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DEVELOPMENT OF THE SUMMET DECISION-AID FOR COUNTERMEASURE DEVELOPMENTS

PHASE 1
FINAL TECHNICAL REPORT

JUNE 1983

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Report describes the first phase of a decision-aid for use at the U.S. Army Tank-Automotive Command (TACOM) in the allocation of funds to develop countermeasures for combat vehicles. The decision-aid being developed is identified as SUMMET (Survivability Measures and Methods Evaluation Technique). SUMMET will aid TACOM managers in deciding which of many countermeasure alternatives to improve combat vehicle survival should be funded for development.

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SUMMET development has progressed to a point where the decision-aid concept is available to try, to test, and to evaluate. Computerized aids are available to support trying, testing, and evaluating the SUMMET concept.

The SUMMET decision-aid is being developed to incorporate features such that it will:

- Dissect the "which countermeasure to fund" decision problem into a manageable number of meaningful "decision-dimensions." At this point, the decision-dimensions in SUMMET are R&D time, R&D risk, R&D cost, performance effectiveness, combat utility, and user acceptance.
- Allow a utility or worth-of-development evaluation of proposed countermeasure projects in each of the decision-dimensions; allow utility to be measured in terms that are familiar to and used by the R&D decision maker. "High," "Medium," and "Low" are the measurement terms for utility that are used in SUMMET.
- Interpret the set of utility evaluations for each proposed development approach to each proposed countermeasure to yield "preferred for funding" indicators, and perform the interpretation in a manner that is consistent with the decision processes of the R&D decision maker. At this point, the preference indicators in SUMMET are "go/no-go," go-likelihood, and cost-benefit.
- Require input that is reasonable in terms of what the decision maker can generate and what is or can be made available to him; accommodate and reflect uncertainty and variability of input.
- Be easy to use and audit and be consistent with the objective to "keep it simple, but not trivial;" further, be easy to modify, permit sensitivity analysis, be paper and pencil testable, and be amenable to computerization.

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1.0. INTRODUCTION AND OVERVIEW

1.1. Introduction

This is the final report for Phase I of a program whose objective is to develop a decision-aid for use at the U.S. Army Tank-Automotive Command (TACOM) in the allocation of funds to develop countermeasures for combat vehicles. The decision-aid being developed is identified as SUMMET (Survivability Measures and Methods Evaluation Technique).

SUMMET is being developed and implemented as a tool that will aid TACOM managers in deciding which of many countermeasure alternatives to improve combat vehicle survival should be funded for development. The SUMMET concept and its development to date are the subject of this Phase I final report. This report covers the work performed by the Honeywell Systems and Research Center during the period from 10 June 1982 through 30 January 1983. This report is submitted in accordance with Data Item A002 of Contract No. DAAE07-82-C-4049. SUMMET is being developed for the Survivability Research Division of the Tank-Automotive Concepts Laboratory, U.S. Army Tank-Automotive Command, with Dr. James L. Thompson, Head of the Survival Technology Function, as the Technical Representative.

Raymond W. Schaefer is the Honeywell Program Manager for SUMMET. Dr. Jan D. Wald is the principal investigator and work director. The other principal contributors to the SUMMET development are Peter L. Gilles, James A. Hawthorne, Dennis J. Adsit, and Jeffrey P. Schwartz.

Additional reference material is contained in Honeywell Report No. F2276-1, dated 5 August 1982 and entitled, "Methodology Base Evaluation of Decision Support Systems." That report covers the front-end Phase I work to first review decision-theoretic, expert-system, and planning-system decision-aid methods and then evaluate their applicability for SUMMET. The report identifies "pieces" of existing or proposed methods that are attractive for incorporation in the decision-aid desired by TACOM.

With completion of Phase I, SUMMET development has progressed to a point where the decision-aid concept is available to try, test, and evaluate. The concept is detailed in Section 2.0 of this report. Computerized aids are available to support the trying, testing, and evaluation of the SUMMET concept. These computerized aids are explained in Section 3.0. More decision makers in the countermeasure arena, both in and out of TACOM, have been identified to participate in finalizing SUMMET and its user interface. The issues of user interface are addressed in Section 4.0. Participation by managers who will use SUMMET and by managers with whom they interact on countermeasure decisions continues as mandatory to develop a decision-aid that is understandable, usable, and acceptable.

To best benefit the users of the SUMMET decision-aid these features are being incorporated:

- It will dissect the "which countermeasures to fund" decision problem into a manageable number of meaningful "decision-dimensions." At this point, the decision-dimensions in SUMMET are R&D time, R&D risk, R&D cost, performance effectiveness, combat utility, and user acceptance. These decision-dimensions are defined in Section 2.0.

- It will allow a utility or worth-of-development evaluation of proposed countermeasure projects in each of the decision-dimensions, and allow utility to be measured in terms that are familiar to and used by the R&D decision maker. "High," "medium," and "low" are the measurement terms for utility that are used in SUMMET.

- It will interpret the set of utility evaluations for each proposed development approach to each proposed countermeasure to yield "preferred for funding" indicators and perform the interpretation in a manner that is consistent with the decision process of the R&D decision maker. At this point, the preference indicators in SUMMET are "go/no-go," go-likelihood, and cost-benefit.

- It will require input that is reasonable in terms of what the decision maker can generate and what is or can be made available to him, and accommodate and reflect uncertainty and variability of input. Candidate inputs are described and exemplified in Sections 2.0, 3.0, and 4.0.

- It will be easy to use and audit and be consistent with the objective to "keep it simple, but not trivial." It must also be easy to modify, permit sensitivity analysis, be paper and pencil testable, and be amenable to computerization. These features underlie the basic structure of SUMMET.

These goal features of SUMMET give some clue as to how SUMMET will operate. Let's look at its envisioned operation a little more closely.

1.2. Summet Overview

Figure 1-1 highlights what might be termed the concept of operation for the decision-aid called SUMMET. With reference to the figure, the concept is as follows. The R&D decision maker is presented with proposals for the development of countermeasures (CMs), intended to improve the survivability of combat vehicles. These proposals will address not only different CMs, but alternative ways to approach their development as well. (For example: a low cost, high risk approach; a high cost, longer time, low risk approach; a low cost, low risk, lower capability approach, and so on.) The CM proposals will vary in information that defines the character of the CM, and of its one or

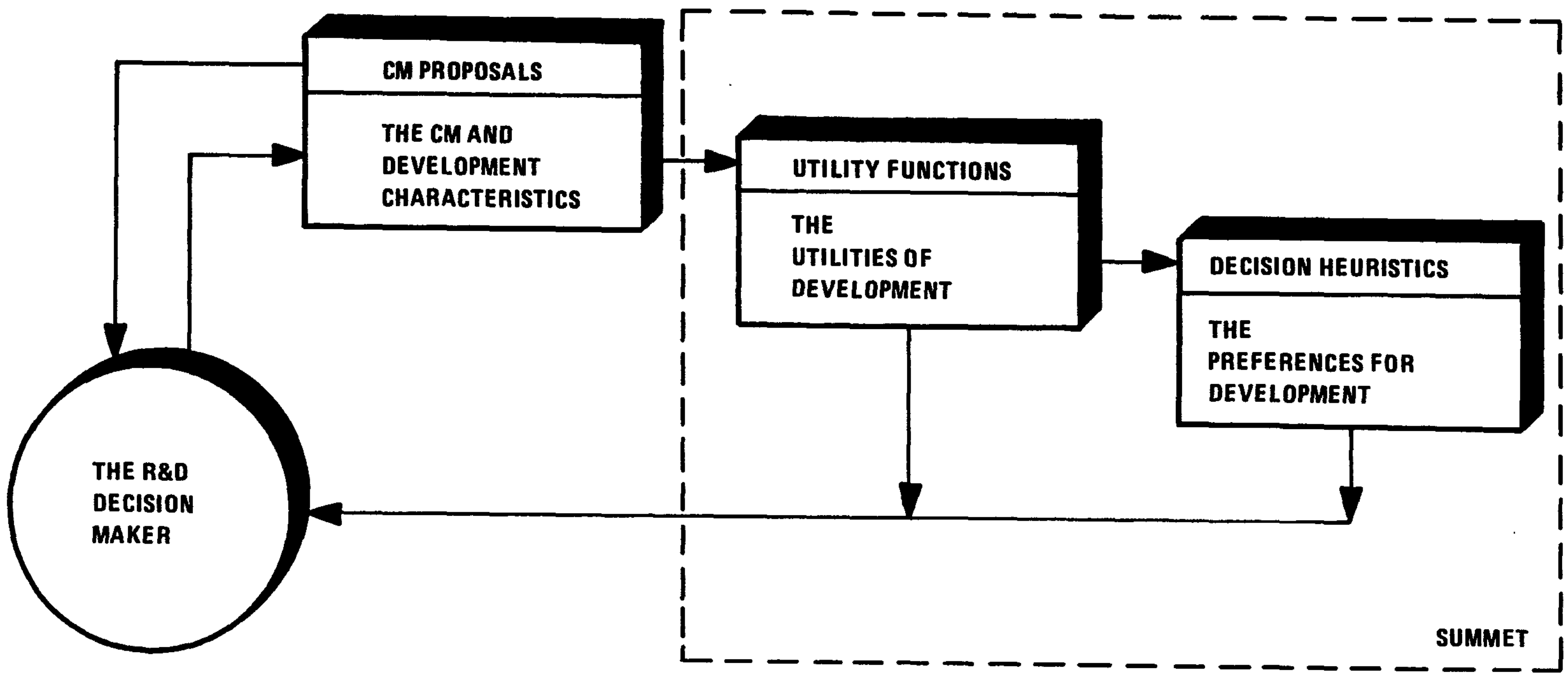


Figure 1-1. SUMMET Concept of Operation

more development approaches, in each of the "decision-dimensions" of interest. As noted earlier, R&D time, R&D risk, R&D cost, performance effectiveness, combat utility, and user acceptance are examples of decision-dimensions. One proposal may include substantiated and quantitative characteristics in all decision-dimensions; another in just some dimensions; another proposal may include only best estimate value ranges, because the CM concept has only just surfaced. Nevertheless, the decision maker wants to consider all proposals and knows that there will never be enough time or enough money to get all of the proposals to provide all of the desired characteristics to all the same level. He will use the characteristics of time, risk, effectiveness and so on, as provided. He will generate or will cause to be generated the missing data to the level of specificity and certainty possible. This results in a set of "input for SUMMET" characteristic data for each proposed CM/development approach combination. Note that if there are four different approaches to one CM (i.e., four different combinations of risk, time, effectiveness, acceptance, and so on), SUMMET will be used to examine four proposals and not one. In this manner, SUMMET will aid the decision on both preferred CMs and development approaches.

With CM and development characteristics in hand for each proposed CM and development approach combination, the R&D decision maker is ready to use SUMMET. He can input one combination at a time and perform sensitivity tests which may in turn flag the need to "firm up" certain "first guess" uncertainties. He may first want a "batch" examination of all proposed CMs and development approaches to aid a "first sort" elimination of less attractive proposals. The decision maker may want to use SUMMET in a number of different ways. More of the envisioned use options are described in Section 4.0.

As indicated in Figure 1-1, a CM and its development characteristics in each decision-dimension are input to what are called the SUMMET "utility functions." What is a utility function? In SUMMET, if may be thought of as something that assigns a "high," "medium," or "low" worth to particular values in each decision-dimension. For example, let's look at the decision-dimension of R&D cost. The utility function for R&D cost may say the following: If a proposed CM R&D cost is projected to be less than 5 percent of the total available budget for CM developments, then the worth or utility of that proposed CM development project is high in the R&D cost dimension; if the projected R&D cost is greater than 10 percent of the total budget, then the worth or utility in this cost dimension is low; otherwise the worth or utility in this cost dimension is medium. Examples of utility functions are presented in Section 2.0 for each of the six dimensions of R&D time, R&D risk, R&D cost, performance effectiveness, combat utility, and user acceptance. The point to be made here is that the first step in the exercise of SUMMET is an assessment of the utilities or the worth of each proposed CM development. The assessment output for each proposed CM development is, in general, a set of probabilities that the CM development is of high, medium, or low utility in each decision-dimension. Table 1-1 exemplifies this development utility output. In SUMMET this development utility output is next input to what are called "decision heuristics." Before discussing this next step another point should be made. When fully implemented, SUMMET will allow for easy modification of what and how many decision-dimensions are to be considered. Similarly, easy modification of utility functions will be provided for. Now, on to the next step in SUMMET.

The next step in SUMMET is the preferential ordering of proposed CM developments. This is accomplished through exercise of what are called decision-heuristics. What is a decision-heuristic? It is one of a set of rules that, when satisfied by a proposed CM development, indicates development acceptability. It is one of a set of rules that is created by decision makers as part of SUMMET implementation and becomes an integral part of the SUMMET decision-aid. Details of these heuristic rules are presented in Section 2.0. Figure 1-2 exemplifies one of the set of these go decision rules that has already been formulated from preliminary interviews with TACOM decision makers.

TABLE 1-1. UTILITIES OF DEVELOPMENT--AN EXAMPLE

CM: Threat warning/reaction system

Development Approach: Low cost, high risk

Utilities of development determined with SUMMET:

	UTILITY LIKELIHOOD FOR:					
UTILITY LEVEL	R&D TIME	R&D RISK	R&D COST	PERFORMANCE EFFECTIVENESS	COMBAT UTILITY	USER ACCEPTANCE
HIGH	0.0	0.0	0.11	0.7	0.3	0.8
MEDIUM	0.75	0.33	0.23	0.3	0.5	0.2
LOW	0.25	0.67	0.66	0.0	0.2	0.0

	1	2	3	4	5	6
RULE NO. 46	M+,	H,	L,	M,	M-,	H

THIS RULE SAYS THAT IF,

1. DEVELOPMENT–TIME UTILITY IS MEDIUM OR HIGH AND,
2. DEVELOPMENT–RISK UTILITY IS HIGH (I.E., RISK IS LOW) AND,
3. DEVELOPMENT–COST UTILITY IS LOW (I.E., COST IS HIGH) AND,
4. PERFORMANCE–EFFECTIVENESS UTILITY IS MEDIUM AND,
5. COMBAT–UTILITY IS MEDIUM OR LOW AND,
6. USER–ACCEPTANCE UTILITY IS HIGH,

THEN, A PROPOSED CM DEVELOPMENT PROJECT IS ACCEPTABLE FOR R&D FUNDING.

Figure 1-2. An Example of an Heuristic "Go" Decision Rule

In SUMMET, the utilities of development, as discussed earlier and as exemplified in Table 1-1, are interacted with all of the go heuristic decision rules. This yields a likelihood (where $0 \leq$ likelihood ≤ 1) that each proposal CM is acceptable for develoment. Once this step is completed for all proposed CM developments, a number of preference rankings of the proposed developments can be provided from SUMMET. One ranking would be on the basis of go likelihood. Another ranking would be on the basis of go likelihood and cost-benefit (a cost-benefit ranking algorithm is presented in Section 2.0). Still another ranking would be on the basis of go likelihood and ranked decision rules (this particular ranking possibility remains under investigation). For each of these preference rankings, SUMMET then provides the decision maker with sets of preferred CM developments, each set chosen on a different basis. For example, one set of preferred CM developments would be on the basis of all top-ranked developments within the R&D budget. Another set of preferred developments would be the maximum number of ranked developments within the R&D budget. The key point is that SUMMET will provide the decision makers with rankings and preferences made on a number of different bases. He then makes the final choice. Remember, SUMMET is a decision-aid and not a decision-maker.

With this as an overview of the concept of operation for the SUMMET decision-aid, let us now proceed with further concept detail (Section 2.0), with explanation of the computer aids developed to date (Section 3.0), and with discussion of SUMMET user interface issues (Section 4.0).

2.0. THE SUMMET CONCEPT

In the previous section we overviewed the concept of operation for the decision-aid called SUMMET. The purpose of this section is to delve deeper into the constructs of SUMMET and explain them in more detail. To preamble the discussion, and because SUMMET involves some new "wrinkles" in the world of decision-aids, let us once more quickly walk through the SUMMET concept (we say concept because SUMMET is not fully developed and implemented at this point in time; its design details are not yet frozen, but its overall philosophy and structure are). To aid the walk through we will follow the flow depicted in Figure 2-1.

As indicated in Figure 2-1, the SUMMET exercise process starts with decision maker input that characterizes one or more proposed CM developments in each of six decision-dimensions: R&D time, R&D risk, R&D cost, performance effectiveness, combat utility, and user acceptance (where user is the military user of the CM to be developed). These input data may be discrete values or distributions of values or mixes of both types. These input data are operated on by utility functions (built into SUMMET) to asssess in each decision-dimension whether the utility of development is high, medium, low, or some likely combination of high, medium, and low (recall that Table 1-1 exemplified this utility assessment step). These high, medium, low, and likelihood measures of utility are then input to and operated on by heuristic decision rules (also built into SUMMET). This step yields measures of the acceptability of the proposed CM development. Ranking algorithms, and perhaps additional heuristic rules, are then exercised within SUMMET to provide one or more orderings of all the CM proposals considered. Now, before we proceed with details, one point needs to be emphasized: while utility functions and decision-heuristics will be built into SUMMET, provisions will be made to allow changes to these functions and heuristics. Such changes will not be made by just anyone, but only by the person or persons who are <u>the</u> decision makers and who want the decision-aid to reflect their philosophy of utility and acceptability of development.

In the further explanation of the SUMMET concept, we will first deal with heuristics, what they are, how they are derived, where they stand at this point in time, and what more needs to be done.

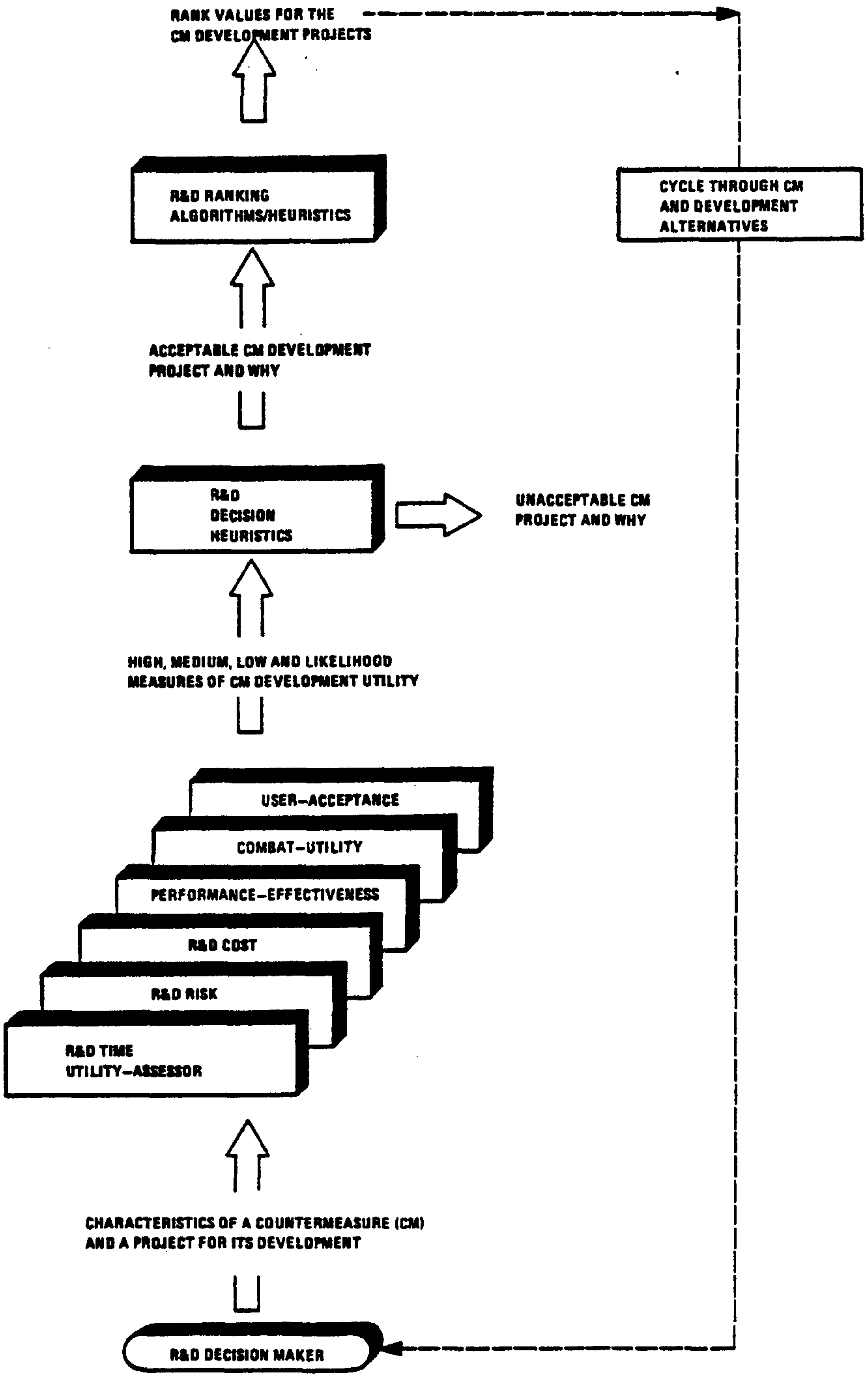


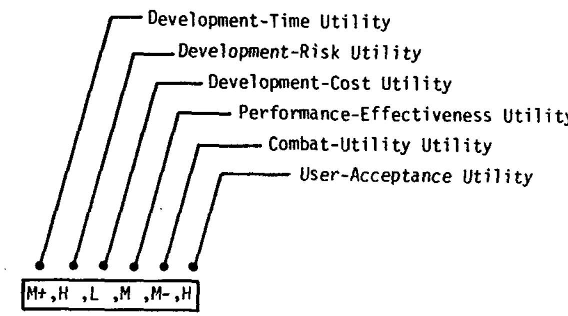
Figure 2-1. SUMMET Information Flow

2.1. Decision Heuristics

2.1.1. Definition and Status. SUMMET decision heuristics are sextuple rules of the form shown in Figure 1-2. They are termed go rules, because they cover the total "acceptable development-utility space." They are independent rules since the acceptable utility space covered by any one rule does not overlap the space covered by any other of the rules. A working set of go decision rules is given in Figure 2-2, where the convention for stating a rule is also defined. We use the term "working set" because this particular set of rules was derived from intentionally exploratory and not sufficiently complete interview sessions with TACOM decision makers. (SUMMET development did not start with the premise of incorporating heuristic decision rules; rather, the desirability of using heuristics evolved from the TACOM manager interview process.) A structured interview process will be used in Phase II to finalize the go decision rule set. It is of value here to review the process of working set rule development and to describe the computer aids now available to enhance the rule development process.

The working set of decision rules or heuristics given in Figure 2-2 is based on interviews with four manager-level individuals; three within and one formerly with the Tank-Automotive Concepts Laboratory of TACOM. Each of these interviewees was presented with preselected sextuples of utility hypothesized to represent the utilities of development determined for each of some 18 different and unnamed CM development proposals. To each of these 18 different sextuples, each interviewee was asked to respond with either a "yes, I would fund that proposal," or with a "no, I would not fund that proposal." (We should note that each of these managers dealt easily and quickly with these sextuple data sets of different high, medium, and low combinations.) Each interviewee also commented on the reasons for his particular responses. To illustrate the questions posed to the interviewees, one of the presented sextuples was: "If development time utility was high, and if development risk utility was medium, and if development cost utility was high, and if

RULE NO.	"GO" CONDITIONS	RULE NO.	"GO" CONDITIONS	RULE NO.	"GO" CONDITIONS
1.	M+,M+,M+,H,L+,L+	24.	L,L,H,H,M+,M+	47.	L,M,M,M,M-,H
2.	L,H,M+,H,L+,L+	25.	H,M+,L,M-,H,M+	48.	M+,L,H,M,M-,H
3.	L,M,H,H,L+,L+	26.	M,H,L,M-,H,M+	49.	M,M,L,H,M-,H
4.	H,H,L,H,M+,L+	27.	H,L,M+,L,H,M+	50.	L,H,L,H,M-,H
5.	L,M,M,H,M+,L+	28.	H,L,M,M,H,M+	51.	L,L,H,H,L,H
6.	M+,M+,M+,M-,H,L+	29.	L,M,M,L,H,M+	52.	M+,H,L,L,M,H
7.	L,H,M+,M-,H,L+	30.	M,L,H,M-,H,M+	53.	M+,L,M+,L,M,H
8.	L,M,H,M-,H,L+	31.	M,M,L,M+,H,M+	54.	M+,L,M,M,M,H
9.	L,M,M,M,H,L+	32.	L,H,L,M,H,H	55.	M,L,M,H,M,H
10.	H,L,H,M+,H,L+	33.	M,L,M,M+,H,M+	56.	M,L,M,L,H,H
11.	H,M,L,H,H,L+	34.	L,L,H,M,H,M+	57.	L,M,M,L,M,H
12.	M,H,L,H,H,L+	35.	L,M+,L,H,H,M+	58.	L+,M,L,M,M,H
13.	H,L,M,H,H,L+	36.	L,L,M,H,H,M+	59.	L,H,L,M,M,H
14.	M,L,H,H,H,L+	37.	L+,L,L,H,H,H	60.	L,M,L,H,M,H
15.	H,M+,L,H,L,M+	38.	M+,M+,M+,M-,L,H	61.	L,M,L,M,H,H
16.	H,M,L,H,M,M+	39.	M+,M+,M+,L,M,H	62.	L,L,M,M,M+,H
17.	M,H,L,H,M-,M+	40.	M+,M,M,M,M,H	63.	L,L,M,H,M,H
18.	H,L,M+,H,M-,M+	41.	M,M,H,M,M,H	64.	L,L,H,M,M,H
19.	L,M,M,H,L,M+	42.	L,H,M+,M-,L,H	65.	L+,L,L,H,M,H
20.	M,L,H,H,M-,M+	43.	L,H,M+,L,M,H	66.	M,M,L,L,H,H
21.	M+,H,M+,M,M,M+	44.	L,H,M,M,M,H	67.	L,H,L,L,H,H
22.	H,M,H,M,M,M+	45.	L,M,H,M-,M-,H	68.	L,L,H,L,H,H
23.	L,H,H,M,M,M+	46.	M+,H,L,M,M-,H	69.	L+,L,L,M,H,H



Where:
- L = low utility
- L+ = low or medium or high utility
- M = medium utility
- M- = medium or low utility
- M+ = medium or high utility
- H = high utility

Figure 2-2. "GO" Decision Rules--A Working Set

performance effectiveness utility was low, and if combat effectiveness utility was low, and if user acceptance utility was high, would you fund such a CM proposal?" Before posing such a question, the interviewer and the interviewee discussed the meaning and the interpretation of high, medium, and low utility in each of the decision-dimensions of time, risk, cost, performance effectiveness, combat utility, and user acceptance (from these discussions, candidate definitions of utility functions evolved; these will be described shortly). The four interviewees agreed on those sextuples which were heavily weighted with highs or lows; they varied on more evenly weighted sextuples, which is to be expected since the moderately weighted sextuples are more debatable as to acceptability for funding. Later in this discussion we will talk about how differences in the go/no-go space among decision makers may be accommodated in SUMMET.

The 18 test sextuples used in the exploratory interviews were not sufficient, of course, to completely determine the go/no-go acceptability for each of the 729 (3^6) possible combinations of high, medium, or low in each of six dimensions. We derived the final working set of decision heuristics in Figure 2-2 by extrapolating primarily from the decision responses made by the individual that had the highest decision-making authority. Two significant accomplishments were achieved in the derivation of this working set of decision rules. The first was to demonstrate that such decision rules are indeed derivable. The second is that computer-aided techniques, developed during the preliminary rule derivation process, are now in place to selectively, and thereby rapidly, take a decision maker through the entire decision space and derive his set of decision rules. Let's briefly describe these rule derivation computer aids.

Figures 2-3 through 2-5 are "screens" generated from a "Heuristics Acquisition Program" we have written in BASIC to run on an Apple II computer. This interactive program aids the efficient acquisition of go decision rules. It takes advantage of the fact that, in general, when any sextuple of utilities

```
IT WILL TAKE ME ABOUT TWO MINUTES
TO GENERATE THE SAMPLE SPACE

FEEL FREE TO CHECK MY WORK
```

```
DO YOU WISH TO:
  A)  LOAD AN OLD CASE
  B)  BEGIN A NEW CASE
WHICH?A
```

```
WHAT CASE NUMBER? 1
```

```
                WAIT

          READING FROM DISK
```

Figure 2-3. Preparatory Screens in the Heuristics Acquisition Program

```
                 RULE 1

    DEVELOPMENT TIME UTILITY IS  M
    DEVELOPMENT RISK UTILITY IS  M
    DEVELOPMENT COST UTILITY IS  M
    PERFORMANCE EFF. UTILITY IS  M
    COMBAT UTILITY UTILITY IS    M
    USER ACCEPTANCE UTILITY IS   M

THIS RULE IS:

A)  GO RULE
B)  GO RULE AND UPPER LIMIT TO NOGO'S
C)  NOGO RULE
D)  NOGO RULE AND LOWER LIMIT TO GO'S

WHICH?C

  NEW GO'S    NEW NOGO'S
      0           64

TOTAL GO'S    TOTAL NOGO    UNDECIDED
      0           64           665

PRESS ESC TO SAVE CURRENT RULES & QUIT
PRESS RETURN TO CONTINUE
```

Figure 2-4. First Question/Answer Screen in the Heuristics Acquisition Program

```
                 RULE 7

    DEVELOPMENT TIME UTILITY IS  H
    DEVELOPMENT RISK UTILITY IS  H
    DEVELOPMENT COST UTILITY IS  H
    PERFORMANCE EFF. UTILITY IS  L
    COMBAT UTILITY UTILITY IS    M
    USER ACCEPTANCE UTILITY IS   M

THIS RULE IS:

A)  GO RULE
B)  GO RULE AND UPPER LIMIT TO NOGO'S
C)  NOGO RULE
D)  NOGO RULE AND LOWER LIMIT TO GO'S

WHICH?A

  NEW GO'S    NEW NOGO'S
      4           0

TOTAL GO'S    TOTAL NOGO    UNDECIDED
      44          120           565

PRESS ESC TO SAVE CURRENT RULES & QUIT
PRESS RETURN TO CONTINUE
```

Figure 2-5. Nth Question/Answer Screen in the Heuristics Acquisition Program is decided as a go or a no-go, such decision automatically decides many other sextuples to also be go or no-go. For example, in the convention of Figure 2-2, if a decision maker says that the utility combination of (H, M, H, L, L, H) is a go, he has by this one decision identified not just one, but 1x2x1x3x3x1, or 18 combinations, as goes. This is because if the utility combination (H, M, H, L, L, H) is a go, then each utility combination in the set (H, M+, H, L+, L+, H) is also a go. This "decision-on-one means a decision-on-many" principle is used in the Heuristics Acquisition Program illustrated by Figures 2-3 through 2-5.

Figure 2-3 illustrates the preparatory steps in the interactive Heuristics Program. Figure 2-4 is the question-starter screen that asks whether the utility combination (M, M, M, M, M, M) is: (a) a go rule; (b) a go rule and an upper bound to no-goes; i.e., all combinations with lesser utility values in each dimension are no-goes; (c) a no-go rule; or (d) a no-go rule and a lower bound to goes, i.e., all combinations with higher utility values in each dimension are goes. In the example of Figure 2-3, (M, M, M, M, M, M) is decided as a no-go rule and when such decision is input, the program identifies that this decision really decided 2x2x2x2x2x2, or 64 utility combinations to be no-goes. The program further identifies that 729 minus 64 (or 665) utility combinations remain to be decided on. The program then advances to another undecided rule, a question is asked, a decision is input, and the number of undecided cases are updated. Figure 2-5 is an illustration of screens presented in the middle of the question and answer process, a process which continues until all combinations are decided. The program then prints out utility combinations that cover the total go space. These combinations are not necessarily non-overlapping or independent. Since non-overlapping or independent rules are required for "likelihood of go" determinations in SUMMET, we have developed another Apple II, BASIC language program that aids the derivation of independent go decision rules, such as are given in Figure 2-2.

2.1.2. Future Directions. There are two issues that future refinements in the SUMMET decision heuristics should address:

- Ordering the decision space as one means to aid the ranking of CM development proposals.
- Resolving or accommodating different or conflicting expert opinion.

The present approach to SUMMET decision heuristics does not distinguish among goes of varying desirability. Intuitively a CM proposal utility corresponding to a sextuple like (H, H, H, H, H, H) is much more desirable than a proposal corresponding to a go sextuple near the go/no-go border, e.g., (M, M, M, H, L, L). The present system does not make such distinctions. All goes are on a par, and all no goes are on a par.

One approach to ordering the goes is to determine weights representing the relative importance of each of the six decision-dimensions. This approach has the drawback that expert decision makers may not have clear intuitions about precise weights. Ordering of the decision space will be studied in the next phase of SUMMET development. Other techniques to aid rank ordering of proposed CM developments will also be investigated. An example of a cost benefit ranking measure will be described later in our discussion of utility functions.

With regard to the issues of how to resolve differences in expert opinion and how to reconcile the resulting different set of heuristics, two approaches come to mind.

The first approach involves developing a compromise set of heuristics. Most sextuples won't be in dispute among decision makers; they will be clear goes or clear no-goes. Disagreements will generally occur on sextuples near the go/no-go borderline. The first approach would get decision makers to work out their borderline differences.

The second approach would involve taking advantage of the differences rather than trying to resolve them. One could, for example, derive a different set of heuristics for each of n decision makers. The SUMMET system would evaluate the go probability of a CM proposal relative to each decision maker's set of heuristics. This simply involves running the same output from the lower level SUMMET evaluation through each of the n heuristic sets. An average go probability for the CM proposal could then be calculated by summing the resulting n go probabilities and dividing by n. This technique gives each heuristic set an equal vote. Extra votes could be given to heuristic sets derived from more authoritative decision makers by weighting their go decisions more heavily. This difference of opinion among decision makers will be addressed further in the next phase of SUMMET development.

Having now defined and described decision heuristics and their status, let us turn our attention to SUMMET utility functions and input data.

2.2. Utility Functions and Input

Our discussion will now deal with utility functions, what they are in SUMMET, and what "trial" definitions for these functions are now in place.

Utility functions in SUMMET are, as noted earlier, assessors of the worth of CM development in each of the decision-dimensions of time, risk, cost, and so on. This assessor role was depicted in Figure 2-1. The utility functions operate on the decision maker's input data, which characterizes each proposed CM and each of its proposed development approaches. The utility functions then output whether the utility or worth of development in each decision-dimension is low, medium, high, or some likely combination of these levels. The notion to use high, medium, and low measures of utility stemmed from our exploratory interviews with TACOM and other decision makers. We found the high, medium, and low descriptors to be convenient, manageable, and often used. Recall such phrases as: "I'd fund that project if the risk were lower," or "I'd accept less than high effectiveness if the cost were moderate."

With this brief introduction, let us now describe the "trial" utility functions that are currently "in place" in SUMMET. We say trial because they need to be examined for acceptability by TACOM decision makers. We say in place because they are incorporated in the SUMMET I computer program described in Section 3.0.

2.2.1. R&D Time and Utility. Let R&D time, T, (sometimes called development time) be the time from initiation of CM research and development to the time when both feasibility has been demonstrated and engineerability has been proven within accepted standards. Let R&D time utility, U(T), be then defined as follows:

T (Years)	U(T)
<2	High
>2 but <4	Medium
>4	Low

R&D time, T, is one of the characteristics of a CM development project that the decision maker must input to SUMMET. As with any SUMMET input, T may be input as a discrete value, as a Beta distribution, or as a histogram of values (this latter form allows for a uniform distribution of values). These input options are described further in Section 3.0. SUMMET will allow these different forms of input in order to best reflect real uncertainty or real variability that may exist in the characteristics of a proposed CM and a proposed development approach.

2.2.2. R&D Risk and Utility. Let R&D risk, R, (sometimes called development risk) be the estimated probability that a propoed approach for a CM development program will not achieve a technical development result at least as good as the intended result. Let R&D risk utility, U(R), then be defined as follows:

R	U(R)
<0.25	High
>0.25 but <0.5	Medium
>0.5	Low

The development risk, R, may be input as a discrete value or as some distribution of values. The notion to input a distribution of risk values stems from the thought that a decision maker may query a team of his experts and ask each expert to estimate the probability that a proposed CM development will not achieve its proposed technical objective. The decision maker may then wish to input the distribution of responses from the team, rather than some average response.

2.2.3. R&D Cost and Utility. Let the R&D cost (sometimes called development cost) of a proposed CM development be measured in "fraction of budget" terms, rather than in absolute dollar terms. Specifically, let the R&D cost metric, \$, for a proposed CM development be the ratio $\$_c/\$_b$ where:

> $\$_c$ is the total R&D dollar cost projected for a proposed CM development over the most likely total time projected for its development (this most likely time is thus the most likely value for the R&D time characteristic, T, defined earlier); and $\$_b$ is the total dollar budget projected to be available for all CM developments during this same most likely development time. Let R&D cost utility, U(\$), be then defined as:

\$ Fraction of Budget	U(\$)
<0.05	High
>0.05 but <0.10	Medium
>0.10	Low

Again, as with all other input characteristics, the R&D cost metric, $, may be input as a discrete or as a distribution of values.

2.2.4. Performance Effectiveness and Utility. Let performance effectiveness of a CM proposed for development be characterized by the increase in survivability that the CM affords to a vehicle against each threat system or systems that the CM is intended to counter. Specifically, let "increase in probability of survival" be the characteristic parameter to describe CM performance effectiveness, E. Let the performance effectiveness utility, U(E), be defined as:

E Increase in Probability of Survival	U(E)
<0.2	Low
>0.2 but <0.4	Medium
>0.4	High

We suggest that any one of the "one-on-one" combat models available to TACOM be used to estimate the expected survival probability increase. Further, we suggest that such one-on-one model be exercised over realistic situation variability (e.g., spectral visibility conditions) to generate a distribution for survival-probability-increase values as input to SUMMET. This last suggestion stems from the notions: that situation variability is real; that survival probability changes with the situation; and that trying to capture probability of survival, and its potential increase, in discrete average numbers is not taking advantage of the more realistic distribution of values.

To illustrate the envisioned use of a one-on-one combat model to generate inputs to SUMMET, consider the following example. Suppose that a proposed CM is to counter two specific threat systems by degrading their ability to track the protected vehicle, given a detection. Further suppose that these threat systems are present in scenarios characterized by a representative terrain and range of spectral visibility conditions. The one-on-one model could then be exercised over a "matrix" of one-on-one runs covering the two threat systems and, say, three positions per threat, three vehicle penetration paths per threat position, and three visibility conditions. Each of these 54 runs would be made first without the CM and then with it. The difference between each with-CM and without-CM run would be tallied as a histogram or distribution of performance effectiveness (E) values for input to SUMMET.

A key requirement for the suggested use of a one-on-one combat model is that such model have the capability to 1) account for the threat capability to detect, acquire or track, hit, and kill a vehicle; and 2) reflect the degradation of any of these threat capabilities by a CM of interest.

2.2.5. Combat Effectiveness and Utility. Whereas performance effectiveness of a proposed CM addressed the benefit afforded to a single combat vehicle, combat utility addresses the benefit afforded to a combat force. In other words, performance effectiveness asks, "Did I save the vehicle?" while combat utility asks, "Did I win the battle?"

As with the other CM decision-dimensions, there are numerous ways to characterize combat utility, C. The characterization we suggest for C is one that would be supported by a "force-on-force" evaluation. Specifically, let combat effectiveness, C, be defined as the "improvement in fractional casualty ratio" afforded by a proposed CM in a force-on-force engagement, where fractional casualty ratio is the outcome percent of "red" losses divided by the outcome percent of "blue" losses and where an outcome ratio value of 1.0 may be viewed to represent a draw. If F_{CO} is the fractional casualty ratio value without the proposed CM, and if F_{CW} is the value with the CM, then $C = (F_{CW} - F_{CO})/F_{CO}$.

Let the combat effectiveness utility, U(C), be defined as:

C, Improvement in Fractional Casualty Ratio	U(C)
<0.2	Low
>0.2 but <0.4	Medium
>0.4	High

In the force-on force evaluation of combat effectiveness, C, a combat model or simulation would be exercised over a matrix of representative combat scenarios to account for a realistic variability in force mixes and in scenario environments. The matrix of runs would be made with and without the benefit of the proposed CM to generate a histogram or distribution of C values.

The force-on-force approach to combat effectiveness requires that a rapidly executable force-on-force model be available. We know that TACOM is seeking to have such a model at their disposal. When available, such a model could tie nicely into the force-on-force approach for combat utility assessment in SUMMET. We do already have one such programmed model available for use. It is called SPIFFI and is documented in Honmeywell Report No. 80SRC89, dated November 1980 and entitled, "SPIFFI, a Lanchester Combat Model."

2.2.6. User Acceptance and Utility. The acceptance dimension, A, measures user acceptance of a proposed CM system on the basis of a number of characteristics. These characteristics indicate the attraction or resistance likely to be encountered if the R&D effort is successful and the CM system is proposed for implementation. We have identified eight user acceptance criteria:

- User Need
- Time to Field
- Retrofitability

- Retrofit Cost
- Operations Cost
- Support Cost
- Tactics Impact
- Useful Life Span

This list may not be complete, but for the purposes of this discussion, we will suppose that it is. The user acceptance evaluation method we will describe is easily adapted to any alteration in the list of criteria. In brief, the listed criteria are defined as follows:

- User Need--This criterion is an estimate of how much the user believes he needs the system.
- Time to Field--How pleased (or displeased) the user will be with the amount of time needed to implement the system.
- Retrofitability--How easily the CM system is retrofitted to present vehicles.
- Costs--How accepting the user will be to the costs of investment, retrofit, operation of the CM system, and support systems for the CM system.
- Tactics Impact--How adaptable the user is to any change in tactics required for the effective use of the CM system.
- Useful Life Span--How acceptable to the user the expected life span is before technological obsolescence.

Now suppose each user acceptance criterion has a value of high, medium, or low and that these translate into the numbers 0.0, 0.5, and 1.0, where 1.0 is assigned to high user acceptance, 0.5 to medium acceptance, and 0.0 to low acceptance. Notice that we describe the acceptance criteria in such a way that high is always associated with positive user acceptance.

Let $C_1, C_2 \ldots, C_n$ stand for each of the acceptance criteria (n = 8 for the set of criteria we have determined above). Let $V(C_i)$ be the acceptance value (i.e., 1.0, 0.5, or 0.0) of C_i. If each acceptance criteria were equally important, then the net CM user acceptance value, A, is the average.

$$A = \left[\sum_{i=1}^{n} V(C_i) \right] \div n$$

But generally, some criteria will be more important than others and should carry more weight in the net value. Let $W(C_i)$ be the weighting factor for the relative importance of criterion C_i, and let the values $W(C_i)$ be normalized so that

$$\sum_{i=1}^{n} W(C_i) = 1$$

(when each C_i is of equal importance, $W(C_i = 1/n)$. Then the value of A is the weighted average:

$$A = \sum_{i=1}^{n} \left[V(C_i) \quad W(C_i) \right]$$

The value of A ranges from 0.0 to 1.0, depending on the values of $V(C_i)$ (i.e., if $V(C_i) = 1$ for each i, then A = 1; if $V(C_i) = 0.0$ for each i, then A = 0.0).

Now the user acceptance value A may be translated into a high-medium-low utility for overall user acceptance as follows:

A	U(A)
<0.33	Low
>0.33 but <0.67	Medium
>0.67	High

In this way the total user acceptance value may be calculated (by the system) from the user acceptance values of its inputs. Both inputs and output are on a utility scale of high, medium, or low. Fixed values for the $W(C_i)$, which indicate the relative importance of the various acceptance criteria, will be determined on the basis of expert opinion drawn from TACOM and the user community.

While we illustrated user acceptance based on discrete assignments of 0.0, 0.5, or 1.0 values to each acceptance criterion, SUMMET can allow for an uncertainty range of values to be assigned (0.6 to 0.7, for example).

2.3 Ranking

As we noted earlier, work in Phase II of SUMMET development will include further development of techniques to rank acceptable CM proposals. Heuristics and algorithms will be investigated. Figure 2-6 exemplifies one cost benefit algorithm that could be incorporated in SUMMET as a ranking means. This cost benefit relationship would rank highest those acceptable CM proposals that have: the highest utility in performance effectiveness, combat effectiveness, and user acceptance; the least R&D risk; and the least R&D cost.

This concludes the discussion of the SUMMET decision-aid concept. Let us now proceed with the description of the computer aids available to aid manual exercise of the SUMMET concept.

$$\text{COST BENEFIT} = \frac{[(\overline{U}_{pe} + \overline{U}_{cu} + \overline{U}_{ua})/3]\ [1 - \overline{\text{R\&D RISK}}]}{[\overline{\text{R\&D COST RATIO}}]}$$

$\overline{U}_{pe}$ = EXPECTED VALUE OF PERFORMANCE-EFFECTIVENESS UTILITY

$\overline{U}_{cu}$ = EXPECTED VALUE OF COMBAT UTILITY

$\overline{U}_{ua}$ = EXPECTED VALUE OF USER ACCEPTANCE UTILITY

$\overline{\text{R\&D RISK}}$ = EXPECTED VALUE OF DEVELOPMENT RISK

$\overline{\text{R\&D COST RATIO}}$ = EXPECTED VALUE OF N-YEAR DEVELOPMENT COST OF A CM AS A FRACTION OF N-YEAR BUDGET AVAILABLE FOR ALL CM DEVELOPMENTS

Figure 2-6. A Cost Benefit Algorithm for Ranking of Proposed CM Developments

3.0. SUMMET I USERS' GUIDE

This section is intended to serve as a users' guide for the SUMMET I computer program. The SUMMET I program is available on the PRIME computer at the U.S. Army Tank-Automotive Command, Warren, Michigan. The program is accessed through TYMNET or through direct dial-up.

As noted earlier, SUMMET I is a program to aid the manual exercise of the SUMMET decision-aid concept. SUMMET I is not intended to represent a final computerized and interactive version of SUMMET. Rather, it is intended to facilitate the testing, evaluation, and refinement of the SUMMET decision-aid concept that will occur in Phase II.

The material in this section is organized into three main parts:

1. A set of input specification sheets that describe the nature and format of each of the SUMMET I input data records. These specification sheets also serve to further describe the character of the data on which the SUMMET concept is based.

2. An annotated terminal session that takes a person through all the steps necessary to login, enter data, execute the program, and review the program output.

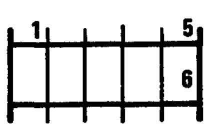
3. Reference material that includes a complete program listing, a complete set of sample inputs, and the corresponding sample output.

3.1. Input Specification

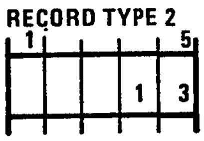
The following pages are a set of format specifications for each of the data records used in the SUMMET I program. Each record format is identified by a Record Type Number. Following the set of input format specification pages is a set of blank forms without the descriptive information. These forms may be copied and used for SUMMET I data inputs.

3.1.1. Format Specifications.

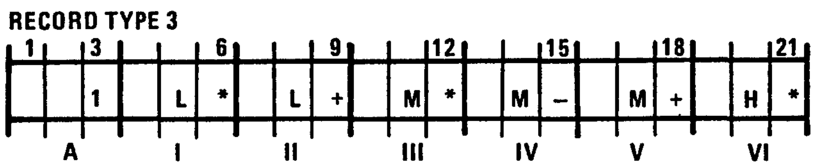
RECORD TYPE 1



Record Type 1 is used to input the number of decision-dimensions.



Record Type 2 is used to input the number of decision heuristics.



Record Type 3 is used to input the decision heuristics. One record is needed for each of the heuristics.

The data field labeled "A" is an index field for numbering the heuristics.

The data fields labeled I through VI correspond to the six decision-dimensions. They are as follows:

I	Development-time utility
II	Development-risk utility
III	Development-cost utility
IV	Performance-effectiveness utility
V	Combat-utility
VI	User-acceptance utility

The utility of each of the decision-dimensions is coded using the following symbols:

L*: Low utility

L+: Low, medium, or high utility

M*: Medium utility

M-: Medium or low utility

M+: Medium or high utility

H*: High utility

The utility of each of the decision-dimensions is defined in terms of a characteristic parameter. Figures 3-1 and 3-2 define two types of utility functions used in defining the data fields for Record Type 4.

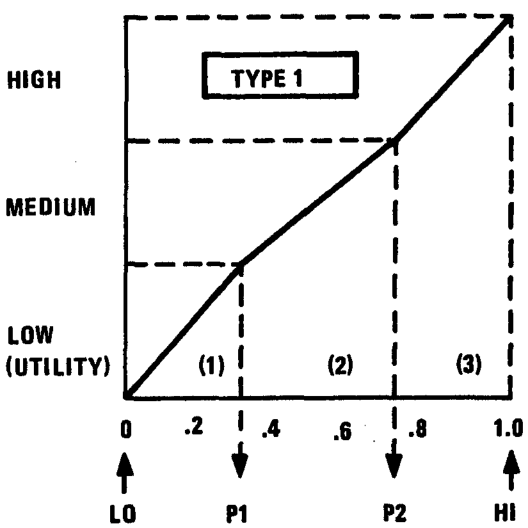


Figure 3-1. Utility Function Type 1

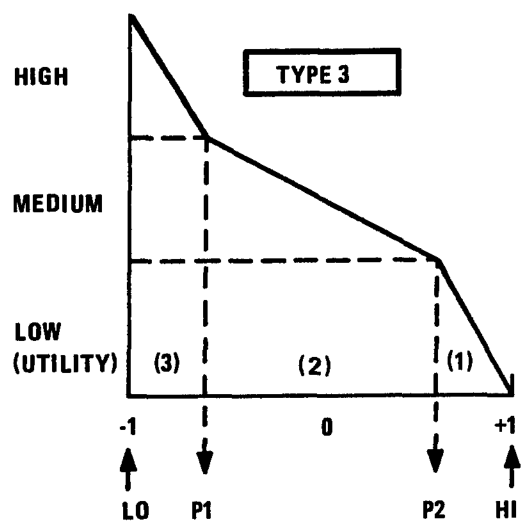
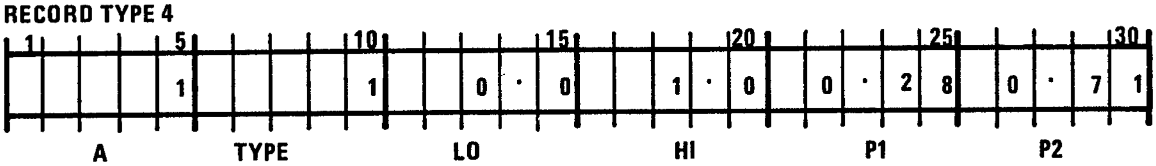


Figure 3-2. Utility Function Type 3

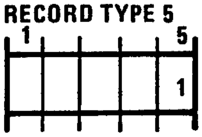
RECORD TYPE 4



Record Type 4 is used to input the utility functions shown above.

Data field "A" is the index of the decision-dimension. Data field "TYPE" is a 1 or 3, as shown in Figures 3-1 and 3-2. Data fields "LO" and "HI" define the minimum and maximum value of the characteristic parameter. Data fields "P_1" and "P_2" define the lower and upper values of the characteristic parameter defining the medium utility.

RECORD TYPE 5

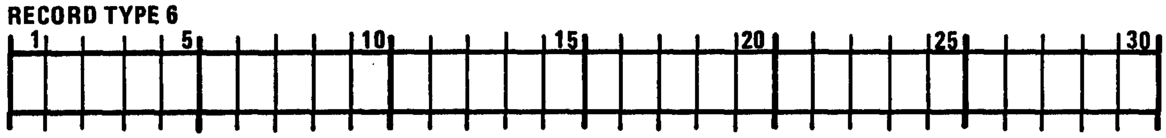


Record Type 5 is used to control the routines used for inputting data.

A zero (0) in column 5 indicates that the likelihood levels for each of the decision-dimensions will be determined outside of the program. This array will be input using record type 12.

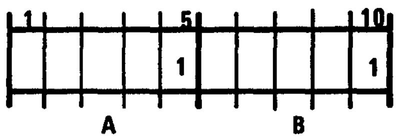
A one (1) in column 5 indicates that the likelihood levels for each of the decision-dimensions will be calculated inside the program. The likelihood levels are a function of the utility of the decision-dimension (input using Record Type 4), and the distribution of the characteristic parameter of the decision parameter (input using Record Type 7).

RECORD TYPE 6



Record Type 6 is used to input an identifying title on the computer output for this project.

RECORD TYPE 7



Field "A" of Record Type 7 is used to define the parameter index. Field B is used to define the type of distribution associated with the characteristic parameter. A one (1) in column 10 indicates the beta distribution, as illustrated in Figure 3-3.

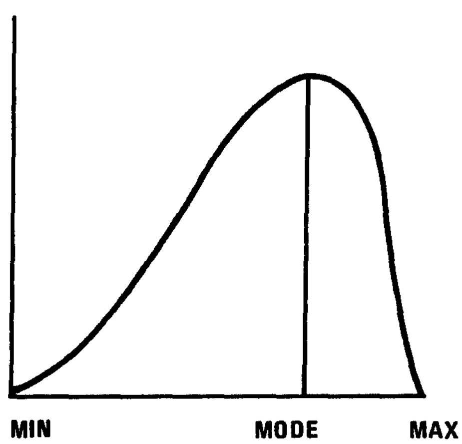
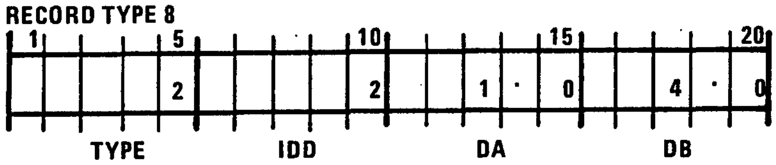


Figure 3-3. Beta Distribution Parameters



Record Type 8 is used to input the parameters necessary to define a unique beta distribution.

Data field "TYPE" is used to input the index of the beta distribution shape selected from Figure 3-4.

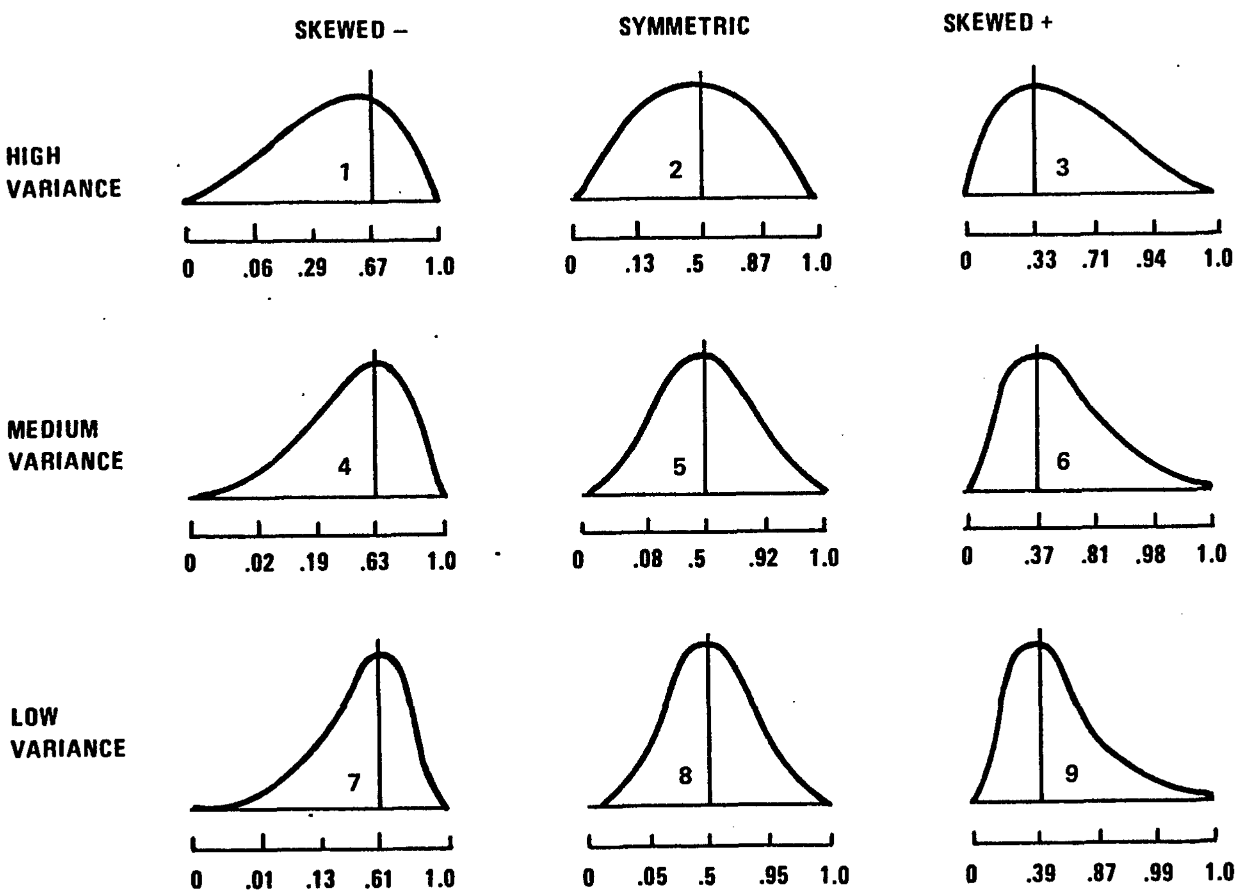


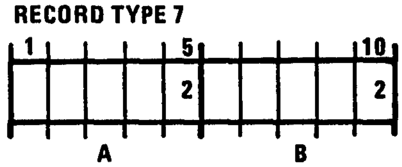
Figure 3-4. Beta Distribution Types

Given the shape of the beta distribution, any two of the parameters (MIN, MODE, or MAX) shown in Figure 3-3 are sufficient to define a unique distribution.

Data field "IDD" is used as an indicator for the pair of parameters that will be used.

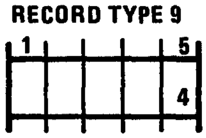
If IDD = 1	then	DA = MIN
		DB = MAX
If IDD = 2	then	DA = MIN
		DB = MODE
If IDD = 3	then	DA = MODE
		DB = MAX

RECORD TYPE 7



Field "A" of Record Type 7 is used to define the parameter index. Field "B" is used to define the type of distribution associated with the characteristic parameter. A two (2) in column 10 indicates a histogram type distribution, as shown in Figure 3-5.

RECORD TYPE 9



Record Type 9 is used to input the number of segments in the histogram.

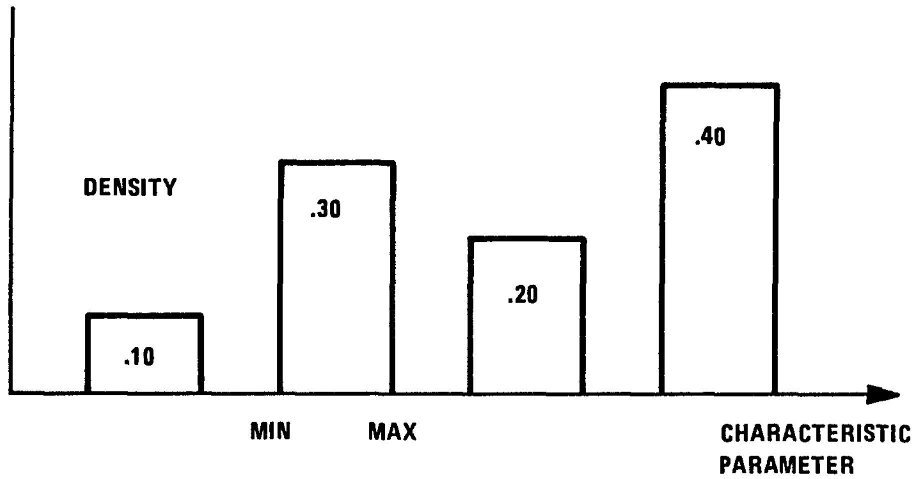
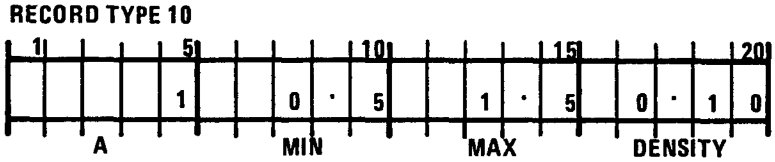


Figure 3-5. Histogram Distribution Parameters

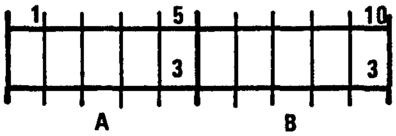
RECORD TYPE 10



There is one Record Type 10 for each histogram segment.

Data field "A" is the segment index. Data fields "MIN" and "MAX" correspond to the lower and upper bounds of the characteristic parameter. Data field "DENSITY" is the density of the segment.

RECORD TYPE 7



Field "A" of Record Type 7 is used to define the parameter index. Field "B" is used to define the type of distribution associated with the characteristic parameter. A three (3) in column 10 indicates a discrete distribution, as shown in Figure 3-6.

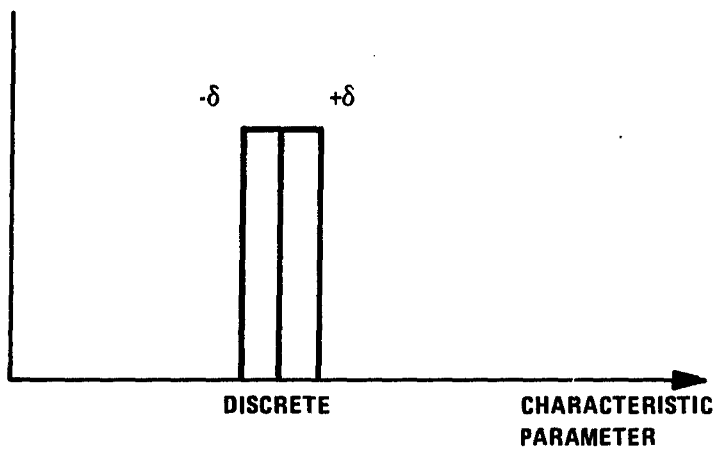
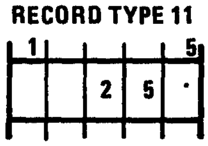


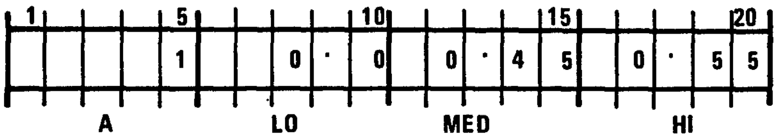
Figure 3-6. Discrete Distribution Parameter

RECORD TYPE 11



Record Type 11 is used to input the discrete value of the characteristic parameter. A small value is built into the program and is used to define a one-segment histogram centered at the discrete value.

RECORD TYPE 12



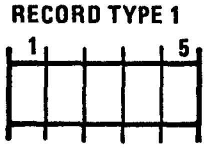
Record Type 12 is used when the likelihood levels of the decision-dimensions are calculated outside of the program.

Data field "A" is the index of the decision-dimension. Data fields "LO," "MED," and "HI" are likelihood probabilities for the low, medium, and high utility of the decision-dimension.

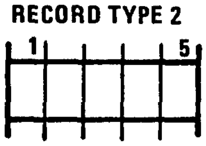
One record is necessary for each dimension.

3.1.2. Blank Forms.

RECORD TYPE 1



RECORD TYPE 2



RECORD TYPE 3

1 5 10 15 20 25 30 35

1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9
0

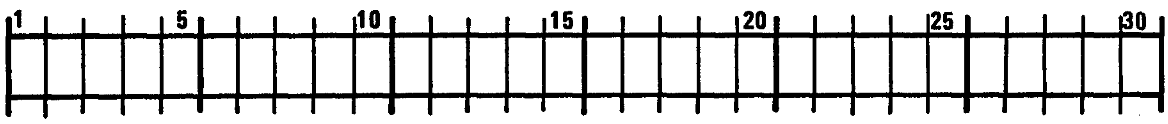
RECORD TYPE 4

1				5					10					15					20					25					30
				1																									
				2																									
				3																									
				4																									
				5																									
				6																									
				7																									
				8																									
				9																									
			1	0																									

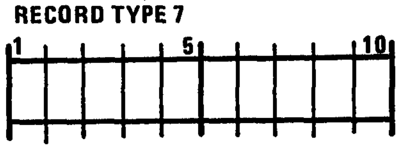
RECORD TYPE 5

1				5

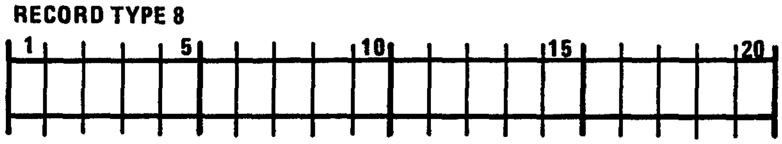
RECORD TYPE 6



RECORD TYPE 7



RECORD TYPE 8



RECORD TYPE 7

1 5 10

RECORD TYPE 9

1 5

RECORD TYPE 10

1 5 10 15 20

1

2

3

4

5

6

7

8

9

1 0

RECORD TYPE 7

1				5					10

RECORD TYPE 11

1				5

RECORD TYPE 12

1				5					10					15					20
				1															
				2															
				3															
				4															
				5															
				6															
				7															
				8															
				9															
			1	0															

3.2. Annotated Terminal Session

With SUMMET I input specification now defined, let's walk through all of the steps necessary to login, enter data, execute the program, review program output, and logout.

The PRIME computer is under the control of the PRIMOS operating system. There are a number of system-level commands and a text editor that a user must become familiar with in order to use the SUMMET I program. The user should refer to Figure 3-7 to follow the flow of the terminal session. After login the user has several options available, depending on the status of previous terminal sessions. If a user has previously used SUMMET I, he may find it necessary only to modify previous input data before executing the program. First-time users will have to build a complete set of input data files.

The annotated terminal session is presented here using sets of opposing pages, as exemplified by Figure 3-8. In each set, the right-hand page is a printout made at a hard copy terminal from an actual terminal session. The left-hand page is a set of comments explaining what is happening on the right-hand page. Each of the system level options shown in Figure 3-7 are represented in the annotated terminal session.

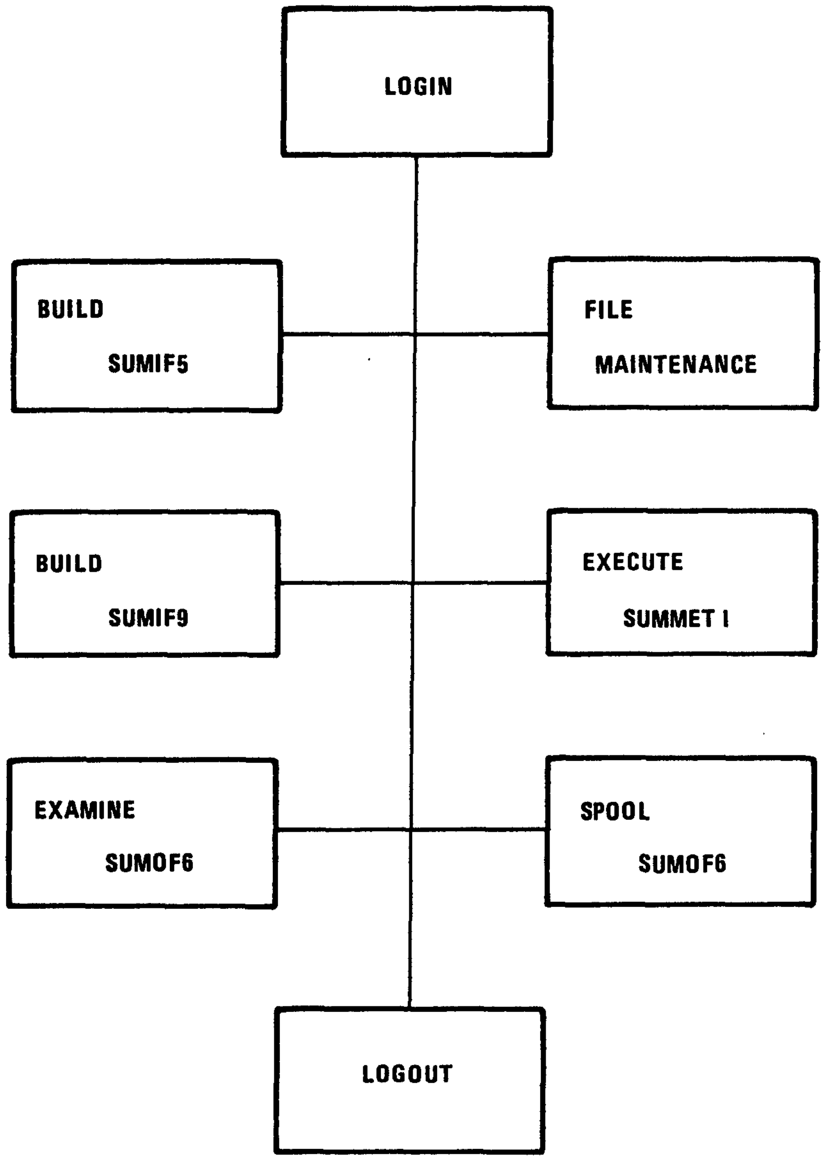


Figure 3-7. Terminal Session Flow for SUMMET I

Login Procedure

To access the SUMMET I program, you must dial up the PRIME computer at the Tank-Automotive Command, Warren, Michigan. Begin by putting your terminal in even parity, full duplex mode. Then dial 1-313-574-6657 and wait for the carrier signal. Place the telephone headset in the modem cradle and watch for the carrier indicator to light on the modem. This signals a completed connection between your terminal and the PRIME computer. The PRIME computer may at this time respond with "OK," which is its command level prompt. It may also not send the "OK," prompt, but just sit and wait for your LOGIN command.

To login to the system, type:

LOGIN GILLES (appropriate password) -ON DRAS (carriage return (CR))

```
OK, LOGIN GILLES PASSWORD –ON DRAS
PRIMENET 18.3.1 DRAS
```

All command-level responses are followed by a carriage return and the explicit directions to do so will be omitted from here on.

The PRIME then prints out the login identification optionally followed by system messages, and finally by the system prompt "OK,".

```
PRIMOS Version 18.3.1
GILLES (55) LOGGED IN AT 14:54 012683
Access Information (i.e., Phone Numbers, Passwords, etc.) shall
'FOR OFFICIAL USE ONLY' material!!!

SCIENTIFIC & ENGINEERING COMPUTER NETWORK
United States Army Tank-Automotive Command
Research & Development Center
Comp Mgt & Appl Rsch Ofc, drsta-ry
Warren, Michigan  48090, Ph: (313) 574-6548

OK,
```

If at any time you issue an invalid system command, the PRIME will respond with an error declaration followed by a different system prompt "ER,". This is logically equivalent to "OK," and you may retype your command or type a new one.

```
OK. FIDDLEFADDLE
Not found. FIDDLEFADDLE (std$cp)
ER!
```

Figure 3-8. Format of Annotated Terminal Session

3.2.1. Login Procedure. To access the SUMMET I program, you must dial-up the PRIME computer at TACOM, Warren, Michigan. Begin by putting your terminal in even parity, full duplex mode. Then dial 1-313-574-6657 and wait for the carrier signal. Place the telephone headset in the modem cradle and watch for the carrier indicator to light on the modem. This signals a completed connection between your terminal and the PRIME computer. The PRIME computer may at this time respond with "OK," which is its command level prompt. It also may not send the "OK," prompt, but just sit and wait for your "LOGIN" command.

To login to the system, type:

LOGIN GILLES (appropriate password) -ON DRAS (carriage return (CR))

All command-level responses are followed by a carriage return and the explicit directions to do so will be omitted from here on.

The PRIME then prints out the login identification, followed by optional system messages, and finally by the system prompt "OK,".

If at any time you issue an invalid system command, the PRIME will respond with an error declaration followed by a different system prompt "ER,". This is logically equivalent to "OK," and you may retype your command or type a new one.

```
OK,LOGIN ACCOUNT PASSWORD -ON DRAS
PRIMENET 18.3.1 DRAS

PRIMOS Version 18.3.1
GILLES (53) LOGGED IN AT  13:49 052783

Please Regard Login Data And Access Phone Numbers As FOUO

SCIENTIFIC & ENGINEERING COMPUTER NETWORK (DRAS)
United States Army Tank-Automotive Command
Research & Development Center
Comp Mgt & Appl Rsch Ofc, DRSTA-RY
Warren, Michigan  48090,  Ph: (313) 574-6228

OK,



 OK, FIDDLEFADDLE
 Not found. FIDDLEFADDLE (std$cp)
 ER!
```

3.2.2 Build SUMMET I Data File SUMIF5. To enter data into a file for use with the SUMMET I program, you will be using the PRIME Text Editor. To begin entering data into a new file, type

ED

after the normal system prompt "OK,". The PRIME Text Editor will respond by telling you that it is in the INPUT mode and give you the INPUT mode prompt "&". You may now begin typing the input records for the projects you wish to evaluate. The format of each of the data records are described in Section 3.1.1.

After each record is entered, the PRIME will return with the INPUT mode prompt "&".

```
OK, ED
INPUT
&    1
& THREAT WARNING / REACTION SYSTEM
&    1     1
&    5     1  3.0  5.0
&    2     2
&    1
&    1  0.1  0.3  1.0
&    3     1
&    5     1 0.03 0.06
&    4     2
&    4
&    1  0.0  0.2  0.2
&    2  0.2  0.4  0.3
&    3  0.4  0.6  0.4
&    4  0.6  0.8  0.1
&    5     2
&    3
&    1  0.0  0.2  0.2
&    2  0.2  0.4  0.7
&    3  0.6  0.8  0.1
&    6     3
& 0.21
& IR SUPPRESSOR - LOW RISK
&    1     1
&    7     1  1.0  2.5
&    2     3
& 0.18
&    3     1
&    7     1 .008 .015
&    4     2
&    3
&    1  0.0  0.2 0.60
&    2  0.2  0.4 0.20
&    3  0.4  0.6 0.20
&    5     2
&    2
&    1  0.0  0.2 0.95
&    2  0.4  0.6 0.05
&    6     3
& 0.40
```

When you have completed all of the input data records, you strike a carriage return following the INPUT mode prompt. The text editor then changes to the EDIT mode and responds with the EDIT Mode prompt "$".

At this point, you should type

    TOP

to return to the beginning of the input data records. Then type

    P 100

to print 100 lines of your input file. The complete syntax of this command is

    (P)RINT n

where P is the abbreviated form and n is the number of lines.

The text editor then lists your entire file (since it was less than 100 records). The five-digit number to the left of the colon is a virtual pointer and is not part of your file. Each of the data records should be carefully checked for accuracy and completeness.

```
& IR SUPPRESSOR - HIGH RISK
&     1     1
&     7     1  1.0   2.5
&     2     3
&  0.6
&     3     1
&     7     1 0.03 0.06
&     4     2
&     3
&     1  0.0   0.2   0.2
&     2  0.2   0.4   0.4
&     3  0.4   0.6   0.4
&     5     2
&     3
&     1  0.0   0.2   .30
&     2  0.2   0.4   .40
&     3  0.4   0.6   .30
&     6     3
& 0.40


$ TOP
$ P 100
.NULL.
00001:     1
00002: THREAT WARNING / REACTION SYSTEM
00003:     1     1
00004:     5     1  3.0   5.0
00005:     2     2
00006:     1
00007:     1  0.1   0.3   1.0
00008:     3     1
00009:     5     1 0.03 0.06
00010:     4     2
00011:     4
00012:     1  0.0   0.2   0.2
00013:     2  0.2   0.4   0.3
00014:     3  0.4   0.6   0.4
00015:     4  0.6   0.8   0.1
00016:     5     2
00017:     3
00018:     1  0.0   0.2   0.2
00019:     2  0.2   0.4   0.7
00020:     3  0.6   0.8   0.1
00021:     6     3
00022: 0.21
```

After a comparison of each of the input records and the data input sheets, assume that you have found errors in records 4, 22, 37, 38, and 43 and wish to correct the errors.

```
00023: IR SUPPRESSOR - LOW RISK
00024:     1     1
00025:     7     1  1.0  2.5
00026:     2     3
00027: 0.18
00028:     3     1
00029:     7     1 .008 .015
00030:     4     2
00031:     3
00032:     1  0.0  0.2 0.60
00033:     2  0.2  0.4 0.20
00034:     3  0.4  0.6 0.20
00035:     5     2
00036:     2
00037:     1  0.0  0.2 0.95
00038:     2  0.4  0.6 0.05
00039:     6     3
00040: 0.40
00041: IR SUPPRESSOR - HIGH RISK
00042:     1     1
00043:     7     2  1.5  2.0
00044:     2     3
00045:  0.6
00046:     3     1
00047:     7     1 0.03 0.06
00048:     4     2
00049:     3
00050:     1  0.0  0.2  0.2
00051:     2  0.2  0.4  0.4
00052:     3  0.4  0.6  0.4
00053:     5     2
00054:     3
00055:     1  0.0  0.2  .30
00056:     2  0.2  0.4  .40
00057:     3  0.4  0.6  .30
00058:     6     3
00059: 0.40
BOTTOM
```

You begin the corrections by moving the EDIT mode pointer to record 4 by typing

    PO 4

This is the abbreviated form of

    (PO)INT n

where n is the record identifier. The text editor lists the contents of that record and you correct the invalid part by typing

    C /3.0 5/1.0 3/

This is the abbreviated form of

    (C)HANGE /string1/string2/

You must select "string1" in such a manner so as to ensure uniqueness within the entire record. The text editor signals the completion of the CHANGE command by listing the contents of the revised record.

After you are satisfied with the new contents of record 4, you move on to record 22 by typing

    PO 22

followed by

    C /21/71/

to correct the incorrect entry "21".

Record 37 is correctd in a similar fashion. You may then move to record 38 by typing

    N

which is the abbreviated form for

    (N)EXT

```
$ PO 4
00004:     5    1  3.0  5.0
$ C /3.0  5/1.0  3/
00004:     5    1  1.0  3.0
```

```
$ PO 22
00022: 0.21
$ C /21/71/
00022: 0.71
```

```
$ PO 37
00037:     1   0.0   0.2 0.95
$ C /95/75/
00037:     1   0.0   0.2 0.75
$ N
00038:     2   0.4   0.6 0.05
$ C /05/25/
00038:     2   0.4   0.6 0.25
```

Now you move on to record 43 and find that it has several errors and it would be easier to retype the entire record. You begin the correction by typing

    D

which is short for

    (D)ELETE n

where n is the number of lines you wish to delete, beginning at the current pointer location. In the example you will see that the PRINT command has been used to show that a NULL line is now at record 43. This is not generally necessary when deleting a record.

The new record is put into the file by typing

    I   7   1   1.0 2.5

The complete syntax for this comand is

    (I)NSERT new data record

Note that there is a space following the letter I or the word INSERT that is not part of the new data record.

You may check the alignment of the data in the new record by typing

    P 2

which prints two records to help you check that the data in record 43 is in the correct columns.

```
$ PO 43
00043:    7    2  1.5  2.0
$ D
$ P
.NULL.
$ I     7    1  1.0  2.5
$ P 2
00043:    7    1  1.0  2.5
00044:    2    3
```

After you have made all of the corrections to your data file, you should return to the top of the data file and once again list the entire contents of the file by typing

```
P 100
```

and check each of the records one more time. If you are working at a terminal which is producing a hard copy, this final listing of your data file may be saved as a permanent record of your inputs.

```
$ TOP
$ P 100
.NULL.
00001:    1
00002: THREAT WARNING / REACTION SYSTEM
00003:    1     1
00004:    5     1  1.0  3.0
00005:    2     2
00006:    1
00007:    1  0.1  0.3  1.0
00008:    3     1
00009:    5     1 0.03 0.06
00010:    4     2
00011:    4
00012:    1  0.0  0.2  0.2
00013:    2  0.2  0.4  0.3
00014:    3  0.4  0.6  0.4
00015:    4  0.6  0.8  0.1
00016:    5     2
00017:    3
00018:    1  0.0  0.2  0.2
00019:    2  0.2  0.4  0.7
00020:    3  0.6  0.8  0.1
00021:    6     3
00022: 0.71
00023: IR SUPPRESSOR - LOW RISK
00024:    1     1
00025:    7     1  1.0  2.5
00026:    2     3
00027: 0.18
00028:    3     1
00029:    7     1 .008 .015
00030:    4     2
00031:    3
00032:    1  0.0  0.2 0.60
00033:    2  0.2  0.4 0.20
00034:    3  0.4  0.6 0.20
00035:    5     2
00036:    2
00037:    1  0.0  0.2 0.75
00038:    2  0.4  0.6 0.25
00039:    6     3
00040: 0.40
00041: IR SUPPRESSOR - HIGH RISK
00042:    1     1
00043:    7     1  1.0  2.5
00044:    2     3
00045:  0.6
```

The data file which you have just created is only a temporary file and would disappear if you were to exit the text editor at this point. To save your new data file, type

FILE SUMIF5

The PRIME responds with the command level prompt "OK," to indicate that you have saved your data and have exited from the text editor.

```
00046:    3    1
00047:    7    1 0.03 0.06
00048:    4    2
00049:    3
00050:    1  0.0  0.2  0.2
00051:    2  0.2  0.4  0.4
00052:    3  0.4  0.6  0.4
00053:    5    2
00054:    3
00055:    1  0.0  0.2  .30
00056:    2  0.2  0.4  .40
00057:    3  0.4  0.6  .30
00058:    6    3
00059: 0.40
BOTTOM
$ FILE SUMIF5
OK,
```

3.2.3. Build SUMMET I Data File SUMIF9. This is the second data file associated with the SUMMET I program. Data are entered into SUMIF9 in the same fashion as discussed for SUMIF5 using the PRIME Text Editor.

```
OK, ED
INPUT
&    6
&   69
&  1 M+ M+ M+ H* L+ L+
&  2 L* H* M+ H* L+ L+
&  3 L* M* H* H* L+ L+
&  4 H* H* L* H* M+ L+
&  5 L* M* M* H* M+ L+
&  6 M+ M+ M+ M- H* L+
&  7 L* H* M+ M- H* L+
&  8 L* M* H* M- H* L+
&  9 L* M* M* M* H* L+
& 10 H* L* H* M+ H* L+
& 11 H* M* L* H* H* L+
& 12 M* H* L* H* H* L+
& 13 H* L* M* H* H* L+
& 14 M* L* H* H* H* L+
& 15 H* M+ L* H* L* M+
& 16 H* M* L* H* M* M+
& 17 M* H* L* H* M- M+
& 18 H* L* M+ H* M- M+
& 19 L* M* M* H* L* M+
& 20 M* L* H* H* M- M+
& 21 M+ H* M+ M* M* M+
& 22 H* M* H* M* M* M+
& 23 L* H* H* M* M* M+
& 24 L* L* H* H* M+ M+
& 25 H* M+ L* M- H* M+
& 26 M* H* L* M- H* M+
& 27 H* L* M+ L* H* M+
& 28 H* L* M* M* H* M+
& 29 L* M* M* L* H* M+
& 30 M* L* H* M- H* M+
& 31 M* M* L* M+ H* M+
& 32 L* H* L* M* H* H*
& 33 M* L* M* M+ H* M+
& 34 L* L* H* M* H* M+
& 35 L* M+ L* H* H* M+
& 36 L* L* M* H* H* M+
& 37 L+ L* L* H* H* H*
& 38 M+ M+ M+ M- L* H*
& 39 M+ M+ M+ L* M* H*
& 40 M+ M* M* M* M* H*
& 41 M* M* H* M* M* H*
& 42 L* H* M+ M- L* H*
& 43 L* H* M+ L* M* H*
```

```
& 44 L* H* M* M* M* H*
& 45 L* M* H* M- M- H*
& 46 M+ H* L* M* M- H*
& 47 L* M* M* M* M- H*
& 48 M+ L* H* M* M- H*
& 49 M* M* L* H* M- H*
& 50 L* H* L* H* M- H*
& 51 L* L* H* H* L* H*
& 52 M+ H* L* L* M* H*
& 53 M+ L* M+ L* M* H*
& 54 M+ L* M* M* M* H*
& 55 M* L* M* H* M* H*
& 56 M* L* M* L* H* H*
& 57 L* M* M* L* M* H*
& 58 L+ M* L* M* M* H*
& 59 L* H* L* M* M* H*
& 60 L* M* L* H* M* H*
& 61 L* M* L* M* H* H*
& 62 L* L* M* M* M+ H*
& 63 L* L* M* H* M* H*
& 64 L* L* H* M* M* H*
& 65 L+ L* L* H* M* H*
& 66 M* M* L* L* H* H*
& 67 L* H* L* L* H* H*
& 68 L* L* H* L* H* H*
& 69 L+ L* L* M* H* H*
&     1    3    0.   10.    2.    4.
&     2    3    0.    1.  0.25  0.50
&     3    3    0.    1.  0.05  0.10
&     4    1    0.    1.  0.20  0.40
&     5    1    0.    1.  0.20  0.40
&     6    1    0.    1.  0.33  0.67
&
EDIT
```

After all of the data records have been entered, you should list the entire file and check for typing errors.

```
$ TOP
$ P 100
.NULL.
00001:     6
00002:    69
00003:  1 M+ M+ M+ H* L+ L+
00004:  2 L* H* M+ H* L+ L+
00005:  3 L* M* H* H* L+ L+
00006:  4 H* H* L* H* M+ L+
00007:  5 L* M* M* H* M+ L+
00008:  6 M+ M+ M+ M- H* L+
00009:  7 L* H* M+ M- H* L+
00010:  8 L* M* H* M- H* L+
00011:  9 L* M* M* M* H* L+
00012: 10 H* L* H* M+ H* L+
00013: 11 H* M* L* H* H* L+
00014: 12 M* H* L* H* H* L+
00015: 13 H* L* M* H* H* L+
00016: 14 M* L* H* H* H* L+
00017: 15 H* M+ L* H* L* M+
00018: 16 H* M* L* H* M* M+
00019: 17 M* H* L* H* M- M+
00020: 18 H* L* M+ H* M- M+
00021: 19 L* M* M* H* L* M+
00022: 20 M* L* H* H* M- M+
00023: 21 M+ H* M+ M* M* M+
00024: 22 H* M* H* M* M* M+
00025: 23 L* H* H* M* M* M+
00026: 24 L* L* H* H* M+ M+
00027: 25 H* M+ L* M- H* M+
00028: 26 M* H* L* M- H* M+
00029: 27 H* L* M+ L* H* M+
00030: 28 H* L* M* M* H* M+
00031: 29 L* M* M* L* H* M+
00032: 30 M* L* H* M- H* M+
00033: 31 M* M* L* M+ H* M+
00034: 32 L* H* L* M* H* H*
00035: 33 M* L* M* M+ H* M+
00036: 34 L* L* H* M* H* M+
00037: 35 L* M+ L* H* H* M+
00038: 36 L* L* M* H* H* M+
00039: 37 L+ L* L* H* H* H*
00040: 38 M+ M+ M+ M- L* H*
00041: 39 M+ M+ M+ L* M* H*
00042: 40 M+ M* M* M* M* H*
00043: 41 M* M* H* M* M* H*
00044: 42 L* H* M+ M- L* H*
00045: 43 L* H* M+ L* M* H*
```

If you are satisfied with the contents of the file, type

    FILE SUMIF9

to save the data in file SUMIF9 and to exit the text editor.

```
00046: 44 L* H* M* M* M* H*
00047: 45 L* M* H* M- M- H*
00048: 46 M+ H* L* M* M- H*
00049: 47 L* M* M* M* M- H*
00050: 48 M+ L* H* M* M- H*
00051: 49 M* M* L* H* M- H*
00052: 50 L* H* L* H* M- H*
00053: 51 L* L* H* H* L* H*
00054: 52 M+ H* L* L* M* H*
00055: 53 M+ L* M+ L* M* H*
00056: 54 M+ L* M* M* M* H*
00057: 55 M* L* M* H* M* H*
00058: 56 M* L* M* L* H* H*
00059: 57 L* M* M* L* M* H*
00060: 58 L+ M* L* M* M* H*
00061: 59 L* H* L* M* M* H*
00062: 60 L* M* L* H* M* H*
00063: 61 L* M* L* M* H* H*
00064: 62 L* L* M* M* M+ H*
00065: 63 L* L* M* H* M* H*
00066: 64 L* L* H* M* M* H*
00067: 65 L+ L* L* H* M* H*
00068: 66 M* M* L* L* H* H*
00069: 67 L* H* L* L* H* H*
00070: 68 L* L* H* L* H* H*
00071: 69 L+ L* L* M* H* H*
00072:     1    3    0.   10.    2.    4.
00073:     2    3    0.    1. 0.25 0.50
00074:     3    3    0.    1. 0.05 0.10
00075:     4    1    0.    1. 0.20 0.40
00076:     5    1    0.    1. 0.20 0.40
00077:     6    1    0.    1. 0.33 0.67
BOTTOM
$ FILE SUMIF9
OK,
```

3.2.4. File Maintenance. The two principal files used with the SUMMET I program are the input file SUMIF5 and the output file SUMOF6. In the course of doing many project evaluations, you may wish to make revisions to the input file SUMIF5 and still retain the original data in that file. You can rename a file in your user directory by typing

```
CNAME SUMIF5 SUMIF5.REVO
```

This adds the suffix ".REVO" to the current file name. This suffix is of course completely arbitrary.

The general syntax for this command is

```
CNAME oldfilename newfilename
```

When you change the name of the input file, you may also wish to save the corresponding output file, as shown in the example.

Occasionally your user directory will become filled with files you no longer want or even remember what they are. In this case you can delete them by typing

```
DELETE filename
```

A log of the data files in your user directory is a handy way of remembering the importance of each data file.

At some point you will surely forget the name of some essential file in your user directory. You may get a list of all of the files in your user directory by typing

```
LISTF
```

```
OK, CNAME SUMIF5 SUMIF5.REVO
OK, CNAME SUMOF6 SUMOF6.REVO
OK,
```

```
OK, DELETE SUMSS1A
OK, DELETE SUMSS1B
OK, DELETE SUMSS1C
OK,
```

```
OK, LISTF

UFD=<DRAS12>GILLES  20  OWNER

SUMQ     HEUR.PGM         HEUR.PLG         HEUR.JAH         ZSS.HEUR
HEUR.DU1         SUMH     SUMD     SUMIF9   B_SUMSF #SUMEX  L_SUMSF SUMD1
SUMOUT1 SUMIF5   SUMOF6   SUMSF.BACKUP
OK,
```

3.2.5. Execute SUMMET I. The SUMMET I program has been compliled and linked with the necessary system subroutines to form an executable module or SEGMENT.

You may execute the SUMMET I program by typing

    SEG #SUMEX

Depending on the number of projects that you are evaluating and the overall system load, it may take several minutes before the PRIME responds with

    **** STOP

and returns the command level prompt "OK,". All of the program output goes to an output file named SUMOF6.

```
OK, SEG #SUMEX
**** STOP

OK,
```

3.2.6. Review SUMMET I Output File SUMOF6. You may examine the SUMMET I output file SUMOF6 by typing

```
ED SUMOF6
```

This puts you in the text editor, ready to list the contents of SUMOF6. You can begin listing the contents of SUMOF6 by typing

```
P 1000
```

This will list the first 1000 lines (or less) of output. Note that if there is a digit 1 immediately following the colon it will cause a page eject when the file is output to a line printer.

This example is a listing of the Decision Heuristics input from SUMIF9.

```
OK, ED SUMOF6
EDIT
$ P 1000
.NULL.
00001:1NUMBER OF DECISION DIMENSIONS =     6
00002: NUMBER OF DECESION HEURISTICS =    69
00003:
00004:
00005: DECISION HEURISTICS:
00006:
00007:     1  M+   M+   M+   H*   L+   L+
00008:     2  L*   H*   M+   H*   L+   L+
00009:     3  L*   M*   H*   H*   L+   L+
00010:     4  H*   H*   L*   H*   M+   L+
00011:     5  L*   M*   M*   H*   M+   L+
00012:     6  M+   M+   M+   M-   H*   L+
00013:     7  L*   H*   M+   M-   H*   L+
00014:     8  L*   M*   H*   M-   H*   L+
00015:     9  L*   M*   M*   M*   H*   L+
00016:    10  H*   L*   H*   M+   H*   L+
00017:    11  H*   M*   L*   H*   H*   L+
00018:    12  M*   H*   L*   H*   H*   L+
00019:    13  H*   L*   M*   H*   H*   L+
00020:    14  M*   L*   H*   H*   H*   L+
00021:    15  H*   M+   L*   H*   L*   M+
00022:    16  H*   M*   L*   H*   M*   M+
00023:    17  M*   H*   L*   H*   M-   M+
00024:    18  H*   L*   M+   H*   M-   M+
00025:    19  L*   M*   M*   H*   L*   M+
00026:    20  M*   L*   H*   H*   M-   M+
00027:    21  M+   H*   M+   M*   M*   M+
00028:    22  H*   M*   H*   M*   M*   M+
00029:    23  L*   H*   H*   M*   M*   M+
00030:    24  L*   L*   H*   H*   M+   M+
00031:    25  H*   M+   L*   M-   H*   M+
00032:    26  M*   H*   L*   M-   H*   M+
00033:    27  H*   L*   M+   L*   H*   M+
00034:    28  H*   L*   M*   M*   H*   M+
00035:    29  L*   M*   M*   L*   H*   M+
00036:    30  M*   L*   H*   M-   H*   M+
00037:    31  M*   M*   L*   M+   H*   M+
00038:    32  L*   H*   L*   M*   H*   H*
00039:    33  M*   L*   M*   M+   H*   M+
00040:    34  L*   L*   H*   M*   H*   M+
00041:    35  L*   M+   L*   H*   H*   M+
00042:    36  L*   L*   M*   H*   H*   M+
00043:    37  L+   L*   L*   H*   H*   H*
00044:    38  M+   M+   M+   M-   L*   H*
00045:    39  M+   M+   M+   L*   M*   H*
```

This is a listing of the Utility Functions also input from SUMIF9.

```
     40   M+   M*   M*   M*   M*   H*
     41   M*   M*   H*   M*   M*   H*
     42   L*   H*   M+   M-   L*   H*
     43   L*   H*   M+   L*   M*   H*
     44   L*   H*   M*   M*   M*   H*
     45   L*   M*   H*   M-   M-   H*
     46   M+   H*   L*   M*   M-   H*
     47   L*   M*   M*   M*   M-   H*
     48   M+   L*   H*   M*   M-   H*
     49   M*   M*   L*   H*   M-   H*
     50   L*   H*   L*   H*   M-   H*
1NUMBER OF DECISION DIMENSIONS =     6
 NUMBER OF DECESION HEURISTICS =    69


 DECISION HEURISTICS:

     51   L*   L*   H*   H*   L*   H*
     52   M+   H*   L*   L*   M*   H*
     53   M+   L*   M+   L*   M*   H*
     54   M+   L*   M*   M*   M*   H*
     55   M*   L*   M*   H*   M*   H*
     56   M*   L*   M*   L*   H*   H*
     57   L*   M*   M*   L*   M*   H*
     58   L+   M*   L*   M*   M*   H*
     59   L*   H*   L*   M*   M*   H*
     60   L*   M*   L*   H*   M*   H*
     61   L*   M*   L*   M*   H*   H*
     62   L*   L*   M*   M*   M+   H*
     63   L*   L*   M*   H*   M*   H*
     64   L*   L*   H*   M*   M*   H*
     65   L+   L*   L*   H*   M*   H*
     66   M*   M*   L*   L*   H*   H*
     67   L*   H*   L*   L*   H*   H*
     68   L*   L*   H*   L*   H*   H*
     69   L+   L*   L*   M*   H*   H*
1UTILITY FUNCTIONS

 DECISION DIMENSION  1

        LO     HI
      0.00  10.00
 INDEX    UTIL     PAR
      1   3.00    2.00
      2   2.00    4.00
      3   1.00   10.00

```

```
DECISION DIMENSION  2

     LO      HI
   0.00    1.00
INDEX    UTIL     PAR
    1    3.00    0.25
    2    2.00    0.50
    3    1.00    1.00

DECISION DIMENSION  3

     LO      HI
   0.00    1.00
INDEX    UTIL     PAR
    1    3.00    0.05
    2    2.00    0.10
    3    1.00    1.00

DECISION DIMENSION  4

     LO      HI
   0.00    1.00
INDEX    UTIL     PAR
    1    1.00    0.20
    2    2.00    0.40
    3    3.00    1.00

DECISION DIMENSION  5

     LO      HI
   0.00    1.00
INDEX    UTIL     PAR
    1    1.00    0.20
    2    2.00    0.40
    3    3.00    1.00

DECISION DIMENSION  6

     LO      HI
   0.00    1.00
INDEX    UTIL     PAR
    1    1.00    0.33
    2    2.00    0.67
    3    3.00    1.00
```

This example is a listing of distributions input for the characteristic parameter for each Decision-Dimension from SUMIF5.

This is the Utility Likelihood Table that results from the convolution of the utility functions and the characteristic parameter distributions.

```
1 THREAT WARNING / REACTION S
 DECISION DIMENSION  1
 BETA DISTRIBUTION TYPE  5
     MIN    MOD     MAX
   1.00    0.00    3.00
 DECISION DIMENSION  2
 HISTOGRAM DISTRIBUTION WITH  1 SEGMENTS
  SEG     LBD     UBD     DEN
     1    0.10    0.30    1.00
 DECISION DIMENSION  3
 BETA DISTRIBUTION TYPE  5
     MIN    MOD     MAX
   0.03    0.00    0.06
 DECISION DIMENSION  4
 HISTOGRAM DISTRIBUTION WITH  4 SEGMENTS
  SEG     LBD     UBD     DEN
     1    0.00    0.20    0.20
     2    0.20    0.40    0.30
     3    0.40    0.60    0.40
     4    0.60    0.80    0.10
 DECISION DIMENSION  5
 HISTOGRAM DISTRIBUTION WITH  3 SEGMENTS
  SEG     LBD     UBD     DEN
     1    0.00    0.20    0.20
     2    0.20    0.40    0.70
     3    0.60    0.80    0.10
 DECISION DIMENSION  6
 DISCRETE DISTRIBUTION AT   0.71
 UTILITY LIKELIHOOD TABLE
  DIM       LOW    MEDIUM     HIGH
     1   0.0000   0.5001   0.4999
     2   0.0000   0.2500   0.7500
     3   0.0000   0.1919   0.8081
     4   0.2000   0.3000   0.5000
     5   0.2000   0.7000   0.1000
     6   0.0000   0.1000   0.9000
```

Following is the go likelihood contribution of each of the Decision Heuristics.

Also listed is the resultant go likelihood for this project.

```
1 THREAT WARNING / REACTION S
LIKELIHOOD CONTRIBUTION OF RULES

   1 0.5000    2 0.0000    3 0.0000    4 0.0000    5 0.0000
   6 0.0500    7 0.0000    8 0.0000    9 0.0000   10 0.0000
  11 0.0000   12 0.0000   13 0.0000   14 0.0000   15 0.0000
  16 0.0000   17 0.0000   18 0.0000   19 0.0000   20 0.0000
  21 0.1575   22 0.0212   23 0.0000   24 0.0000   25 0.0000
  26 0.0000   27 0.0000   28 0.0000   29 0.0000   30 0.0000
  31 0.0000   32 0.0000   33 0.0000   34 0.0000   35 0.0000
  36 0.0000   37 0.0000   38 0.0900   39 0.1260   40 0.0091
  41 0.0191   42 0.0000   43 0.0000   44 0.0000   45 0.0000
  46 0.0000   47 0.0000   48 0.0000   49 0.0000   50 0.0000
  51 0.0000   52 0.0000   53 0.0000   54 0.0000   55 0.0000
  56 0.0000   57 0.0000   58 0.0000   59 0.0000   60 0.0000
  61 0.0000   62 0.0000   63 0.0000   64 0.0000   65 0.0000
  66 0.0000   67 0.0000   68 0.0000   69 0.0000

'GO' LIKELIHOOD = 0.9729 FOR  THREAT WARNING / REACTION S
```

Each of the projects is treated in the same fashion as the first.

```
1 IR SUPPRESSOR - LOW RISK

DECISION DIMENSION  1

BETA DISTRIBUTION TYPE  7
     MIN    MOD     MAX
    1.00   0.00    2.50

DECISION DIMENSION  2

DISCRETE DISTRIBUTION AT   0.18

DECISION DIMENSION  3

BETA DISTRIBUTION TYPE  7
     MIN    MOD     MAX
    0.01   0.00    0.01

DECISION DIMENSION  4

HISTOGRAM DISTRIBUTION WITH  3 SEGMENTS
  SEG     LBD     UBD     DEN
    1    0.00    0.20    0.60
    2    0.20    0.40    0.20
    3    0.40    0.60    0.20

DECISION DIMENSION  5

HISTOGRAM DISTRIBUTION WITH  2 SEGMENTS
  SEG     LBD     UBD     DEN
    1    0.00    0.20    0.75
    2    0.40    0.60    0.25

DECISION DIMENSION  6

DISCRETE DISTRIBUTION AT   0.40

UTILITY LIKELIHOOD TABLE
  DIM        LOW    MEDIUM      HIGH
    1    0.0000    0.6014    0.3986
    2    0.0000    0.0000    1.0000
    3    0.0000    0.0000    1.0000
    4    0.6000    0.2000    0.2000
    5    0.7500    0.0000    0.2500
    6    0.0000    1.0000    0.0000
```

```
1 IR SUPPRESSOR - LOW RISK
 LIKELIHOOD CONTRIBUTION OF RULES

    1 0.2000    2 0.0000    3 0.0000    4 0.0000    5 0.0000
    6 0.2000    7 0.0000    8 0.0000    9 0.0000   10 0.0000
   11 0.0000   12 0.0000   13 0.0000   14 0.0000   15 0.0000
   16 0.0000   17 0.0000   18 0.0000   19 0.0000   20 0.0000
   21 0.0000   22 0.0000   23 0.0000   24 0.0000   25 0.0000
   26 0.0000   27 0.0000   28 0.0000   29 0.0000   30 0.0000
   31 0.0000   32 0.0000   33 0.0000   34 0.0000   35 0.0000
   36 0.0000   37 0.0000   38 0.0000   39 0.0000   40 0.0000
   41 0.0000   42 0.0000   43 0.0000   44 0.0000   45 0.0000
   46 0.0000   47 0.0000   48 0.0000   49 0.0000   50 0.0000
   51 0.0000   52 0.0000   53 0.0000   54 0.0000   55 0.0000
   56 0.0000   57 0.0000   58 0.0000   59 0.0000   60 0.0000
   61 0.0000   62 0.0000   63 0.0000   64 0.0000   65 0.0000
   66 0.0000   67 0.0000   68 0.0000   69 0.0000

 'GO' LIKELIHOOD = 0.4000 FOR  IR SUPPRESSOR - LOW RISK
```

```
1 IR SUPPRESSOR - HIGH RISK

DECISION DIMENSION  1

BETA DISTRIBUTION TYPE  7
     MIN    MOD     MAX
   1.00    0.00    2.50

DECISION DIMENSION  2

DISCRETE DISTRIBUTION AT    0.60

DECISION DIMENSION  3

BETA DISTRIBUTION TYPE  7
     MIN    MOD     MAX
   0.03    0.00    0.06

DECISION DIMENSION  4

HISTOGRAM DISTRIBUTION WITH  3 SEGMENTS
  SEG     LBD     UBD     DEN
     1   0.00    0.20    0.20
     2   0.20    0.40    0.40
     3   0.40    0.60    0.40

DECISION DIMENSION  5

HISTOGRAM DISTRIBUTION WITH  3 SEGMENTS
  SEG     LBD     UBD     DEN
     1   0.00    0.20    0.30
     2   0.20    0.40    0.40
     3   0.40    0.60    0.30

DECISION DIMENSION  6

DISCRETE DISTRIBUTION AT    0.40

UTILITY LIKELIHOOD TABLE
  DIM        LOW   MEDIUM      HIGH
     1   0.0000    0.6014    0.3986
     2   1.0000    0.0000    0.0000
     3   0.0000    0.6014    0.3986
     4   0.2000    0.4000    0.4000
     5   0.3000    0.4000    0.3000
     6   0.0000    1.0000    0.0000
```

When you have completed your examination of the output file SUMOF6, you type

Q

to (Q)UIT or exit the text editor. Note that if you have only reviewed the data in a file and have not modified it, you do not use the FILE command to exit the text editor.

```
00315:1 IR SUPPRESSOR - HIGH RISK
00316: LIKELIHOOD CONTRIBUTION OF RULES
00317:
00318:     1 0.0000     2 0.0000     3 0.0000     4 0.0000     5 0.0000
00319:     6 0.0000     7 0.0000     8 0.0000     9 0.0000    10 0.0381
00320:    11 0.0000    12 0.0000    13 0.0288    14 0.0288    15 0.0000
00321:    16 0.0000    17 0.0000    18 0.1116    19 0.0000    20 0.0671
00322:    21 0.0000    22 0.0000    23 0.0000    24 0.0000    25 0.0000
00323:    26 0.0000    27 0.0239    28 0.0288    29 0.0000    30 0.0431
00324:    31 0.0000    32 0.0000    33 0.0868    34 0.0000    35 0.0000
00325:    36 0.0000    37 0.0000    38 0.0000    39 0.0000    40 0.0000
00326:    41 0.0000    42 0.0000    43 0.0000    44 0.0000    45 0.0000
00327:    46 0.0000    47 0.0000    48 0.0000    49 0.0000    50 0.0000
00328:    51 0.0000    52 0.0000    53 0.0000    54 0.0000    55 0.0000
00329:    56 0.0000    57 0.0000    58 0.0000    59 0.0000    60 0.0000
00330:    61 0.0000    62 0.0000    63 0.0000    64 0.0000    65 0.0000
00331:    66 0.0000    67 0.0000    68 0.0000    69 0.0000
00332:
00333: 'GO' LIKELIHOOD = 0.4570 FOR  IR SUPPRESSOR - HIGH RISK
00334:
BOTTOM
$ Q
OK,
```

After you have executed the SUMMET I program, you may wish to examine only the go likelihoods for each of the projects. You may do this by entering the text editor as before, but instead of using the (P)RINT command, you type

```
L GO;*
```

This is an abbreviated form for

```
(L)OCATE string
```

This will find the first occurrence of the string "GO" in the output file. Using the suffix ";*" will find all occurrences of the string "GO".

Note that the results are not sorted from highest to lowest, but rather in the order in which they were evaluated.

To exit the text editor type

```
Q
```

and return to the command level.

```
OK, ED SUMOF6
EDIT
$ L GO;*
00204: 'GO' LIKELIHOOD = 0.9729 FOR  THREAT WARNING / REACTION S
00268: 'GO' LIKELIHOOD = 0.4000 FOR  IR SUPPRESSOR - LOW RISK
00333: 'GO' LIKELIHOOD = 0.4570 FOR  IR SUPPRESSOR - HIGH RISK
BOTTOM
$ Q
OK,
```

3.2.7. Spooling the Output File to the Printer. After you have done a quick scan of your output file, SUMOF6, using the text editor, you may wish to have a hard copy of the entire file. You can send your output file to a high speed printer at TACOM by typing

```
SPOOL SUMOF6 -FTN
```

The option -FTN tells the print handler that the output file contains special characters in column 1 that control pagination and other output spacing.

```
OK, SPOOL SUMOF6 -FTN
[SPOOL rev 18.3]
PRT002 spooled,  records:   10, name: SUMOF6
OK, .
```

3.2.8. Logout Procedure. You logout of the PRIME computer by simply typing

LOGOUT

when you are at the system command level. After the terminal session statistics have been printed out, remove the telephone headset from the modem cradle and hang it up. Your terminal session is now complete.

```
OK, LOGOUT
GILLES (53) LOGGED OUT AT  13:50 052783
TIME USED=  0:01   0:01   0:01

WAIT...

Disconnected from DRAS
OK,
```

3.3. Reference Material

As a reference guide to the entire SUMMET I program, we provide here a complete program listing and a complete set of sample data for both the SUMIF5 and SUMIF9 data files. A sample output that corresponds to the reference sample inputs is also provided.

The program listing of SUMMET I is well commented and should provide ample documentation of the program code. The sample inputs are the same as were used in the annotated terminal session presentation, and are adequately discussed there. The same is true for the reference output. These input/output samples are included here for completeness of the reference section.

3.3.1. Program Listing.

```
OK, ED SUMSF
EDIT
$ P 1000
.NULL.
C
C
C     SUMMET PROGRAM
C
C     MAIN
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      CHARACTER XRFSYM*1
      CHARACTER PLUS*1
      CHARACTER SYM*1
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK01/ SYM(MXRULE,MXDIM2),NUM(MXRULE,MXDIM)
      COMMON /BLK02/ VAL(MXDIM,3)
      COMMON /BLK03/ UTIL(MXDIM,3),PAR(MXDIM,3)
      COMMON /BLK04/ BETA(9,100),VMODB(9)
      COMMON /BLK05/ HIST(MXDIM,21),HDEN(MXDIM,10)
      COMMON /BLK06/ PLO(MXDIM),PHI(MXDIM)
      COMMON /BLK07/ PDT(MXDIM),BTYPE(MXDIM),DSCRT(MXDIM)
      COMMON /BLK08/ XMIN(MXDIM),XMOD(MXDIM),XMAX(MXDIM)
      COMMON /BLK09/ TITLE(8)
      COMMON /BLK10/ PRULE(MXRULE)
      COMMON /BLK99/ IOD5,IOD9,IOD6
      IOD5 = 5
      IOD9 = 9
      IOD6 = 6
      OPEN(IOD5,FILE= 'SUMIF5')
      OPEN(IOD9,FILE= 'SUMIF9')
      OPEN(IOD6,FILE= 'SUMOF6')
      READ(IOD5,1110) INPUTC
 1110 FORMAT(I5)
C
C     INPUT DECISION HEURISTICS
C
      CALL INPUT1
C
C     INPUT UTILITY FUNCTIONS
C
      IF(INPUTC .EQ. 1) CALL INPUT2
C
C     BEGIN PROJECT EVALUATION LOOP
C
 2210 CONTINUE
      READ(IOD5,2410,END=7000) (TITLE(IT), IT=1,7)
 2410 FORMAT(7A4)
      WRITE(IOD6,2510) (TITLE(IT), IT=1,7)
 2510 FORMAT(1H1,7A4)
```

```
C
C     INITALIZE TABLES FOR NEW PROJECT
C
      CALL INITL
C
C     INPUT PARAMETER DISTRIBUTIONS
C     AND PERFORM CONVOLUTIONS
C
      IF(INPUTC .EQ. 1) CALL INPUT3
C
C     INPUT UTILITY LIKELYHOOD TABLE
C     IF CONVOLUTIONS ARE NOT CALCULATED
C
      IF(INPUTC .EQ. 0) CALL INPUTV
C
C     COMPUTE 'GO' LIKELYHOOD
C
      CALL FINDGO
C     CALL OUTPUT
      GOTO 2210
C
C     END OF PROJECT EVALUATION LOOP
C
 7000 CONTINUE
      CLOSE(IOD5)
      CLOSE(IOD9)
      CLOSE(IOD6)
      STOP
      END
```

```
      SUBROUTINE INPUT1
C
C     INPUT DECISION HEURISTICS
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      CHARACTER XRFSYM*1
      CHARACTER PLUS*1
      CHARACTER MINUS*1
      CHARACTER SYM*1
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK01/ SYM(MXRULE,MXDIM2),NUM(MXRULE,MXDIM)
      COMMON /BLK03/ UTIL(MXDIM,3),PAR(MXDIM,3)
      COMMON /BLK06/ PLO(MXDIM),PHI(MXDIM)
      COMMON /BLK99/ IOD5,IOD9,IOD6
      DIMENSION XRFSYM(3)
      XRFSYM(3) = 1HH
      XRFSYM(2) = 1HM
      XRFSYM(1) = 1HL
      PLUS = 1H+
      MINUS = 1H-
      READ(IOD9,3110) NDIM
      READ(IOD9,3110) NRULE
 3110 FORMAT(10I5)
C
C     READ DECISION HEURISTICS
C
      NDIM2 = 2 * NDIM
      DO 3300 IR = 1,NRULE
      READ(IOD9,3220) IRD,(SYM(IR,IP-1),SYM(IR,IP), IP=2,NDIM2,2)
 3220 FORMAT(I3,10(1X,A1,A1))
 3300 CONTINUE
C
C     CONVERT SYMBOLIC INPUT TO NUMERIC EQUIVALENT
C
      DO 3600 IR = 1,NRULE
      DO 3500 IP = 1,NDIM
      NUMI = 0
      DO 3400 IX = 1,3
      IF(SYM(IR,2*IP-1) .NE. XRFSYM(IX)) GO TO 3400
      NUMI = 3 * IX
      IF(SYM(IR,2*IP) .EQ. PLUS) NUMI = NUMI + 1
      IF(SYM(IR,2*IP) .EQ. MINUS) NUMI = NUMI - 1
      NUM(IR,IP) = NUMI
 3400 CONTINUE
 3500 CONTINUE
 3600 CONTINUE
```

```
C
C     LIST DECISION HEURISTICS TO OUTPUT FILE
C
      DO 5000 IRR = 1,NRULE,50
      WRITE(IOD6,3620) NDIM,NRULE
 3620 FORMAT(1H1,'NUMBER OF DECISION DIMENSIONS =',I5,
     * /,' NUMBER OF DECESION HEURISTICS =',I5)
      WRITE(IOD6,3640)
 3640 FORMAT(//,' DECISION HEURISTICS:',/)
      IR1 = IRR
      IR2 = IRR + 49
      IF(IR2 .GT. NRULE) IR2 = NRULE
      DO 4000 IR = IR1,IR2
      WRITE(IOD6,3720) IR,(SYM(IR,IP-1),SYM(IR,IP),IP=2,NDIM2,2)
 3720 FORMAT(I5,10(3X,A1,A1))
 4000 CONTINUE
 5000 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE INPUT2
C
C     INPUT UTILITY FUNCTIONS
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK03/ UTIL(MXDIM,3),PAR(MXDIM,3)
      COMMON /BLK06/ PLO(MXDIM),PHI(MXDIM)
      COMMON /BLK99/ IOD5,IOD9,IOD6
      WRITE(IOD6,1010)
 1010 FORMAT(1H1,'UTILITY FUNCTIONS')
C
C     READ UTILITY FUNCTION PARAMETERS
C
      DO 2000 IP = 1,NDIM
      READ(IOD9,1110) IPD,UTIL(IP,1),PLO(IP),PHI(IP),PAR(IP,1),PAR(IP,2)
 1110 FORMAT(I5,5F5.0)
C
C     COMPUTE REMAINING PARAMETERS
C
      UTIL(IP,2) = 2
      UTIL(IP,3) = 4. - UTIL(IP,1)
      PAR(IP,3) = PHI(IP)
C
C     LIST UTILITY FUNCTION PARAMETERS TO OUTPUT FILE
C
      WRITE(IOD6,1150) IP,PLO(IP),PHI(IP)
 1150 FORMAT(/,' DECISION DIMENSION',I3,//,'     LO     HI',/,2F7.2)
      WRITE(IOD6,1170)
 1170 FORMAT(' INDEX   UTIL    PAR')
      DO 1800 IV = 1,3
      WRITE(IOD6,1210) IV,UTIL(IP,IV),PAR(IP,IV)
 1210 FORMAT(I6,2F7.2)
 1800 CONTINUE
 2000 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE BETALU(IP,IB)
C
C     PERFORM BETA FUNCTION CONVOLUTION FOR DIMENSION IP
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK02/ VAL(MXDIM,3)
      COMMON /BLK03/ UTIL(MXDIM,3),PAR(MXDIM,3)
      COMMON /BLK04/ BETA(9,100),VMODB(9)
      COMMON /BLK08/ XMIN(MXDIM),XMOD(MXDIM),XMAX(MXDIM)
      DENOM = XMAX(IP) - XMIN(IP)
      V1 = 0.0
      J1 = UTIL(IP,1)
      I1 = INT(100.*(PAR(IP,1)-XMIN(IP))/DENOM)
      IF(I1 .GT. 100) I1 = 100
      IF(I1 .GE. 1) V1 = BETA(IB,I1)
      VAL(IP,J1) = V1
      V2 = 0.0
      J2 = UTIL(IP,2)
      I2 = INT(100.*(PAR(IP,2)-XMIN(IP))/DENOM)
      IF(I2 .GT. 100) I2 = 100
      IF(I2 .GE. 1) V2 = BETA(IB,I2)
      VAL(IP,J2) = V2 - V1
      J3 = UTIL(IP,3)
      VAL(IP,J3) = 1. - V2
      RETURN
      END
```

```
      SUBROUTINE HISTLU(IP)
C
C     PERFORM HISTOGRAM FUNCTION CONVOLUTION FOR DIMENSION IP
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
       COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK02/ VAL(MXDIM,3)
      COMMON /BLK03/ UTIL(MXDIM,3),PAR(MXDIM,3)
      COMMON /BLK05/ HIST(MXDIM,21),HDEN(MXDIM,10)
      COMMON /BLK06/ PLO(MXDIM),PHI(MXDIM)
      SCALE(XPAR) = (XPAR-PLO(IP))/(PHI(IP)-PLO(IP))
      NSEG = INT(HIST(IP,21))
      DO 3000 IV = 1,2
      PI = SCALE(PAR(IP,IV))
      JI = UTIL(IP,IV)
      VI = 0.
      DO 2500 IS = 1,NSEG
      A = SCALE(HIST(IP,2*IS-1))
      B = SCALE(HIST(IP,2*IS))
      IF(PI .LE. A) GOTO 2700
      IF(PI .GE. B) GOTO 2200
      VI = VI + (PI-A) * HDEN(IP,IS) / (B-A)
      GOTO 2700
 2200 CONTINUE
      VI = VI + HDEN(IP,IS)
 2500 CONTINUE
 2700 CONTINUE
      VAL(IP,JI) = VI
 3000 CONTINUE
      J1 = UTIL(IP,1)
      J2 = UTIL(IP,2)
      VAL(IP,J2) = VAL(IP,J2) - VAL(IP,J1)
      JI = UTIL(IP,3)
      VAL(IP,JI) = 1. - VI
      RETURN
      END
```

```
      SUBROUTINE INPUT3
C
C     INPUT DISTRIBUTION FUNCTIONS FOR EACH DIMENSION
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      COMMON /BLK04/ BETA(9,100),VMODB(9)
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK05/ HIST(MXDIM,21),HDEN(MXDIM,10)
      COMMON /BLK06/ PLO(MXDIM),PHI(MXDIM)
      COMMON /BLK07/ PDT(MXDIM),BTYPE(MXDIM),DSCRT(MXDIM)
      COMMON /BLK08/ XMIN(MXDIM),XMOD(MXDIM),XMAX(MXDIM)
      COMMON /BLK99/ IOD5,IOD9,IOD6
      DO 5000 IP = 1,NDIM
      IPP = IP
C
C     INPUT DIMENSION NUMBER AND DISTRIBUTION TYPE
C
      READ(IOD5,1010) IPX,IPDT
 1010 FORMAT(3I5)
      WRITE(IOD6,1110) IP
 1110 FORMAT(/,' DECISION DIMENSION',I3)
      PDT(IP) = IPDT
      GO TO (2000, 3000, 4000), IPDT
 2000 CONTINUE
C
C     INPUT BETA DISTRIBUTION PARAMETERS
C
      READ(IOD5,2110) IBT,IDD,DA,DB
 2110 FORMAT(2I5,2F5.0)
      BTYPE(IP) = IBT
      IF(IDD .NE. 1) GOTO 2200
      XMIN(IP) = DA
      XMAX(IP) = DB
      GOTO 2500
 2200 CONTINUE
      IF(IDD .NE. 2) GOTO 2300
      XMIN(IP) = DA
      XMOD(IP) = DB
      XMAX(IP) = XMIN(IP) - (XMOD(IP)-XMIN(IP))/VMODB(IBT)
      GOTO 2500
 2300 CONTINUE
      XMOD(IP) = DA
      XMAX(IP) = DB
      XMIN(IP) = (XMOD(IP)-VMODB(IBT)*XMAX(IP))/(1. - VMODB(IBT))
 2500 CONTINUE
      WRITE(IOD6,2530) IBT,XMIN(IP),XMOD(IP),XMAX(IP)
 2530 FORMAT(/,' BETA DISTRIBUTION TYPE',I3,/,
     *          '    MIN    MOD    MAX',/, 3F7.2)
```

```
C
C     PERFORM BETA FUNCTION CONVOLUTION
C
      CALL BETALU(IPP,IBT)
      GOTO 5000
 3000 CONTINUE
C
C     INPUT HISTOGRAM FUNCTION PARAMETERS
C
      READ(IOD5,3110) NSEG
 3110 FORMAT(I5)
      WRITE(IOD6,3115) NSEG
 3115 FORMAT(/,' HISTOGRAM DISTRIBUTION WITH',I3,' SEGMENTS')
      WRITE(IOD6,3117)
 3117 FORMAT( '  SEG    LBD    UBD    DEN')
      HIST(IP,21) = NSEG
      DO 3300 IS = 1,NSEG
      READ(IOD5,3120) ISD,HIST(IP,2*IS-1),HIST(IP,2*IS),HDEN(IP,IS)
 3120 FORMAT(I5,3F5.0)
      WRITE(IOD6,3140) IS,HIST(IP,2*IS-1),HIST(IP,2*IS),HDEN(IP,IS)
 3140 FORMAT(I5,3F7.2)
 3300 CONTINUE
C
C     PERFORM HISTOGRAM DISTRIBUTION CONVOLUTION
C
      CALL HISTLU(IPP)
      GOTO 5000
 4000 CONTINUE
C
C     INPUT DISCRETE DISTRIBUTION PARAMETER
C
      READ(IOD5,4110) DSC
 4110 FORMAT(F5.0)
      WRITE(IOD6,4210) DSC
 4210 FORMAT(/,' DISCRETE DISTRIBUTION AT',F7.2)
      DSCRT(IP) = DSC
      HDEN(IP,1) = 1.
      HIST(IP,21) = 1
      DELTA = (PHI(IP) - PLO(IP)) / 20.
      HIST(IP,1) = DSC - DELTA
      IF(HIST(IP,1) .LT. PLO(IP)) HIST(IP,1) = PLO(IP)
      HIST(IP,2) = DSC + DELTA
      IF(HIST(IP,2) .GT. PHI(IP)) HIST(IP,2) = PHI(IP)
C
C     PERFORM DISCRETE DISTRIBUTION CONVOLUTION
C
      CALL HISTLU(IPP)
 5000 CONTINUE
      CALL TABL1
      RETURN
      END
```

```
      SUBROUTINE FINDGO
C
C     COMPUTE 'GO' LIKELIHOOD
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      CHARACTER SYM*1
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK01/ SYM(MXRULE,MXDIM2),NUM(MXRULE,MXDIM)
      COMMON /BLK02/ VAL(MXDIM,3)
      COMMON /BLK09/ TITLE(8)
      COMMON /BLK10/ PRULE(MXRULE)
      COMMON /BLK99/ IOD5,IOD9,IOD6
      SUM = 0.0
      DO 8600 IR = 1,NRULE
      PR = 1.0
      DO 8500 IP = 1,NDIM
      SVAL = 0.
      N1 = NUM(IR,IP)
      L1 = INT(N1/3)
      L2 = INT((N1+1)/3)
      IF(MOD(N1,3) .EQ. 1) L2 = 3
      IF(MOD(N1,3) .EQ. 2) L1 = 1
      DO 8400 IV = L1,L2
      SVAL = SVAL + VAL(IP,IV)
 8400 CONTINUE
      PR = PR * SVAL
 8500 CONTINUE
      PRULE(IR) = PR
      SUM = SUM + PR
 8530 FORMAT(2I5,2F7.4)
 8600 CONTINUE
      WRITE(IOD6,8610) (TITLE(IT), IT=1,7)
 8610 FORMAT(1H1, 7A4, /
     *       ' LIKELIHOOD CONTRIBUTION OF RULES', /)
      WRITE(IOD6,8630) (IR,PRULE(IR), IR=1,NRULE)
 8630 FORMAT(5(I5,F7.4))
      WRITE(IOD6,8710) SUM,(TITLE(IT), IT=1,7)
 8710 FORMAT(/,18H 'GO' LIKELIHOOD =  ,F7.4,' FOR ',7A4)
      RETURN
      END
```

```
      SUBROUTINE INITL
C
C     INITIALIZE INTERNAL ARRAYS
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK02/ VAL(MXDIM,3)
      COMMON /BLK05/ HIST(MXDIM,21),HDEN(MXDIM,10)
      COMMON /BLK07/ PDT(MXDIM),BTYPE(MXDIM),DSCRT(MXDIM)
      COMMON /BLK08/ XMIN(MXDIM),XMOD(MXDIM),XMAX(MXDIM)
      DO 3000 IP = 1,NDIM
      PDT(IP) = 0.
      BTYPE(IP) = 0.
      DSCRT(IP) = 0.
      XMIN(IP) = 0.
      XMOD(IP) = 0.
      XMAX(IP) = 0.
      DO 2000 IV = 1,3
      VAL(IP,IV) = 0.
 2000 CONTINUE
      HIST(IP,21) = 0.
      DO 2700 IS = 1,10
      HIST(IP,2*IS-1) = 0.
      HIST(IP,2*IS) = 0.
      HDEN(IP,IS) = 0.
 2700 CONTINUE
 3000 CONTINUE
      RETURN
      END
      SUBROUTINE INPUTV
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK02/ VAL(MXDIM,3)
      COMMON /BLK99/ IOD5,IOD9,IOD6
      DO 1600 IP = 1,NDIM
      READ(IOD5,1410) IPD,(VAL(IP,IV), IV=1,3)
 1410 FORMAT(I5,3F5.0)
 1600 CONTINUE
      CALL TABL1
      RETURN
      END
```

```
      SUBROUTINE TABL1
C
C     LIST LIKELIHOOD TABLE
C
      PARAMETER MXRULE = 100, MXDIM = 6, MXDIM2 = 12
      COMMON /BLK00/ NRULE,NDIM
      COMMON /BLK02/ VAL(MXDIM,3)
      COMMON /BLK99/ IOD5,IOD9,IOD6
      WRITE(IOD6,1110)
 1110 FORMAT(/,' UTILITY LIKELIHOOD TABLE')
      WRITE(IOD6,1210)
 1210 FORMAT( '  DIM      LOW   MEDIUM    HIGH')
      DO 2000 IP = 1,NDIM
      WRITE(IOD6,1410) IP,(VAL(IP,IV), IV=1,3)
 1410 FORMAT(I5,3F9.4)
 2000 CONTINUE
      RETURN
      END
```

```
      BLOCK DATA
C
C     DEFINE CUMULATIVE (INCOMPLETE) BETA FUNCTION FOR TYPES 1 TO 9
C
      COMMON /BLK04/ BETA(9,100),VMODB(9)
      DATA (BETA(1,I), I=1,100) / 0.0000
     *,0.0001,0.0003,0.0006,0.0011,0.0017,0.0025,0.0035,0.0047,0.0061
     *,0.0078,0.0097,0.0118,0.0141,0.0167,0.0196,0.0227,0.0261,0.0297
     *,0.0337,0.0379,0.0424,0.0472,0.0522,0.0576,0.0633,0.0692,0.0755
     *,0.0820,0.0889,0.0960,0.1035,0.1112,0.1193,0.1276,0.1363,0.1452
     *,0.1545,0.1640,0.1739,0.1840,0.1944,0.2051,0.2161,0.2274,0.2389
     *,0.2507,0.2628,0.2751,0.2877,0.3006,0.3137,0.3271,0.3406,0.3545
     *,0.3685,0.3828,0.3973,0.4119,0.4268,0.4419,0.4571,0.4725,0.4881
     *,0.5038,0.5197,0.5357,0.5518,0.5680,0.5843,0.6006,0.6171,0.6336
     *,0.6501,0.6666,0.6832,0.6997,0.7162,0.7326,0.7489,0.7652,0.7813
     *,0.7973,0.8130,0.8286,0.8439,0.8590,0.8737,0.8881,0.9021,0.9156
     *,0.9286,0.9410,0.9528,0.9637,0.9738,0.9828,0.9906,0.9967,1.0000
     *  /
      DATA (BETA(2,I), I=1,100) / 0.0000
     *,0.0004,0.0011,0.0022,0.0037,0.0057,0.0081,0.0110,0.0144,0.0183
     *,0.0227,0.0276,0.0329,0.0388,0.0452,0.0520,0.0594,0.0672,0.0755
     *,0.0842,0.0934,0.1031,0.1132,0.1237,0.1346,0.1460,0.1577,0.1698
     *,0.1822,0.1950,0.2081,0.2216,0.2353,0.2494,0.2637,0.2783,0.2931
     *,0.3081,0.3234,0.3388,0.3544,0.3702,0.3861,0.4021,0.4183,0.4345
     *,0.4508,0.4672,0.4835,0.5000,0.5164,0.5327,0.5491,0.5654,0.5816
     *,0.5978,0.6138,0.6297,0.6455,0.6611,0.6765,0.6918,0.7068,0.7216
     *,0.7362,0.7505,0.7646,0.7783,0.7918,0.8049,0.8177,0.8302,0.8422
     *,0.8540,0.8653,0.8762,0.8867,0.8968,0.9065,0.9157,0.9244,0.9327
     *,0.9405,0.9479,0.9547,0.9611,0.9670,0.9723,0.9772,0.9816,0.9855
     *,0.9889,0.9918,0.9942,0.9962,0.9977,0.9988,0.9995,0.9999,1.0000
     *  /
      DATA (BETA(3,I), I=1,100) / 0.0000
     *,0.0096,0.0174,0.0264,0.0365,0.0475,0.0592,0.0716,0.0846,0.0981
     *,0.1121,0.1265,0.1412,0.1563,0.1716,0.1872,0.2030,0.2189,0.2350
     *,0.2513,0.2676,0.2841,0.3005,0.3171,0.3336,0.3501,0.3667,0.3831
     *,0.3996,0.4160,0.4322,0.4485,0.4646,0.4805,0.4964,0.5121,0.5277
     *,0.5431,0.5583,0.5734,0.5883,0.6030,0.6174,0.6317,0.6457,0.6596
     *,0.6732,0.6865,0.6996,0.7125,0.7251,0.7374,0.7495,0.7613,0.7729
     *,0.7841,0.7951,0.8058,0.8162,0.8263,0.8362,0.8457,0.8550,0.8639
     *,0.8726,0.8809,0.8890,0.8967,0.9042,0.9113,0.9182,0.9247,0.9310
     *,0.9369,0.9426,0.9480,0.9530,0.9578,0.9623,0.9665,0.9705,0.9741
     *,0.9775,0.9806,0.9835,0.9861,0.9885,0.9906,0.9924,0.9941,0.9955
     *,0.9967,0.9977,0.9985,0.9992,0.9996,1.0000,1.0000,1.0000,1.0000
     *  /
```

```
      DATA (BETA(4,I), I=1,100) / 0.0000
     *,0.0000,0.0000,0.0000,0.0000,0.0000,0.0001,0.0001,0.0003,0.0004
     *,0.0006,0.0009,0.0012,0.0017,0.0022,0.0028,0.0036,0.0044,0.0055
     *,0.0067,0.0080,0.0096,0.0114,0.0133,0.0156,0.0180,0.0208,0.0238
     *,0.0271,0.0307,0.0347,0.0389,0.0436,0.0486,0.0540,0.0597,0.0659
     *,0.0725,0.0795,0.0870,0.0949,0.1032,0.1121,0.1214,0.1311,0.1414
     *,0.1522,0.1634,0.1752,0.1874,0.2002,0.2134,0.2272,0.2414,0.2561
     *,0.2714,0.2871,0.3032,0.3198,0.3369,0.3544,0.3723,0.3906,0.4093
     *,0.4284,0.4477,0.4674,0.4874,0.5077,0.5282,0.5488,0.5697,0.5906
     *,0.6117,0.6328,0.6539,0.6749,0.6958,0.7166,0.7372,0.7576,0.7776
     *,0.7973,0.8165,0.8352,0.8533,0.8708,0.8875,0.9035,0.9185,0.9326
     *,0.9456,0.9575,0.9681,0.9774,0.9853,0.9915,0.9962,0.9990,1.0000
     *  /
      DATA (BETA(5,I), I=1,100) / 0.0000
     *,0.0000,0.0000,0.0001,0.0002,0.0005,0.0010,0.0016,0.0024,0.0036
     *,0.0050,0.0068,0.0090,0.0116,0.0146,0.0182,0.0223,0.0270,0.0322
     *,0.0381,0.0446,0.0518,0.0597,0.0682,0.0774,0.0874,0.0980,0.1093
     *,0.1214,0.1341,0.1476,0.1617,0.1764,0.1918,0.2078,0.2244,0.2416
     *,0.2593,0.2775,0.2962,0.3153,0.3348,0.3546,0.3748,0.3952,0.4159
     *,0.4367,0.4577,0.4788,0.4999,0.5211,0.5422,0.5632,0.5840,0.6047
     *,0.6251,0.6453,0.6651,0.6846,0.7037,0.7224,0.7406,0.7583,0.7755
     *,0.7921,0.8081,0.8235,0.8382,0.8523,0.8658,0.8785,0.8906,0.9019
     *,0.9125,0.9225,0.9317,0.9402,0.9481,0.9553,0.9618,0.9677,0.9729
     *,0.9776,0.9817,0.9853,0.9883,0.9909,0.9931,0.9949,0.9963,0.9975
     *,0.9983,0.9989,0.9994,0.9997,0.9998,0.9999,0.9999,0.9999,1.0000
     *  /
      DATA (BETA(6,I), I=1,100) / 0.0000
     *,0.0038,0.0084,0.0147,0.0226,0.0318,0.0425,0.0543,0.0674,0.0815
     *,0.0965,0.1125,0.1292,0.1467,0.1648,0.1835,0.2027,0.2224,0.2424
     *,0.2627,0.2833,0.3041,0.3251,0.3461,0.3672,0.3883,0.4094,0.4303
     *,0.4511,0.4718,0.4923,0.5125,0.5325,0.5522,0.5716,0.5907,0.6094
     *,0.6277,0.6456,0.6631,0.6802,0.6968,0.7129,0.7286,0.7438,0.7586
     *,0.7728,0.7866,0.7998,0.8126,0.8248,0.8366,0.8478,0.8586,0.8688
     *,0.8786,0.8879,0.8967,0.9051,0.9130,0.9205,0.9275,0.9341,0.9403
     *,0.9460,0.9514,0.9564,0.9610,0.9653,0.9693,0.9729,0.9762,0.9792
     *,0.9819,0.9844,0.9866,0.9886,0.9904,0.9920,0.9933,0.9945,0.9955
     *,0.9964,0.9972,0.9978,0.9983,0.9988,0.9991,0.9994,0.9996,0.9997
     *,0.9998,0.9999,1.0000,1.0000,1.0000,1.0000,1.0000,1.0000,1.0000
     *  /
```

```
      DATA (BETA(7,I), I=1,100) / 0.0000
     *,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000,0.0000
     *,0.0000,0.0000,0.0001,0.0002,0.0003,0.0004,0.0006,0.0008,0.0010
     *,0.0014,0.0018,0.0023,0.0029,0.0036,0.0044,0.0054,0.0066,0.0079
     *,0.0095,0.0112,0.0133,0.0155,0.0181,0.0209,0.0241,0.0277,0.0316
     *,0.0360,0.0407,0.0459,0.0516,0.0578,0.0645,0.0718,0.0796,0.0881
     *,0.0971,0.1068,0.1171,0.1281,0.1397,0.1521,0.1651,0.1789,0.1934
     *,0.2086,0.2245,0.2411,0.2585,0.2765,0.2952,0.3147,0.3347,0.3554
     *,0.3767,0.3986,0.4210,0.4439,0.4672,0.4909,0.5150,0.5394,0.5639
     *,0.5887,0.6135,0.6383,0.6630,0.6875,0.7118,0.7358,0.7593,0.7822
     *,0.8045,0.8261,0.8468,0.8666,0.8853,0.9028,0.9191,0.9341,0.9476
     *,0.9597,0.9701,0.9790,0.9863,0.9919,0.9959,0.9985,0.9997,1.0000
     *  /
      DATA (BETA(8,I), I=1,100) / 0.0000
     *,0.0000,0.0000,0.0000,0.0000,0.0000,0.0001,0.0003,0.0005,0.0008
     *,0.0013,0.0020,0.0029,0.0041,0.0056,0.0074,0.0097,0.0124,0.0157
     *,0.0195,0.0240,0.0291,0.0349,0.0415,0.0488,0.0570,0.0661,0.0761
     *,0.0869,0.0987,0.1114,0.1251,0.1397,0.1552,0.1716,0.1889,0.2071
     *,0.2261,0.2459,0.2665,0.2877,0.3096,0.3321,0.3551,0.3785,0.4023
     *,0.4265,0.4508,0.4754,0.5000,0.5245,0.5491,0.5734,0.5976,0.6214
     *,0.6448,0.6678,0.6903,0.7122,0.7334,0.7540,0.7738,0.7928,0.8110
     *,0.8283,0.8447,0.8602,0.8748,0.8885,0.9012,0.9130,0.9238,0.9338
     *,0.9429,0.9511,0.9584,0.9650,0.9708,0.9759,0.9804,0.9842,0.9875
     *,0.9902,0.9925,0.9943,0.9958,0.9970,0.9979,0.9986,0.9991,0.9994
     *,0.9996,0.9998,0.9999,0.9999,0.9999,0.9999,0.9999,0.9999,1.0000
     *  /
      DATA (BETA(9,I), I=1,100) / 0.0000
     *,0.0014,0.0040,0.0080,0.0137,0.0209,0.0298,0.0402,0.0523,0.0658
     *,0.0808,0.0971,0.1146,0.1333,0.1531,0.1738,0.1954,0.2177,0.2407
     *,0.2642,0.2881,0.3124,0.3369,0.3617,0.3865,0.4113,0.4360,0.4606
     *,0.4849,0.5090,0.5327,0.5561,0.5789,0.6013,0.6232,0.6445,0.6652
     *,0.6853,0.7047,0.7234,0.7415,0.7588,0.7754,0.7914,0.8066,0.8210
     *,0.8348,0.8479,0.8602,0.8719,0.8828,0.8932,0.9028,0.9119,0.9203
     *,0.9281,0.9354,0.9421,0.9483,0.9540,0.9592,0.9640,0.9683,0.9722
     *,0.9758,0.9790,0.9818,0.9844,0.9867,0.9887,0.9904,0.9920,0.9933
     *,0.9945,0.9955,0.9963,0.9970,0.9976,0.9981,0.9985,0.9989,0.9991
     *,0.9994,0.9995,0.9997,0.9997,0.9998,0.9999,0.9999,0.9999,0.9999
     *,1.0000,1.0000,1.0000,1.0000,1.0000,1.0000,1.0000,1.0000,1.0000
     *  /
      DATA (VMODB(I), I=1,9) / 0.75,0.50,0.25,0.75,0.50,0.25
     *                        ,0.75,0.50,0.25 /
      END
BOTTOM
$ Q
OK,
```

3.3.2. **Sample Input Data SUMIF5.**

```
OK, ED SUMIF5
EDIT
$ P100
.NULL.
00001:    1
00002: THREAT WARNING / REACTION SYSTEM
00003:    1    1
00004:    5    1  1.0  3.0
00005:    2    2
00006:    1
00007:    1  0.1  0.3  1.0
00008:    3    1
00009:    5    1 0.03 0.06
00010:    4    2
00011:    4
00012:    1  0.0  0.2  0.2
00013:    2  0.2  0.4  0.3
00014:    3  0.4  0.6  0.4
00015:    4  0.6  0.8  0.1
00016:    5    2
00017:    3
00018:    1  0.0  0.2  0.2
00019:    2  0.2  0.4  0.7
00020:    3  0.6  0.8  0.1
00021:    6    3
00022: 0.71
00023: IR SUPPRESSOR - LOW RISK
00024:    1    1
00025:    7    1  1.0  2.5
00026:    2    3
00027: 0.18
00028:    3    1
00029:    7    1 .008 .015
00030:    4    2
00031:    3
00032:    1  0.0  0.2 0.60
00033:    2  0.2  0.4 0.20
00034:    3  0.4  0.6 0.20
00035:    5    2
00036:    2
00037:    1  0.0  0.2 0.75
00038:    2  0.4  0.6 0.25
00039:    6    3
00040: 0.40
```

```
00041: IR SUPPRESSOR - HIGH RISK
00042:    1    1
00043:    7    1   1.0   2.5
00044:    2    3
00045:  0.6
00046:    3    1
00047:    7    1  0.03  0.06
00048:    4    2
00049:    3
00050:    1  0.0   0.2   0.2
00051:    2  0.2   0.4   0.4
00052:    3  0.4   0.6   0.4
00053:    5    2
00054:    3
00055:    1  0.0   0.2   .30
00056:    2  0.2   0.4   .40
00057:    3  0.4   0.6   .30
00058:    6    3
00059: 0.40
BOTTOM
$ Q
OK,
```

3.3.3. Sample Input Data SUMIF9.

```
OK, ED SUMIF9
EDIT
$ P 100
.NULL.
00001:    6
00002:   69
00003:  1 M+ M+ M+ H* L+ L+
00004:  2 L* H* M+ H* L+ L+
00005:  3 L* M* H* H* L+ L+
00006:  4 H* H* L* H* M+ L+
00007:  5 L* M* M* H* M+ L+
00008:  6 M+ M+ M+ M- H* L+
00009:  7 L* H* M+ M- H* L+
00010:  8 L* M* H* M- H* L+
00011:  9 L* M* M* M* H* L+
00012: 10 H* L* H* M+ H* L+
00013: 11 H* M* L* H* H* L+
00014: 12 M* H* L* H* H* L+
00015: 13 H* L* M* H* H* L+
00016: 14 M* L* H* H* H* L+
00017: 15 H* M+ L* H* L* M+
00018: 16 H* M* L* H* M* M+
00019: 17 M* H* L* H* M- M+
00020: 18 H* L* M+ H* M- M+
00021: 19 L* M* M* H* L* M+
00022: 20 M* L* H* H* M- M+
00023: 21 M+ H* M+ M* M* M+
00024: 22 H* M* H* M* M* M+
00025: 23 L* H* H* M* M* M+
00026: 24 L* L* H* H* M+ M+
00027: 25 H* M+ L* M- H* M+
00028: 26 M* H* L* M- H* M+
00029: 27 H* L* M+ L* H* M+
00030: 28 H* L* M* M* H* M+
00031: 29 L* M* M* L* H* M+
00032: 30 M* L* H* M- H* M+
00033: 31 M* M* L* M+ H* M+
00034: 32 L* H* L* M* H* H*
00035: 33 M* L* M* M+ H* M+
00036: 34 L* L* H* M* H* M+
00037: 35 L* M+ L* H* H* M+
00038: 36 L* L* M* H* H* M+
00039: 37 L+ L* L* H* H* H*
00040: 38 M+ M+ M+ M- L* H*
00041: 39 M+ M+ M+ L* M* H*
00042: 40 M+ M* M* M* M* H*
```

```
00043: 41 M* M* H* M* M* H*
00044: 42 L* H* M+ M- L* H*
00045: 43 L* H* M+ L* M* H*
00046: 44 L* H* M* M* M* H*
00047: 45 L* M* H* M- M- H*
00048: 46 M+ H* L* M* M- H*
00049: 47 L* M* M* M* M- H*
00050: 48 M+ L* H* M* M- H*
00051: 49 M* M* L* H* M- H*
00052: 50 L* H* L* H* M- H*
00053: 51 L* L* H* H* L* H*
00054: 52 M+ H* L* L* M* H*
00055: 53 M+ L* M+ L* M* H*
00056: 54 M+ L* M* M* M* H*
00057: 55 M* L* M* H* M* H*
00058: 56 M* L* M* L* H* H*
00059: 57 L* M* M* L* M* H*
00060: 58 L+ M* L* M* M* H*
00061: 59 L* H* L* M* M* H*
00062: 60 L* M* L* H* M* H*
00063: 61 L* M* L* M* H* H*
00064: 62 L* L* M* M* M+ H*
00065: 63 L* L* M* H* M* H*
00066: 64 L* L* H* M* M* H*
00067: 65 L+ L* L* H* M* H*
00068: 66 M* M* L* L* H* H*
00069: 67 L* H* L* L* H* H*
00070: 68 L* L* H* L* H* H*
00071: 69 L+ L* L* M* H* H*
00072:     1    3    0.  10.    2.    4.
00073:     2    3    0.   1.  0.25  0.50
00074:     3    3    0.   1.  0.05  0.10
00075:     4    1    0.   1.  0.20  0.40
00076:     5    1    0.   1.  0.20  0.40
00077:     6    1    0.   1.  0.33  0.67
BOTTOM
```

3.3.4. Sample Output Data SUMOF6.

```
OK, ED SUMOF6
EDIT
$ P 1000
.NULL.
00001:1NUMBER OF DECISION DIMENSIONS =     6
00002: NUMBER OF DECESION HEURISTICS =    69
00003:
00004:
00005: DECISION HEURISTICS:
00006:
00007:     1   M+    M+    M+    H*    L+    L+
00008:     2   L*    H*    M+    H*    L+    L+
00009:     3   L*    M*    H*    H*    L+    L+
00010:     4   H*    H*    L*    H*    M+    L+
00011:     5   L*    M*    M*    H*    M+    L+
00012:     6   M+    M+    M+    M-    H*    L+
00013:     7   L*    H*    M+    M-    H*    L+
00014:     8   L*    M*    H*    M-    H*    L+
00015:     9   L*    M*    M*    M*    H*    L+
00016:    10   H*    L*    H*    M+    H*    L+
00017:    11   H*    M*    L*    H*    H*    L+
00018:    12   M*    H*    L*    H*    H*    L+
00019:    13   H*    L*    M*    H*    H*    L+
00020:    14   M*    L*    H*    H*    H*    L+
00021:    15   H*    M+    L*    H*    L*    M+
00022:    16   H*    M*    L*    H*    M*    M+
00023:    17   M*    H*    L*    H*    M-    M+
00024:    18   H*    L*    M+    H*    M-    M+
00025:    19   L*    M*    M*    H*    L*    M+
00026:    20   M*    L*    H*    H*    M-    M+
00027:    21   M+    H*    M+    M*    M*    M+
00028:    22   H*    M*    H*    M*    M*    M+
00029:    23   L*    H*    H*    M*    M*    M+
00030:    24   L*    L*    H*    H*    M+    M+
00031:    25   H*    M+    L*    M-    H*    M+
00032:    26   M*    H*    L*    M-    H*    M+
00033:    27   H*    L*    M+    L*    H*    M+
00034:    28   H*    L*    M*    M*    H*    M+
00035:    29   L*    M*    M*    L*    H*    M+
00036:    30   M*    L*    H*    M-    H*    M+
00037:    31   M*    M*    L*    M+    H*    M+
00038:    32   L*    H*    L*    M*    H*    H*
00039:    33   M*    L*    M*    M+    H*    M+
00040:    34   L*    L*    H*    M*    H*    M+
00041:    35   L*    M+    L*    H*    H*    M+
00042:    36   L*    L*    M*    H*    H*    M+
00043:    37   L+    L*    L*    H*    H*    H*
00044:    38   M+    M+    M+    M-    L*    H*
00045:    39   M+    M+    M+    L*    M*    H*
00046:    40   M+    M*    M*    M*    M*    H*
```

```
41   M*   M*   H*   M*   M*   H*
42   L*   H*   M+   M-   L*   H*
43   L*   H*   M+   L*   M*   H*
44   L*   H*   M*   M*   M*   H*
45   L*   M*   H*   M-   M-   H*
46   M+   H*   L*   M*   M-   H*
47   L*   M*   M*   M*   M-   H*
48   M+   L*   H*   M*   M-   H*
49   M*   M*   L*   H*   M-   H*
50   L*   H*   L*   H*   M-   H*
1NUMBER OF DECISION DIMENSIONS =     6
 NUMBER OF DECESION HEURISTICS =    69


 DECISION HEURISTICS:

51   L*   L*   H*   H*   L*   H*
52   M+   H*   L*   L*   M*   H*
53   M+   L*   M+   L*   M*   H*
54   M+   L*   M*   M*   M*   H*
55   M*   L*   M*   H*   M*   H*
56   M*   L*   M*   L*   H*   H*
57   L*   M*   M*   L*   M*   H*
58   L+   M*   L*   M*   M*   H*
59   L*   H*   L*   M*   M*   H*
60   L*   M*   L*   H*   M*   H*
61   L*   M*   L*   M*   H*   H*
62   L*   L*   M*   M*   M+   H*
63   L*   L*   M*   H*   M*   H*
64   L*   L*   H*   M*   M*   H*
65   L+   L*   L*   H*   M*   H*
66   M*   M*   L*   L*   H*   H*
67   L*   H*   L*   L*   H*   H*
68   L*   L*   H*   L*   H*   H*
69   L+   L*   L*   M*   H*   H*
```

```
1UTILITY FUNCTIONS

 DECISION DIMENSION  1

       LO      HI
     0.00   10.00
 INDEX    UTIL     PAR
     1    3.00    2.00
     2    2.00    4.00
     3    1.00   10.00

 DECISION DIMENSION  2

       LO      HI
     0.00    1.00
 INDEX    UTIL     PAR
     1    3.00    0.25
     2    2.00    0.50
     3    1.00    1.00

 DECISION DIMENSION  3

       LO      HI
     0.00    1.00
 INDEX    UTIL     PAR
     1    3.00    0.05
     2    2.00    0.10
     3    1.00    1.00

 DECISION DIMENSION  4

       LO      HI
     0.00    1.00
 INDEX    UTIL     PAR
     1    1.00    0.20
     2    2.00    0.40
     3    3.00    1.00

 DECISION DIMENSION  5

       LO      HI
     0.00    1.00
 INDEX    UTIL     PAR
     1    1.00    0.20
     2    2.00    0.40
     3    3.00    1.00

 DECISION DIMENSION  6

       LO      HI
     0.00    1.00
 INDEX    UTIL     PAR
     1    1.00    0.33
     2    2.00    0.67
     3    3.00    1.00
```

```
1 THREAT WARNING / REACTION S

DECISION DIMENSION  1

BETA DISTRIBUTION TYPE  5
   MIN    MOD     MAX
  1.00   0.00    3.00

DECISION DIMENSION  2

HISTOGRAM DISTRIBUTION WITH  1 SEGMENTS
 SEG     LBD     UBD     DEN
   1    0.10    0.30    1.00

DECISION DIMENSION  3

BETA DISTRIBUTION TYPE  5
   MIN    MOD     MAX
  0.03   0.00    0.06

DECISION DIMENSION  4

HISTOGRAM DISTRIBUTION WITH  4 SEGMENTS
 SEG     LBD     UBD     DEN
   1    0.00    0.20    0.20
   2    0.20    0.40    0.30
   3    0.40    0.60    0.40
   4    0.60    0.80    0.10

DECISION DIMENSION  5

HISTOGRAM DISTRIBUTION WITH  3 SEGMENTS
 SEG     LBD     UBD     DEN
   1    0.00    0.20    0.20
   2    0.20    0.40    0.70
   3    0.60    0.80    0.10

DECISION DIMENSION  6

DISCRETE DISTRIBUTION AT   0.71

UTILITY LIKELYHOOD TABLE
 DIM        LOW   MEDIUM      HIGH
   1    0.0000    0.5001    0.4999
   2    0.0000    0.2500    0.7500
   3    0.0000    0.1919    0.8081
   4    0.2000    0.3000    0.5000
   5    0.2000    0.7000    0.1000
   6    0.0000    0.1000    0.9000
```

```
1 THREAT WARNING / REACTION S
LIKELIHOOD CONTRIBUTION OF RULES

     1 0.5000     2 0.0000     3 0.0000     4 0.0000     5 0.0000
     6 0.0500     7 0.0000     8 0.0000     9 0.0000    10 0.0000
    11 0.0000    12 0.0000    13 0.0000    14 0.0000    15 0.0000
    16 0.0000    17 0.0000    18 0.0000    19 0.0000    20 0.0000
    21 0.1575    22 0.0212    23 0.0000    24 0.0000    25 0.0000
    26 0.0000    27 0.0000    28 0.0000    29 0.0000    30 0.0000
    31 0.0000    32 0.0000    33 0.0000    34 0.0000    35 0.0000
    36 0.0000    37 0.0000    38 0.0900    39 0.1260    40 0.0091
    41 0.0191    42 0.0000    43 0.0000    44 0.0000    45 0.0000
    46 0.0000    47 0.0000    48 0.0000    49 0.0000    50 0.0000
    51 0.0000    52 0.0000    53 0.0000    54 0.0000    55 0.0000
    56 0.0000    57 0.0000    58 0.0000    59 0.0000    60 0.0000
    61 0.0000    62 0.0000    63 0.0000    64 0.0000    65 0.0000
    66 0.0000    67 0.0000    68 0.0000    69 0.0000

'GO' LIKELIHOOD = 0.9729 FOR  THREAT WARNING / REACTION S
```

```
IR SUPPRESSOR - LOW RISK

DECISION DIMENSION  1

BETA DISTRIBUTION TYPE  7
   MIN    MOD    MAX
  1.00   0.00   2.50

DECISION DIMENSION  2

DISCRETE DISTRIBUTION AT   0.18

DECISION DIMENSION  3

BETA DISTRIBUTION TYPE  7
   MIN    MOD    MAX
  0.01   0.00   0.01

DECISION DIMENSION  4

HISTOGRAM DISTRIBUTION WITH  3 SEGMENTS
 SEG    LBD    UBD    DEN
   1   0.00   0.20   0.60
   2   0.20   0.40   0.20
   3   0.40   0.60   0.20

DECISION DIMENSION  5

HISTOGRAM DISTRIBUTION WITH  2 SEGMENTS
 SEG    LBD    UBD    DEN
   1   0.00   0.20   0.75
   2   0.40   0.60   0.25

DECISION DIMENSION  6

DISCRETE DISTRIBUTION AT   0.40

UTILITY LIKELIHOOD TABLE
 DIM      LOW   MEDIUM     HIGH
   1   0.0000   0.6014   0.3986
   2   0.0000   0.0000   1.0000
   3   0.0000   0.0000   1.0000
   4   0.6000   0.2000   0.2000
   5   0.7500   0.0000   0.2500
   6   0.0000   1.0000   0.0000
```

1 IR SUPPRESSOR - LOW RISK

LIKELIHOOD CONTRIBUTION OF RULES

1	0.2000	2	0.0000	3	0.0000	4	0.0000	5	0.0000
6	0.2000	7	0.0000	8	0.0000	9	0.0000	10	0.0000
11	0.0000	12	0.0000	13	0.0000	14	0.0000	15	0.0000
16	0.0000	17	0.0000	18	0.0000	19	0.0000	20	0.0000
21	0.0000	22	0.0000	23	0.0000	24	0.0000	25	0.0000
26	0.0000	27	0.0000	28	0.0000	29	0.0000	30	0.0000
31	0.0000	32	0.0000	33	0.0000	34	0.0000	35	0.0000
36	0.0000	37	0.0000	38	0.0000	39	0.0000	40	0.0000
41	0.0000	42	0.0000	43	0.0000	44	0.0000	45	0.0000
46	0.0000	47	0.0000	48	0.0000	49	0.0000	50	0.0000
51	0.0000	52	0.0000	53	0.0000	54	0.0000	55	0.0000
56	0.0000	57	0.0000	58	0.0000	59	0.0000	60	0.0000
61	0.0000	62	0.0000	63	0.0000	64	0.0000	65	0.0000
66	0.0000	67	0.0000	68	0.0000	69	0.0000		

'GO' LIKELIHOOD = 0.4000 FOR IR SUPPRESSOR - LOW RISK

```
1 IR SUPPRESSOR - HIGH RISK

DECISION DIMENSION  1

BETA DISTRIBUTION TYPE  7
   MIN    MOD    MAX
  1.00   0.00   2.50

DECISION DIMENSION  2

DISCRETE DISTRIBUTION AT   0.60

DECISION DIMENSION  3

BETA DISTRIBUTION TYPE  7
   MIN    MOD    MAX
  0.03   0.00   0.06

DECISION DIMENSION  4

HISTOGRAM DISTRIBUTION WITH  3 SEGMENTS
 SEG    LBD    UBD    DEN
   1   0.00   0.20   0.20
   2   0.20   0.40   0.40
   3   0.40   0.60   0.40

DECISION DIMENSION  5

HISTOGRAM DISTRIBUTION WITH  3 SEGMENTS
 SEG    LBD    UBD    DEN
   1   0.00   0.20   0.30
   2   0.20   0.40   0.40
   3   0.40   0.60   0.30

DECISION DIMENSION  6

DISCRETE DISTRIBUTION AT   0.40

UTILITY LIKELIHOOD TABLE
 DIM        LOW   MEDIUM     HIGH
   1   0.0000   0.6014   0.3986
   2   1.0000   0.0000   0.0000
   3   0.0000   0.6014   0.3986
   4   0.2000   0.4000   0.4000
   5   0.3000   0.4000   0.3000
   6   0.0000   1.0000   0.0000
```

```
1 IR SUPPRESSOR - HIGH RISK
LIKELIHOOD CONTRIBUTION OF RULES

   1 0.0000    2 0.0000    3 0.0000    4 0.0000    5 0.0000
   6 0.0000    7 0.0000    8 0.0000    9 0.0000   10 0.0381
  11 0.0000   12 0.0000   13 0.0288   14 0.0288   15 0.0000
  16 0.0000   17 0.0000   18 0.1116   19 0.0000   20 0.0671
  21 0.0000   22 0.0000   23 0.0000   24 0.0000   25 0.0000
  26 0.0000   27 0.0239   28 0.0288   29 0.0000   30 0.0431
  31 0.0000   32 0.0000   33 0.0868   34 0.0000   35 0.0000
  36 0.0000   37 0.0000   38 0.0000   39 0.0000   40 0.0000
  41 0.0000   42 0.0000   43 0.0000   44 0.0000   45 0.0000
  46 0.0000   47 0.0000   48 0.0000   49 0.0000   50 0.0000
  51 0.0000   52 0.0000   53 0.0000   54 0.0000   55 0.0000
  56 0.0000   57 0.0000   58 0.0000   59 0.0000   60 0.0000
  61 0.0000   62 0.0000   63 0.0000   64 0.0000   65 0.0000
  66 0.0000   67 0.0000   68 0.0000   69 0.0000

'GO' LIKELIHOOD = 0.4570 FOR  IR SUPPRESSOR - HIGH RISK

BOTTOM
```

4.0. USER INTERFACE DEVELOPMENTS

In Section 3.0 we described and exemplified the computer aids that are now available to facilitate trying, testing, and refining the SUMMET decision-aid structure. In this section we describe the Phase I work on issues of "user interface"--issues that are important to proper implementation of SUMMET as a computerized, interactive, and user-friendly decision-aid.

Human factors issues are important considerations in the design of any man-machine interface. Attention to these issues is mandatory in the design of a decision-aid in order to prevent the use of the aid from being more difficult than making the decision unaided.

To design an effective interface one must know the characteristics of the user population in addition to how the system will be used. Typically, such information is obtained through a detailed task analysis. A task analysis of the decision-making process for the R&D funding of CM proposals is planned as an integral part of the Phase II effort.

In Phase I our goal was to begin to address the interface problem. Elements of an ideal interface concept have been formulated, based on assumptions drawn from interviews with TACOM personnel about who would use the SUMMET decision-aid and the tasks that it would perform. These assumptions are:

- The SUMMET decision-aid would have multiple users.
- The users would be very proficient at making funding decisions, but would have varying levels of knowledge about computers and their use.
- There is neither a lot of time for, nor interest in, learning how to use a computer (e.g., a systems editor and a file management system).
- The system should be "user-friendly."

To best discuss how the SUMMET-user interface can be implemented to specifically address each of these characteristics, let us first describe and illustrate key elements of the ideal SUMMET-user interface concept as we see it.

4.1. Summet Interface Concept

A flow diagram of the envisioned SUMMET-user interface is presented in Figure 4-1. This diagram exemplifies the logic, flexibility, options, and overall flow of control that the interface will possess. The boxes (process points) and diamonds (decision points) represent abbreviated versions of actual frames that a user would see. Much of the detail about individual frames is given on the storyboards of Figures 4-2 through 4-30. In Figure 4-1 each frame is numbered for identification purposes and for specifying the branching options on individual storyboards. A word or number sometimes appears on the line connecting two frames (e.g., the word "RETURN" between Frame 2 and Frame 3). This represents the response (pressing the carriage return) that the user provides on Frame 2 to advance to Frame 3. Where none is indicated, RETURN is the appropriate response. The main functional areas of the interface depicted in Figure 4-1 are the frames that are multiples of 100, i.e.: 100--Parameter Input; 200--Proposal Evaluation; 300--Ordering and Output Review; 400--Summary Table Review; 500--Sensitivity Analysis; 600--Edit Proposal Descriptions; 700--Hardcopy; 800--Continue Previous Session; and 900--Exit/End Session.

To depict the envisioned exercise of SUMMET by a user, let us step through the various functions highlighted in Figure 4-1.

The user first sees an introductory frame (Figure 4-2) followed by a login frame (Figure 4-3), which also asks the user to identify the CM proposals that are being considered for funding. If the user wishes to continue a session that was begun earlier, he may branch to that function (Frame 800, Figure 4-1) from the name/proposal input frame (Figure 4-3).

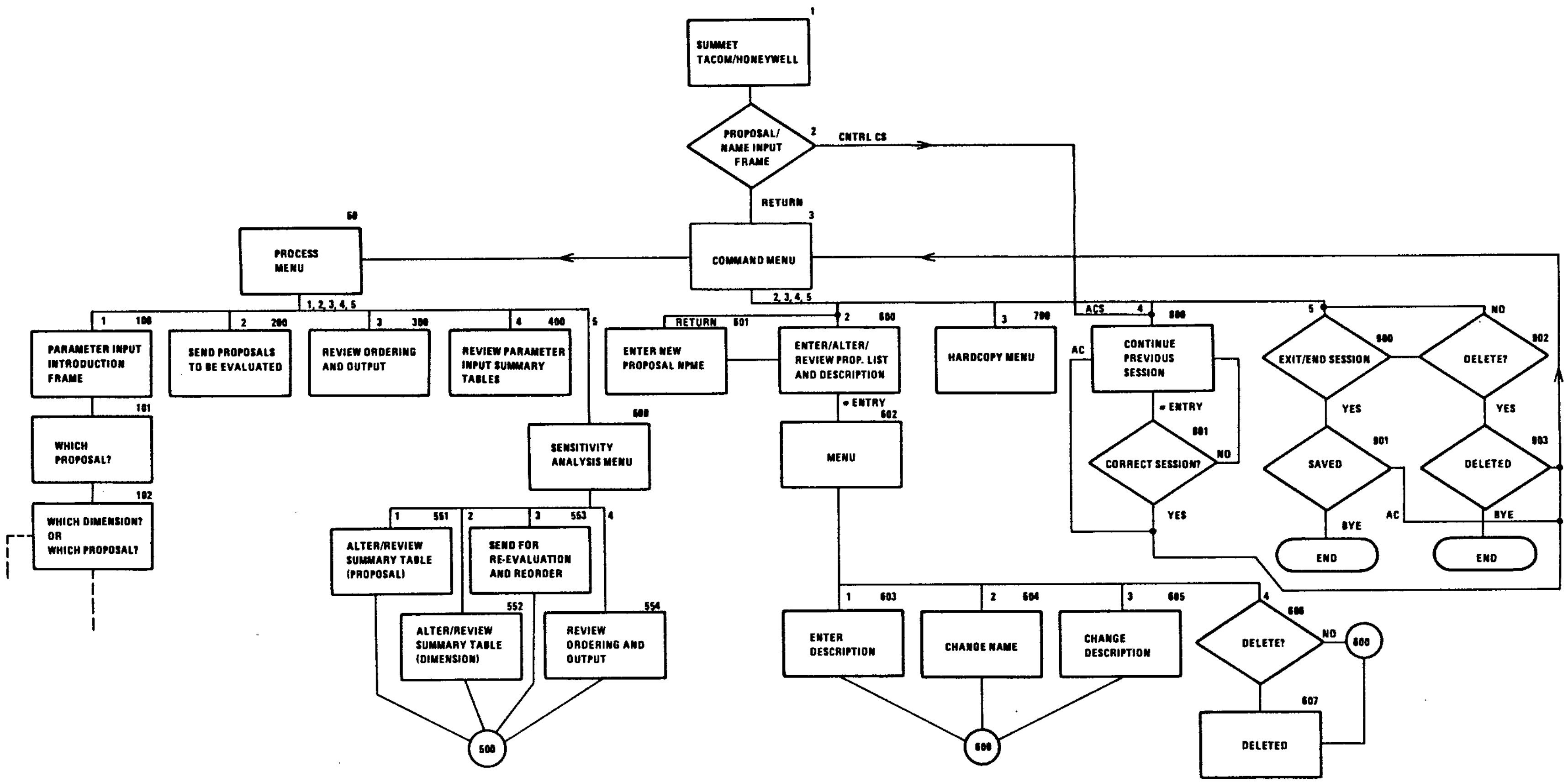


Figure 4-1. Proposed User Interface Structure

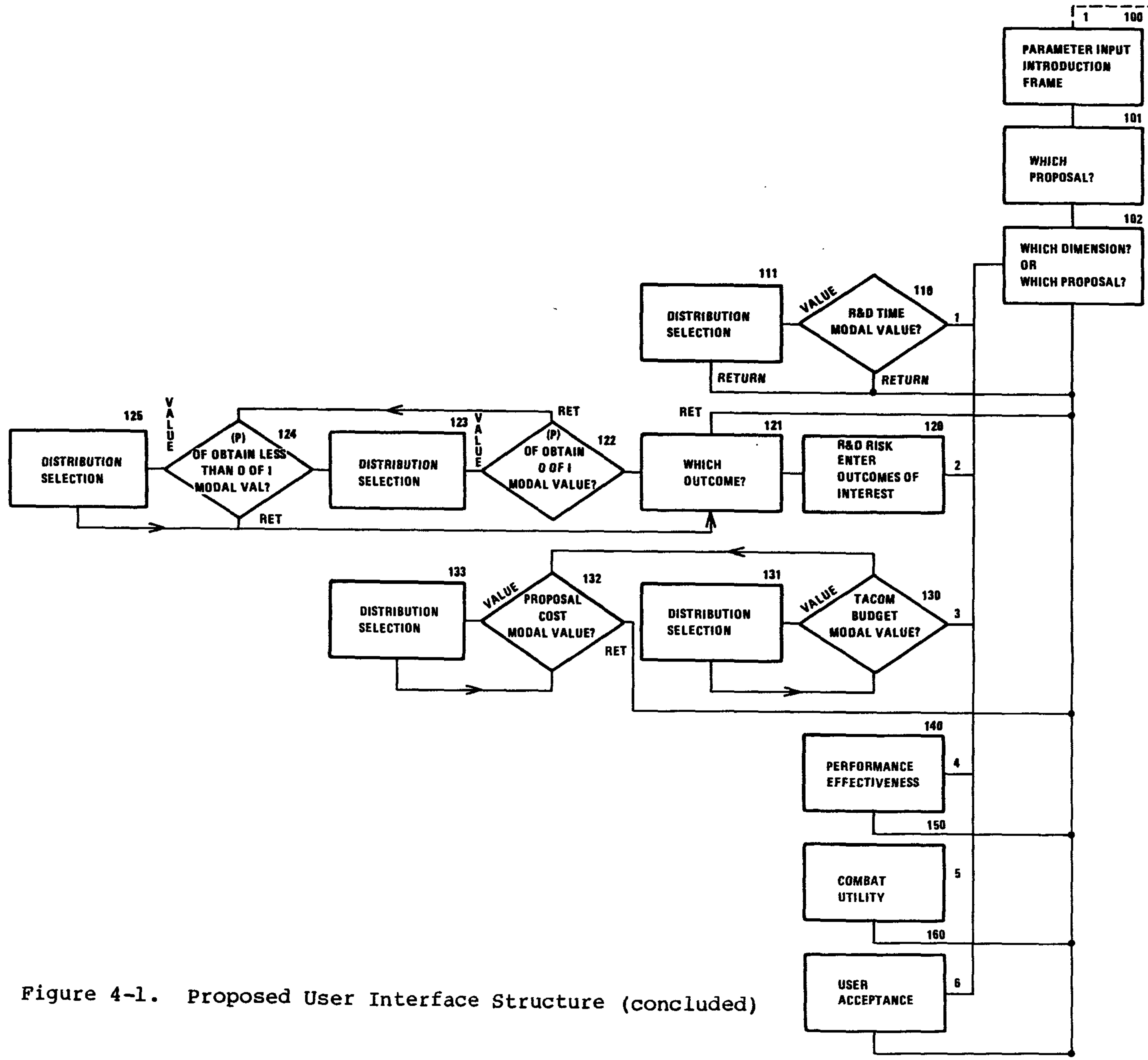


Figure 4-1. Proposed User Interface Structure (concluded)

SUMMET DISPLAY FRAME STORYBOARD

From ____________

User Response ________

Frame Number __1__

---

1. Text

SURVIVABILITY MEASURES AND METHODS EVALUATION TECHNIQUE

(SUMMET)

TACOM/HONEYWELL INC.

(Press RETURN to continue)

---

2. Programmer's Information	3. Branching
	Return: 2

Figure 4-2. Frame Number 1

SUMMET DISPLAY FRAME STORYBOARD

From 1

User Response Return

Frame Number 2

---

1. Text

PROPOSAL/NAME INPUT FRAME

USER NAME: (1)

PASSWORD: (2)

Press CNTRL CS to continue a previous session

OR

Enter the titles of (or a mnemonic for) the counter-measure proposals being considered for funding. Press Return after each proposal

(3)

Press Return to continue

---

2. Programmer's Information

Print standard error message for invalid log-in name or password.

Do not allow user to continue until log-in/password is complete.

(1), (2), (3) are cursor positions.

Store date, time, name, and proposal list in a file that can be accessed to continue or review a previous session.

3. Branching

Return: 3
CNTRL CS: 800

Figure 4-3. Frame Number 2

SUMMET DISPLAY FRAME STORYBOARD

From 2

User Response Return

Frame Number 3

---

1. Text

COMMAND LEVEL MENU

Please enter the number of the function you wish to initiate:

1. Process Menu
2. Edit Proposal List and Description
3. Hardcopy
4. Continue Previous Session
5. Exit/End Session

ENTER CHOICE NUMBER (1)

---

2. Programmer's Information	3. Branching
(1) is cursor position Print "DATA ENTRY ERROR -- INVALID CHARACTER Please enter a valid menu selection" for characters other than 1-5	1. 50 2. 600 3. 700 4. 800 5. 900

Figure 4-4. Frame Number 3

SUMMET DISPLAY FRAME STORYBOARD

From 3

User Response 1

Frame Number 50

---

1. Text

PROCESS LEVEL MENU

Please enter the number of the process you would like to run:

1. Characteristic Parameter Input
2. Send Proposals to be Evaluated
3. Review Ordering and Output
4. Review Parameter Input Summary Table
5. Sensitivity Analysis

ENTER CHOICE NUMBER (1)

---

2. Programmer's Information	3. Branching
(1) is cursor position Print: "DATA ENTRY ERROR – INVALID CHARACTER Please enter valid menu selection," for characters other than 1-5.	1. 100 2. 200 3. 300 4. 400 5. 500

Figure 4-5. Frame Number 50

SUMMET DISPLAY FRAME STORYBOARD

From 50

User Response 1

Frame Number 100

1. Text

MODE: Parameter Input

(NAME), you will now begin the process of inputting characteristic parameter values for each of the six dimensions: R&D Time, R&D Risk, R&D Cost, Performance Effectiveness, Combat Utility, and User Acceptance. You will do this for each of the (#) proposals you are currently considering.

Press Return To Continue

2. Programmer's Information	**3. Branching**
(NAME) is to be the name the user logged in with. (#) is the number of proposals in the list of proposals being considered.	Return: 101

Figure 4-6. Frame Number 100

SUMMET DISPLAY FRAME STORYBOARD

From 100

User Response Return

Frame Number 101

1. Text

MODE: Parameter Input

PROPOSAL SELECTION MENU

Enter the number of the proposal you wish to consider first:

1.
2.
3.
.
.
N.

ENTER CHOICE NUMBER (1)

2. Programmer's Information

The list of proposals is that entered on frame and provided the list has not been altered on Frame 601 or 606.

Print error message from Frame 50 if a valid number is not entered.

(1) is cursor position.

3. Branching

No matter what choice go to 102, but change the proposal being considered line accordingly.

Figure 4-7. Frame Number 101

SUMMET DISPLAY FRAME STORYBOARD

From 101

User Response Valid Menu Selection

Frame Number 102

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

Enter the number of the dimension for which you wish to input parameter values:

1. R&D Time
2. R&D Risk
3. R&D Cost
4. Performance Effectiveness
5. Combat Utility
6. User Acceptance

OR

Enter the letter of another proposal you wish to consider:

A.
B.
.
.
N.

ENTER CHOICE NUMBER (1)

2. Programmer's Information

(NAME) depends on choice on Frame 101.

Letters "A. . .end of proposal list" contain the list of proposals being considered.

(1) is cursor position.

3. Branching

1. 110
2. 120
3. 130
4. 140
5. 150
6. 160

If letter is entered, redisplay same frame with a new name on the proposal being considered line.

Figure 4-8. Frame Number 102

SUMMET DISPLAY FRAME STORYBOARD

From 102

User Response 1

Frame Number 110

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Time

Please enter your estimate of the R&D Time necessary to develop the countermeasure proposal being considered in terms of a value or range of values.

Current Value(s) ________ New Value(s) (1)

If you entered a range of values, please enter the modal value; if not, press Return

Current Value ________ New Value (2)

2. Programmer's Information

(NAME) as last entered on 101 or 102.

1 and 2 are cursor positions.

Error message if range is input and Return given at (2).

Second value must be within range of values specified in (1).

Update PI SUMMARY FRAMES if Return for (2).

Update Current Value line.

Reverse video the R&D Time line of frame.

102 if just a value for (1).

Display appropriate three distributions on 111 if value for (2), and appropriate ranges.

3. Branching

If value for (2) then 111, if Return for (2) go to 102.

Figure 4-9. Frame Number 110

SUMMET DISPLAY FRAME STORYBOARD

From 110

User Response Value

Frame Number 111

---

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Time

DISTRIBUTION SELECTION

Select the most appropriate distribution from the three displayed below.

ENTER CHOICE NUMBER ________

---

2. Programmer's Information

3. Branching

Valid Menu: 102
Input
(1,2,3)

Figure 4-10. Frame Number 111

SUMMET DISPLAY FRAME STORYBOARD

From 102

User Response 2

Frame Number 120

---

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Risk

Please enter the technical outcomes that are trying to be achieved in the (Proposal Name) proposal. Follow each outcome with a Return.

(1)

Press Return to continue

---

2. Programmer's Information

Use the list that is input as a menu on the next frame (121).

(1) is cursor position. It drops a line after each Return until Return occurs after nothing has been input.

3. Branching

Return: 121

Figure 4-11. Frame Number 120

SUMMET DISPLAY FRAME STORYBOARD

From 120

User Response Return

Frame Number 121

---

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Risk

R&D RISK OUTCOME MENU

Enter the number of the outcome you wish to evaluate first:

1.
2.
.
.
N.

ENTER CHOICE NUMBER (1)

---

2. Programmer's Information

These menu choices are based on input on Frame 120.

Reverse video once an outcome has been evaluated.

Standard Menu Error Message should be ready for this frame.

(1) is cursor position.

Update Outcome Being Considered line on next four frames.

3. Branching

Any valid number: 122

Figure 4-12. Frame Number 121

SUMMET DISPLAY FRAME STORYBOARD

From 121

User Response Valid Menu Selection

Frame Number 122

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Risk

OUTCOME BEING CONSIDERED: (Outcome NAME)

First, input the probability or a range of probabilities for achieving this particular outcome:

Current Value ________ New Value (1)

Then, if you have input a range, please indicate the modal probability value; if not, press Return

Current Value ________ New Value (2)

2. Programmer's Information

(1) and (2) are cursor positions.

If value in (2) w/i range of values in (1), display appropriate distributions on 123 with appropriate values.

Update PI Summary Frames (551 and 552) and Current Value line.

Reverse video appropriate Menu line of 121 if signal value for (1).

3. Branching

Valid Value for (2): 123
Return: 124

Figure 4-13. Frame Number 122

SUMMET DISPLAY FRAME STORYBOARD

From 122

User Response Modal Value Input

Frame Number 123

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Risk

OUTCOME BEING CONSIDERED: (Outcome NAME)

DISTRIBUTION SELECTION

Select the most appropriate distribution from the three displayed below:

ENTER CHOICE NUMBER ____________

2. Programmer's Information

Need Outcome name and proposal name.
Store distribution in PI Summary Tables.

3. Branching

Valid Menu Input: 124
(1, 2, 3)

Figure 4-14. Frame Number 123

SUMMET DISPLAY FRAME STORYBOARD

From 122, 123

User Response Return

Frame Number 124

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Risk

OUTCOME BEING CONSIDERED: (Outcome NAME)

Assume that the Outcome Being Considered is not attained. Please enter your description of the minimally acceptable result.
(1)
Now what is the probability (discrete or range) or attaining this minimally acceptable result, given that the original Outcome Being Considered is not attained; i.e., P(result > min. acceptable/result < Outcome Being Considered).

Current Value ________ New Value (2)

If you have input a range, please input the modal value; otherwise, press Return.

Current Value ________ New Value (3)

2. Programmer's Information

Need to file in Proposal and Outcome names.

(1), (2), (3) are cursor positions.

Update PI Summary Table.

Update and display distributions on 125 if value for (3).

Reverse video (once outcome has been evaluated) for said outcome on Frame 121.

Update Current Value line.

3. Branching

Valid Modal Value: 125
Return at (3): 121

Figure 4-15. Frame Number 124

SUMMET DISPLAY FRAME STORYBOARD

From 124

User Response Modal Value

Frame Number 125

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Risk

OUTCOME BEING CONSIDERED: (Outcome NAME)

DISTRIBUTION SELECTION

Select the most appropriate distribution from the three displayed below:

ENTER CHOICE NUMBER ______

2. Programmer's Information

Need Proposal and Outcome names.

Update PI Summary Tables.

Reverse video on 121 (after distribution has been centered here) for this outcome.

3. Branching

Valid Menu Selection (1,2,3): 121

Figure 4-16. Frame Number 125

SUMMET DISPLAY FRAME STORYBOARD

From 102

User Response 3

Frame Number 130

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Cost

If you have already entered TACOM's BUDGET ESTIMATES, press Return. If not, please enter the year and an estimate (discrete/range) of TACOM's BUDGET for each year that any of the proposals being considered is expected to cover:

Year		TACOM Budget	
Current Value ____	New Value ____	Current Value ____	New Value ____

If you entered a range for the budget estimate, please enter the modal value; otherwise, press Return.

Current Value ____________ New Value (3)

2. Programmer's Information

Suppress Proposal Being Considered line.

Update PI Table.

(1), (2), (3) are cursor positions. After Return at (3) go back to (1), but one line lower.

Update distributions on 131 if value for (3).

If Return for Year and no input, then go to 132.

3. Branching

Modal Value: 121
Return at (1) and no input: 132

Figure 4-17. Frame Number 130

SUMMET DISPLAY FRAME STORYBOARD

From 130

User Response Modal Value

Frame Number 131

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Cost

DISTRIBUTION SELECTION

Select the most appropriate distribution from the three displayed below:

ENTER CHOICE NUMBER ______

2. Programmer's Information

Update PI Summary Tables.

Suppress Proposal Being Considered line.

3. Branching

Valid Menu Selection
(1), (2), (3): 130

Figure 4-18. Frame Number 131

SUMMET DISPLAY FRAME STORYBOARD

From 130

User Response Return

Frame Number 132

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Cost

Please enter the R&D Cost estimates for work done in each year the project is expected to run for:

Year		R&D Cost Estimate	
Current Value ____	New Value ____	Current Value ____	New Value ____

If you entered a range for R&D cost, please enter the modal value; if not, press Return.

Current Value __________ New Value (3)

2. Programmer's Information

(1), (2), (3) are cursor positions.

Need proposal name.

If return for (3), go to (1), but one line lower.

Value at (3) must be in range specified in (2).

Error Message if Return for (3) and range at (2).

Update Summary frames.

3. Branching

Valid value at (3), then 133.

Return at (1) with no input, then 102.

Figure 4-19. Frame Number 132

SUMMET DISPLAY FRAME STORYBOARD

From 132

User Response Modal Value

Frame Number 133

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: R&D Cost

DISTRIBUTION SELECTION

Select the most appropriate distribution from the three displayed below:

ENTER CHOICE NUMBER ____________

2. Programmer's Information

Update Summary frames.

3. Branching

Valid Menu Selection
(1), (2), (3): 132

Figure 4-20. Frame Number 133

SUMMET DISPLAY FRAME STORYBOARD

From 102

User Response 4

Frame Number 140

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: Performance Effectiveness

Using histogram results from a one-on-one engagement analysis, enter the frequency values for each ΔP_s interval below. Enter a zero if there are no occurrences for a given interval.

ΔP_s	f
.00 - .10	(1)
.11 - .20	(2)
.21 - .30	(.)
.31 - .40	.
.41 - .50	.
.51 - .60	.
.61 - .70	.
.71 - .80	.
.81 - .90	.
.91 - 1.0	

Press Return to continue

2. Programmer's Information

(1) ..... (10) are cursor positions.

Update PI Summary Tables.

3. Branching

11th Return: 102

Figure 4-21. Frame Number 140

SUMMET DISPLAY FRAME STORYBOARD

From 102

User Response 5

Frame Number 150

---

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: Combat Utility

Using histogram data obtained from force-on-force analysis, input the interval range for $\Delta F_c/F_{co}$ and the associated frequency. Press Return after each.

$\Delta F_c/F_{co}$	f
(1)	(2)
(2)	(4)
(5)	(6)
.	.
.	.
.	.
(M)	(N)

---

2. Programmer's Information

(1) ... (N) are cursor positions.

Update Summary Tables.

3. Branching

Return with no input: 102

Figure 4-22. Frame Number 150

SUMMET DISPLAY FRAME STORYBOARD

From 102

User Response 6

Frame Number 160

---

1. Text

MODE: Parameter Input

PROPOSAL BEING CONSIDERED: (Proposal NAME)

DIMENSION: User Acceptance

Input an L, M, or H for Low, Medium, and High utility, respectively, for each of the user acceptance criteria below:

ACCEPTANCE CRITERIA	UTILITY
User Need	(1)
Time to Field	(2)
Retrofitability	(3)
Tactic Impact	(4)
Useful Life	(5)
Retrofit Cost	(6)
Operation Cost	(7)
Support Cost	(8)

Press Return when all eight utilities have been entered.

---

2. Programmer's Information

(1)...(8) cursor positions.

Update PI Summary Tables.

3. Branching

Return w/no input: 102

Figure 4-23. Frame Number 160

SUMMET DISPLAY FRAME STORYBOARD

From 50

User Response 2

Frame Number 200

1. Text

MODE: Send Proposals to be Rank Ordered

The following proposals have been ordered and evaluated based on the characteristic parameter values that were input and the stored utility functions and heuristics:

1. (Prop name)
2. (Prop name)

. .

. .

N. (Prop name)

Press Return to get back to PROCESS MENU

2. Programmer's Information

If all of the parameter values have not been input, then print Initial evaluation and ordering cannot be done until the characteristic parameter values have been entered for:

Press Return to get back to PROCESS MENU.

3. Branching

Return: 50

Figure 4-24. Frame Number 200

SUMMET DISPLAY FRAME STORYBOARD

From 50

User Response 3

Frame Number 300

1. Text

MODE: Review Ordering and Output

Initial rank order of "go" proposals and "go" likelihoods

1.	---	---
2.	---	---
.	---	---
.	---	---
N.	---	---

Rejected Proposals

1. ---
2. ---
. ---
. ---
N. ---

Press Return to get back to PROCESS MENU

2. Programmer's Information

Need an error message if this mode is entered before the proposals have been sent for evaluation.

3. Branching

Return: 50

Figure 4-25. Frame Number 300

SUMMET DISPLAY FRAME STORYBOARD

From 50

User Response 5

Frame Number 500

1. Text

MODE: Sensitivity Analysis

SENSITIVITY ANALYSIS MENU

Enter the number of the function you wish to perform:

1. Edit the Characteristic Parameter Table Grouped by Proposal
2. Edit the Summary Table Grouped by Dimension
3. Send Proposals to be Re-evaluated and Reordered
4. Review Ordering and Output

ENTER CHOICE NUMBER (1)

2. Programmer's Information

Need error message if user attempts to enter this mode before first level analysis has been done.

(1) is cursor position.

3. Branching

1. 551
2. 552
3. 553
4. 554

Figure 4-26. Frame Number 500

SUMMET DISPLAY FRAME STORYBOARD

From 500

User Response 1

Frame Number 551

1. Text

MODE: Sensitivity Analysis

FUNCTION: Edit

Control F: Scroll forward
Control B: Scroll backward

CHARACTERISTIC PARAMETER TABLE BY PROPOSAL

Proposal NAME

R&D Time

.
.
.

User Acceptance

Proposal NAME

R&D Time

.
.
.

User Acceptance

.
.
.

Press Return to get back to Sensitivity Analysis Menu

2. Programmer's Information

Changes in data will be made directly to this table. Therefore, this table should be linked to the data file. The initial parameters that are sent to be evaluated should be saved, however, and should not be alterable. Center part of screen should scroll.

3. Branching

Return: 500

Figure 4-27. Frame Number 551

SUMMET DISPLAY FRAME STORYBOARD

From 500

User Response 2

Frame Number 552

1. Text

MODE: Sensitivity Analysis

Control F: Scroll forward
Control B: Scroll backward

FUNCTION: Edit

CHARACTERISTIC PARAMETERS BY DIMENSION

R&D Time

Prop 1
Prop 2
.
.
.
Prop N

R&D Risk

Prop 1
Prop 2
.
.
.
Prop N

Press Return to get back to Sensitivity Analysis Menu

2. Programmer's Information

Center part of screen scrolls.
Changes can be made in table, which should then be changed in the data file.
Original data file should not be changed, however.

3. Branching

Return: 500

Figure 4-28. Frame Number 552

SUMMET DISPLAY FRAME STORYBOARD

From 500

User Response 3

Frame Number 553

1. Text

MODE: Sensitivity Analysis

FUNCTION: Send Proposals to be Re-evaluated and Ordered

The following proposals have been re-evaluated. Those with reverse video had changes made to their initial parameter values:

1. —
2. —
. —
. —
N. —

Press Return to get back to Sensitivity Analysis Menu

2. Programmer's Information

Compare buffers to allow for reverse video feature.

3. Branching

Return: 500

Figure 4-29. Frame Number 553

SUMMET DISPLAY FRAME STORYBOARD

From 500

User Response 4

Frame Number 554

---

1. Text

MODE: Sensitivity Analysis

FUNCTION: Review Ordering and Output

NEW RANK ORDER OF "GO" PROPOSALS AND "GO" LIKELIHOODS

1.	---	---
2.	---	---
.	---	---
.	---	---
N.	---	---

REJECTED PROPOSALS

1.
2.
.
.
N.

Press Return to get back to Sensitivity Analysis Menu

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2. Programmer's Information

3. Branching
Return: 500

Figure 4-30. Frame Number 554

If this is a new session, the user continues to the command level menu (Figure 4-4) after entering the list of proposals being considered. The main working space is accessed from the command level menu by entering a one (1). That branches the user to a process level menu (Figure 4-5), which allows access to parameter input, proposal evaluation, review, summary table review, and sensitivity analysis.

If the user enters the parameter input mode, there is an introductory frame (Figure 4-6) and a menu (Figure 4-7) that let the user select the proposal to be evaluated first. Frame 102 (Figure 4-8) asks the user to select the decision-dimension that they wish to input data for first. This frame also allows the user to change the CM proposal that data is being entered for. Thus, he has the capability to enter information across proposals or across the six decision-dimensions (R&D Time, R&D Risk, R&D Cost, Performance Effectiveness, Combat Utility, User Acceptance). For R&D Time (Figure 4-9) the user is asked to input the estimate for development time in terms of a value or range of values. If a range is input, the user is asked to input the modal value, and then select one of three distributions possessing different amounts of variance (Figure 4-10). After each dimension the user returns to Frame 102 (Figure 4-8), to select the next dimension. Let's assume that the user proceeds in the order given.

For R&D Risk (Figure 4-11), the user first enters the outcomes to be achieved by a particular proposal; for example, a 95 percent reduction in IR visibility and a 60 percent reduction in threat missile hit probability.

Then he selects the outcome that is to be considered first (Figure 4-12). For each outcome the user enters the probability of obtaining that outcome (Figure 4-13), and the minimally acceptable alternative and the probability of attaining the alternative, given that the original outcome is not achieved (Figure 4-15). Both probabilities can be in the form of a range or a discrete value. If a range is entered, then a distribution must be selected (Figures 4-14 and 4-16).

For R&D Cost, a budget value is entered for each year that the longest project is expected to run (Figure 4-17). Again, a range of estimates can be entered and the appropriate distribution can be picked for each range entered (Figure 4-18). Then, the user enters the estimated amount of money the project will cost for each year it runs (Figure 4-19), and a distribution is selected if a range is entered (Figure 4-20).

For Performance Effectiveness, the user inputs normalized histogram data, as indicated in Figure 4-21. These data, generated for the decision maker by a one-on-one engagement model, estimate the improvement (ΔP_s) in vehicle survival probability when protected by the proposed CM. A similar input procedure (Figure 4-22) follows for Combat Utility, except that rather than for ΔP_s, the histogram input is for the $\Delta F_c/F_{co}$ parameter, which measures the improvement in fractional casualty ratio offered by the proposed CM and estimated from force-on-force analysis.

Finally, User Acceptance is handled by having the user enter an L, M, or H (Low, Medium, or High Utility) for each of the eight facets of User Acceptance (Figure 4-23).

Once all of the parameters have been entered for all of the CM proposals, the proposals can be evaluated (Figure 4-24) and the output can be reviewed (Figure 4-25). If the user wishes to make any changes to the input parameters to determine the effects on the rank order, decision space metric, go/no-go decisions, etc., then the sensitivity analysis mode (Figure 4-26) can be accessed. From there the user can edit changes to the data files that are grouped by proposal (Figure 4-27) or dimension (Figure 4-28). The parameters can then be re-evaluated (Figure 4-29) and the analysis reviewed (Figure 4-30). The user can return to the command level menu at any point in the program by pressing CONTROL C. From there, the user may exercise several options. He may wish to:

- Enter short descriptions of each proposal (Frame 603 of Figure 4-1) to serve as a reminder about various proposal details, should the analysis need to be stored and then called up again at a later time.
- Enter new proposals for consideration (Frame 601, Figure 4-1).
- Change proposal names (Frame 604, Figure 4-2).
- Change descriptions (Frame 605, Figure 4-2).
- Delete proposals from the list (Frame 606, Figure 4-1).

Hardcopy documentation can be obtained of the initial parameter inputs, initial output, and/or any of the sensitivity analysis parameter changes and re-ranking (Frame 700, Figure 4-1).

Finally, Frames 800 and 900 (Figure 4-1) allow the user to continue or review a previous session or exit/end when finished with the current session.

The user interface just described will be refined in Phase II of SUMMET development. This refinement will follow review and critique with decision makers/aid users at TACOM.

At this point let us critique the interface concept described in terms of aforementioned user and decision-aid characteristics, i.e., multiple users, expertise and knowledge, time and desire to learn computerese, and user-friendliness.

4.2. Multiple Users

In addition to logging on to the PRIME computer, the user also has a log-on sequence for SUMMET (see Figure 4-3). This allows individuals to keep separate files and analyses on various proposals. In addition, it lowers the search space for each user who may be looking for a past run to either revise or review.

The notion of multiple users implies another consideration -- the various degrees of knowledge and experience with computers.

4.3. Varying Levels of Computer Knowledge

This user variance poses a slightly more difficult interface problem. The interface should not have so much embedded help that the experienced users are forced to wade through screens of material that they are already familiar with, nor should it have so little help that the computer novice is lost as to how to proceed.

To address this user variability, the interface concept is menu-driven, has error messages that provide guidance, and has an associated off-line manual to provide help and guidance for the optimal use of the aid. Menu-driven systems provide a good balance between the varying levels of experience. They are quick and easy to learn and relatively quick to use. Figure 4-4 shows the main command level menu for the SUMMET interface. From there one can access the process menu (Figure 4-5) or any of the other system functions, such as edit proposal descriptions, continue previous session, obtain hardcopy, and exit/end session. The main working space is accessed from the process level menu. From there the user can input the characteristic parameter values, send proposals off to be reviewed and evaluated, review ordering and output, examine the parameter input summary tables, and carry out a sensitivity analysis. Menus are used elsewhere for some of the other functions as well. The main command menu can be accessed from anywhere in the aid by pressing CONTROL C.

Error messages are designed to not only flag the fact that an error has been made, but also to provide some guidance as to how to correct the situation. In Figure 4-4 one can see that if a user attempts to enter this mode before all of the characteristic parameters have been input, the system displays a message flagging the fact and directs the user to get back into parameter input mode and finish entering values.

An off-line manual will also be provided as a further form of help. The manual will provide examples on how to exercise the system, explain the input dimensions and the assumptions behind them, and describe how the aid is actually using the data that is given.

The menu structure, error messages with guidance, and an off-line menu should allow users of all levels to learn to use SUMMET quickly and efficiently.

4.4. Limited Time/Desire to Learn the Computer

With a new computer system or the computerization of a formerly manual process, a lot of front-end time can be required to learn how to use such features as the system editor and the file management system. In the case of the file management system, we avoid the time requirement by allowing the user to store analyses, based on the proposal names that are being analyzed and on the date and time that the work is being done. If users wish to stop in the middle of a session, they merely have to log out. When they are able to continue later on, they can enter the Continue Previous Session mode and find the files listed from most recently used to oldest. They merely indicate the number of the file they wish to continue and the computer uploads all of the data associated with that file.

The system editor is usually the most complicated function to use, with different systems having their own, often unique, set of editing commands. The proposed interface allows the user to change parameter inputs immediately after they are made (by entering a different input onto the New Value line) or later on in the sensitivity analysis mode when all of the data is stored together for easy review. This process is much simpler to use than trying to leave and remember a host of system editor commands.

4.5. User-Friendliness

A user-friendly system encompasses the following features:

- o Easy to use/understand
- o Easy to control
- o Task-oriented
- o Allows flexibility of task handling
- o Tolerates mistakes
- o Fulfills user expectations

The first four features are handled by having a menu-driven system. Menu systems, as long as the hierarchy does not become too deep, are easy to use, understand, and control, and are very task-oriented. Figures 4-7, 4-27, and 4-28 show that data can be input or edited across decision-dimensions for each proposal or across proposals for each dimension. This feature, and the ability to get to the command level menu from anywhere in the program, allow for task flexibility.

The last feature may very well be the most important. In order to fulfill user expectations, the system must do what the user expects it to do. For this to happen, the users must become involved in the development process in terms of both design and implementation of the aid and of the user interface. In this way, information is collected, analyzed, and displayed in a manner that is both useful and consistent with the user's expectation. We stress this point, because user involvement will be an integral part of the Phase II user interface definition.