE OPINT MODEL

To use OPINT, the decision maker must create an OPINT decision model. To facilitate understanding of the model-structuring process, this section uses a case study approach. Consider the following hypothetical scenario.

3.1 Hypothetical Crisis

Fifty U.S. military and civilian contractor personnel man a small communications installation located in mountainous terrain on the outskirts of the capital city of the country of Arman. Arman, which gained its independence only four years ago, has maintained a very friendly and stable relationship with the U.S. Because of its close proximity to adversary nations, the communications installation is vital to U.S. national security.

However, within the past two weeks the national mood in Arman has changed drastically, becoming decidedly one of xenophobia. Public outcry against foreign influence has been fueled by the verbal flames of X. Morai, a fanatical, charismatic, and very influential religious leader. Foreigners of all nations have been subjected to unprovoked mob violence, and several have been slain. U.S. nationals are leaving the country rapidly by every means available.

One hour ago, at 8:00 a.m. Arman time, a crowd of one hundred demonstrators assembled at the main gate of the U.S. communications installation, demanding that the gate be opened and the land be returned to the people of Arman. One-half of the demonstrators appear to be armed. Several dozen shots have been fired without damage or casualty.

The mood of the demonstrators is growing increasingly violent and their number is swelling rapidly. There are repeated appeals to the crowd to breach the gate and destroy the installation and its personnel in the name of Arman. X. Morai's personal aide has been spotted in the crowd, but his presence has been low key.

The installation commander advises that his security personnel are very lightly armed and, should

the crowd grow much larger and more violent, his forces could temporarily detain but not prevent the ultimate seizure and destruction of property and personnel.

3.2 Decision Model

The OPINT decision model is structured from left to right, starting at the left with a single decision block that represents the current point in time. The flow then branches outward as the various decision alternatives meet the future events. The model terminates on the right with all of the possible decision outcomes, following the general format of Figure 2.1.

The OPINT model is composed of the following elements.

3.2.1 The decision block - The OPINT model begins at the left with a single block representing the key decision point, the current point in time. The key decision must be described by a concise identifying label, which also uniquely identifies the decision model for storage and retrieval. ARMAN would be an appropriate label for the decision problem at hand.

3.2.2 Decision alternatives - The next step is to create a list of the specific viable courses of action, or decision alternatives, that are available to the decision maker. There are several guidelines that pertain to the creation of that list.

a. The list should be exhaustive. That is, it should include all of the alternatives that are under serious consideration. A key assumption here is that one of the alternatives on the list will in fact be chosen. In

that regard, note that the alternative "not to decide yet" (to buy additional time or to purchase additional information, perhaps) is a perfectly legitimate alternative for inclusion on the list.

b. The list should also be exclusive; that is, the alternatives should be independent. The selection of one alternative should preclude the implied selection of another. This restriction, together with the previous one, ensures that one and only one of the alternatives on the list will ultimately be chosen.

c. The alternatives on the list should be reasonable ones. The list should not include any alternatives that are impossible to implement (because of time and space factors, for example) or that, although possible, are so impracticable that they would never be selected under any circumstance.

d. Similar alternatives should be combined where possible in order to reduce the total number of choices to a reasonable length. Ten alternatives is an upper bound; three or four are preferred.

e. At this point the short, refined list of decision alternatives should pose a true dilemma for the decision maker. Each one of the alternatives should have a strong appeal to the decision maker on at least one dimension

of value. If not, if any alternative seems to have nothing at all to recommend it, that alternative should be removed from the list.

Considering the Arman situation, a list of four decision alternatives might be appropriate:

1. STATUS QUO — No change; buy time and information.

2. DEFEND — Adopt an aggressive, armed defensive posture. Use necessary force to repulse and disband the demonstrators should they trespass.

3. EVACUATE — Use helicopters from a nearby U.S. base to remove all personnel and vital portable property from the installation.

4. SURRENDER — Deliver the installation and its personnel to X. Morai's aide.

3.2.3 Key uncertainty - The next step in developing the model is to identify the one key uncertain event whose outcome will directly influence the eventual degree of success of the decision. That is, there is one key event that will not transpire until after one of the decision alternatives has actually been selected and implemented. In the Arman situation, let that event be the ultimate action of the demonstrators; the decision maker does not know what they will do.

The uncertain future event may unfold in several different ways, each of which is referred to as an event outcome. OPINT requires that the decision maker list all of the possible event outcomes. As in the case of preparing the list of the decision alternatives, the list of event outcomes should be exhaustive, exclusive, reasonable and relatively short. Again, the intent is not to capture reality, but rather to approximate it.

One of the event outcomes on the list must actually occur in the future; otherwise the list is incomplete. In the Arman situation, suppose that various information sources suggest that three event outcomes are appropriate:

1. CONTROLLED DEMONSTRATION — Purely a lengthy and noisy but tightly controlled demonstration staged for the media; it ended with no breaching of the gate.

2. TEMPORARY OCCUPATION — A controlled demonstration that ended, for symbolic purposes, with breaching of the gate, minor violence, and temporary occupation of the installation.

3. UNCONTROLLED RIOT — The demonstrators were actually an uncontrolled and violent mob that breached the gate and destroyed property and personnel. Their avowed intent is permanent occupation of the installation.

3.2.4 Event probabilities - OPINT requires that the decision maker also reflect the current state of knowledge concerning the relative likelihood of occurrence of the possible event outcomes. That knowledge may stem from many sources, but it must be explicitly specified using probability as the standard measure of uncertainty. Recall that the OPINT model assumes that the likelihoods of the event outcomes do not depend on which decision alternative is chosen.

OPINT requires that the probability of occurrence of each event outcome be specified directly as an input to the system. Note, however, that INFER, a companion software system described in Reference 1.2.5, provides assistance to the decision maker in determining such probabilities.

In the Arman situation, assume that a variety of intelligence sources lead the decision maker to believe that the most likely of the event outcomes is TEMPORARY OCCUPATION and the least likely is UNCONTROLLED RIOT. Furthermore, the former is considered to be five times more likely than the latter. The first event, CONTROLLED DEMONSTRATION, is judged four times more likely than an UNCONTROLLED RIOT. Thus, using a scale ranging from 0 to 100 and assigning the value of 100 to the most likely event, the least likely would be scored at 20 and the CONTROLLED DEMONSTRATION event scored at 80. Normalizing those values so that the probabilities sum to 100%, the event probabilities become:

P(CONTROLLED DEMONSTRATION) = 40%
P(TEMPORARY OCCUPATION) = 50%
P(UNCONTROLLED RIOT) = 10%

3.2.5 Decision outcomes - The logical flow of the OPINT model terminates with the decision outcomes. A decision

outcome is represented by the combination of a decision alternative with an event outcome. For example, in the Arman situation, there are twelve possible decision outcomes. One of them is the following:

(EVACUATE, CONTROLLED DEMONSTRATION)	Personnel and vital portable property are evacuated. However, after a noisy and lengthy demonstration, the demonstrators disbanded and left, leaving the installation unmanned and unoccupied.

3.2.6 Assessing decision outcomes - OPINT requires that the decision maker assess the relative regret, or degree of dissatisfaction, associated with each decision outcome. The process is difficult because several different criteria may be used in assessing the total regret.

Criteria. The first step in performing a regret assessment is to identify the regret criteria. In doing so, the decision maker must consider the multifaceted goals and objectives that pertain to the crisis situation.

The criteria should be relatively independent, and they must effectively discriminate among the various decision outcomes. That is, the relative appeal of an individual decision outcome should be quite different when viewed from the standpoint of one criterion at a time.

In deriving the criteria, it is helpful to examine two particular decision outcomes, noting their different appeal. One of the outcomes is the pairing of the decision alternative that is easiest to implement with the worst event outcome. The other is the pairing of

the most difficult decision alternative to implement with the best event outcome. In the Arman case, those pairings might be:

(STATUS QUO, UNCONTROLLED RIOT)	No change in posture, demonstrators destroy all property and personnel.
(SURRENDER, CONTROLLED DEMONSTRATION)	Surrender; demonstrators taunt U.S. personnel and leave the installation peaceably without breaching the gate.

Consideration of those two outcomes, together with other pertinent factors and goals, suggest three criteria for assessing total regret:

1.	PERSONNEL	Exposure risk to installation personnel; effect on morale.
2.	MISSION	Loss of vital equipment and loss of the installation's vital function.
3.	POLITICAL	Political ramifications on a broad scale, both in Arman and in the whole international sphere.

Criteria Weights. OPINT also requires that the criteria be assigned relative importance weights. In deriving those weights, the decision maker should examine each criterion with respect to its full range over the decision outcomes, considering the impact on that criterion of the difference between the best and worst outcomes. The criteria weighting issue is thus one that involves the relative importance of the variations in the possible outcomes with respect to each criterion.

In the Arman situation, the three criteria might be weighted 60%, 20%, and 20%, respectively.

Regrets. Once the criteria are identified, OPINT requires that a measure of regret, or degree of dissatification (or loss of opportunity), be assigned to each decision outcome. To facilitate the process, regrets are assigned to the outcomes by considering outcomes with respect to one criterion at a time.

Regrets vary along a numerical scale ranging from 0 (no regret) to -100 (maximum regret). A matrix, as shown in Figure 3-1, is used to aid in the process of assigning regrets. A different matrix would be constructed for each criterion. Several rules apply to the process of constructing a regret matrix:

a. The matrix is filled by focusing attention on one column at a time. Thus, the process is one of fixing the event outcome (examining one column) and assessing the relative dissatisfaction of having chosen each of the decision alternatives given that that particular outcome would actually occur.

b. Each column in the matrix must have at least one 0 assigned, since for the event outcome represented by the column there must be one best course of action, that is, one having no regret. If not, then add whatever is the best course of action for that outcome to the list of decision alternatives. Note that more than one zero may be assigned to a column.

c. There must be at least one value of -100 (maximum regret) assigned to the entire matrix, representing the least desirable decision outcome with respect to the criterion at hand. The worst outcome in each column is scaled relative to the worst decision outcome in the matrix.

d. Each matrix should be accompanied by concise written rationale that justifies the values selected for the regrets.

	CONTROLLED DEMONSTRATION	TEMPORARY OCCUPATION	UNCONTROLLED RIOT
STATUS QUO	0	-10	-100
DEFEND	0	-40	- 80
EVACUATE	-60	-50	0
SURRENDER	-80	0	- 60

Figure 3-1
A Regret Matrix

Reference Gamble - OPINT provides the user with a technique known as a reference gamble for validating the values of regret assigned to the decision outcomes. The software assists the user by focusing on the value of regret assigned to one column of a regret matrix and attempting to ensure that the assigned regrets are coherent.

For each column, the technique assumes that the decision outcomes having the greatest and least regrets have been correctly specified by the user. It then addresses in turn each of the remaining decision outcomes (those having

intermediate values of regret), by asking the user to choose one of the following two options:

(a) to participate in a gamble in which the best outcome would occur with probability P and the worst outcome with probability 100% - P, or

(b) to have the specific decision outcome under consideration occur for certain.

OPINT sets the initial value of P at 100%, so that a rational user would always select the first option, since obtaining the best outcome with 100% probability is certainly preferable to any intermediate outcome, by definition.

OPINT then methodically reduces the probability of P in steps of 10%, each time asking the user to choose between the two options until, at some point, the user must choose the second option. That must happen eventually, because if P follows its downward course all the way to 0, then option (a) leads to the worst outcome for sure, and any intermediate outcome, option (b), must be preferred to the worst outcome, again by definition.

OPINT assumes that at the point of switching the preferred choice from option (a) to option (b), the user is indifferent between the two options. At the point of indifference, the regret of the addressed outcome must equal the expected value of the regret associated with the reference gamble. That expected value of regret is presented to the user, who may then, if it appears necessary, change the original value of regret that was assigned to that outcome. The process is repeated for another column, if desired.

4.0 RESULTS OF THE MODEL

Two output results of the model are of interest to the user:

- o a combined value regret matrix, and
- o an expected value matrix and expected value vector.

In addition, the user can perform analyses to test the sensitivity of the decision alternatives to variations in the probabilities of the event outcomes and the weights of the criteria.

4.1 Combined Value Regret Matrix

OPINT will produce and display a single matrix in which the entries represent the combined regret associated with each decision outcome. The combined regret is computed by adding the individual criterion regrets, properly weighted. The combined value regret matrix is used to check consistency and to identify obvious discrepancies.

4.2 Expected Value Matrix and Expected Value Vector

OPINT produces an expected value matrix which displays the expected regret associated with each decision outcome. The expected value matrix is computed from the combined value regret matrix, and is distinguished from it in that the expected value matrix takes into account the probabilities assigned to the various event outcomes. (The combined value matrix does not.)

In addition, OPINT displays an expected value vector to the right of the expected value matrix. The expected value

vector displays the total regret expected from choosing each of the decision alternatives. The decision alternative having the least expected regret should be the preferred course of action, consistent with the decision maker's value structure and beliefs about the key uncertainty.

4.3 Sensitivity Analyses

OPINT provides the user with the capability to determine the sensitivity of the regret vector to variations in the event outcome probabilities and the criteria weights.

For any designated criterion, OPINT displays a threshold matrix that displays the regret vectors as a function of the weight of the criterion, varied from 0 to 100%, in steps of 10%. The contributions of the remaining criteria maintain their correct proportional relationships to one another as the weight of the designated criterion changes.

For any designated event outcome, OPINT produces a similar threshold matrix in which the probability of an event outcome is varied from 0 to 100%, in steps of 10%.

In each of the above analyses, the decision alternative having the least expected regret is identified, as are the threshold values of the probability or criterion weight. A threshold value is defined as the value of an event outcome probability or a criterion weight which produces a change in the preferred decision alternative.

Finally, OPINT permits the user to specify a particular set of event outcome probabilities which are then used to produce an associated set of regret vectors.

5.0 TECHNICAL OPERATIONS

This section explains in detail how a user interfaces with the OPINT software. It is assumed that an OPINT model exists in conceptual form.

When the OPINT program has been loaded into the computer and the program started, a menu of options will be displayed to the user.

5.1 Option Menus

OPINT is hierarchically structured and menu-driven. At each level of the hierarchy, a menu of options is displayed to the user. Selection of any particular option will either cause an operation to be performed directly or it will result in the display of a new menu. If another menu appears and the user subsequently wishes to return to the starting point, the user need only return the carriage without choosing any specific option. With few exceptions, returning the carriage at any time (without inputting other instructions or making selections) will cause the computer to display the next higher menu in the hierarchy. If the menu displayed is the one at the top of the hierarchy, returning the carriage will result in a query to the user regarding termination of the program.

As an example of this procedure, assume that the user begins with the primary (i.e., highest level) menu (discussed more fully in the next section) containing the following options:

- Display Results
- Revise Estimates

- Sensitivity
- Load Model
- Create New Model
- Save Model.

Selecting "Display Results" and returning the carriage causes a new menu, which requests more information, to appear. Thus, selecting the "Display Results" option requires the user to specify in more detail the type of results to be displayed. That is accomplished by selecting one of the new options appearing in the secondary menu:

- Expected Value
- Combined Value
- Event Likelihood
- Values
- Criteria Weights.

If, however, instead of selecting one of those options, the user simply returns the carriage, the program will return to the primary menu.

5.2 The Primary Menu

After the user has loaded the OPINT program into the computer, the primary menu will be displayed. This menu contains six options:

- Display Results
- Revise Estimates
- Sensitivity
- Load Model
- Create New Model
- Save Model.

This menu provides entry to various secondary menus. Each of these primary options and the options appearing in the secondary menus are discussed in the sections which follow.

5.2.1 Display results - When this option is selected, the primary menu will be replaced by a secondary menu containing the following options:

- o Expected Value
- o Combined Value
- o Event Likelihood
- o Values
- o Criteria.

These options indicate the various data or results which, on the user's command, can be displayed.

The "Display Results" option is passive in that it allows the user to display the results of a decision model previously stored in or loaded into the computer, or calculations based on those previous results. It does not provide the user with a mechanism for changing any of the inputs and generating new outputs. Such revision is accomplished by using the "Revise Estimates" option of the primary menu.

Expected Value. Selection of this option displays the regret matrix and regret vector associated with each of the decision options. One of the tenets of decision analysis states that a rational criterion for choice is to select that decision alternative which yields the lowest expected regret. Choosing the "Expected Value" option displays that result. It is calculated from the event

outcome probabilities and the values of regrets assigned by the user to the various decision outcomes.

Combined Value. This is a calculated result which shows the value of regret associated with each decision outcome. This display provides a tentative approach to selecting a preferred decision alternative, taking into account the trade-offs in the regrets which exist across the various criteria that comprise the decision maker's value structure. However, the combined value regret matrix ignores the relative likelihoods of the event outcomes.

Event Likelihood. The "Event Likelihood" option displays the assessed probabilities of the event outcomes. The probability of each of the possible outcomes which could affect the ultimate decision outcome is displayed. Thus, those probabilities will sum to 100.

Values. Selecting this option will cause another menu of options to be displayed. The new menu lists the various criteria for assessing regret which the user specified while creating the model. The user indicates which one of the criteria he wishes to examine. Upon specification of a particular criterion, the associated regret matrix will be displayed.

Criteria Weights. This option displays the weights assigned to the various criteria. Those weights were directly assessed by the user to reflect the relative importance of the individual criteria, and the computer normalizes them to sum to 100 after they are input during the model's creation.

5.2.2 Revise Estimates - This option produces a secondary menu which allows the user to modify an existing model in a variety of ways, by identifying the specific model elements to be modified. Those options available in the secondary menu are:

- o Event Likelihood
- o Combined Value
- o Criteria Weights
- o Values
- o Add Action
- o Add Criterion
- o Edit Labels.

Event Likelihood. This option displays the current probabilities assigned to the various event outcomes and allows the user to modify these probabilities. This can be done either by typing in relative likelihoods, which the computer will then normalize, or by typing in probabilities directly.

Combined Value. This option displays the combined value regret matrix and allows any of the individual regrets to be modified by specifying the appropriate row and column of the matrix. Note that modifying the combined value matrix does not result in changes either to the criteria weights or to the individual regret matrices. In addition, the selection of any option which would subsequently cause the combined value matrix to be recalculated will have the effect of erasing the modified values and replacing them with values calculated by using the individual regret matrices and criteria weights. Thus, the only way to effect a permanent change in the combined value regret matrix is to change either the criteria weights or the regrets contained in the individual regret matrices.

Criteria Weights. This option allows the individual criteria weights to be modified. The weights may be described either in terms of relative preferences (which the computer will automatically normalize) or as normalized weights.

Values. This option, like the "Values" option under "Display Results," causes a list of criteria to be displayed. Selection of any one of the criteria results in that particular regret matrix being displayed and allows the user to alter the value of any of the regrets in that matrix. Altering regrets in any of the individual regret matrices or altering the criteria weights will cause the combined value matrix to be recalculated.

Add Alternative. In the course of a decision analysis, it often becomes apparent that a feasible decision alternative has been left out and should be included. The "Add Alternative" option permits the user to specify additional decision alternatives after the basic decision model has been structured, and to evaluate those alternatives. Selection of this option requires that the user type in the label of the new alternative and also requires the specification of regrets associated with the alternative for each criterion contained in the model.

Add Criterion. In the course of the analysis, it often becomes apparent that a criterion for judging the decision outcomes has been forgotten. The "Add Criterion" option allows the user to add a new criterion to those already specified. Selection of this option requires the user to specify a regret matrix for each new criterion and to revise the relative weights of the criteria.

Edit Labels. This option is used when an incorrect label has been entered or when a new label seems

more descriptive. It permits the user to correct any typographical errors or to replace any particular label by an entirely new label. The labels include those assigned to decision alternatives, criteria, and event outcomes.

5.2.3 Sensitivity - The "Sensitivity" option permits the user to vary the event outcome probabilities or the criteria weights in order to evaluate the impact that changes in those values have on the recommended course of action. In particular, the user can discover the range of event outcome probabilities or criteria weights which cause a particular decision alternative to be preferred. This permits, for example, the identification in advance of probability thresholds so that, should the probability of an event outcome change, the user can determine whether or not a new decision alternative should be recommended.

There are two sensitivity analyses which can be performed, "Determine Thresholds" and "Manually Change Probabilities." The former permits the user to vary either the event outcome probabilities or the criteria weights. The latter only permits variation of the event outcome probabilities.

Determine Thresholds. After selecting "Determine Thresholds," the user is asked to choose between varying event probabilities or criteria weights. When the "Event Probabilities" option is selected, the computer responds by showing the user the different event outcomes and asking which one the user wishes to vary. The probability of the designated outcome is then varied in 10% increments from 0% to 100%, maintaining the probabilities of the other event outcomes in the same ratio as those specified by the initial event outcome probability assignments.

The program displays the expected regret or payoff associated with each course of action as a function of the varied outcome probability. The recommended decision alternative (least regret) for every specified set of outcome probabilities is indicated on the display, as are the probability thresholds for which it is optimal to shift from one decision alternative to another.

Manually Change Probabilities. The second sensitivity option allows the probabilities assigned to each event outcome to be varied directly. The user may either assess the probabilities directly or assess relative likelihoods, which the computer will then normalize to sum to 100%. The computer allows the user to try several combinations of probabilities simultaneously. After the assessment is complete, the computer displays the expected value of regret resulting from both the original probability assessments and the revised probabilities. Note that the probabilities stored in the computer have not been modified using this option; the original probabilities are retained in the model.

5.2.4 Load model - Selection of this option causes the computer to inform the user of the labels of the models already built and available for loading. A user may wish to do this to display an existing model, or to revise a model. Selecting a specific model label causes the computer to load that model.

5.2.5 Create new model - If the user desires to create a new model rather than to work with one previously constructed, the "Create New Model" option must be chosen. This option allows the user to create an altogether new model, including the input of all values required. When the user selects

this option, the computer begins to request the various items required to specify an entirely new model.

Decision Alternatives. The computer will first instruct the user to input the decision alternatives available. They should be typed in one at a time, returning the carriage after each alternative is input. After all the alternatives have been input, returning the carriage without typing anything will cause the computer to request confirmation that the labels for the decision alternatives are correct. If the user fails to give confirmation, the computer will give the user a second opportunity to type in all of the decision alternatives. If only a spelling or naming error has been made (rather than an error involving the number or type of decision options available), this can be corrected later by using the "Edit Labels" option, if the user prefers.

Event Outcomes. After the decision options have been confirmed, the computer will instruct the user to input the name of the key uncertain event involved in the decision. This should be the one event which, if the decision maker knew its outcome with absolute certainty, would allow an optimal decision to be made. Again, the computer will request confirmation that the event label has been input correctly. The computer then asks what outcomes this key event may have, reminding the user to type in an exhaustive and exclusive set of event outcome labels. The user must now type in the labels one at a time, returning the carriage after each, and must again return the carriage without typing anything to signal the computer that the set of event outcomes is complete. Again, the computer will request confirmation.

Criteria. The next step in the process of building the model is to obtain a set of criteria by which the decision maker judges the decision outcomes. These criteria should discriminate substantially with respect to the decision outcomes. They may involve any of a range of objective or subjective aspects, from political considerations to simplicity of operations. Once the criteria are identified, they are input in the same manner as were the events and outcomes.

Regrets. The computer next asks the user to construct a regret matrix for each criterion. The entries into a single matrix represent the relative amount of regret associated with each decision outcome, with respect to the specified criterion only. All entries in the matrix fall between zero and -100, where zero represents no regret and -100 represents the amount of regret suffered under the worst decision outcome. Each column in each matrix must contain at least one zero, since at least one decision option would have been optimal if the event outcome were known in advance. However, only one -100 need appear in the matrix.

The computer will allow the user to type in the regret matrices one line at a time. After each matrix is completely filled in, the computer will ask for confirmation of the input values.

Reference Gamble. The computer allows the user to test any column of regrets for internal consistency by using the "reference gamble" technique. If the user wishes to check the regrets, both the criterion and the event outcome of interest must be typed in as requested. The computer will then engage the user in a series of hypothetical reference gambles to help clarify the nature of the regret values.

For each gamble, the user is offered a choice between receiving with certainty the regret associated with the decision outcome under examination (one which neither gives the best nor the worst regret) or else taking a gamble and receiving either the best or the worst regret possible for the designated event outcome. After one or more such gambles, the computer will display the regret implied by the user's responses to the gamble. This display should, within ten percent, reflect the user's true regret assessment. The user will then be given an opportunity to alter the original estimates of regret if the implied values differ substantially from those which the user previously assessed directly.

Criteria Weights. The computer next instructs the user to input the relative importance weights associated with the various criteria. That is, if three criteria have been selected for consideration, and the first is twice as important as the second and five times as important as the third, the weights 10, 5, and 2 might be typed in. The computer will then normalize the weights so that they sum to 100 and request confirmation of the normalized values.

Event Probabilities. The final step in creating a model involves inputting the relative probability of each possible event outcome. When the user types in the relative probabilities, the computer will normalize them and request confirmation.

At this point, the program will return the user to the primary menu. Normally, the user should immediately save the model by using the "Save Model" option so that it is not accidentally changed or erased.

6.0 AN EXAMPLE OF THE USE OF THE OPINT SYSTEM

This chapter presents a hypothetical decision analysis using the OPINT software system. The decision problem contains all of the qualities necessary to make it ideal for OPINT: a single decision, a single key uncertain event, a well-formed list of decision alternatives, and multiple criteria for judging the relative regret associated with the possible decision outcomes. The event outcome probabilities are independent of the decision alternatives.

6.1 Background of the Example

This example concerns the contingency planning required before committing U.S. forces to a particular readiness posture. It involves an analysis of various military evacuation posture options that a commander would consider in the light of uncertainty about a developing crisis situation that could make it necessary to evacuate U.S. nationals from a foreign country. This example concerns the possible evacuation of U.S. citizens from Lebanon during the civil war of 1976. In the example, fighting has broken out in the Middle East, and the U.S. European Command may be required to evacuate U.S. nationals from the area.

There are a number of posturing actions that the staff would like to analyze in anticipation of a worsening situation, before making a recommendation to the commander. The staff members working on the problem realize that advanced alert postures such as staging aircraft and crews to forward bases could be costly in terms of disruption of normal training schedules and that locating large fleet units in the combat area could have an adverse political impact. With these kinds of considerations in mind, the staff structures the problem as follows.

The evacuation posturing alternatives to be evaluated are:

- o Normal Posture. No action taken beyond alerting subordinate commanders that evacuation is a distinct possibility.

- o Low Profile Posture. Modest capability to airlift 500 personnel out of the area. This requires minimal forward staging and a permissive evacuation environment.

- o Medium Profile Naval Posture. Capability to evacuate 2000 personnel. This requires selected fleet units to operate in the eastern Mediterranean and does not require a secure in-country airfield.

- o Full-Scale Evacuation Posture. Capability to evacuate 6000 personnel, including nationals of other countries. This requires major fleet units to be located offshore and has a good capability to operate in a hostile environment.

The criteria for analyzing various posture options consist of:

- o Exposure Risk. Safety of U.S. nationals once the decision to evacuate them had become necessary.

- o Flexibility Loss. Loss of flexibility while in an advanced deployment posture.

- o Readiness Cost. Loss of normal crew proficiency training while in advanced alert postures.

- o Political Costs. Political implications.

The range of possible outcomes the staff considers varies from a situation in which a small number of American citizens might become concerned about their safety and wish to return to the U.S., to a much worse situation in which it would become necessary to evacuate about 6000 Americans and allied personnel during heavy fighting. The specific outcomes of the key uncertainty considered for the analysis are:

- o No Evacuation Required. No evacuation necessary because a ceasefire agreement had been negotiated.

- o Permitted Evacuation--300 People. The fighting continues, commercial airlines cancel flights into the area, and a small number of personnel wish to leave the country. Friendly security forces control the airport and access routes from Beirut.

- o Permitted Evacuation--2,000 People. The fighting continues, commercial airlines cancel flights into the area, and a large number of personnel wish to leave the country. Friendly security forces control the airport and access routes from Beirut.

- o Non-Permitted Evacuation--2,000 People. Fighting increases in Beirut, and most of the U.S. nationals living in the immediate area want to leave. The airport is subjected to sporadic gunfire; therefore, armed helicopters and security forces may be required.

- o Non-Permitted Evacuation--6,000 People. Heavy fighting spreads throughout the country, and up to

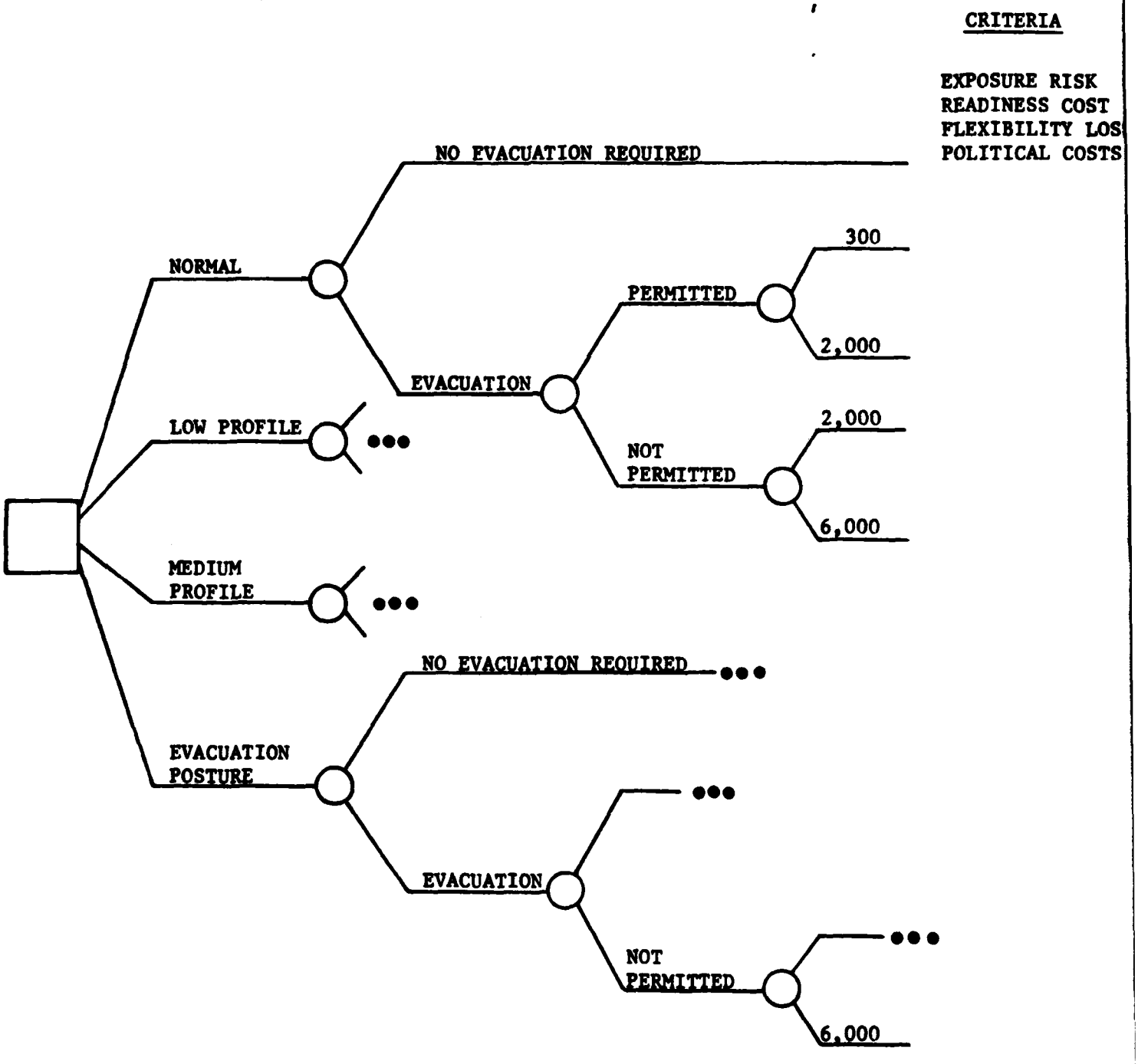


Figure 6-1
The Example Decision Problem

6000 U.S. and allied nationals may want to leave. The evacuation force must be prepared to operate in a warlike environment.

Figure 6-1 illustrates the decision problem being considered.

Before structuring this model using the OPINT software, the user should make some specific assessments. The relative probabilities of each of the possible outcomes of the key uncertainty must be assessed, as must the relative importance of each of the criteria. Finally, the regret associated with each decision outcome must be assessed for each criterion.

6.2 Using the OPINT Software to Structure the Example Problem

In this section, the above example will be structured. The figures are representations of possible input and output formats. Other input data would lead to other suitable output displays.

First, the user must load the program. A menu of options such as the one in Figure 6-2 will be displayed. In this and all succeeding figures, user inputs have been underlined for clarity.

```
SELECT THE NUMBER OF THE OPTION YOU DESIRE

          1)   DISPLAY RESULTS
          2)   REVISE ESTIMATES
          3)   SENSITIVITY
          4)   LOAD MODEL
          5)   CREATE NEW MODEL
          6)   SAVE MODEL
SELECTION:  5
```

Figure 6-2
The Primary Menu

Selecting "Create New Model" places the program in the model-structuring mode. The computer will ask for the labels of the decision alternatives. After the user types in the alternative labels and returns the carriage, the computer will request confirmation. Normally, some limitation in the length of option names will be specified to preserve space in the computer memory. Figure 6-3 shows one possible representation of input of the decision alternatives:

```
ENTER THE LABELS FOR THE DECISION ALTERNATIVES,
ONE PER LINE, NO MORE THAN 8 CHARACTERS PER LABEL.
 1)   NORMAL
 2)   LOW PROF
 3)   MED PROF
 4)   EVAC PST
 5)

THE LABELS YOU HAVE ENTERED ARE:

      1 - NORMAL
      2 - LOW PROF
      3 - MED PROF
      4 - EVAC PST

IF THESE ARE CORRECT TYPE GO:  GO
```

Figure 6-3
Inputting Decision Options

The computer will then request the name of the key uncertainty and its possible outcomes. For the current example, the computer output might appear as in Figure 6-4. For the events of interest, "P" means a "permissive" evacuation whereby U.S. nationals are permitted to leave peacefully and "NP" means a non-permissive evacuation. The numbers 300, 2K (2000), and 6K (6000) refer to the number of individuals wishing to leave.

ENTER THE LABEL FOR THE EVENT OF INTEREST.
PLEASE LIMIT THE LABEL TO 10 CHARACTERS.

1) - EVACUATION

THE LABELS YOU HAVE ENTERED ARE:

1 - EVACUATION

IF THESE ARE CORRECT TYPE GO: GO

ENTER THE LABELS FOR THE POSSIBLE OUTCOMES OF THE EVENT OF INTEREST, 1 PER LINE, NO MORE THAN 5 LETTERS PER LABEL.

1) NONE
2) P-300
3) P-2K
4) NP-2K
5) NP-6K
6)

THE LABELS YOU HAVE ENTERED ARE:

1 - NONE
2 - P-300
3 - P-2K
4 - NP-2K
5 - NP-6K

IF THESE ARE CORRECT TYPE GO: GO

Figure 6-4
Inputting Possible Outcomes of the Key Event

The next step in the process of structuring the model is to input the criteria which distinguish among the specific decision option-event outcome pairs. The user also inputs these in response to computer prompts, as in Figure 6-5.

```
ENTER THE LABEL FOR EACH CRITERION, ONE PER
LINE, NO MORE THAN 20 CHARACTERS EACH.

1)   EXPOSURE RISK
2)   READINESS COST
3)   FLEXIBILITY LOSS
4)   POLITICAL COSTS
5)

THE LABELS YOU HAVE ENTERED ARE:

     1 - EXPOSURE RISK
     2 - READINESS COST
     3 - FLEXIBILITY LOSS
     4 - POLITICAL COSTS

IF THESE ARE CORRECT TYPE GO:  GO
```

Figure 6-5
Inputting the Criteria

The computer then asks the user to input, line by line, the regret matrix for each of the criteria. The first line might look like Figure 6-6.

```
ENTER THE FOLLOWING REGRET VALUATIONS:
                EXPOSURE RISK
          NONE   P-300   P-2K   NP-2K   NP-6K
NORMAL     0      -10     -30    -100    -100
```

Figure 6-6
Single Line of Regret Inputs

The entire series of regret matrix inputs might look like Figure 6-7.

ENTER THE FOLLOWING REGRET VALUATIONS

EXPOSURE RISK

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	-10	-30	-100	-100
LOW PROF	0	0	-5	-80	-80
MED PROF	-1	0	0	-5	-10
EVAC PST	-1	0	0	0	0

YOU HAVE TYPED:

EXPOSURE RISK

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	-10	-30	-100	-100
LOW PROF	0	0	-5	-80	-80
MED PROF	-1	0	0	-5	-10
EVAC PST	-1	0	0	0	0

IF THESE ARE CORRECT TYPE GO: GO

READINESS COST

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	0	0	0	0
LOW PROF	-30	-30	-30	-30	-30
MED PROF	-80	-80	-80	-80	-80
EVAC PST	-100	-100	-100	-100	-100

YOU HAVE TYPED:

READINESS COST

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	0	0	0	0
LOW PROF	-30	-30	-30	-30	-30
MED PROF	-80	-80	-80	-80	-80
EVAC PST	-100	-100	-100	-100	-100

IF THESE ARE CORRECT TYPE GO: GO

FLEXIBILITY LOSS

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	0	0	0	0
LOW PROF	-40	-40	-40	-40	-40
MED PROF	-90	-90	-90	-90	-90
EVAC PST	-100	-100	-100	-100	-100

YOU HAVE TYPED:

FLEXIBILITY LOSS

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	0	0	0	0
LOW PROF	-40	-40	-40	-40	-40
MED PROF	-90	-90	-90	-90	-90
EVAC PST	-100	-100	-100	-100	-100

IF THESE ARE CORRECT TYPE GO: GO

POLITICAL COSTS

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	-40	-60	-100	-100
LOW PROF	0	0	-20	-90	-90
MED PROF	-5	0	0	-20	-20
EVAC PST	-10	0	0	0	0

YOU HAVE TYPED:

POLITICAL COSTS

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	-40	-60	-100	-100
LOW PROF	0	0	-20	-90	-90
MED PROF	-5	0	0	-20	-20
EVAC PST	-10	0	0	0	0

IF THESE ARE CORRECT TYPE GO: GO

Figure 6-7
Inputting the Regrets

The computer will next allow the user to test any column of regrets for internal consistency using the "reference gamble" technique. Figure 6-8 gives an example of the reference gamble technique in use.

```
DO YOU WISH TO CHECK THESE WITH A REFERENCE GAMBLE? YES
WHICH CRITERION MATRIX DO YOU WISH TO TEST? EXPOSURE RISK
WHICH OUTCOME COLUMN DO YOU WISH TO TEST? NP-2K
WOULD YOU PREFER TO HAVE CHOSEN
1)  MED PROF (WITH NP-2K OCCURRING) FOR CERTAIN
      OR
2)  A 100% CHANCE OF NORMAL (WITH NP-2K OCCURRING) AND
    A 0% CHANCE OF EVAC PST (WITH NP-2K OCCURRING)?
INDICATE YOUR CHOICE BY TYPING 1 OR 2. 2

WOULD YOU PREFER TO HAVE CHOSEN
1)  MED PROF (WITH NP-2K OCCURRING) FOR CERTAIN
      OR
2)  A 90% CHANCE OF NORMAL (WITH NP-2K OCCURRING) AND
    A 10% CHANCE OF EVAC PST (WITH NP-2K OCCURRING)?
INDICATE YOUR CHOICE BY TYPING 1 OR 2. 2

WOULD YOU PREFER TO HAVE CHOSEN
1)  MED PROF (WITH NP-2K OCCURRING) FOR CERTAIN
      OR
2)  AN 80% CHANCE OF NORMAL (WITH NP-2K OCCURRING) AND
    A 20% CHANCE OF EVAC PST (WITH NP-2K OCCURRING)?
INDICATE YOUR CHOICE BY TYPING 1 OR 2. 1

YOUR RESPONSES TO THESE QUESTIONS IMPLY THAT YOUR REGRET FOR
MED PROF IN THE NP-2K COLUMN OF THE EXPOSURE RISK MATRIX
SHOULD FALL BETWEEN 80% AND 90% OF THE WAY FROM NORMAL TO
EVAC PST.
WOULD YOU LIKE TO CHANGE YOUR ORIGINAL ASSESSMENTS? NO
WOULD YOU LIKE TO TRY ANOTHER REFERENCE GAMBLE? NO
```

Figure 6-8
The Reference Gamble

The computer now instructs the user to input the relative importance weights associated with the various criteria. When relative weights have been typed in, the computer will (if necessary) calculate normalized weights and display them for confirmation, as shown in Figure 6-9.

```
ENTER THE RELATIVE IMPORTANCE WEIGHT ASSOCIATED WITH
EACH CRITERION.
          EXPOSURE RISK              10
          READINESS COST              4
          FLEXIBILITY LOSS            2
          POLITICAL COSTS             7
THE NORMALIZED WEIGHTS YOU HAVE ENTERED ARE:
          EXPOSURE RISK              43
          READINESS COST             17
          FLEXIBILITY LOSS            9
          POLITICAL COSTS            30
IF THESE ARE CORRECT TYPE GO:  GO
```

Figure 6-9
Inputting the Value Weights

The final step in structuring the model requires the user to input, through direct assessment, the relative probabilities of the event outcomes of interest. The computer will normalize the probabilities (if necessary) and request confirmation. Figure 6-10 shows how this final step might appear.

```
ENTER THE RELATIVE PROBABILITY OF EACH OUTCOME.
                NONE          1000
                P-300           50
                P-2K           275
                NP-2K          333
                NP-6K          275
NORMALIZED PROBABILITIES:
                NONE            52
                P-300            3
                P-2K            14
                NP-2K           17
                NP-6K           14
IF THESE ARE CORRECT TYPE GO:  GO
```

Figure 6-10
Inputting the Probabilities

After the user gives final confirmation, returning the carriage will cause the program to revert to the primary menu.

6.3 Using the OPINT Software to View the Results of the Example Problem

Now that a new model has been created, the user may wish to view the computed results of the original inputs. Changes, either permanent or experimental, may be made; but first, the user should save the newly created model so that it is not accidentally lost. Selecting the "Save Model" option causes the computer to list the names of the models already saved and ask for the name of the new model. To replace an old version of the current model, the user need only assign the name of the old model to the new model. Figure 6-11 shows a typical computer-user exchange.

```
CURRENT MODELS:
1)  RECCE
2)  WARSAW
3)  KENYA
ENTER THE NEW MODEL NAME:  EVACUATION
IF "EVACUATION" IS CORRECT TYPE GO:  GO
```

Figure 6-11
The "Save Model" Option

The user might now wish to view the results of the model. To do this, the "Display Results" option should be selected. Under "Display Results," the user may either view calculated results or values directly assessed during the program's construction. Selecting "Event Likelihood," "Values," and "Value Weights" will merely result in the display of the assessed relative likelihoods, regret matrices of the criteria, and the criteria weights discussed in Section 6.2 and shown in Figures 6-7, 6-9, and 6-10. They will not be repeated here. Selecting "Expected Value" will cause a display similar to Figure 6-12 to appear,

whereas selecting "Combined Value" will provide a display such as that shown in Figure 6-13. According to the expected value of regrest displayed in Figure 6-13, the user would select the MED PROF decision alternative, because it has the minimum total regret of the four alternatives.

	EXPECTED VALUE					
	NONE	P-300	P-2K	NP-2K	NP-6K	TOTAL
NORMAL	0	0	-4	-13	-10	-28
LOW PROF	-5	0	-2	-12	-10	-29
MED PROF	-12	-1	-3	-5	-5	-26
EVAC PST	-15	-1	-4	-4	-4	-28

Figure 6-12
Output of the "Expected Value" Option

	COMBINED VALUE				
	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	-17	-31	-74	-74
LOW PROF	-9	-9	-17	-71	-71
MED PROF	-24	-22	-22	-30	-32
EVAC PST	-30	-26	-26	-26	-26

Figure 6-13
Output of the "Combined Value" Option

The user may now wish to test various changes in the assessments to see whether they alter the decision option to be chosen. The "Sensitivity" option should be used to try new relative value weights and relative likelihoods before changing the model permanently. None of the changes made under "Sensitivity" are recorded in the computer's memory; the original model remains intact.

After selecting "Sensitivity," the user has a choice between "Determine Thresholds" or "Manually Change Probabilities." The former option may be used to vary either the

probabilities of a designated event outcome or a designated criterion weight. Any single probability or value weight may be varied, with the remaining probabilities or weights retaining their original ratios. Figure 6-14 shows the format for displaying a sensitivity analysis with the probability of "None" (no evacuation necessary) changed, and Figure 6-15 shows a sensitivity analysis with the weight of the criterion "Exposure Risk" changed. In each, the asterisk signifies the optimal choice among the decision alternatives (according to the least expected regret criterion) for that particular probability or weight. The arrows designate thresholds, or points of change from one decision option to another. Often, a sensitivity analysis will be performed on each criterion and possible event outcome, so that the user can view the results and make necessary changes.

EXPECTED VALUE WHEN
PROBABILITY OF NONE IS:

	0	10	20	30	40	50	60	70	80	90	100
NORMAL	-57	-51	-45	-40	-34	-28	-23*	-17*	-11*	-6*	0*
LOW PROF	-50	-46	-42	-38	-34	-29	-25	-21	-17	-13	-9
MED PROF	-27	-27	-27	-26*	-26*	-25*	-25	-25	-24	-24	-24
EVAC PST	-26*	-26*	-26*	-27	-27	-28	-28	-28	-29	-29	-29
				↑			↑				

Figure 6-14
Sensitivity: Probability Varying

EXPECTED VALUE WHEN
WEIGHT OF EXPOSURE RISK IS:

	0	10	20	30	40	50	60	70	80	90	100
NORMAL	-22*	-23*	-25*	-26*	-27	-29	-30	-31	-33	-34	-35
LOW PROF	-32	-31	-31	-30	-29	-29	-28	-27	-27	-26	-25
MED PROF	-44	-39	-35	-31	-27*	-23*	-19*	-15*	-11	-7	-3
EVAC PST	-49	-44	-40	-35	-30	-25	-20	-15	-10*	-5*	-1*
					↑				↑		

Figure 6-15
Sensitivity: Value Weight Varying

The other option under "Sensitivity," is "Manually Change Probabilities," which is used to investigate the effects of varying the probabilities of the event outcomes. The computer allows the user to input a limited number of trials simultaneously (the limit depends on the computer system and display techniques used). After the user has input the sets of probabilities to be tried, the computer normalizes them and displays the expected values associated with them. A possible format for the user-computer exchange is shown in Figure 6-16.

	NONE	P-300	P-2K	NP-2K	NP-6K
CURRENT PROBS (TRIAL 0)	53	3	14	17	1
PROBS, TRIAL 1	1	1	1	1	1
NORMALIZED	20	20	20	20	20
PROBS, TRIAL 2	10	1	5	6	5
NORMALIZED	37	4	19	22	19
PROBS, TRIAL 3	20	1	5	6	5
NORMALIZED	54	3	14	16	14
PROBS, TRIAL 4					

	EXPECTED VALUE			
TRIAL	NORMAL	LOW PROF	MED PROF	EVAC PST
0	-27	-29	-26	-28
1	-39	-35	-26	-27
2	-36	-36	-26	-28
3	-27	-28	-26	-28

Figure 6-16
The "Manually Change Probabilities" Option

Now that various values of the probabilities and criterion weights have been tested and the consequences viewed, the user may wish to make some permanent alterations in the assessments. Not only can permanent changes be made in the criterion weights and probabilities, but regret values and combined values ca.. also be changed and tested (though changes to the combined value matrix are only temporary,

reverting to the values calculated from the criterion weights and regret matrices if these are subsequently changed). Furthermore, labels can be changed or corrected and new criteria or alternative decision options can be added (requiring assessment of totally new regret matrices or new regrets associated with the specified alternatives). Figures 6-17 through 6-23 show how the various user-computer interchanges under "Revise Estimates" might appear.

```
                    LIKELIHOOD OF EVACUATION
                    NONE   P-300   P-2K   NP-2K   NP-6K
CURRENT PROBS        52      3      14      17      14
NEW PROBS            10      1       5       6       5
     NORMALIZED      37      4      19      22      19
IF THESE ARE CORRECT TYPE GO:  GO
```

Figure 6-17
Revising Event Likelihoods

```
                        COMBINED VALUE
                    NONE   P-300   P-2K   NP-2K   NP-6K
NORMAL               0     -17     -31    -74     -74
LOW PROF            -9     -9      -17    -71     -71
MED PROF            -24    -22     -22    -30     -32
EVAC PST            -30    -26     -26    -26     -26
ENTER THE NAME OF THE ROW OR COLUMN TO BE EDITED:  NORMAL

NORMAL:              0     -17     -31    -74     -74
NEW VALUES:          0     -20     -25    -75     -80
IF THESE ARE CORRECT TYPE GO:  GO

ENTER THE NAME OF THE ROW OR COLUMN TO BE EDITED:
```

Figure 6-18
Revising the Combined Value Matrix

VALUE WEIGHTS

CRITERION	CURRENT WEIGHTS
EXPOSURE RISK	43
READINESS COST	17
FLEXIBILITY LOSS	9
POLITICAL COSTS	30

NEW WEIGHTS: 9 3 1 7
NORMALIZED: 45 15 5 35
IF THESE ARE CORRECT TYPE GO: GO

Figure 6-19
Revising Value Weights

REGRET MATRICES AVAILABLE
1) EXPOSURE RISK
2) READINESS COST
3) FLEXIBILITY LOSS
4) POLITICAL COSTS
TYPE THE NUMBER OF THE MATRIX TO BE EDITED: 1

EXPOSURE RISK

	NONE	P-300	P-2K	NP-2K	NP-6K
NORMAL	0	-10	-30	-100	-100
LOW PROF	0	0	-5	-80	-80
MED PROF	-1	0	0	-5	-10
EVAC PST	-1	0	0	0	0

ENTER THE NAME OF THE ROW OR COLUMN TO BE EDITED: NONE
NONE: 0 0 -1 -1
NEW VALUES: 0 -1 -5 -5
IF THESE ARE CORRECT TYPE GO: GO

ENTER THE NAME OF THE ROW OR COLUMN TO BE EDITED:

Figure 6-20
Revising Values of Regret

```
WHAT IS THE NAME OF THE NEW CRITERION? OTHER COSTS
ENTER THE FOLLOWING REGRETS:
                          OTHER COSTS
                NONE    P-300    P-2K    NP-2K    NP-6K
NORMAL           0        0      -20      -60      -100
LOW PROF        -3       -2        0      -50       -80
MED PROF        -6       -5       -2        0       -60
EVAC PST       -10       -8       -5       -1         0
IF THESE ARE CORRECT TYPE GO: GO
WHAT IS THE NAME OF THE NEW CRITERION?

BE SURE TO EDIT VALUE WEIGHTS TO INCORPORATE NEW CRITERIA!
```

Figure 6-21
Revision Using "Add Criterion"

```
WHAT IS THE NAME OF THE NEW ALTERNATIVE? HI PROF
ENTER THE FOLLOWING REGRETS:
                          EXPOSURE RISK
                NONE    P-300    P-2K    NP-2K    NP-6K
HI PROF         -1        0        0       -3       -5
IF THESE ARE CORRECT TYPE GO: GO
                          READINESS COST
                NONE    P-300    P-2K    NP-2K    NP-6K
HI PROF         -90      -90      -90      -90      -90
IF THESE ARE CORRECT TYPE GO: GO
                          FLEXIBILITY LOSS
                NONE    P-300    P-2K    NP-2K    NP-6K
HI PROF         -98      -98      -98      -98      -98
IF THESE ARE CORRECT TYPE GO: GO
                          POLITICAL COSTS
                NONE    P-300    P-2K    NP-2K    NP-6K
HI PROF         -10        0        0       -5       -5
IF THESE ARE CORRECT TYPE GO: GO
                          OTHER COSTS
                NONE    P-300    P-2K    NP-2K    NP-6K
HI PROF         -8       -7       -3        0       -30
IF THESE ARE CORRECT TYPE GO: GO
WHAT IS THE NAME OF THE NEW ALTERNATIVE?
```

Figure 6-22
Revision Using "Add Alternative"

```
LABELS AVAILABLE
     1)  CRITERIA
     2)  KEY UNCERTAINTY
     3)  OUTCOMES OF KEY UNCERTAINTY
     4)  DECISION OPTIONS
     5)  MODEL NAME
ENTER THE NUMBER OF THE TYPE OF LABEL YOU WOULD LIKE TO EDIT:  1

CRITERION NAMES AVAILABLE
     1)  EXPOSURE RISK
     2)  READINESS COST
     3)  FLEXIBILITY LOSS
     4)  POLITICAL COSTS
     5)  OTHER COSTS

ENTER THE NUMBER OF THE CRITERION NAME TO BE EDITED:  4
LABEL IS LIMITED TO 20 CHARACTERS
CURRENT LABEL:  POLITICAL COSTS
NEW LABEL:  POLITICAL IMPACT
```

Figure 6-23
Revision Using "Edit Labels"

After making whatever revisions are necessary, the user may wish to view the effects of the changes by selecting "Display Results." The user must remember, though, that none of the changes made are recorded permanently until the new version is saved by using the "Save Model" option. This is done as shown in Figure 6-24.

Finally, after the user has completely finished viewing, changing, and using the current model, the user may wish to build another model using "Create New Model" or display another previously constructed model. To load a new model, the "Load Model" option should be selected. Figure 6-25 shows a typical computer response to this command.

```
CURRENT MODELS:
     1)  RECCE
     2)  WARSAW
     3)  KENYA
     4)  EVACUATION
ENTER THE MODEL NAME:  EVACUATION
THAT MODEL EXISTS ALREADY.  IF YOU WISH TO REPLACE THE
CURRENTLY SAVED VERSION BY A NEW VERSION, PLEASE TYPE GO:  GO
```

Figure 6-24
Saving a Revised Model

```
MODELS CURRENTLY AVAILABLE
     1)  RECCE
     2)  WARSAW
     3)  KENYA
     4)  EVACUATION
ENTER THE NUMBER OF THE MODEL TO BE LOADED:  2
```

Figure 6-25
The "Load Model" Option

The selected model will be loaded and the user will be ready for additional use of OPINT.

7.0 ABRIDGED USERS MANUAL

This section is designed for the user who is already familiar with OPINT. It describes the essential elements of the decision problem and discusses how those are molded into an OPINT model.

7.1 Structuring the Decision Problem

An OPINT model is always structured in the form shown in Figure 2-1. Every decision problem appropriate for OPINT includes the following elements:

- a single decision to be made;
- a list of decision alternatives;
- a single key uncertain event;
- a list of event outcomes; and
- a list of criteria for analyzing the relative regret of the ultimate decision outcome.

Assessments which must be made include:

- the probabilities of the possible event outcomes;
- the regrets associated with the possible decision outcome, for each criterion; and
- the relative importance weights of the criteria.

Once the elements are identified and the assessments prepared, the user is ready to use the program.

7.2 Options Available in OPINT

OPINT is a hierarchically structured, menu-driven system. Once OPINT is loaded into the computer, a menu of options becomes available to the user. The first menu contains the following options:

- Display Results
- Revise Estimates
- Sensitivity
- Load Model
- Create New Model
- Save Model.

Selecting "Display Results" allows the user to instruct OPINT to provide any of the following displays for the currently stored or previously loaded model:

- Expected Value
- Combined Value
- Event Likelihoods
- Values of Regret
- Criteria Weights.

Selecting "Revise Estimates" allows the user to perform any of the following editing operations:

- Event Likelihood
- Combined Value
- Criteria Weights
- Values
- Add Alternative
- Add Criterion
- Edit Labels.

Selecting "Sensitivity" allows the user either to determine threshold values for probabilities or criterion weights, or to manually change probability weights.

Selecting "Load Model" allows the user to load from storage any existing model.

Selecting "Save Model" allows the user to permanently save a newly created or recently edited model.

Selecting "Create New Model" permits the user to structure an altogether new OPINT model, as described below.

7.3 Structuring a New Model Using OPINT

In order to structure the model, the user must load the OPINT software program and select the "Create New Model" option. The user will first be asked to type in the names of the decision alternatives. OPINT will then ask for the name of the key uncertain event and the possible event outcomes. The next user input will be the names of the criteria used to assess the regret associated with the decision outcomes. When the decision alternatives, the key uncertain event, and the criteria have been typed in, the framework is complete, and the model is ready for the input of assessments.

The program will next request that the user input regret valuations associated with each criterion for each decision outcome. The computer will allow the user to check these valuations by using reference gambles. Once the user has checked these valuations, the computer will request weights describing the relative importance of the criteria. The user will then be asked to assess the relative probability of each possible outcome of the key uncertainty.

The computer will generally request confirmation that all of the above values and labels are correct.

Once the model is structured, the user should immediately save the model (using the "Save Model" option) to avoid

accidental loss caused either by computer malfunction or human error. The user may now use the "Display Results" and "Sensitivity" options described in Section 7.2 to examine the results, or use the "Revise Estimates" option to edit the model.