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DOCUMENTATION OF DECISION-AIDING SOFTWARE: OPINT SYSTEM SPECIFICATION

DECISIONS AND DESIGNS INC.

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Roy M. Gulick

April 1979

N00014-79-C-0069

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DOCUMENTATION OF DECISION-AIDING SOFTWARE:

OPINT SYSTEM SPECIFICATION

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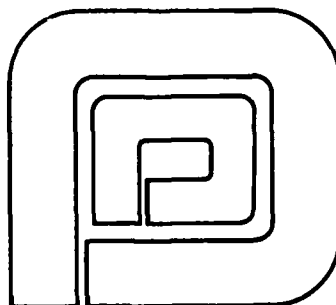
Dorothy M. Amey, Phillip H. Feuerwerger, and Roy M. Gulick

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OPINT SYSTEM SPECIFICATION

1.0 INTRODUCTION

1.1 Purpose of the System Specification

The OPINT System Specification is a technical document written for software development personnel. Together with the OPINT Functional Description, it guides the software development effort by identifying the functional requirements and by providing structured logic diagrams that depict the flow, control, and processing of information within the system.

The system specification is generic and is intended to guide and facilitate the preparation of the language-specific program documentation and coding that are necessary to implement and operate OPINT at an installation.

1.2 References

- 1.2.1 IBM, HIPO--A Design Aid and Documentation Technique. Technical Publication GC20-1851-0. White Plains, New York: IBM, October 1974.
- 1.2.2 Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: OPINT Functional Description. McLean, Virginia: Decisions and Designs, Inc., April 1979.
- 1.2.3 Amey, Dorothy M.; Feuerwerger, Phillip H.; Gulick, Roy M. Documentation of Decision-Aiding Software: OPINT Users Manual. McLean, Virginia: Decisions and Designs, Inc., April 1979.

1.3 Terms

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

1.3.2 HIPO - The specification uses the standard Hierarchy plus Input-Process-Output (HIPO) diagramming technique to depict the structural design and logical flow of the system. A legend explaining the HIPO diagramming symbols is included. Reference 1.2.1 provides a complete description of the HIPO documentation technique.

2.0 DESIGN DETAILS

2.1 Background

Systems development personnel should refer to the OPINT Functional Description, Reference 1.2.2, in conjunction with the documentation contained in this specification. The functional description details the decision model implemented by OPINT and discusses the specific functions that the software performs. In addition, systems development personnel may wish to refer to the OPINT User's Manual, Reference 1.2.3.

2.2 General Operating Procedures

OPINT is a menu-driven system. That is, the system is designed to interact with the user by presenting a sequential hierarchy of menus and asking the user to respond by selecting one option from the current menu. If the user does not select one of the menu options, the system displays the previous menu. In this manner, the user moves up and down the hierarchy, as desired. Whenever data entry is required as a result of option selection, the system specifically requests the data and specifies the format.

The system is also designed to be generally forgiving of procedural errors by the user.

2.3 System Logical Flow

OPINT is a hierarchically structured, modular system. The system structure and logical flow lends itself to presentation in the form of HIPO diagrams, which are contained in this document.

The main purpose of the HIPO diagrams is to provide, in a pictorial manner, the complete set of modular elements necessary to the operation of OPINT including all input, output, and internal functional processing. This is done by displaying input items to the process step which uses them, defining the process, and showing the resulting output of the process step.

The documentation diagrams are designed and drawn in a hierarchical fashion from the main calling routines to the detail-level operation/calculation routines. Extended written descriptions are given below a HIPO diagram whenever it is deemed necessary.

A complete explanation of the symbolic notation used in the HIPO diagrams is given in Reference 1.2.1. An abbreviated legend for the symbols used in this specification is given in Figure 2-1. Note that:

- a. External subroutines appear partly in the process block and partly out. Internal subroutines are shown within the process block.
- b. Overview diagrams show general inputs and outputs only, whereas detail/subroutine-level diagrams show specific input/output tables and/or displays.
- c. Rectangular boxes inside the input/output block areas are generally used to denote single data items. Two or more boxes are grouped to show several data items are input/output.
- d. Rectangular boxes inside the process block indicate repetitive subprocesses.

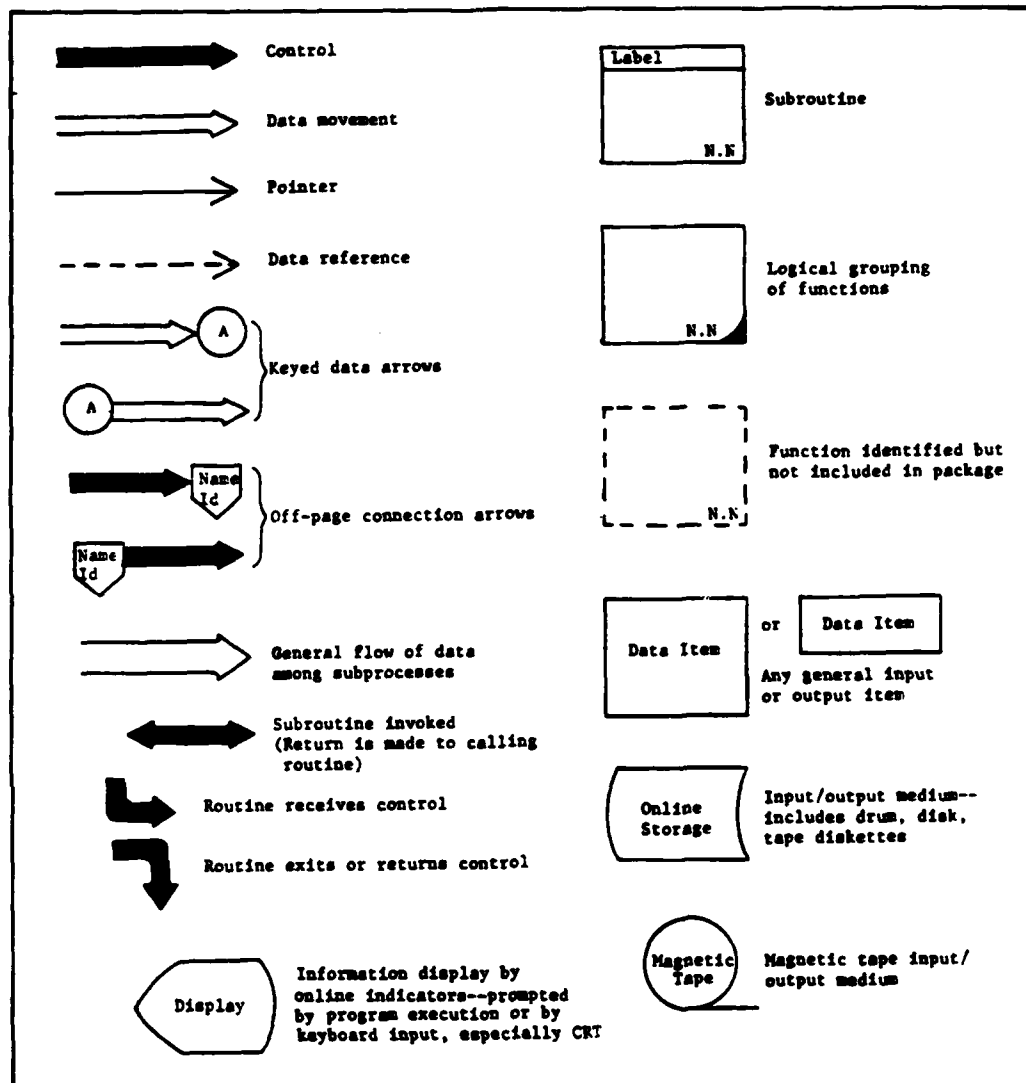


Figure 2-1
LEGEND OF HIPO SYMBOLS

The HIPO diagrams appear in the next section, which completes the system specification.

2.4 HIPO Documentation

The HIPO diagram identification numbers and figure numbers used in this section stand alone; i.e., they start with 1.0, increase hierarchically, and are independent of the numbering scheme used to this point in this document.

Figure 2-2 is a system structure chart and represents the overall program logic flow in a visual table of contents. The Visual Table of Contents diagram shows the hierarchical structure, the functional description labels, and the diagram (chart) identifiers of functions of OPINT.

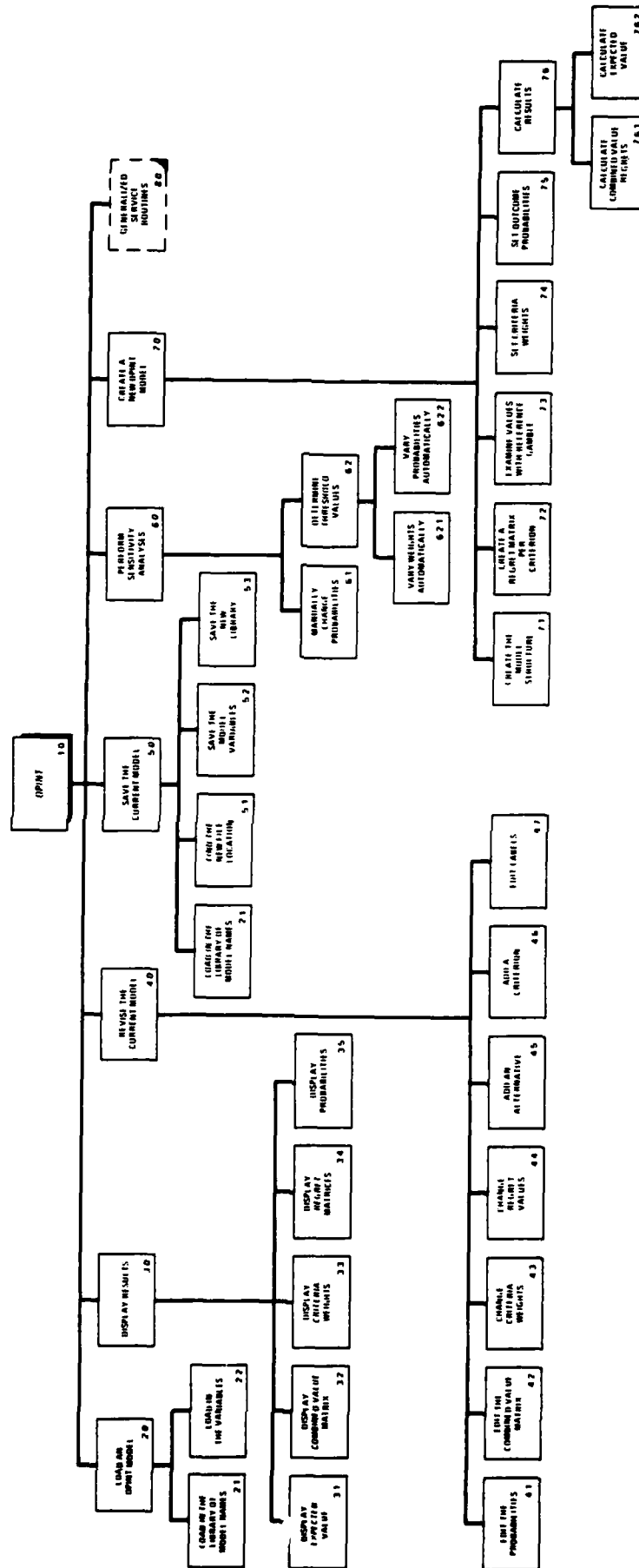
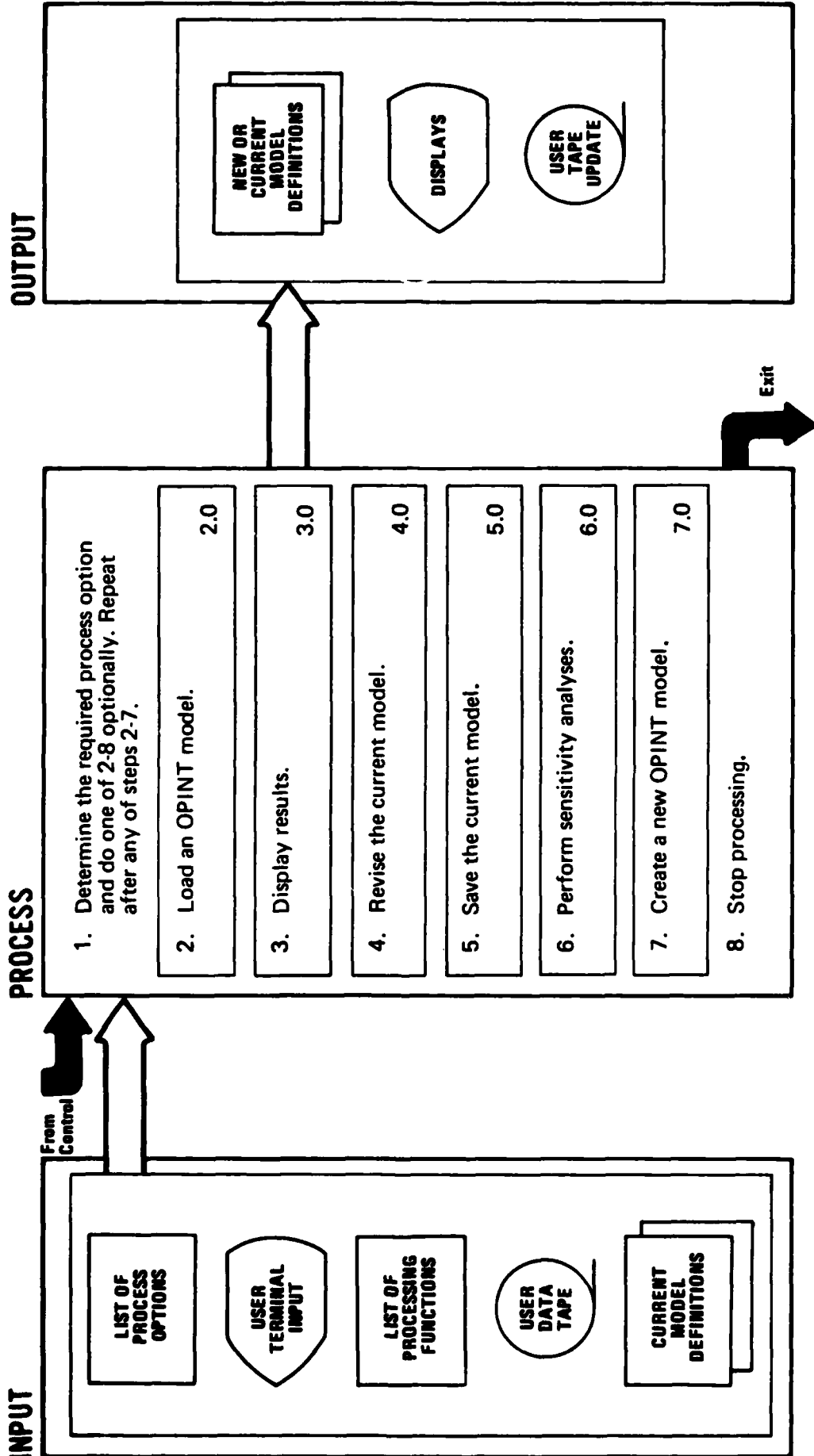


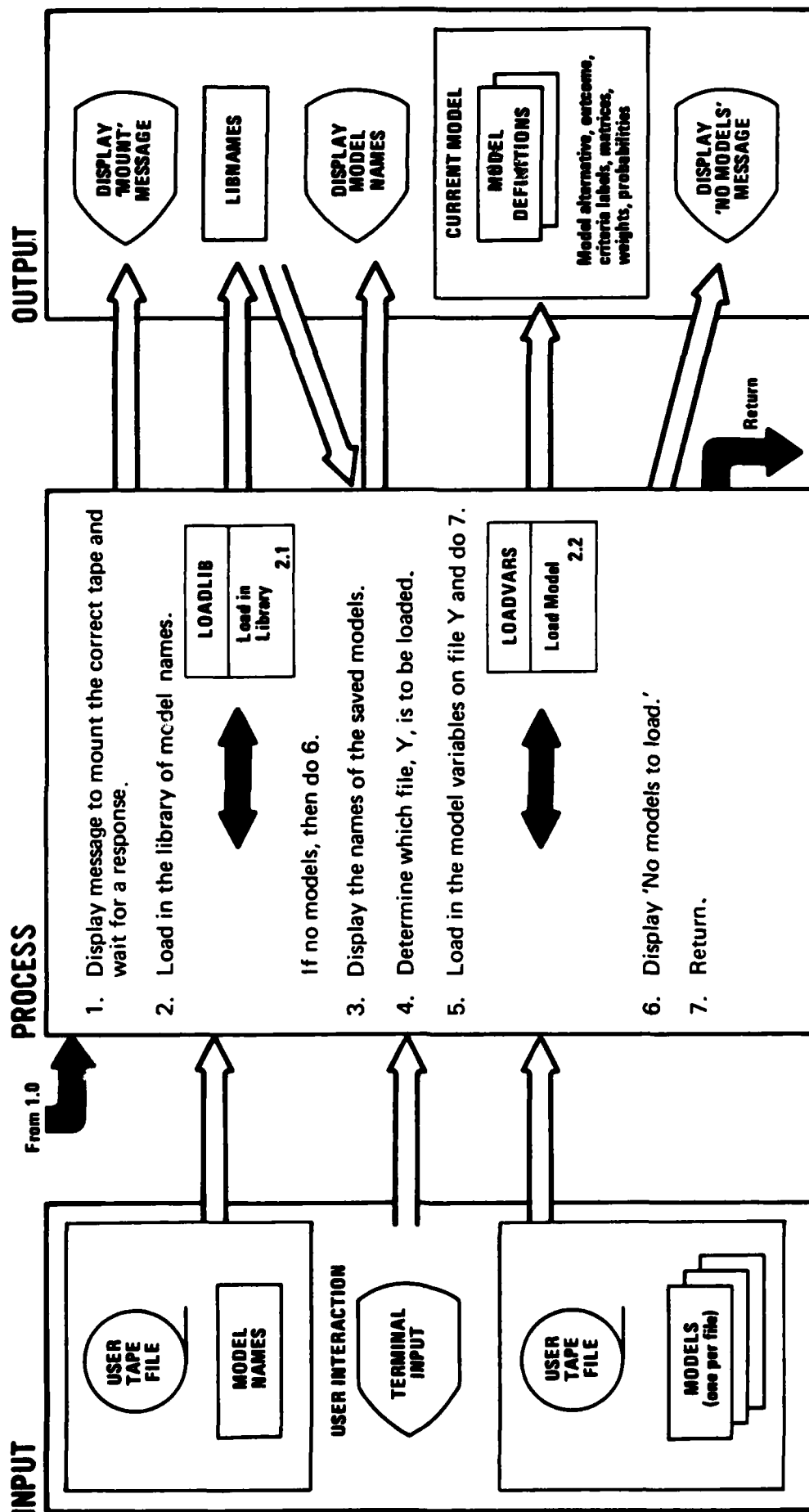
Figure 2-2
OPINT OVERVIEW CHART AND VISUAL TABLE OF CONTENTS



1. In this step, the user is allowed to select from among six different processes. This is done by the display of an options list in menu format and the user's response of inputting a selection via the keyboard display. Once a process is selected, one of steps 2-7 will be invoked to perform the function. If no process is selected (usually indicated by a blank entry from the keyboard), then all processing stops and OPINT returns to the control system.

2-7. These functions are performed only upon selection by the user. See subsequent charts for detail process documentations.

After a process has been selected and the function performed, control returns to step 1. The process options menu is again displayed and a new or the same process may be selected.

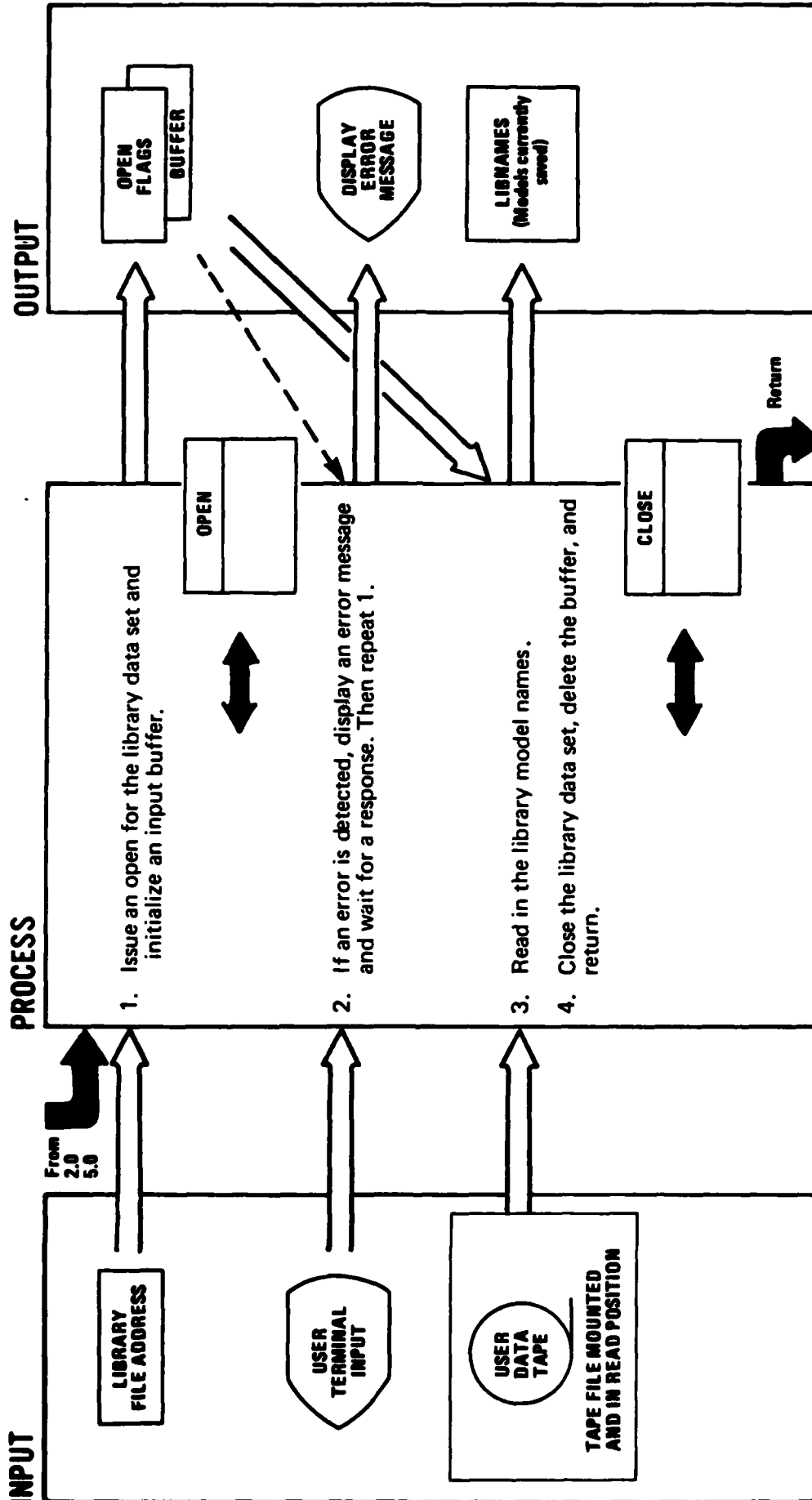


1. The user may have many tape files on which OPINT formatted models are stored. In this step, the user is prompted for a response indicating the desired tape is mounted or online.

3. The names of the models existing on the mounted tape are displayed in list or MENU format so that the user may select a model for loading.

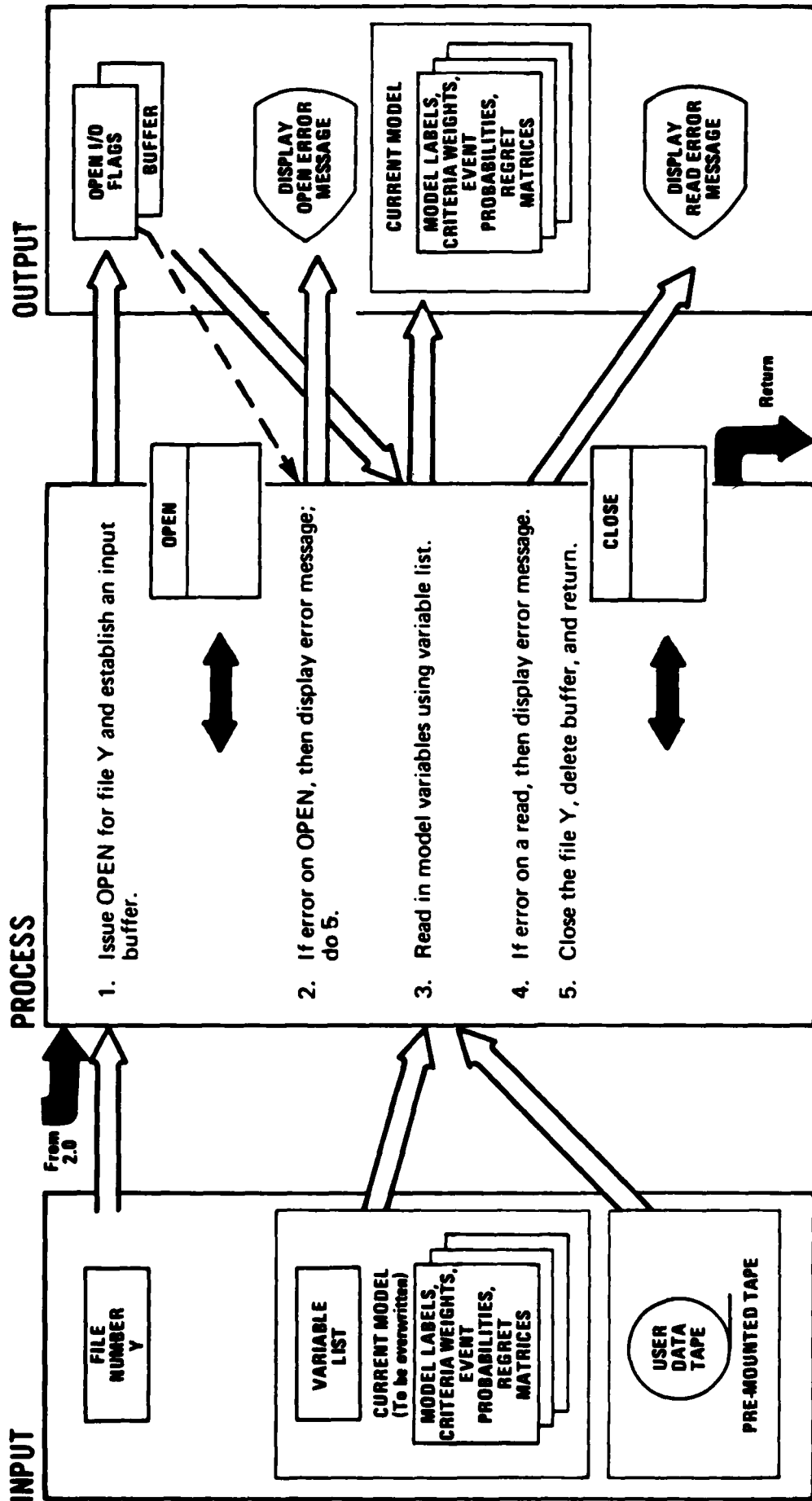
4. The user is prompted for a model selection: the response may be the list item number or the model name. The requested model is stored in the same tape file as its position relative to the other model names in the displayed list.

System/Program: OPINT Name: LOADLIB
 Diagram ID: 2.1 Description: Load in Library Page: of



1. The library file of model names is available on each OPINT formatted data tape. The file is usually stored and retrieved as a character array and resides on the same device with model data. A system OPEN command is needed to ensure that the data file is online and accessible for reading. An input buffer is needed and provides the link between stored information and program addressable information.
3. The library model names are retrieved from storage. The character array used for holding these model names, LIBNAMES, is of a form which facilitates display; thus, the names may all be of equal character lengths.

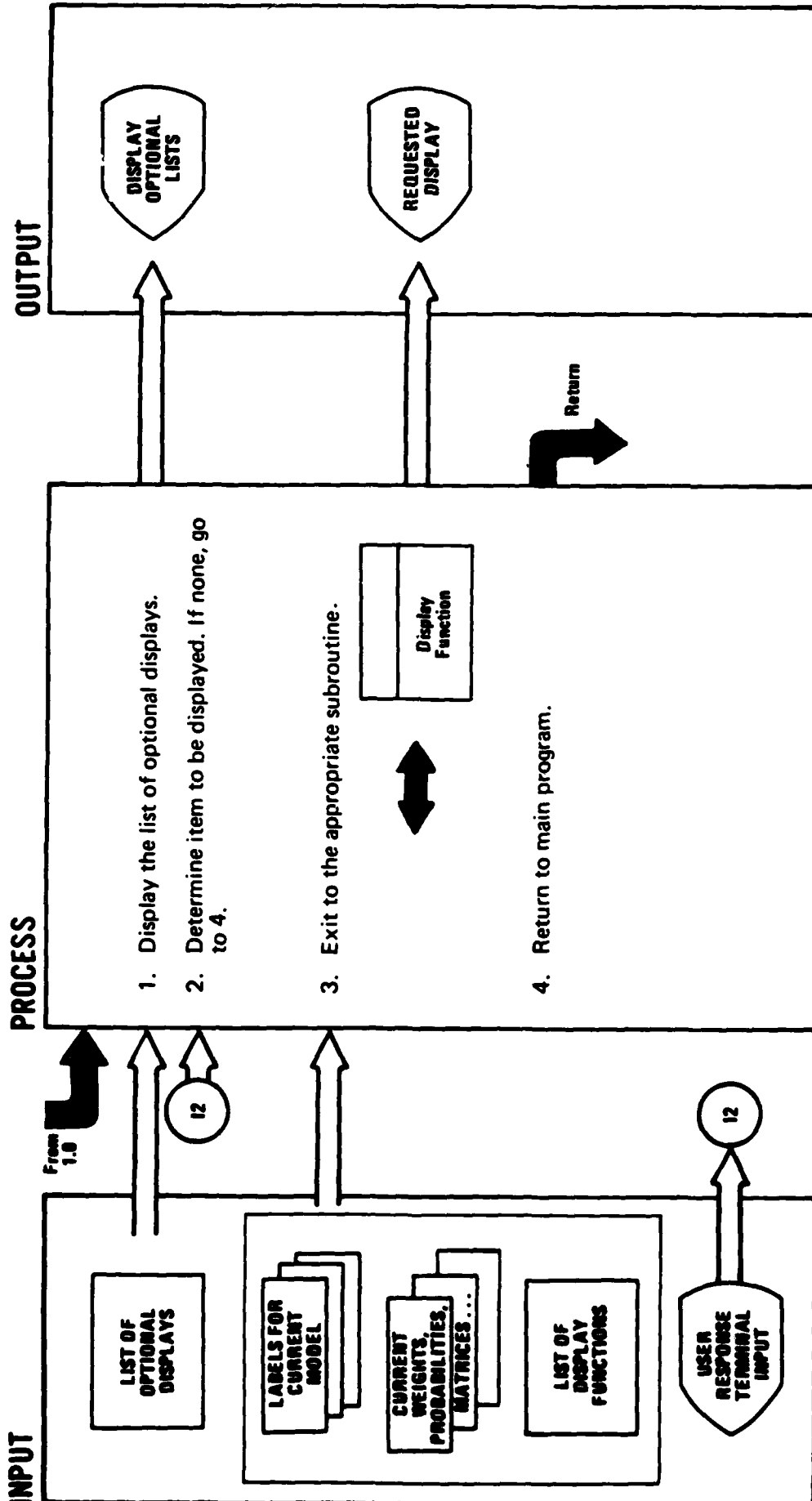
4. A system CLOSE command is issued to free the data file for later use.



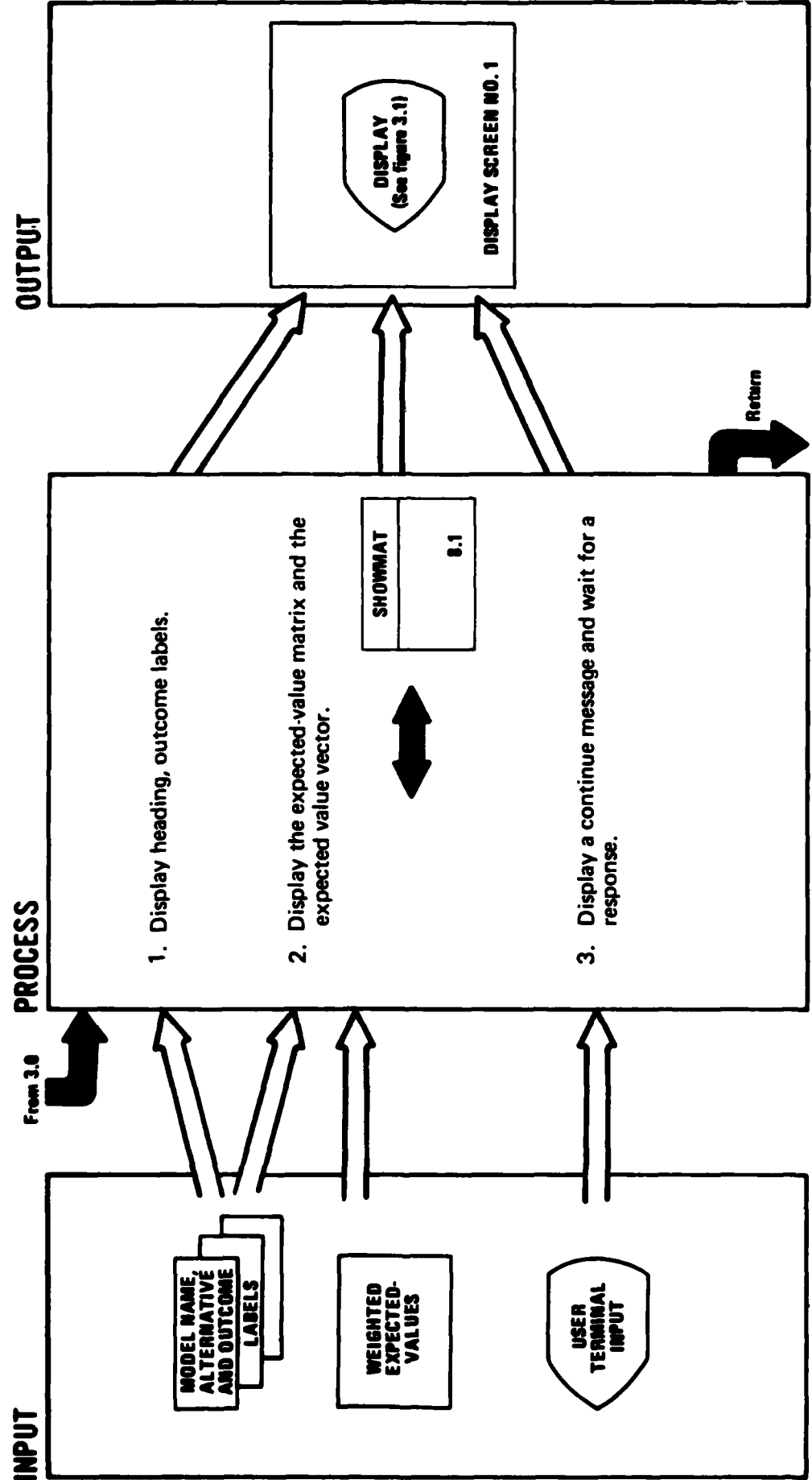
- DECISION ALTERNATIVE LABELS
- EVENT OUTCOME LABELS
- KEY EVENT NAME
- CRITERIA LABELS
- CRITERIA WEIGHT VALUES
- EVENT PROBABILITY VALUES
- REGRET VALUES
- COMPUTED COMBINED-REGRET

3. A list of variable Names or identifiers is kept so that load and store routines will always process the variables in the same sequence order.
4. The Model variables retrieved from storage are used in all other program functions (see chart 1.0). The variables which must be loaded are the following:

System Program: OPINT Name: _____
 Diagram ID: 3.0 Description: Display Results Page: _____ of _____



1. The List of Optional displays is shown in Menu format. The list of displays corresponds exactly with the associated list of display functions.
2. A display selection is requested from the user. If the user responds with a blank entry (no MENU selection), then control returns to the calling routine.
3. The display routine which provides the required display is in the list of display functions which corresponds to the order of optional displays. (See Charts 3.1 - 3.5 for detail descriptions.)

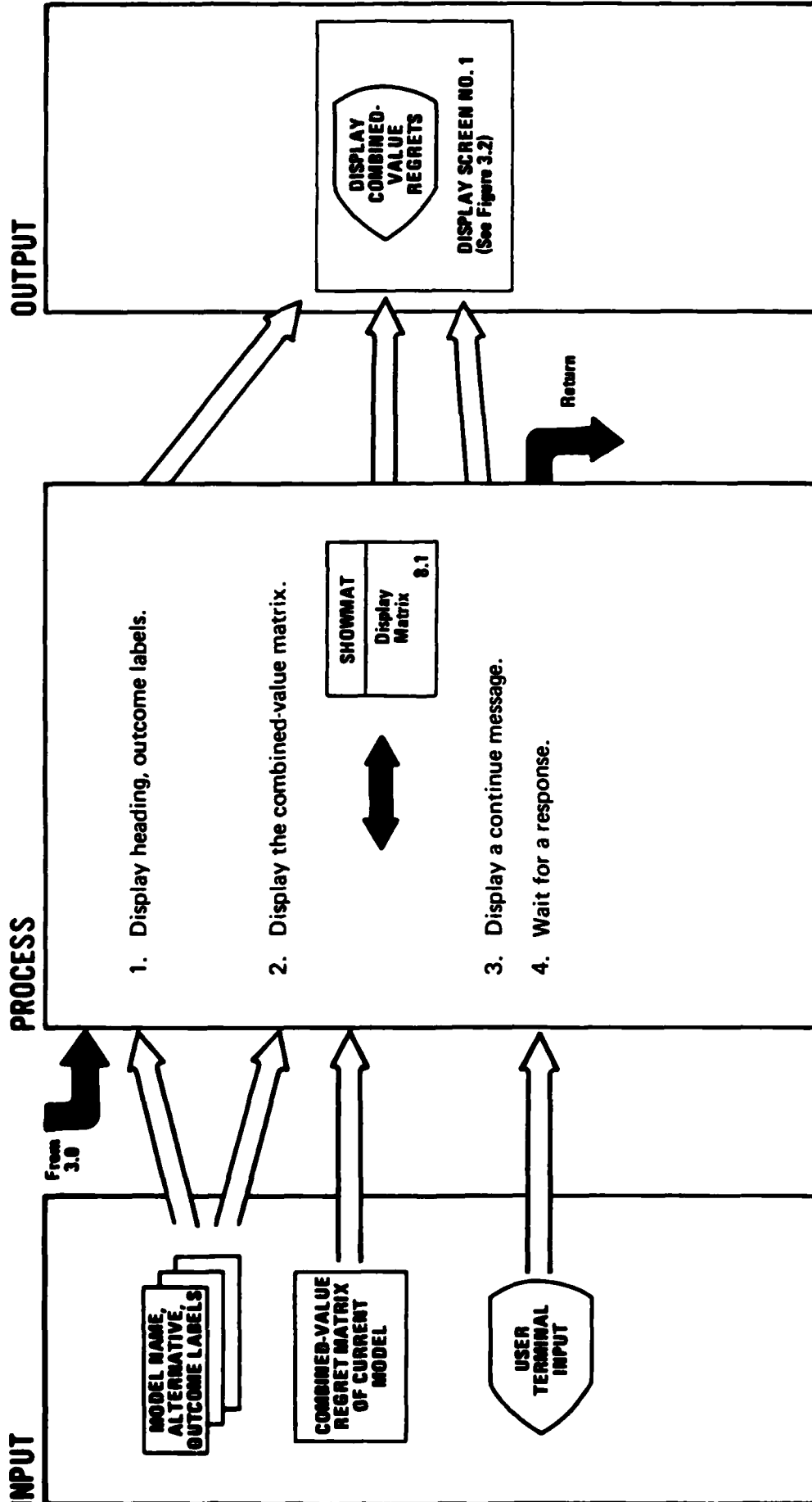


1. The headings for the display are unique to the model that is currently available. This display should show the model name and labels for outcomes in horizontal fashion.
3. The user is prompted to input any response from the keyboard to cause processing to continue.

MODEL -- EVACUATION

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

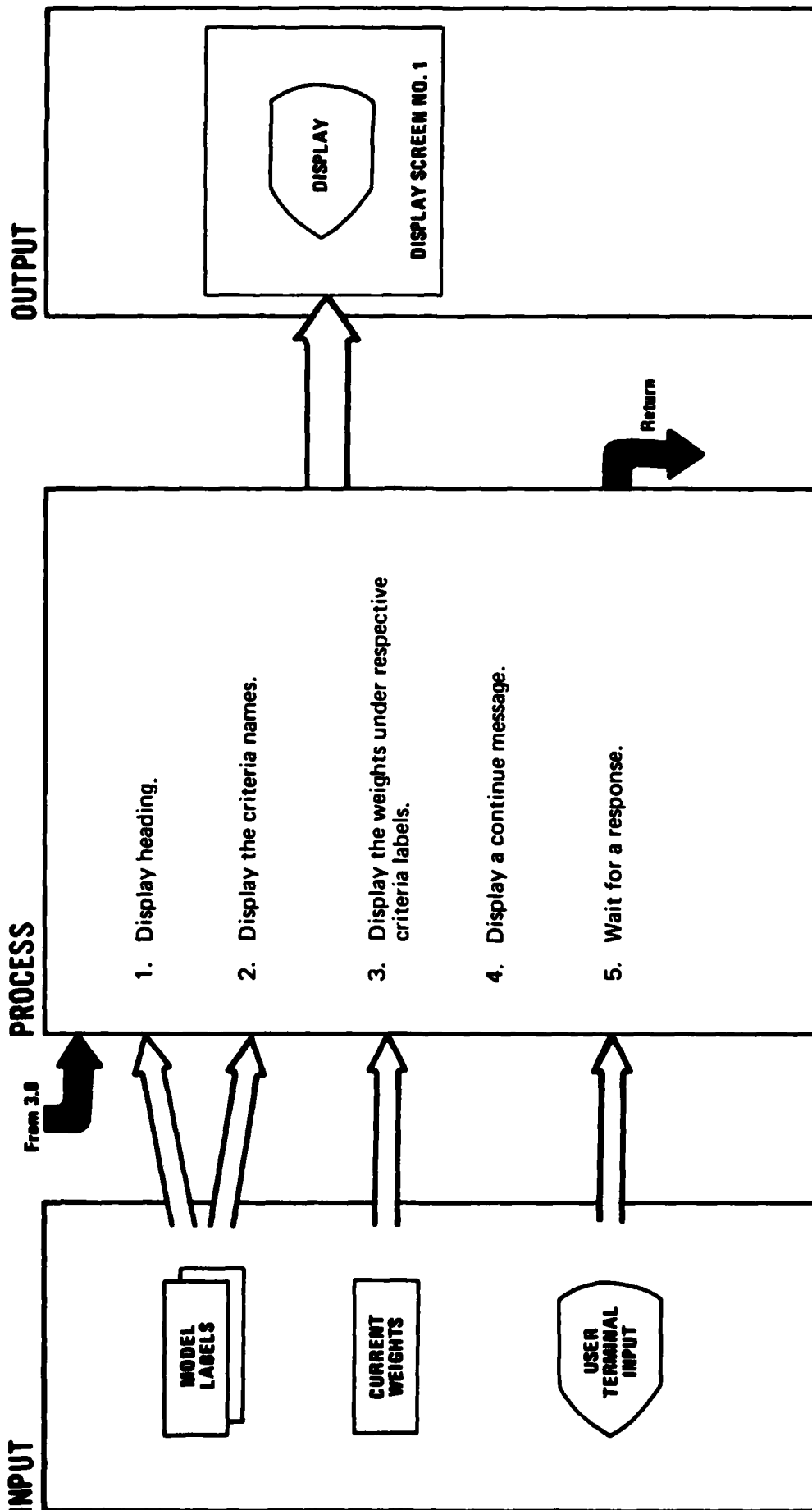
Figure 3.1
EXAMPLE OF OUTPUT FROM DISPLAY FUNCTION 3.1



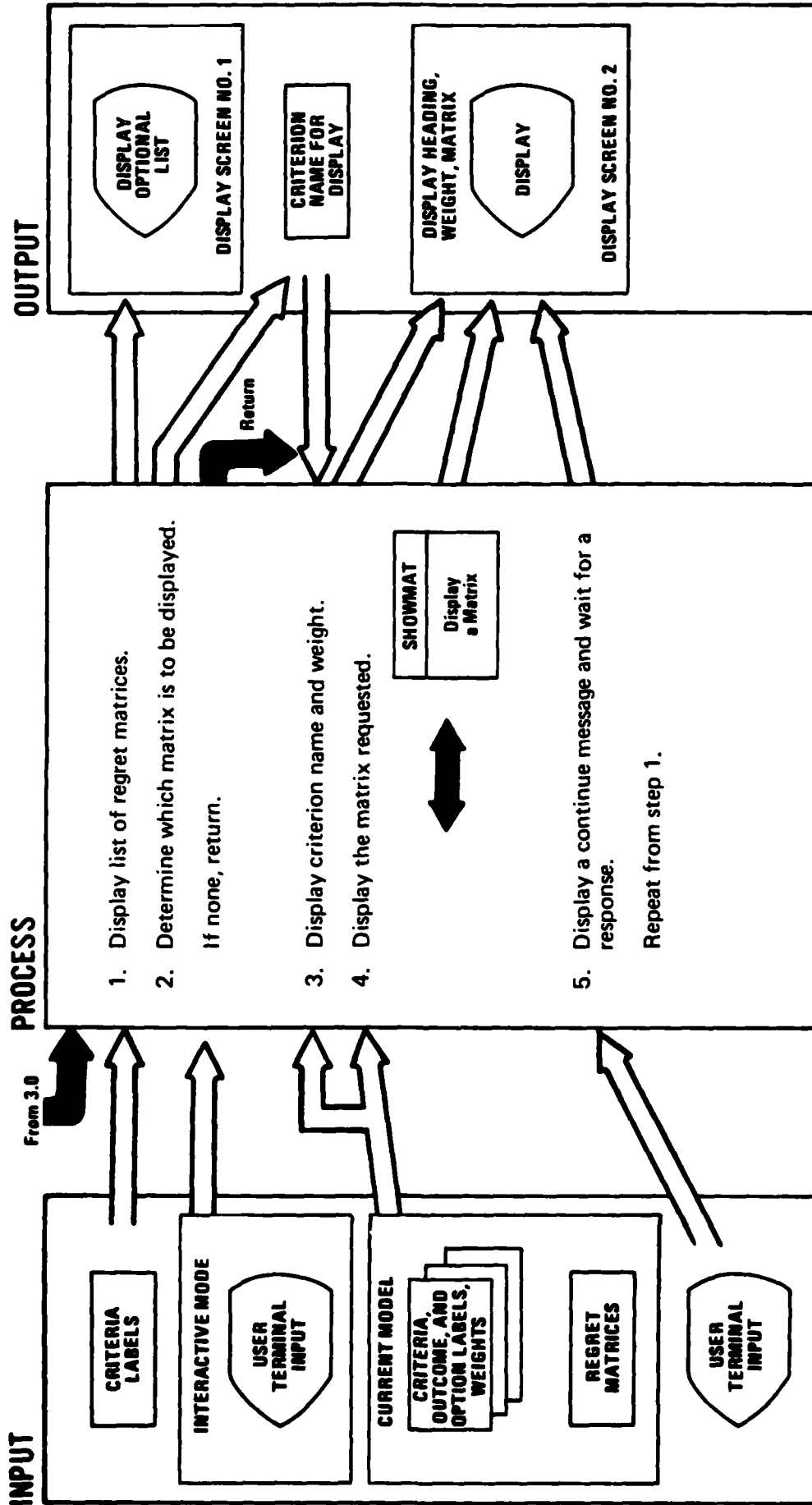
MODEL -- EVACUATION

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

Figure 3.2
EXAMPLE OF OUTPUT FROM DISPLAY FUNCTION 3.2

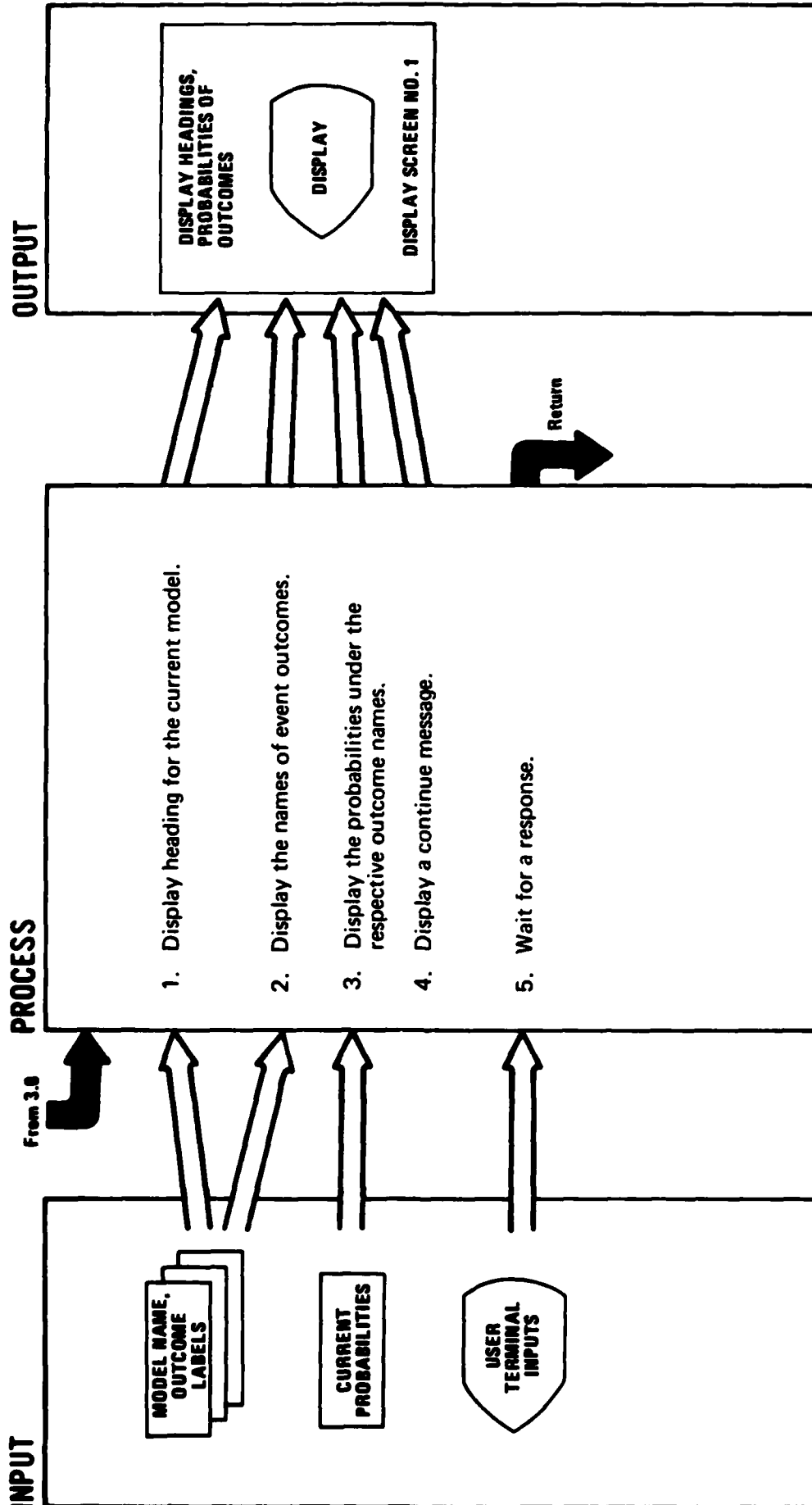


1. The display heading should include the Model name.

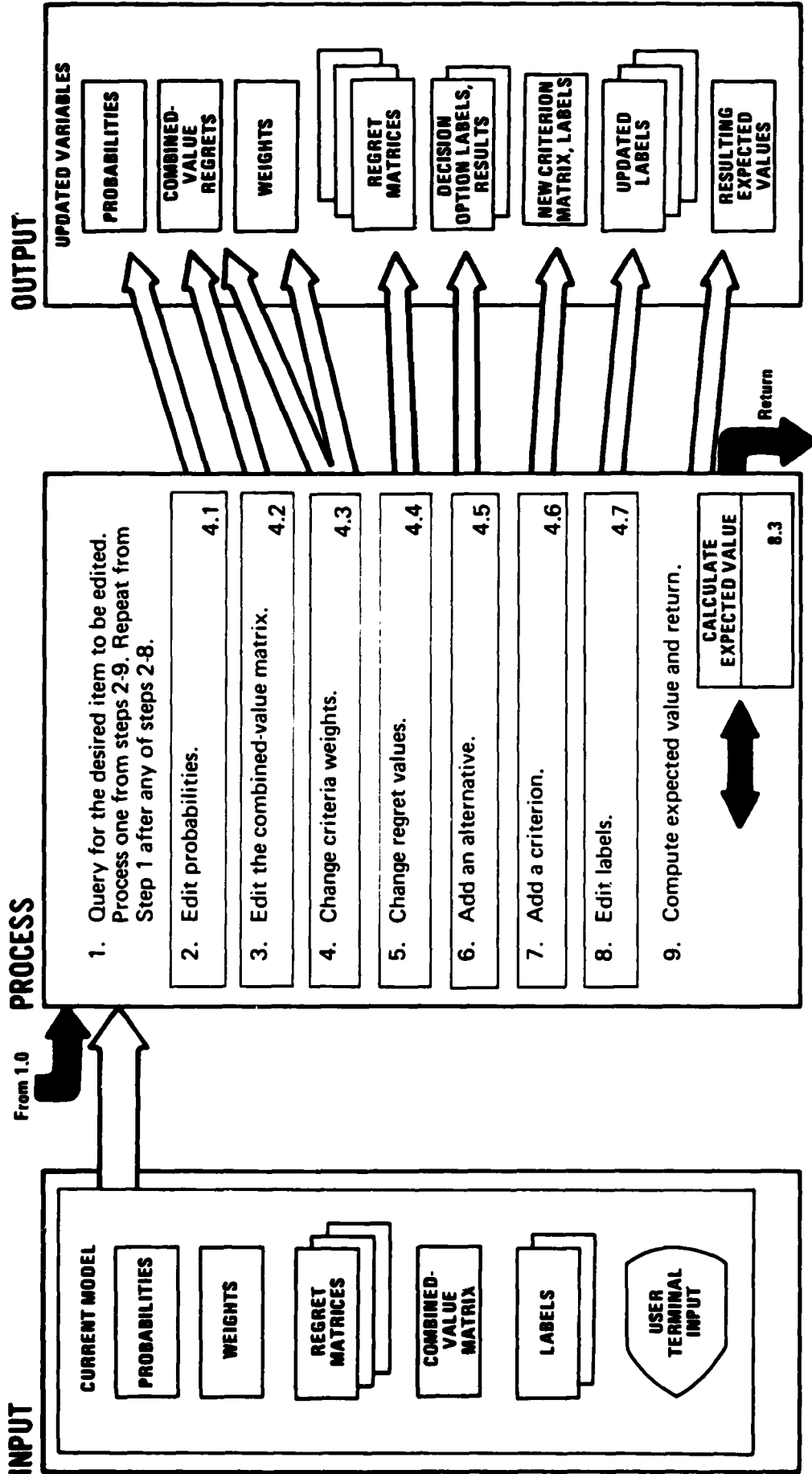


1. The list of Regret Matrix names is shown in MENU format.
 2. The user inputs his selection for display. A blank input causes a return to the calling routine.
 - 3.4. The requested matrix is displayed along with the appropriate alternative, outcome, and criterion labels. (SHOWMAT, Chart 8.1)
 5. A message is written underneath the matrix display which tells the user that a keyboard response will cause the current screen display to vanish. (WAIT, Chart 8.2)
- The processing can be repeated for other matrices by the return to step 1.

System/Program:	OPINT	Name:	
Diagram ID:	3.5	Description:	Display Probabilities
		Page:	of



The display should show the model name as a heading, the unique outcome labels horizontally, and the respective outcome probability values below the outcome labels.

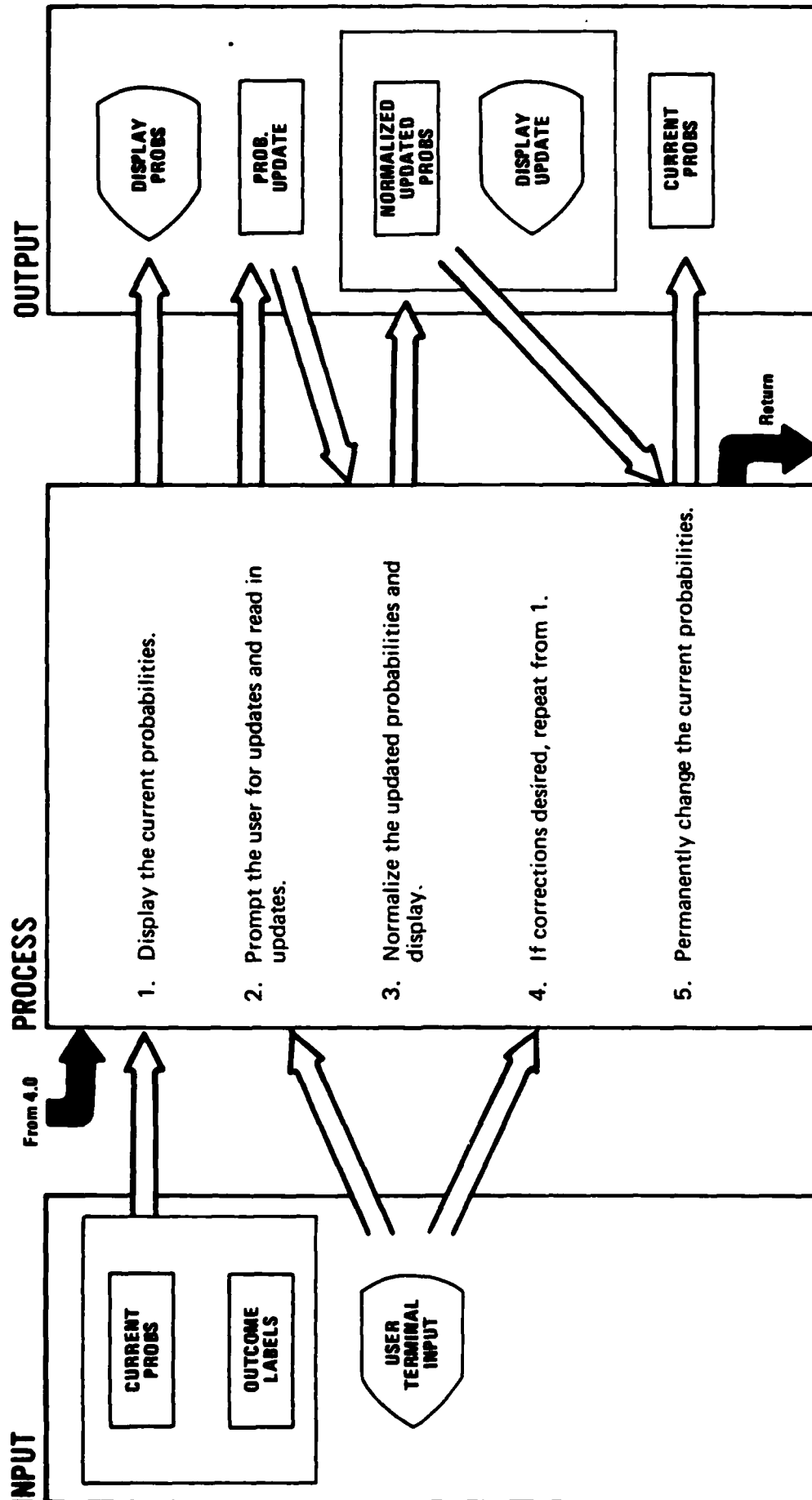


1. The list of model definition items available for editing or revision is displayed in Menu format. The user is then prompted for a selection which causes one of steps 2 through 9 to be executed.

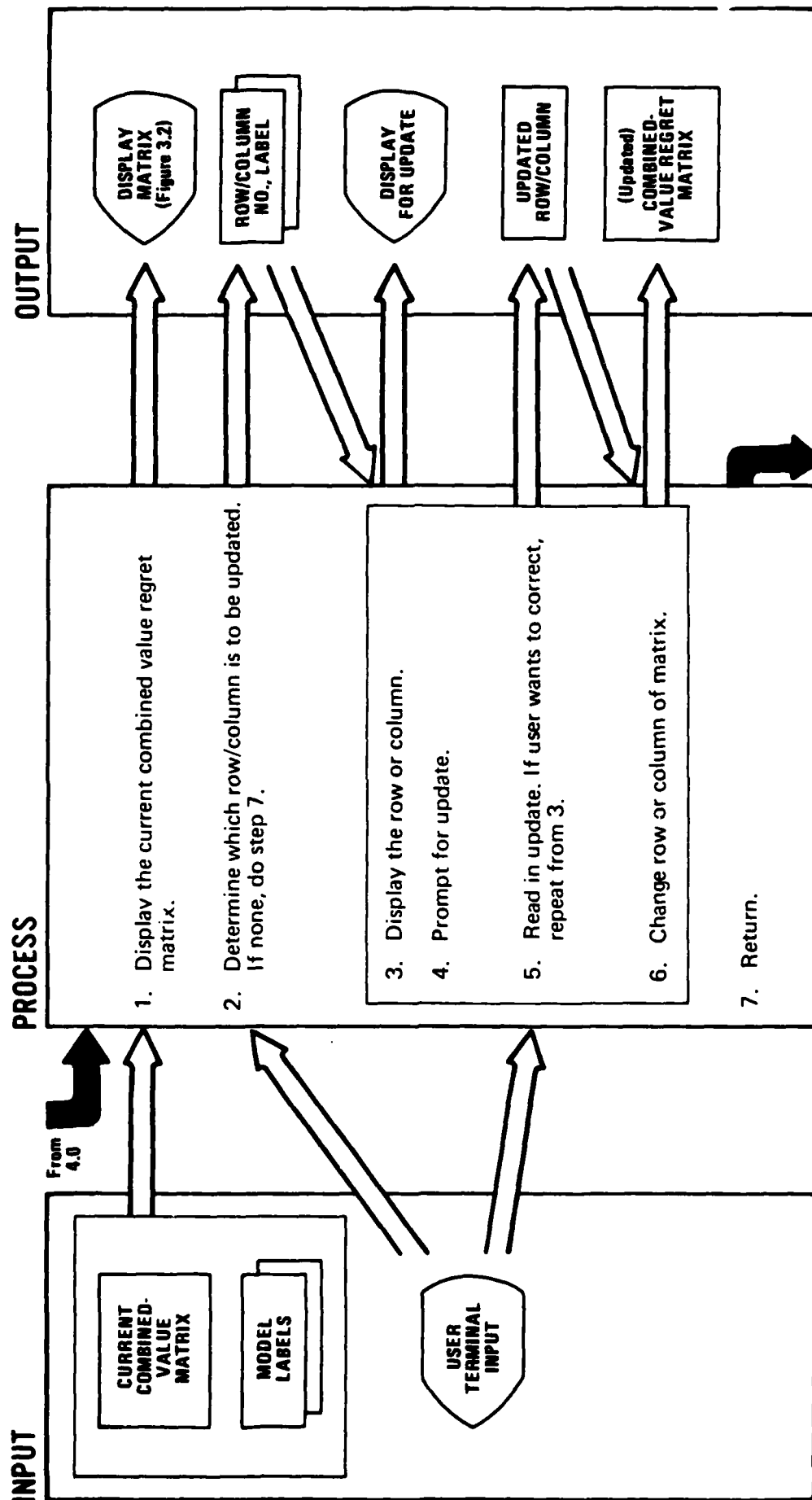
2-8. These subprocesses are explained in the next seven charts as indicated in the diagram (4.1 - 4.7).

9. Always, the expected values are recomputed as the final result after editing. The output from the edit processes effect a permanent change in the model variables which are updated as long as the program OPINT is in operation. To secure these changes, the user must store the new values via the SAVE A MODEL processing option (See chart 5.0).

System/Program: OPINT Name: _____
 Diagram ID: 4.1 Description: Edit the Probabilities Page: _____ of _____



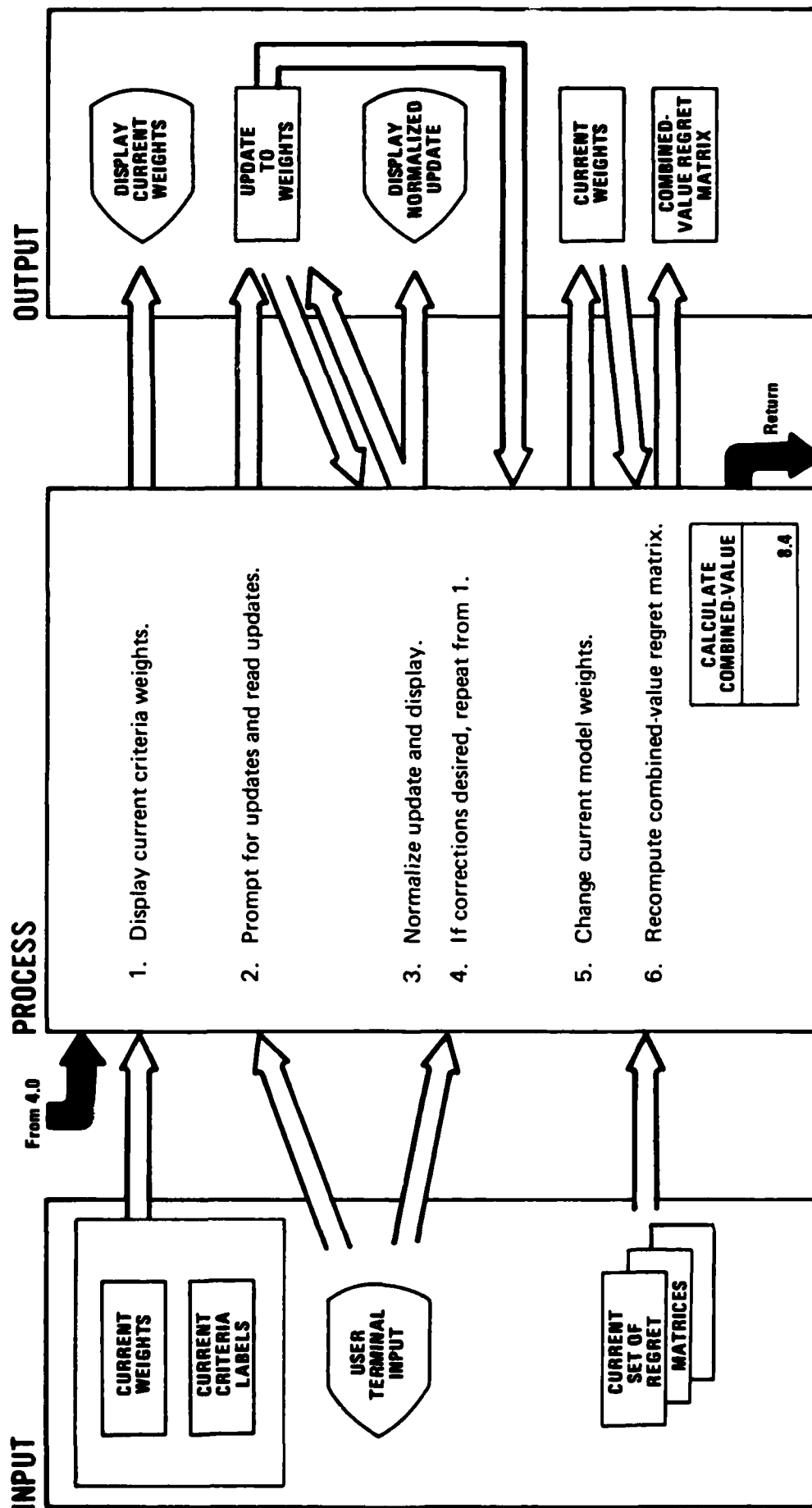
1. Display the current outcome probability values with/below the respective unique outcome labels.
2. The updates which are input by the user are normalized (divided by the sum of the updates and then multiplied by 100) to sum to 100. The resulting numbers are displayed below the input values.
3. The user is queried for corrections. At this point, the current probabilities have not been disturbed.
4. After all corrections are made to the updated values, the current set of outcome probabilities is permanently updated.



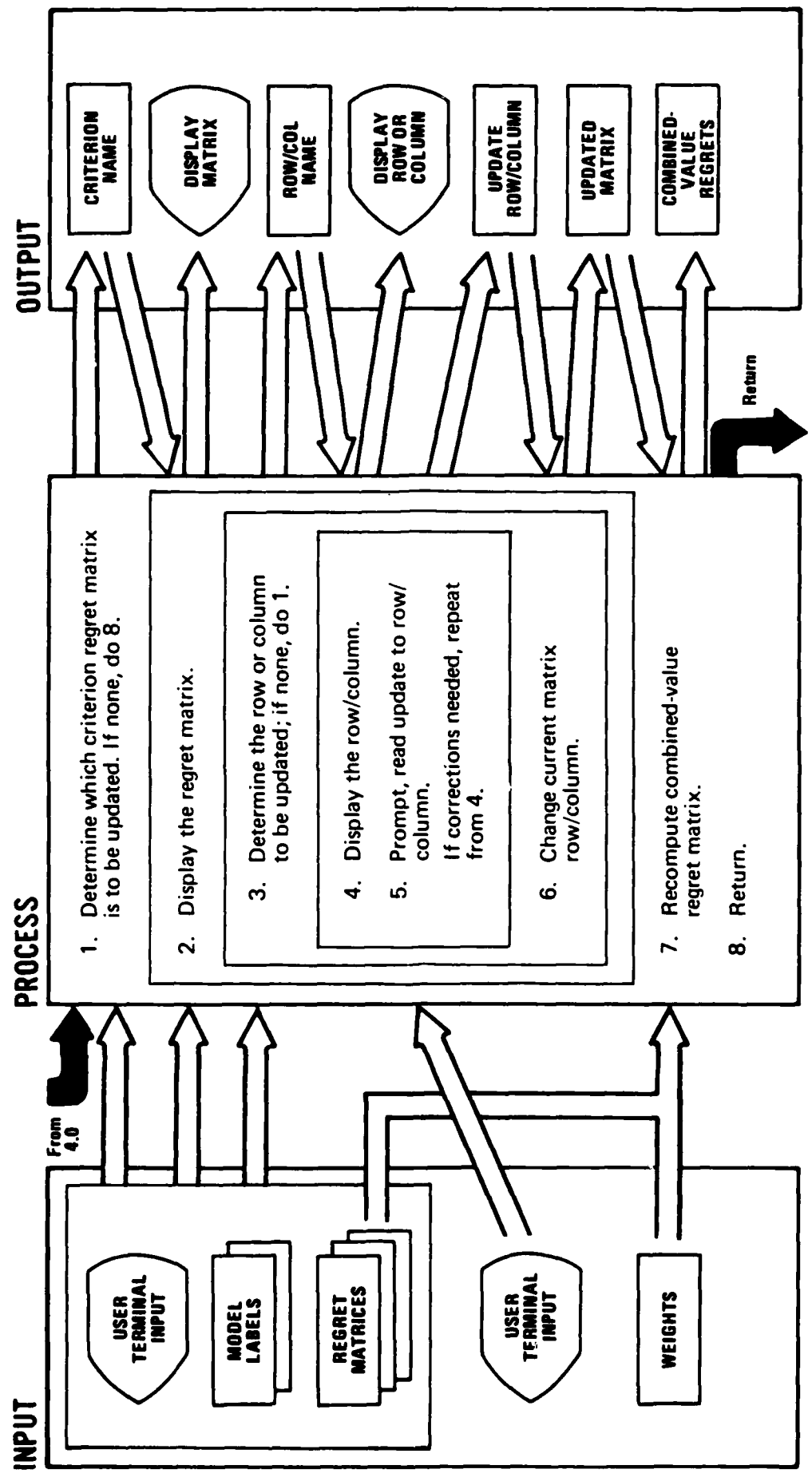
1. Display the combined-value regret matrix with outcome and alternative labels (see chart 3.2 and figure 3.2).
2. This step begins an iterative process. The user is prompted for the name of the row (alternative) or column (outcome) to be updated. If no name is specified, then the process ends. Otherwise, steps 3-6 are executed.
6. The input update values are used to permanently change (until later updates to regrets or criteria weights) the combined-value regrets.

System/Program: OPINT Name: Change Criteria Weights Page: of

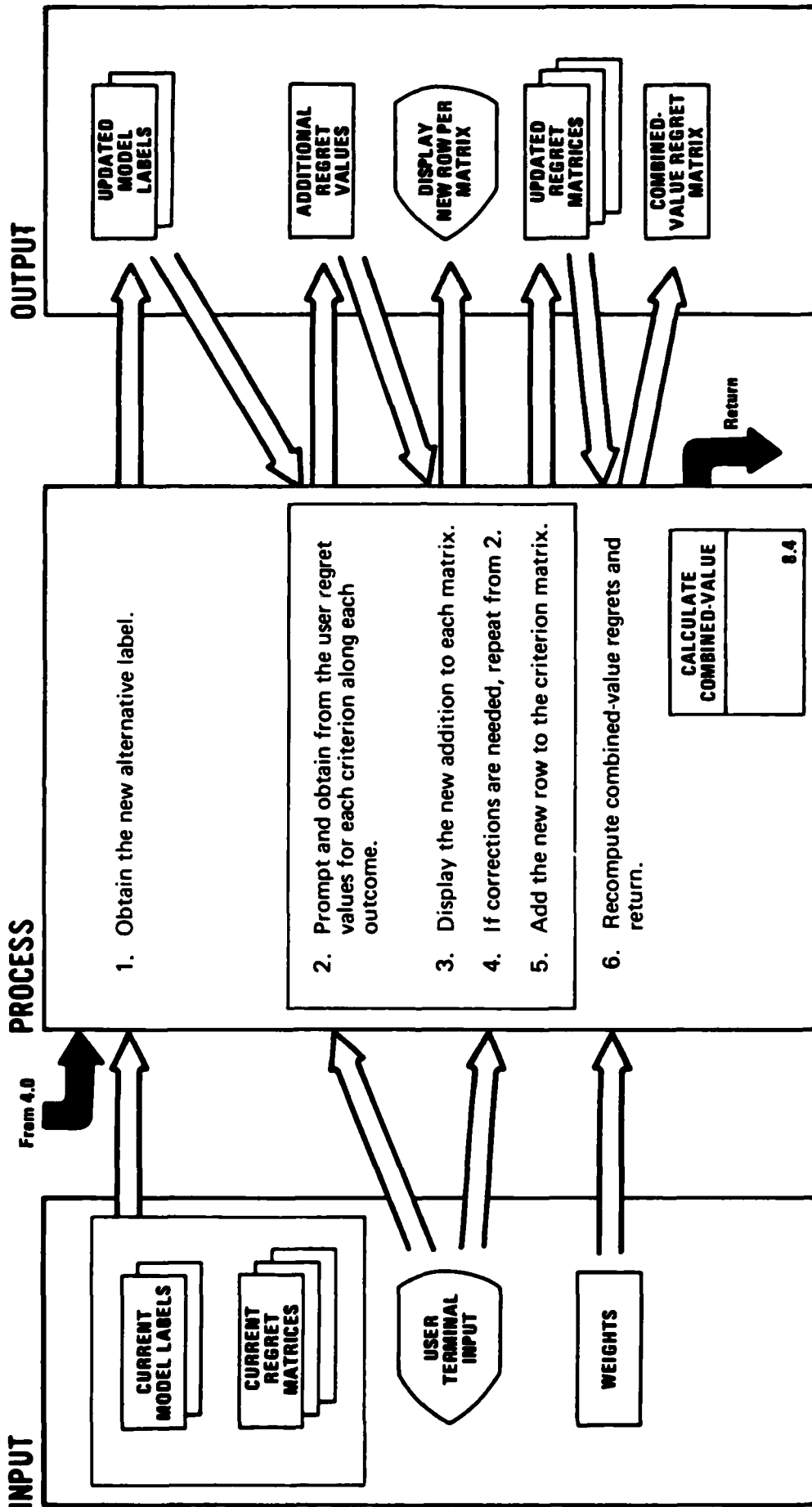
Diagram ID: 4.3 Description: Change Criteria Weights



5. At this step, final corrections to the updates are used to permanently change the set of criteria weights.



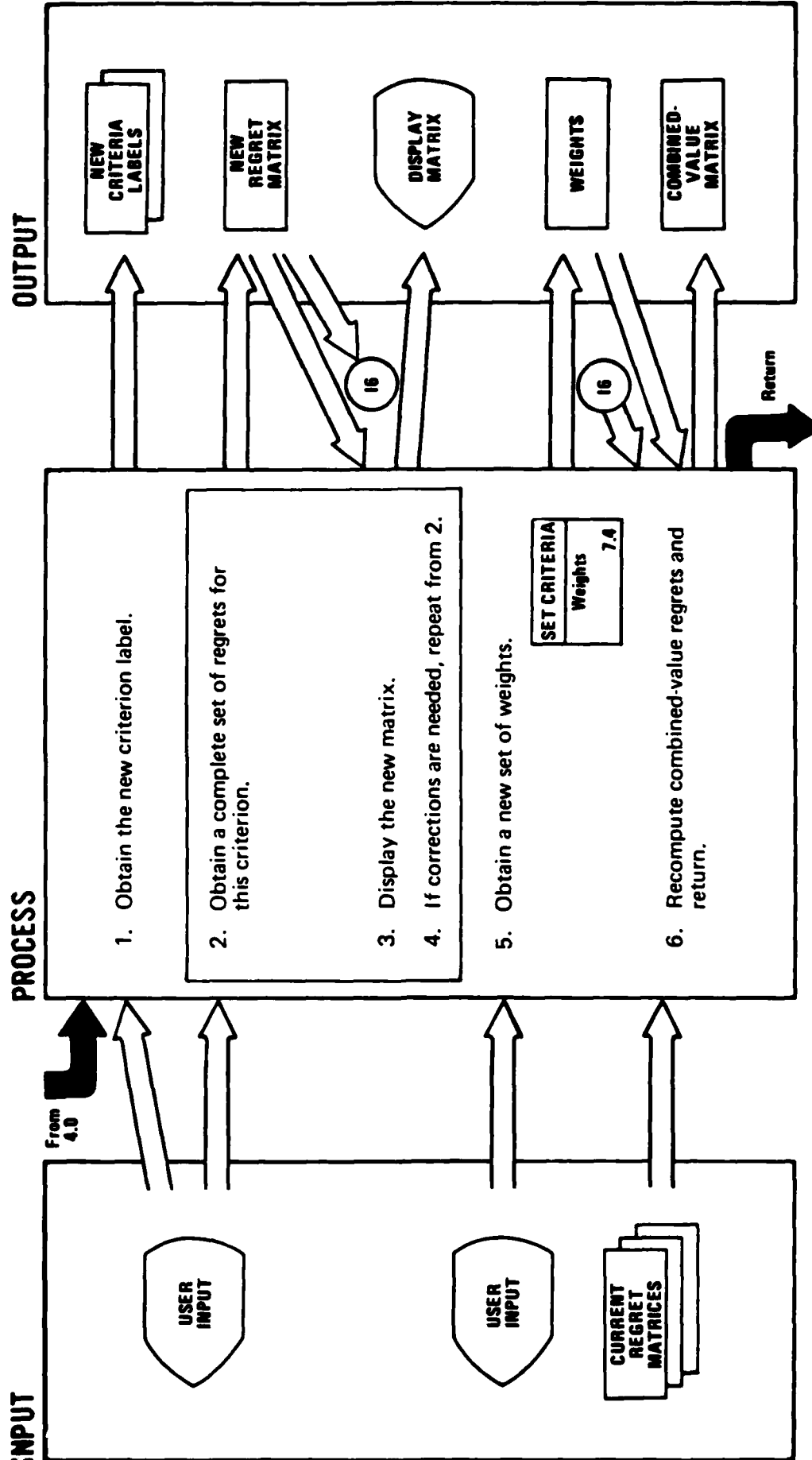
1. Prompt the user for the name of criterion matrix to be updated. If no name is specified, then return to the calling routine. Otherwise continue processing.
2. Display regret values along with the appropriate alternative and outcome labels.
3. In repetitive manner, prompt the user for the row or column name (or number) to be modified. If no row or column is given, then exit from the inner loop and repeat step 1. Otherwise, execute steps 3-6.
6. Do not permanently change the selected regret matrix row/column until this step in the procedure.
7. Subroutine invoked for this step is documented in chart 8.4.



1. Prompt the user for the new alternative label and update the list of alternative labels with the new label.
2. For each criterion, prompt the user for numerical regret value input. This is done by displaying the event outcome labels horizontally to remind the user of the Matrix cell position and prompting values along the outcomes for the new alternative.

System Program: OPINT Name: _____ Page: _____ of _____

Diagram ID: 4.6 Description: Add a Criterion

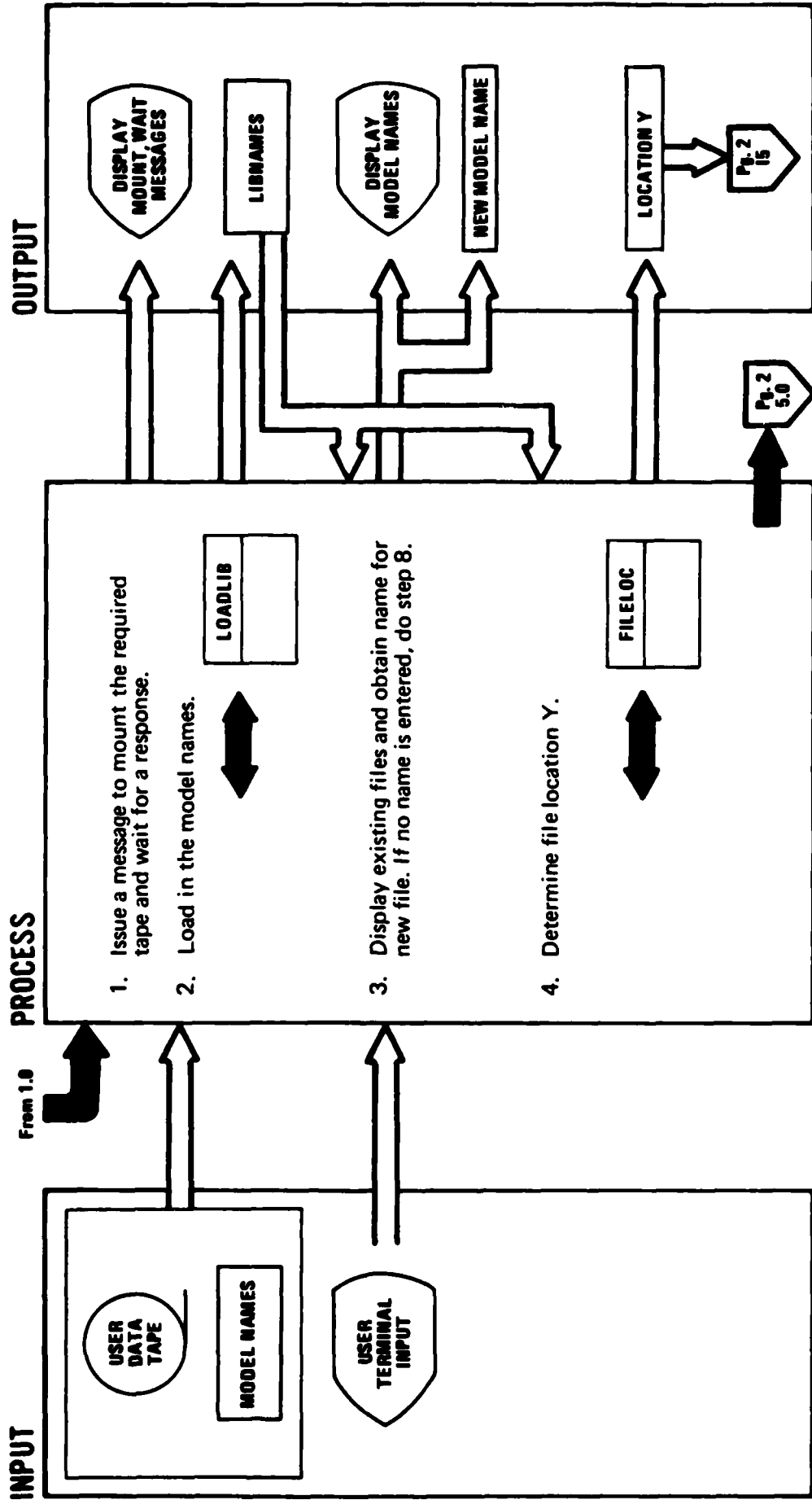


1. The user is prompted for a new criterion name to be input from the keyboard display. The criterion name is added to the list of criteria labels.

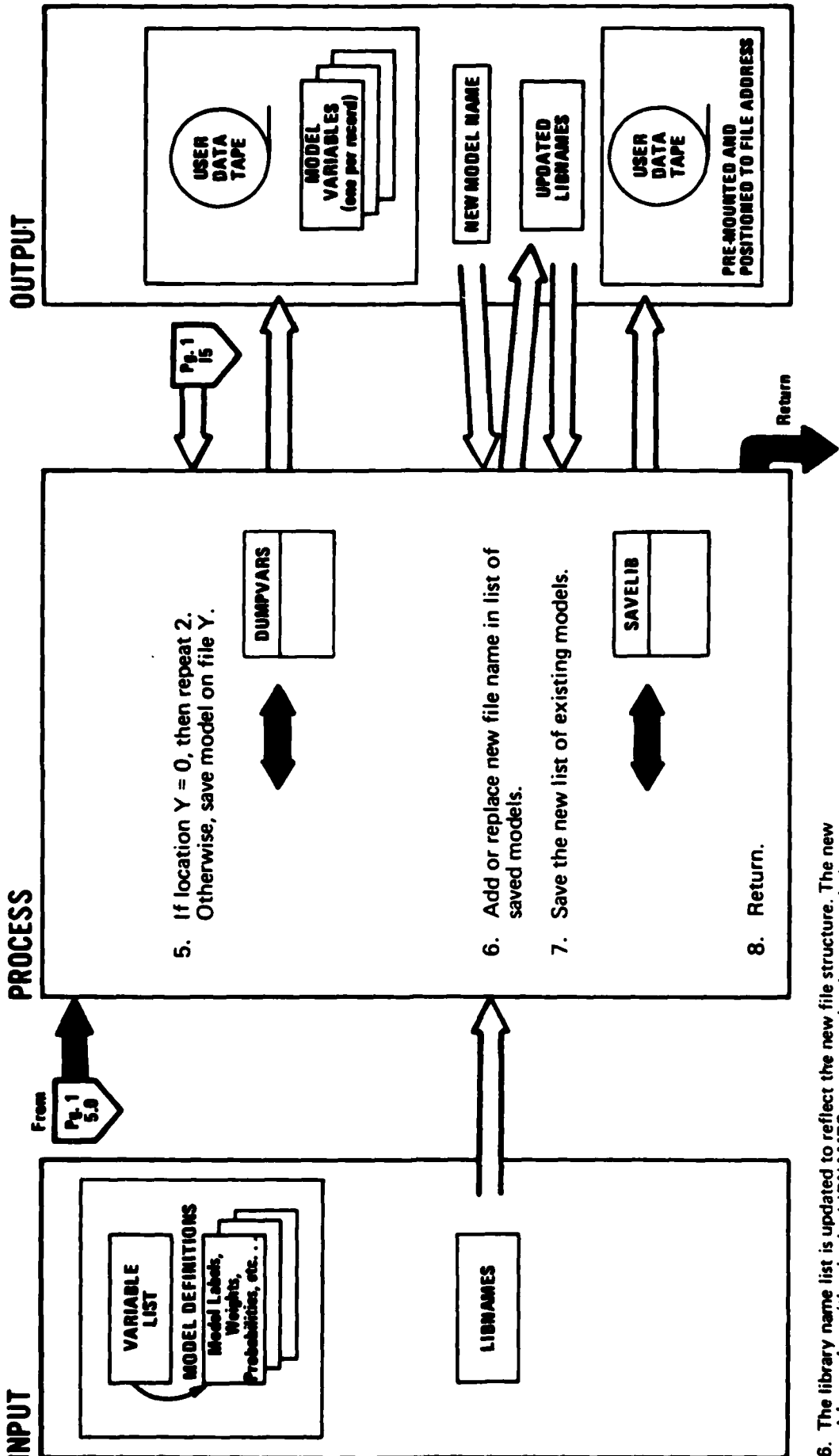
2. For each alternative, prompt the user for a regret value along each event outcome. The event outcome labels should appear on the display as a heading.

5. A new set of weights are input via the keyboard for all criteria in the model. (see chart 7.4)

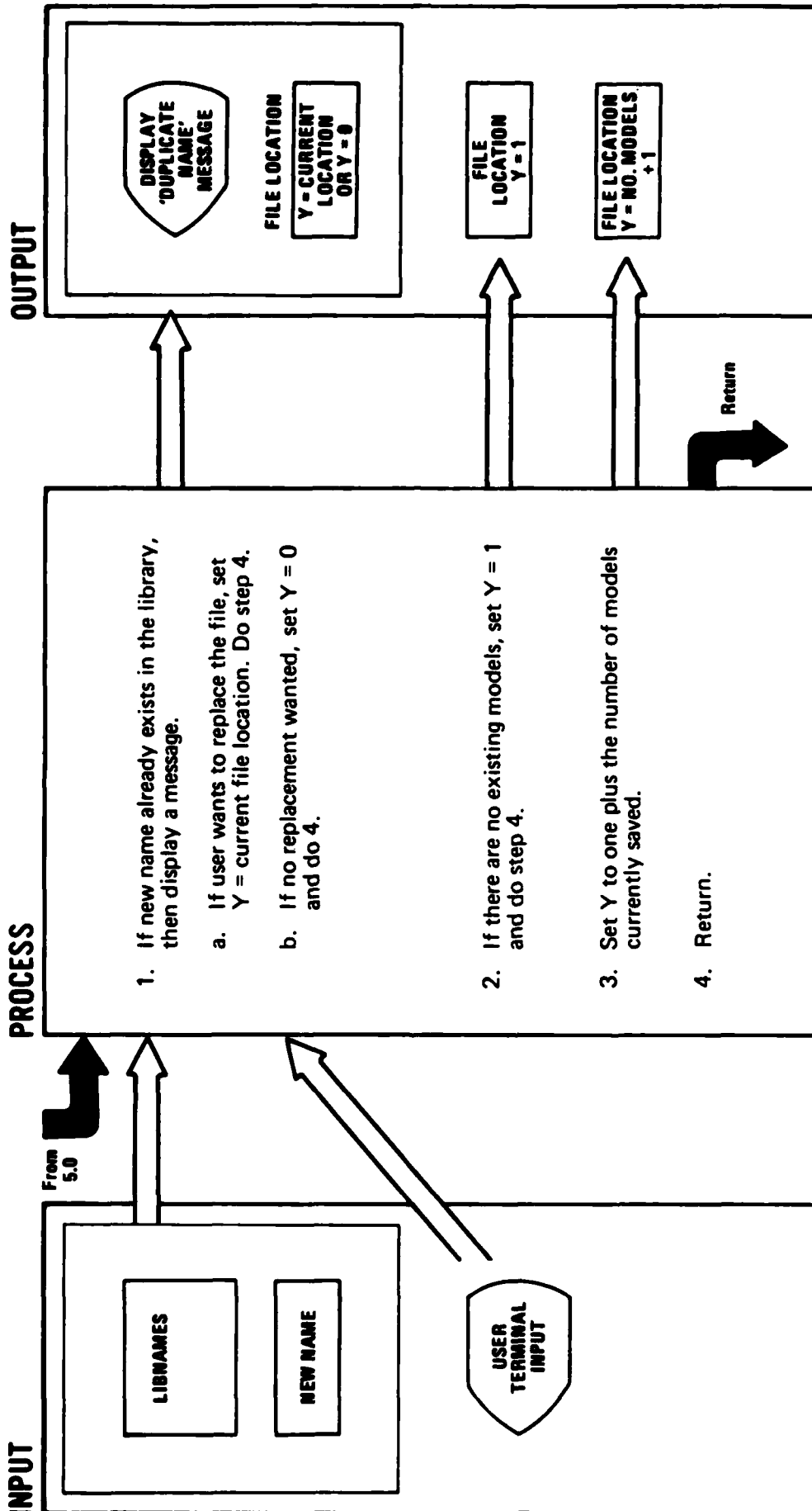
6. The subroutine invoked for this step is documented in chart 8.4.

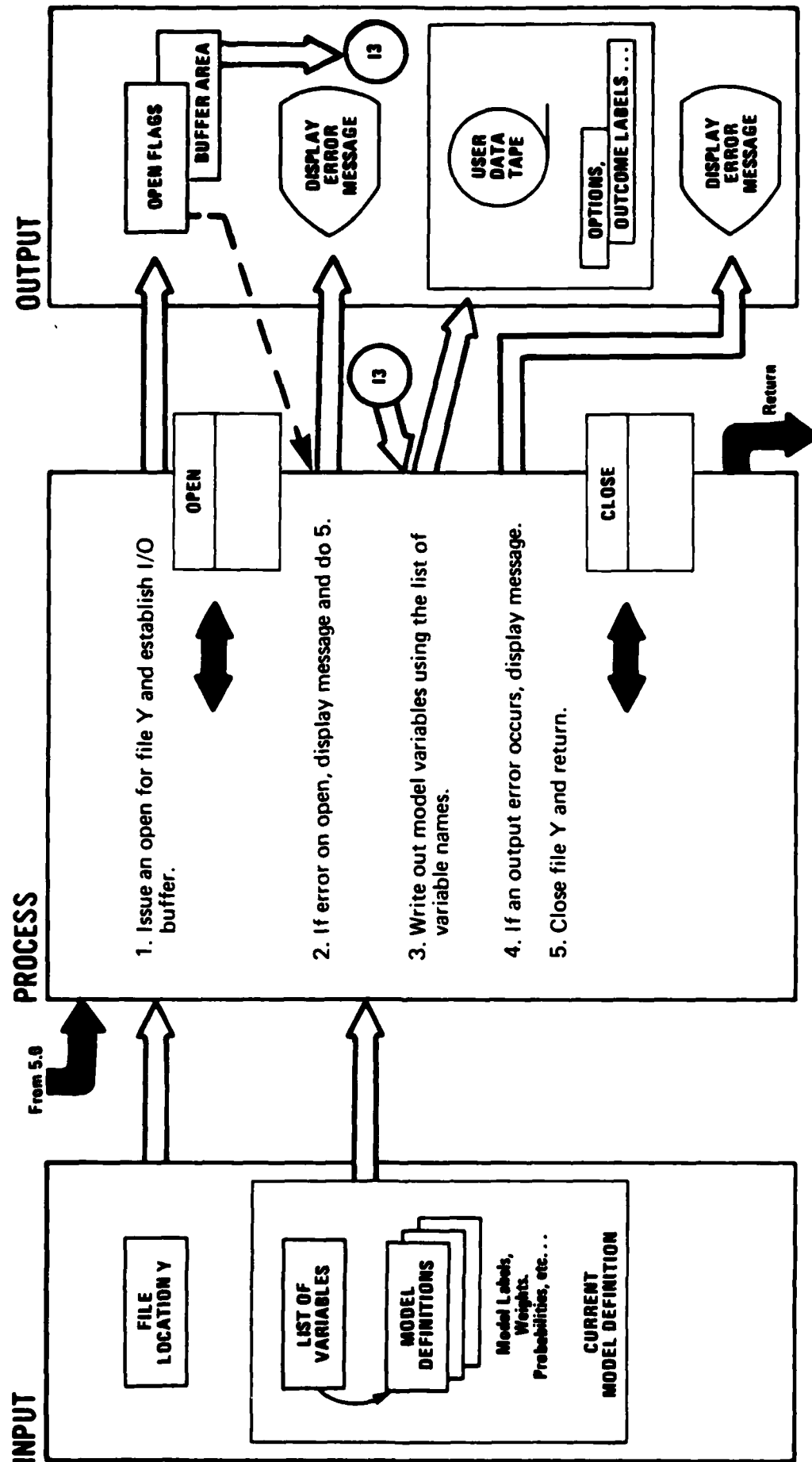


1. The computer program prompts for an indication that the desired storage file/device has been selected and placed online. Any response from the keyboard causes processing to resume.
4. The existing file structure and the amount of available space on the data tape are checked along with the user specification to determine where the model variables are to be stored.



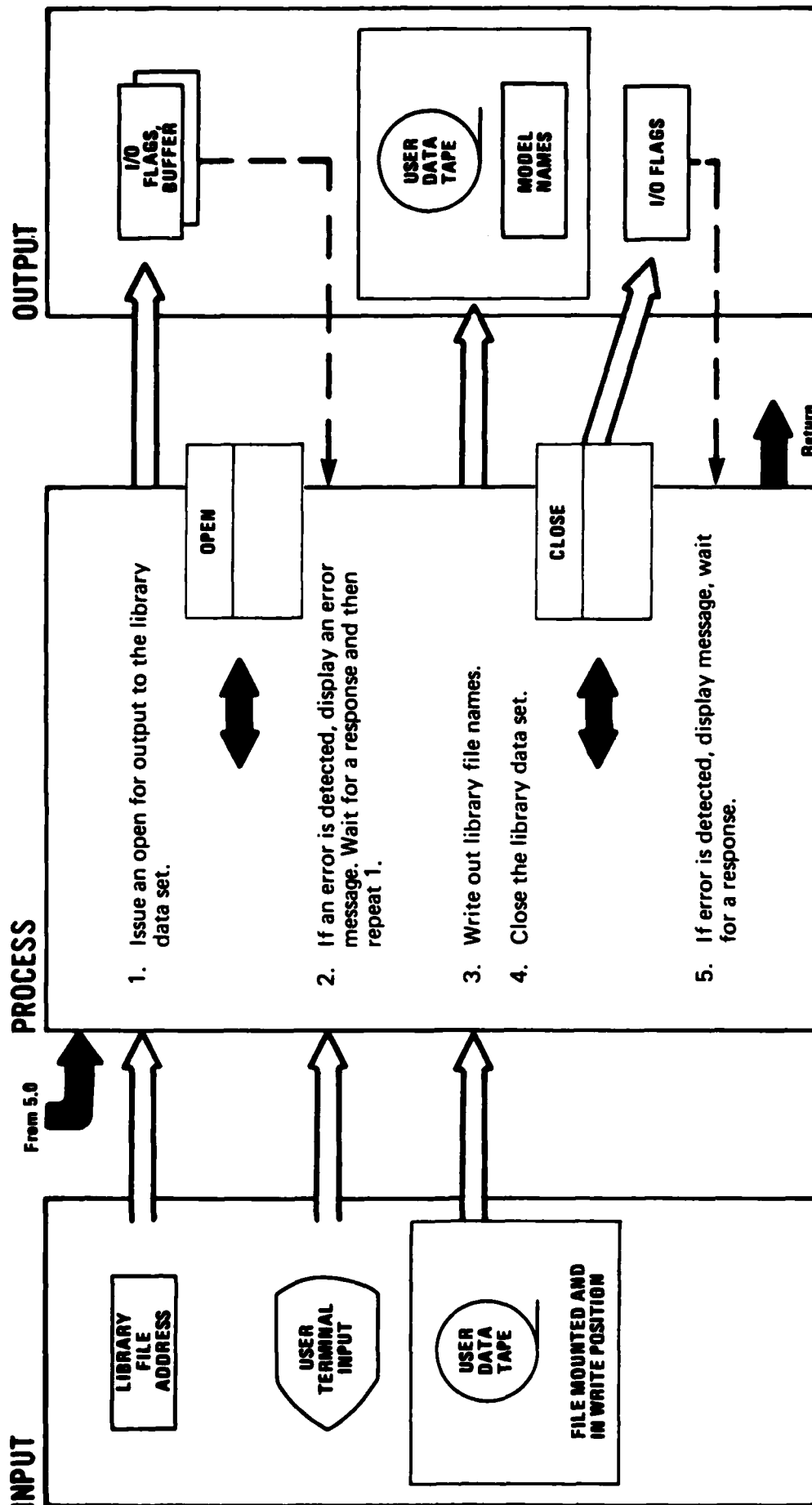
6. The library name list is updated to reflect the new file structure. The new model name's position in the LIBNAMES array must be the same relative position to other models stored on the device.

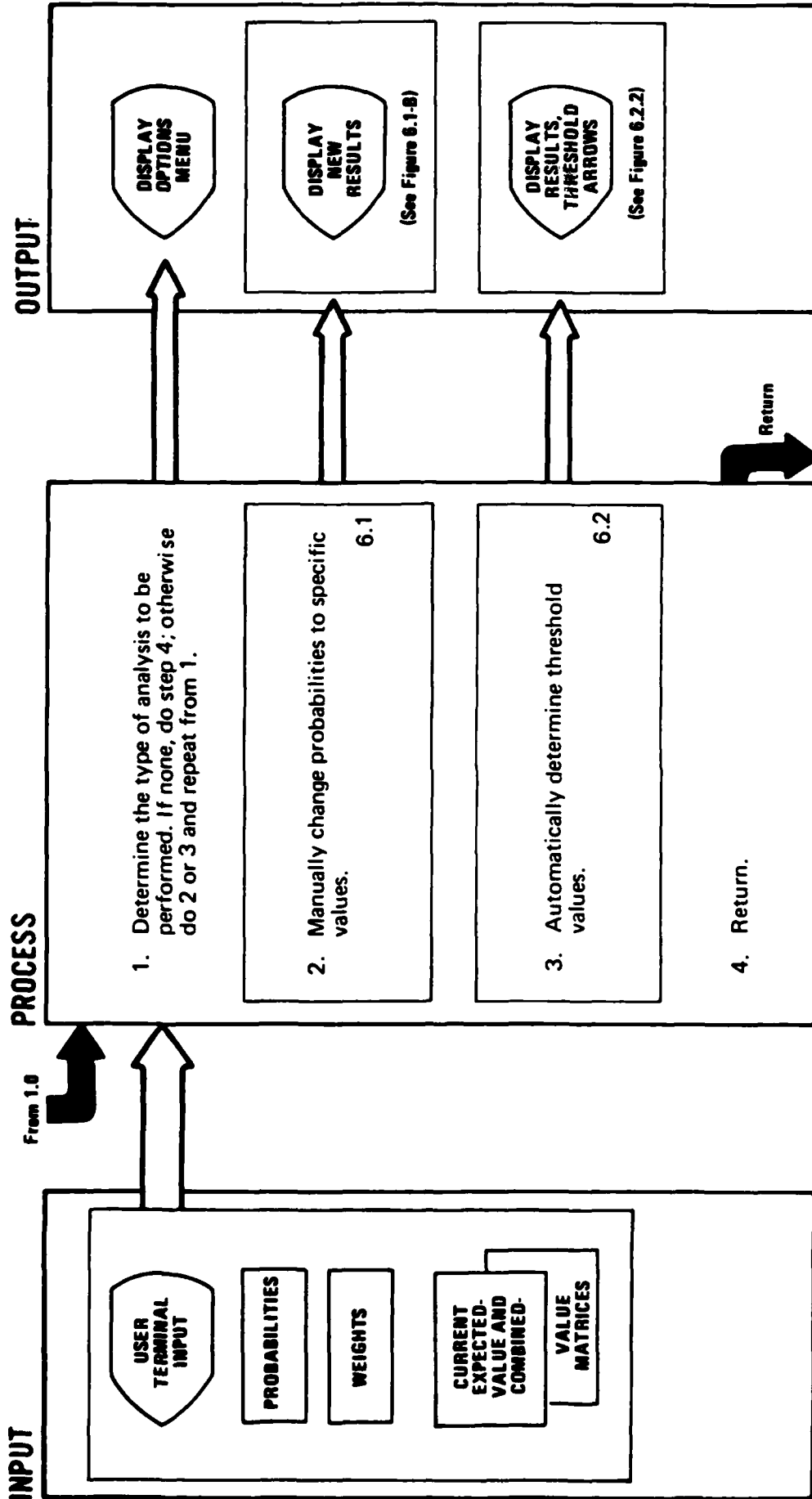




1. The file location Y is used to determine an exact storage position on the selected device.

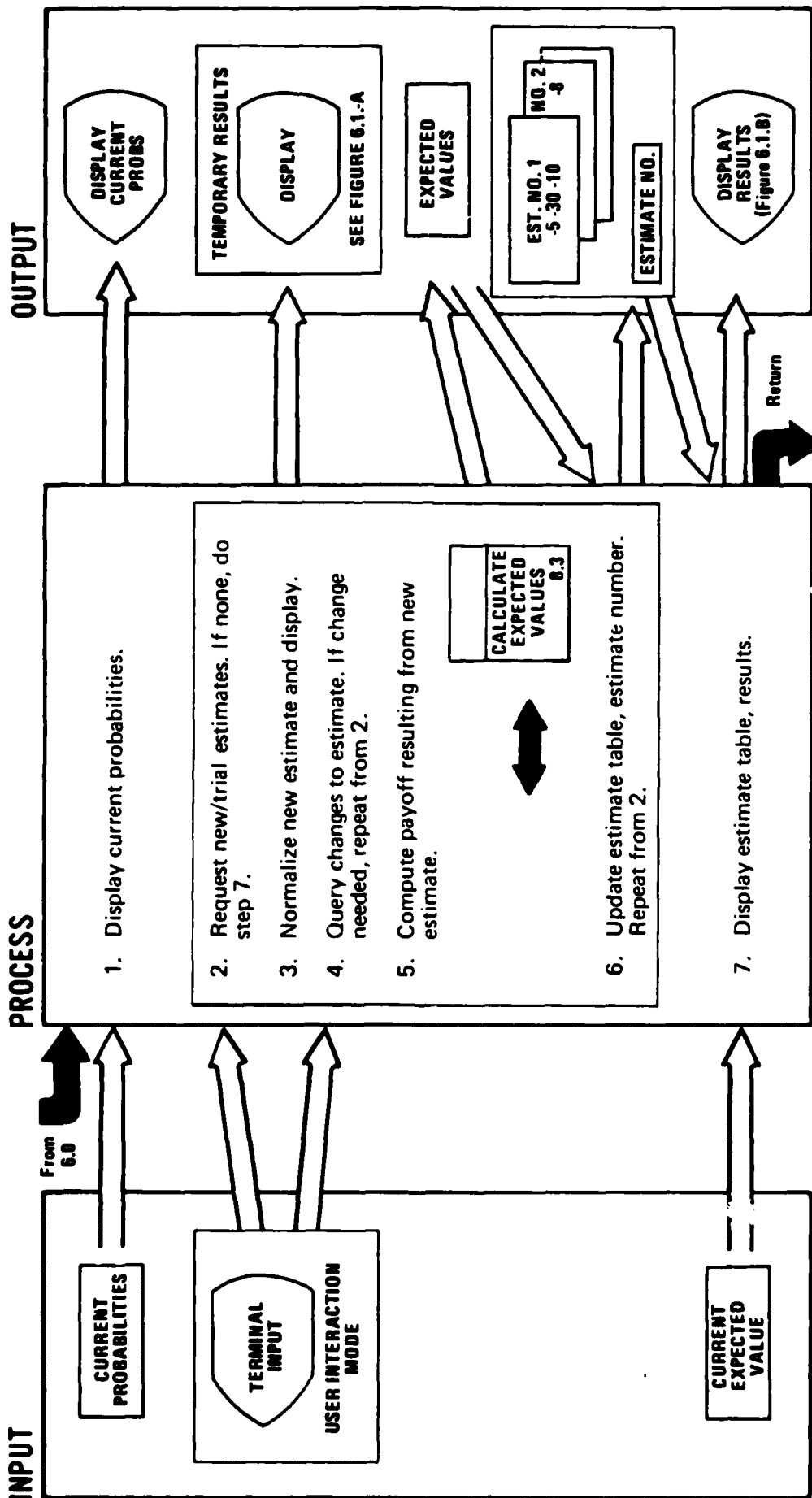
3. The list of variable names is identical to the list of names used to Load a Model. (see Chart 2.2)





1. Display the types of processing available via a Menu list and prompt the user for his choice of operation. If no analysis is desired, return to the calling routine. Otherwise, perform step 2 (chart 6.1) or step 3 (chart 6.2) and repeat the display and selection prompting.

All changes made in steps 2 and 3 are temporary and they are used only for display purposes.



- The current set of probabilities (PROBS) in the user's model are displayed so that new estimates may be selected which differ from the current.
- In interactive mode, the user is asked to specify new estimates for the probabilities of event outcomes in the current model. If no new estimates are given (a blank input line is entered by the user), then results computed from the current probabilities and previous estimates are displayed.
- A new set of probabilities is normalized to sum to 100. The result of this calculation is displayed below the user's original input.

- The user is allowed to make corrections before the results are computed.
- A general routine is called to compute the expected values for options with the new set of probabilities (see chart 8.3)
- The results of step 5 above are added to a table for estimated expected values. The number of estimates is incremented by one and the process (steps 2-6) is repeated.

MANUALLY CHANGE PROBS - EVACUATION

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

Figure 6.1-A

SENSITIVITY ANALYSIS: EXAMPLE OF USER-INTERACTIVE DISPLAY OUTPUT

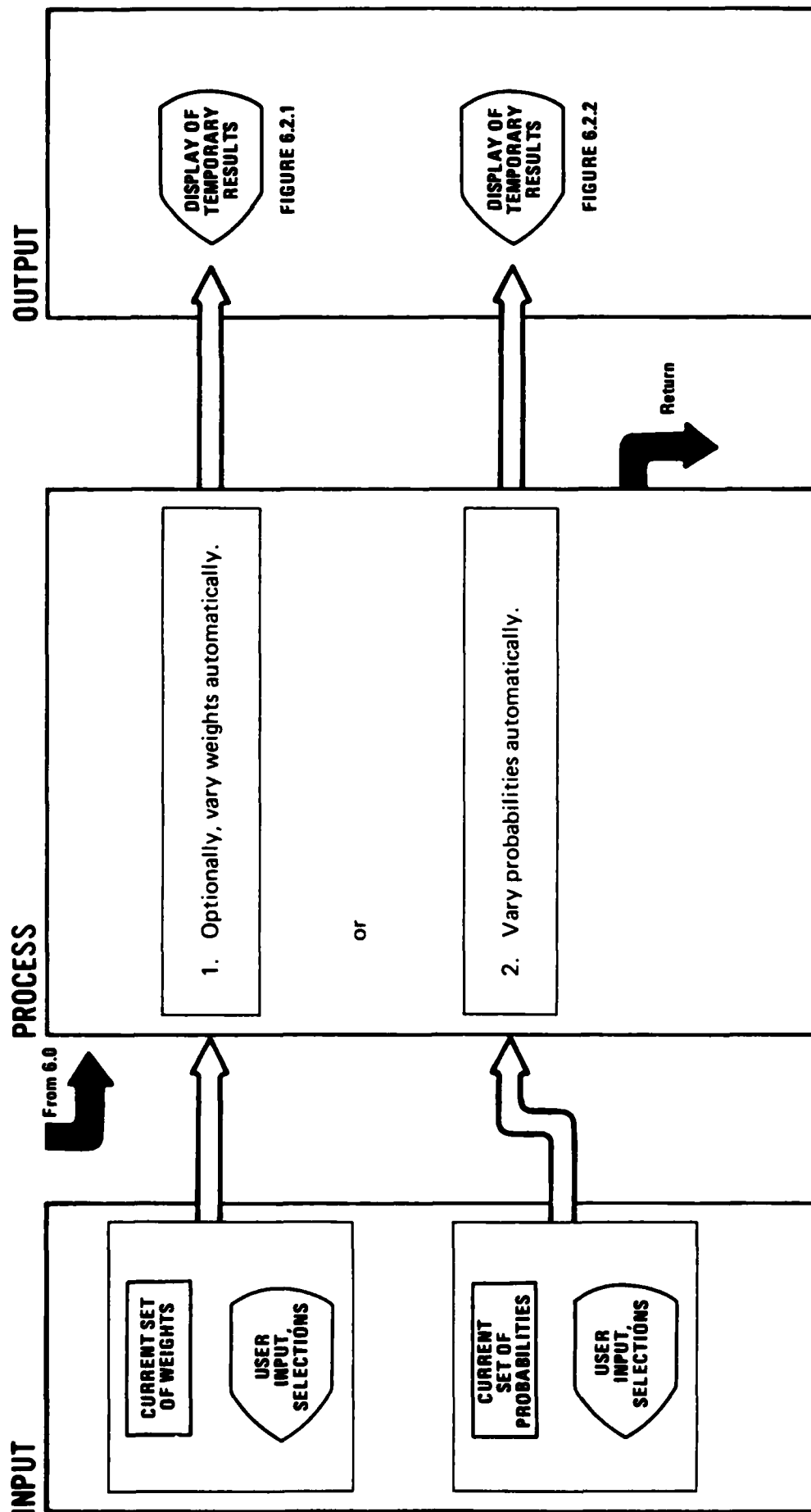
NOTE: Underlined values indicate user terminal input

MANUALLY CHANGE PROBS – EVACUATION

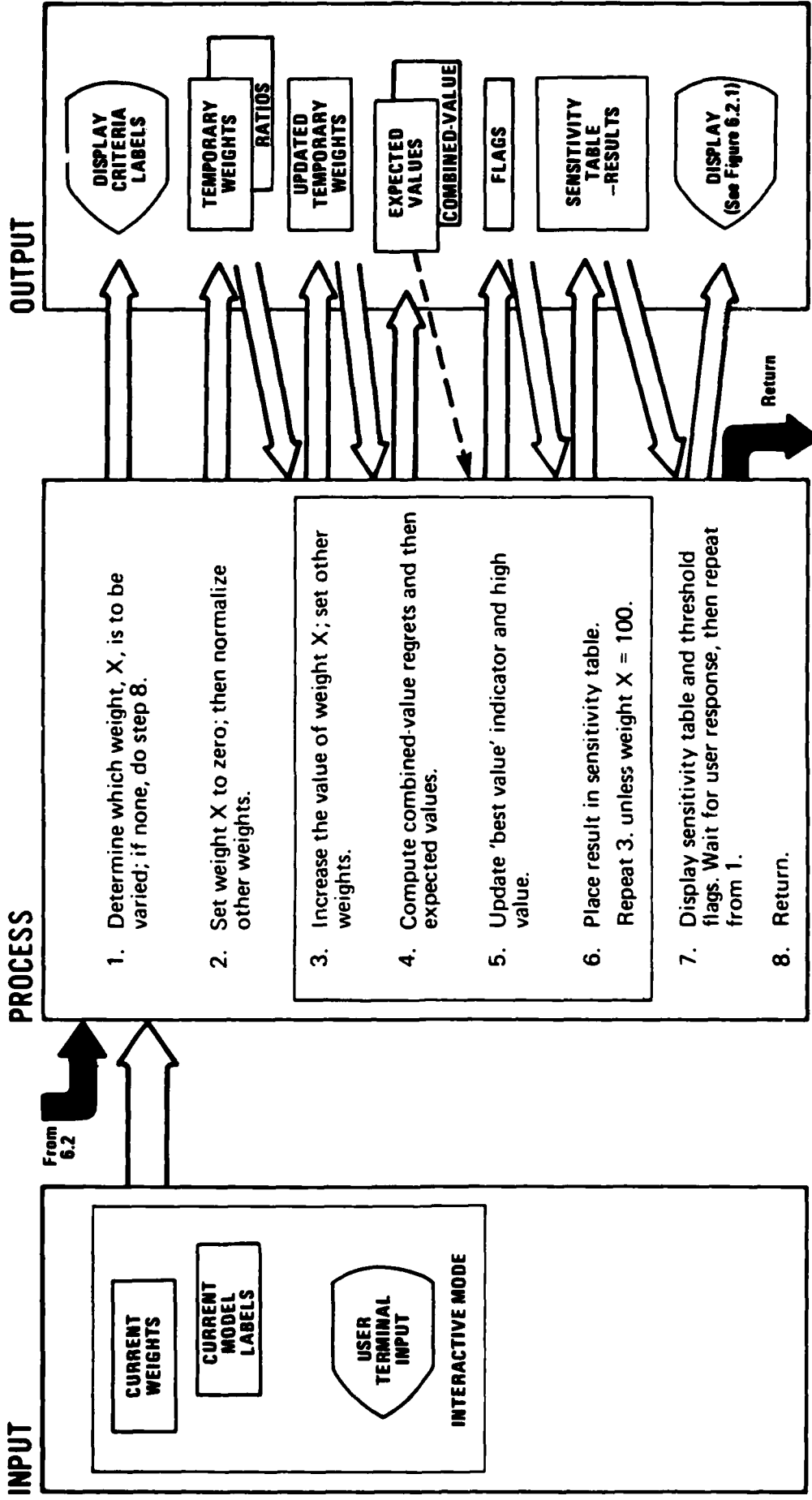
TRIAL	NORMAL	LOW PROF	MED PROF	EVAC PST
0	-27	-29	-26	-28
1	-39	-35	-26	-27
2	-36	-36	-26	-28
3	-27	-28	-26	-28

Figure 6.1-B

SENSITIVITY ANALYSIS: EXAMPLE OF OUTPUT FROM FUNCTION 6.1



The results of these operations are derived for display purposes only and are temporary values. The weights (WEIGHTS) and probabilities (PROBS) of the current model are never modified permanently by these operations.



The above procedure is an iterative one.

1. The user specifies which criterion weight he wants varied automatically. If no criterion name is entered, control is returned to the caller.
2. The weight for the specified criterion is set to zero and will remain zero when the weights are normalized to sum to 100. This process preserves the current ratio of values (RATIOS) for the non-specified weights. (NORMALIZE, Chart 8.7)
3. The step increment for automatic variation is usually set at 10. The ratio values for the other weights is multiplied by the difference between 100 and WEIGHT X value.
4. Subroutines are called to calculate new combined regrets and expected values. (See Charts 8.4 and 8.3)
5. An indicator value is then set for each step increment which specifies the option with the lowest (best) expected value. A threshold flag is set whenever the actual value is better than previous ones.
6. The results are temporarily held in a table until displayed in 7.
7. Threshold arrows are displayed below the new best-value level increments.

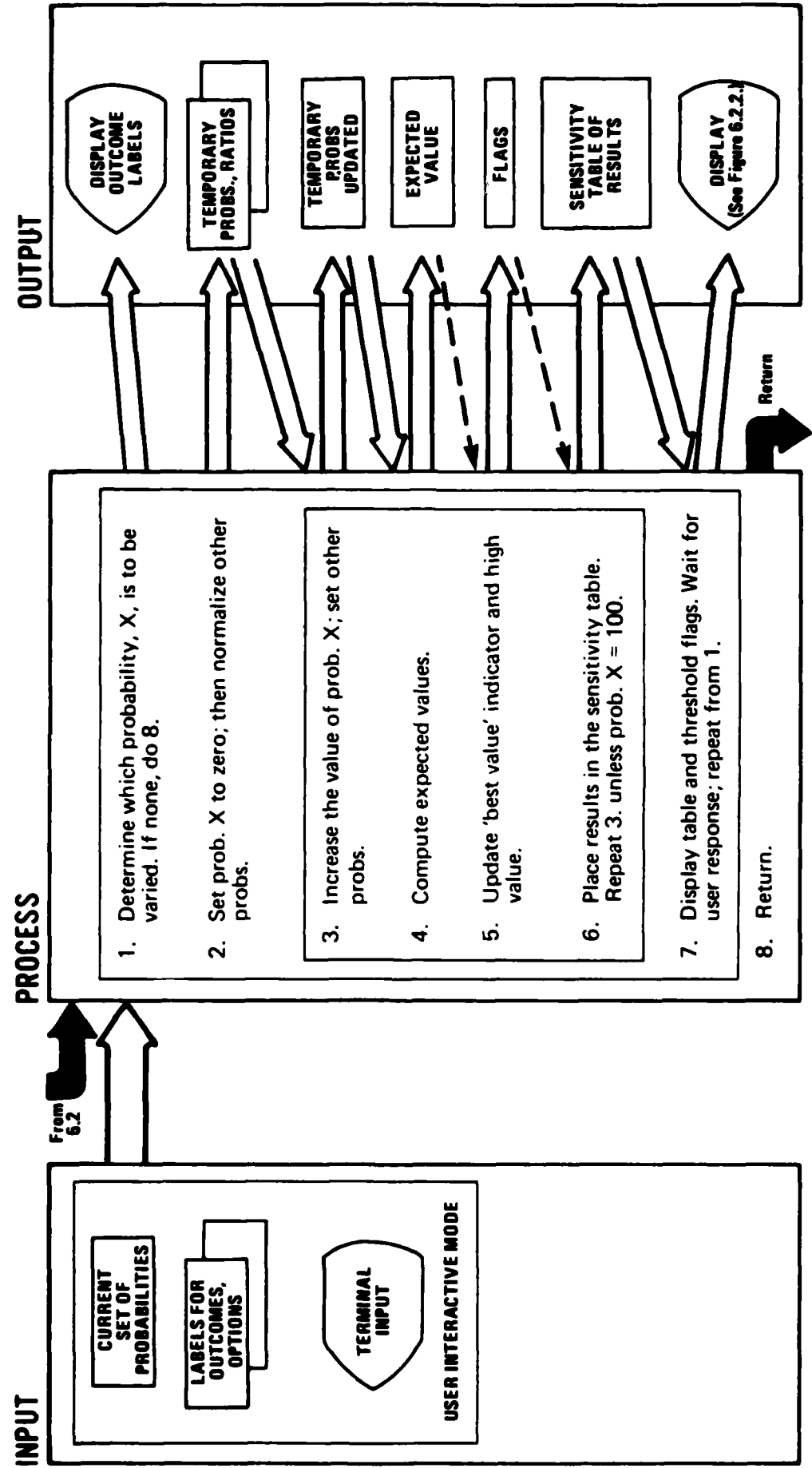
SENSITIVITY ANALYSIS

EXPECTED VALUE WHEN WEIGHT OF EXPOSURE RISK IS:

	0	10	20	30	40	50	60	70	80	90	100
NORMAL	-22°	-23°	-25°	-26°	-27	-29	-30	-31	-33	-34	-35
LOWPROF	-32	-31	-31	-30	-29	-29	-28	-27	-27	-26	-25
MEDPROF	-44	-39	-35	-31	-27°	-23°	-19°	-15°	-11	-7	-3
EVACPST	-49	-44	-40	-35	-30	-25	-20	-15	-10°	-5°	-1°
					↑				↑		

Figure 6.2.1

SENSITIVITY ANALYSIS: EXAMPLE OF OUTPUT FROM FUNCTION 6.2.1



This procedure is an iterative one.

1. The user specifies which event outcome probability is to be varied. If no event name is specified, then processing control is returned to the calling routine.
2. The probability for the specified outcome is set to zero and the set of (PROBS) current probabilities is normalized. The values for the non-specified outcome probabilities are maintained ratios. (RATIOS)
3. A step increment value of 10 is used to automatically modify the value of Prob. X for sensitivity testing. Other probabilities are maintained in constant ratio such that all probabilities sum to 100.
4. Expected values for temporary probabilities are computed via subroutine. (See Chart 8.3)
5. The option considered to have the best expected value is indicated via a flag setting for each step increment. Another flag/indicator is set when a value is higher than the previous PAYOFF "best" value indicators. An arrow is shown later in the display to show this threshold value.

SENSITIVITY ANALYSIS

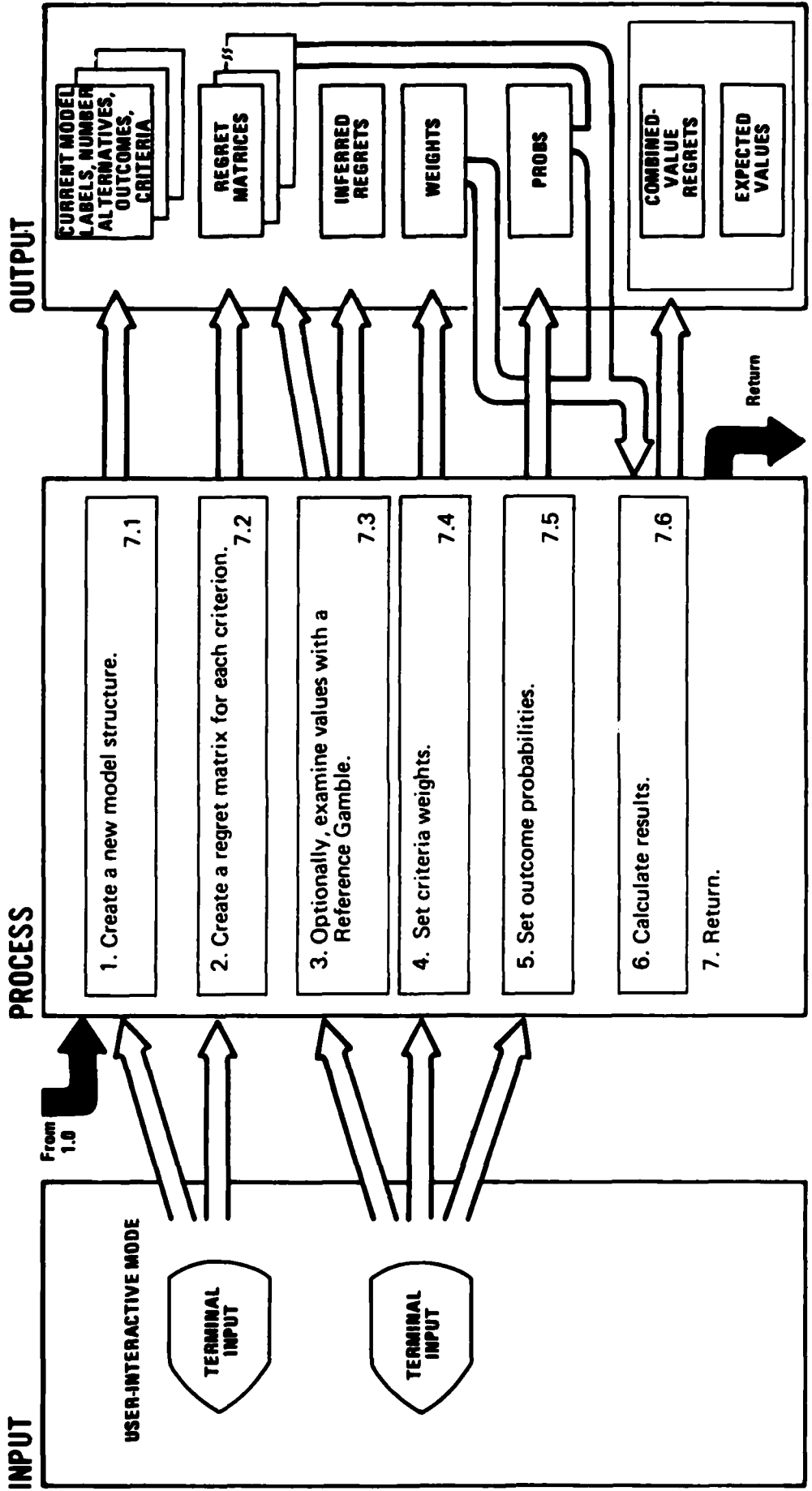
EXPECTED VALUE WHEN PROBABILITY OF NONE IS:

	0	10	20	30	40	50	60	70	80	90	100
NORMAL	-57	-51	-45	-40	-34	-28	-23*	-17*	-11*	-6*	0*
LOWPROF	-50	-46	-42	-38	-34	-29	-25	-21	-17	-13	-9
MEDPROF	-27	-27	-27	-26*	-26*	-25*	-25	-25	-24	-24	-24
EVACPST	-26*	-26*	-26*	-27	-27	-28	-28	-28	-29	-29	-29



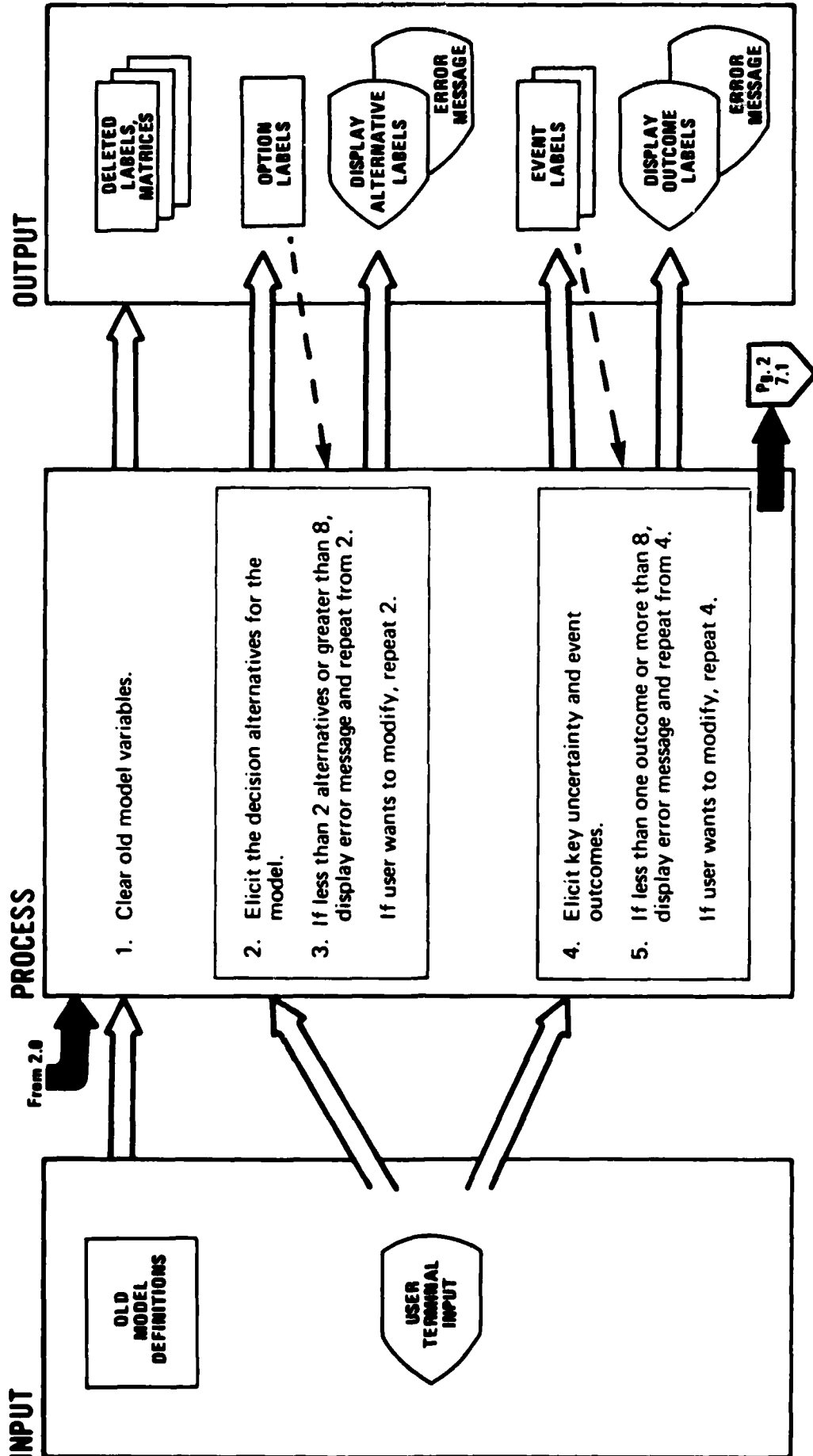
Figure 6.2.2

SENSITIVITY ANALYSIS: EXAMPLE OF OUTPUT FROM FUNCTION 6.2.2



This function causes the operating model definitions to be replaced by a new set of model definitions.

Charts 7.1 – 7.6 describe the subprocesses that are denoted here in steps 1-6. The subprocesses are executed in the order shown in the diagram.



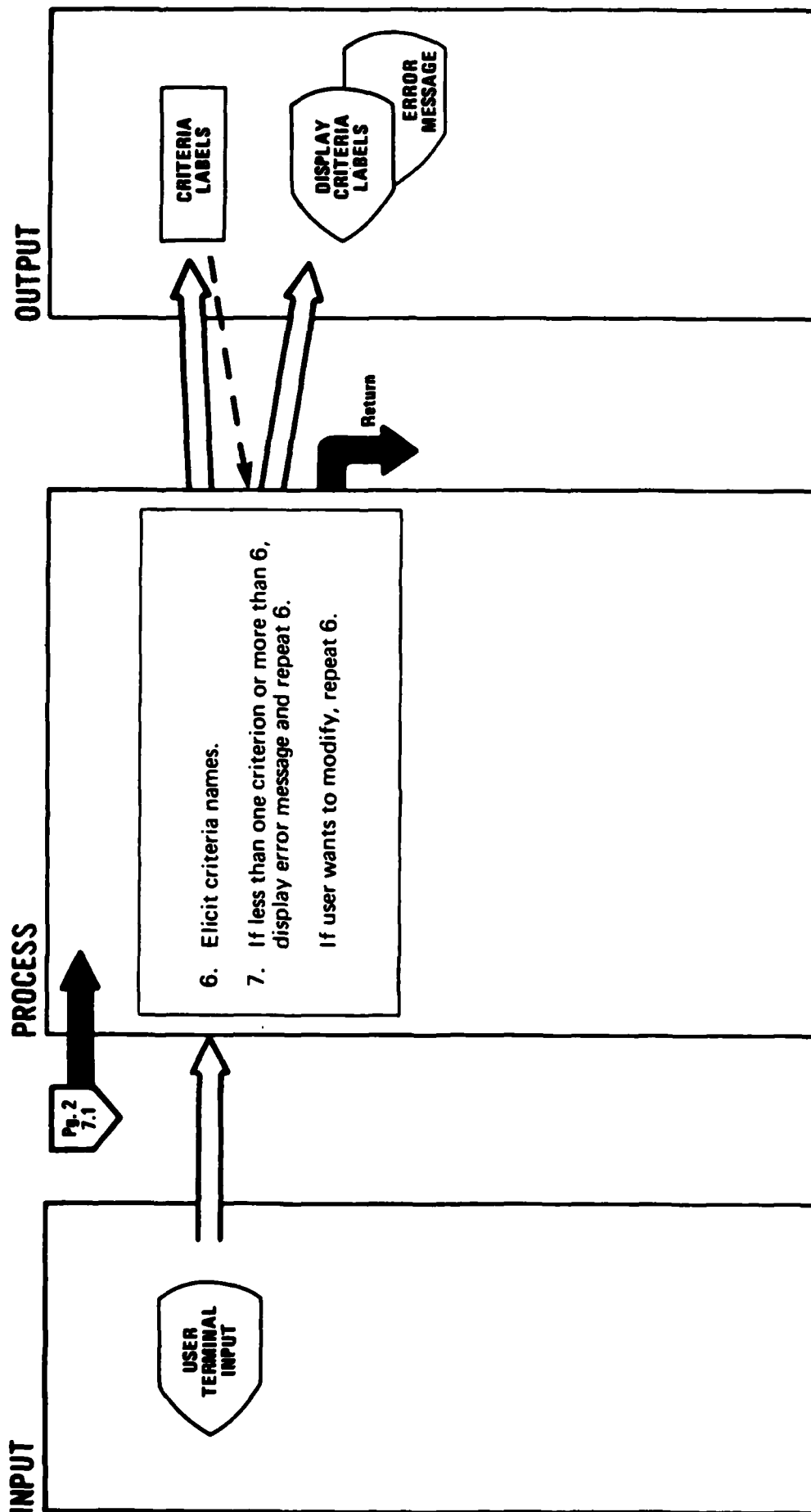
1. Set variables to null value.
 2. In interactive mode the user is requested to input decision alternative labels. A blank entry terminates the prompting and thereby, the number of decision alternatives is determined.
 3. The number of decision alternatives is checked for validity. If not valid, the appropriate message is displayed and the elicitation procedure is repeated. If valid, the labels are displayed as a group and the user is given a change to modify these labels. Otherwise, processing continues at the next step.
- Steps 4 and 5, 6 and 7 are handled in the same manner as steps 2 and 3.

System Program: OPINT

Name:

Diagram ID: 7.1 Description: Create the Model Structure

Page: 2 of 2

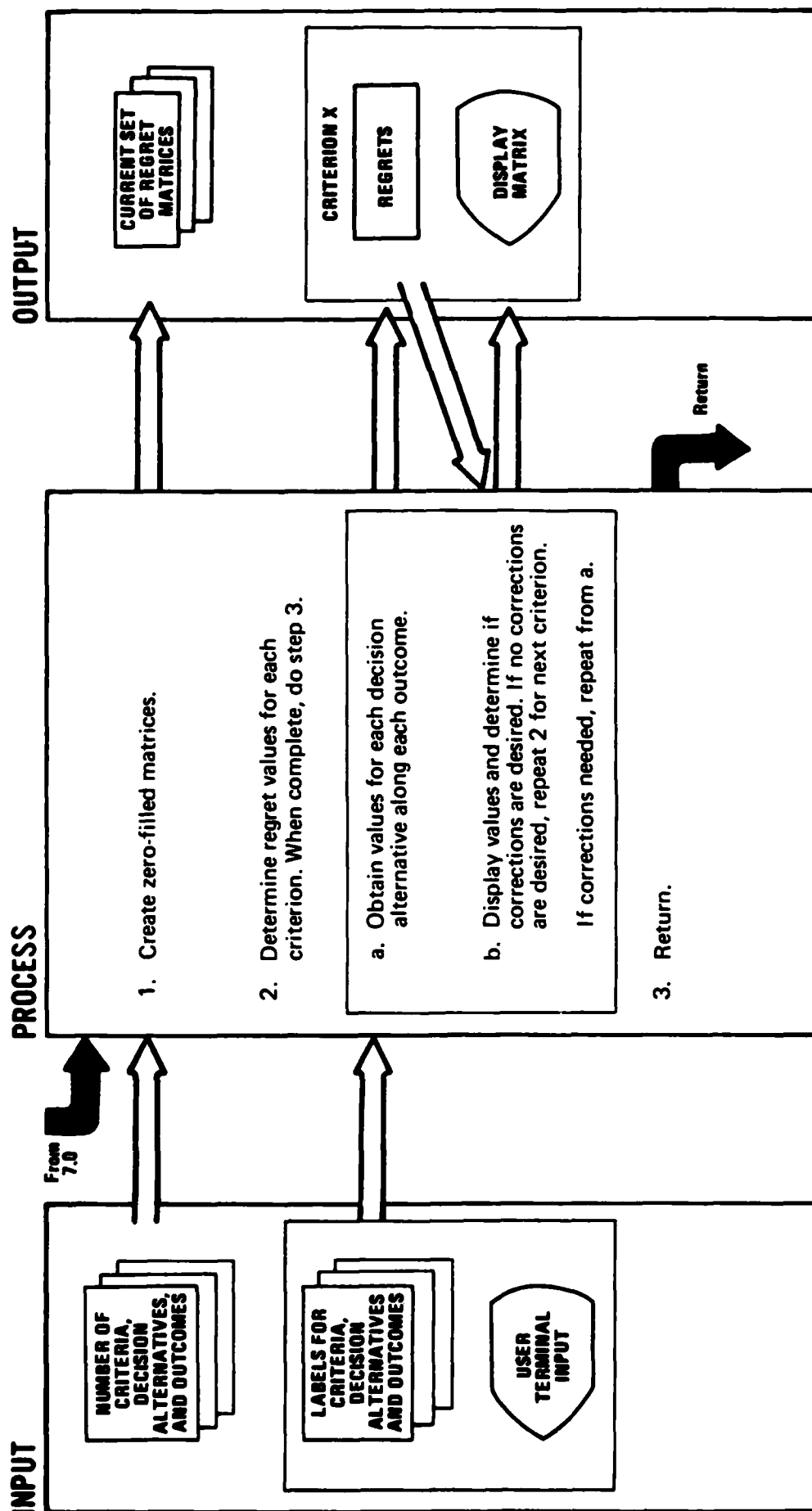


Name:

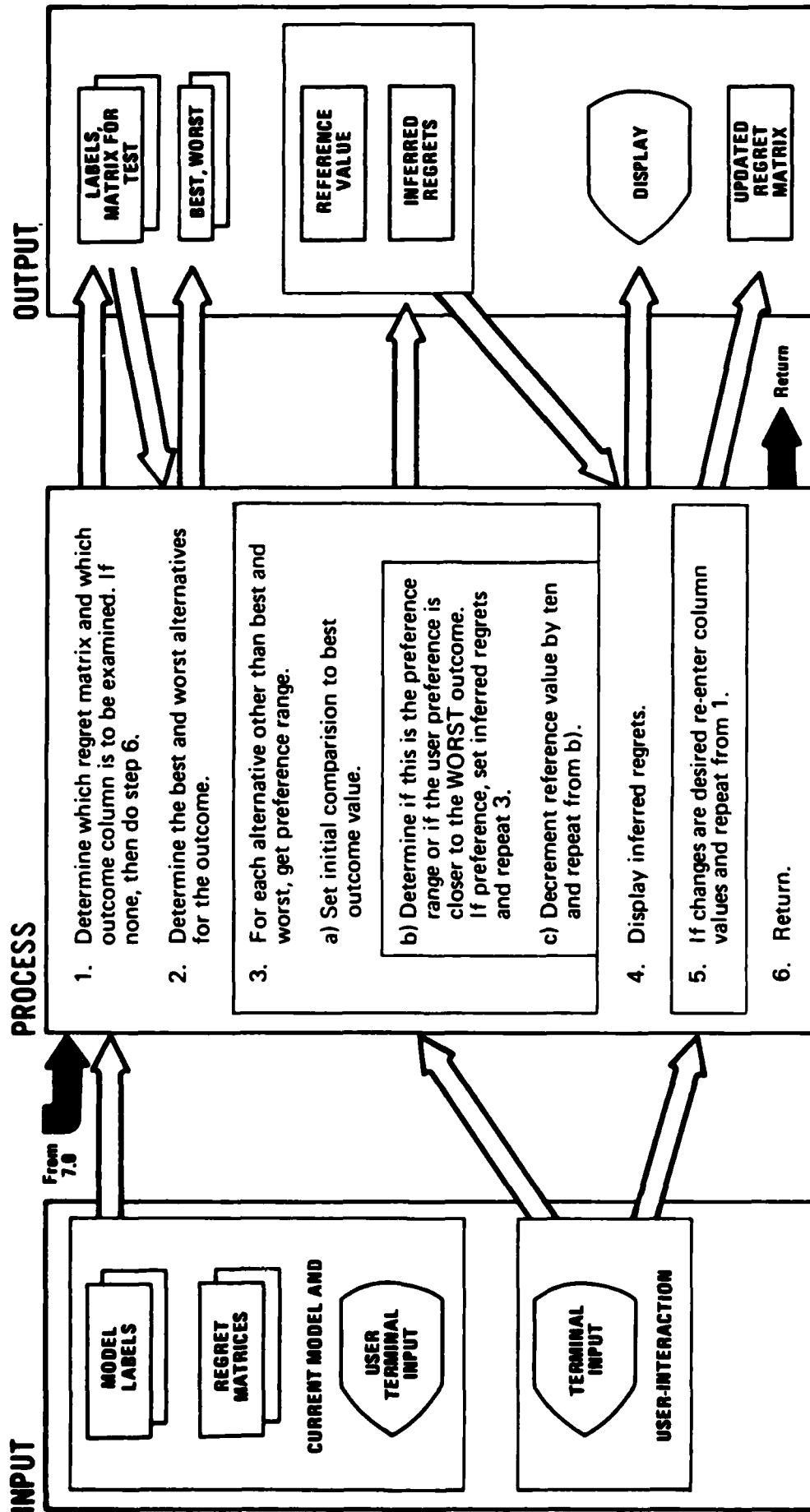
Diagram ID: 7.2

Create Regret Matrices

Page: — of —



1. Zero-filled arrays of the correct size at this step will allow the user to input values on the same display line with existing values, thus facilitating the entry process.
2. Regrets are entered for each criterion, one row (decision alternative) at a time. Corrections, when needed, are also entered by rows.



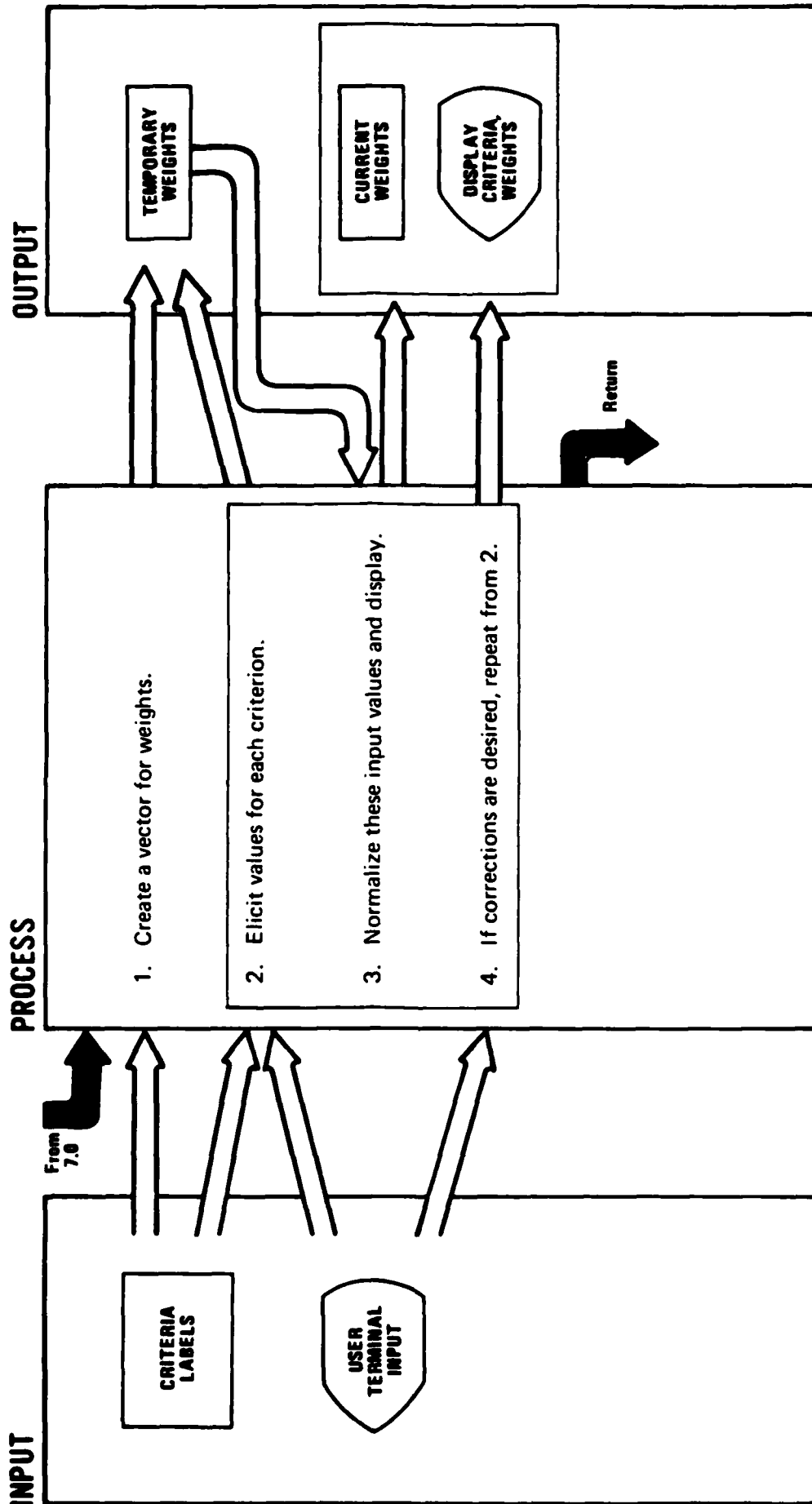
1. The user is prompted to input the name of the regret matrix (criterion label) and the outcome label for the column to be analyzed.

2. The best or minimum regret value in the selected column is determined for comparison tests. Next, the worst or maximum regret value is computed.

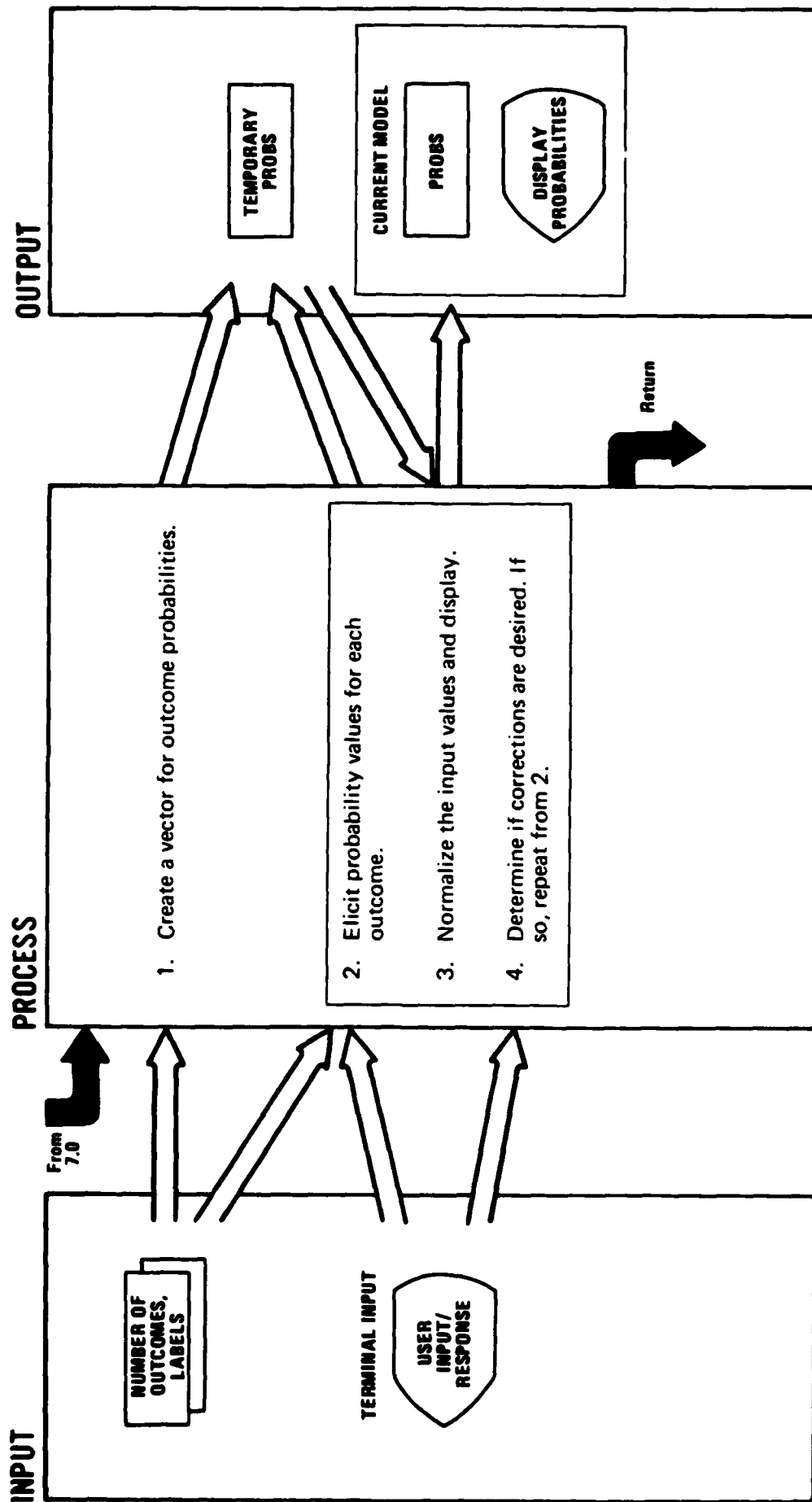
3. For each decision alternative regret value other than the best or worst, a probability p is selected (the preference value), by the user in interactive mode, which determines the user preference for that alternative-outcome event versus the probability p of the best alternative-outcome occurrence and $1 - p$ probability of the worst alternative-outcome occurrence.

The probability p starts at 100 (or absolute 1.0) and is automatically decremented by 10 points each time the user is asked to indicate his preference value. If p is not the preference value, the user returns a blank response and another decrement of p is made. This process is repeated until $p = 0$ or the user indicates the specified p is preferred. At this point the inferred regret is $100 - p$ times the worst regret value plus p times the best.

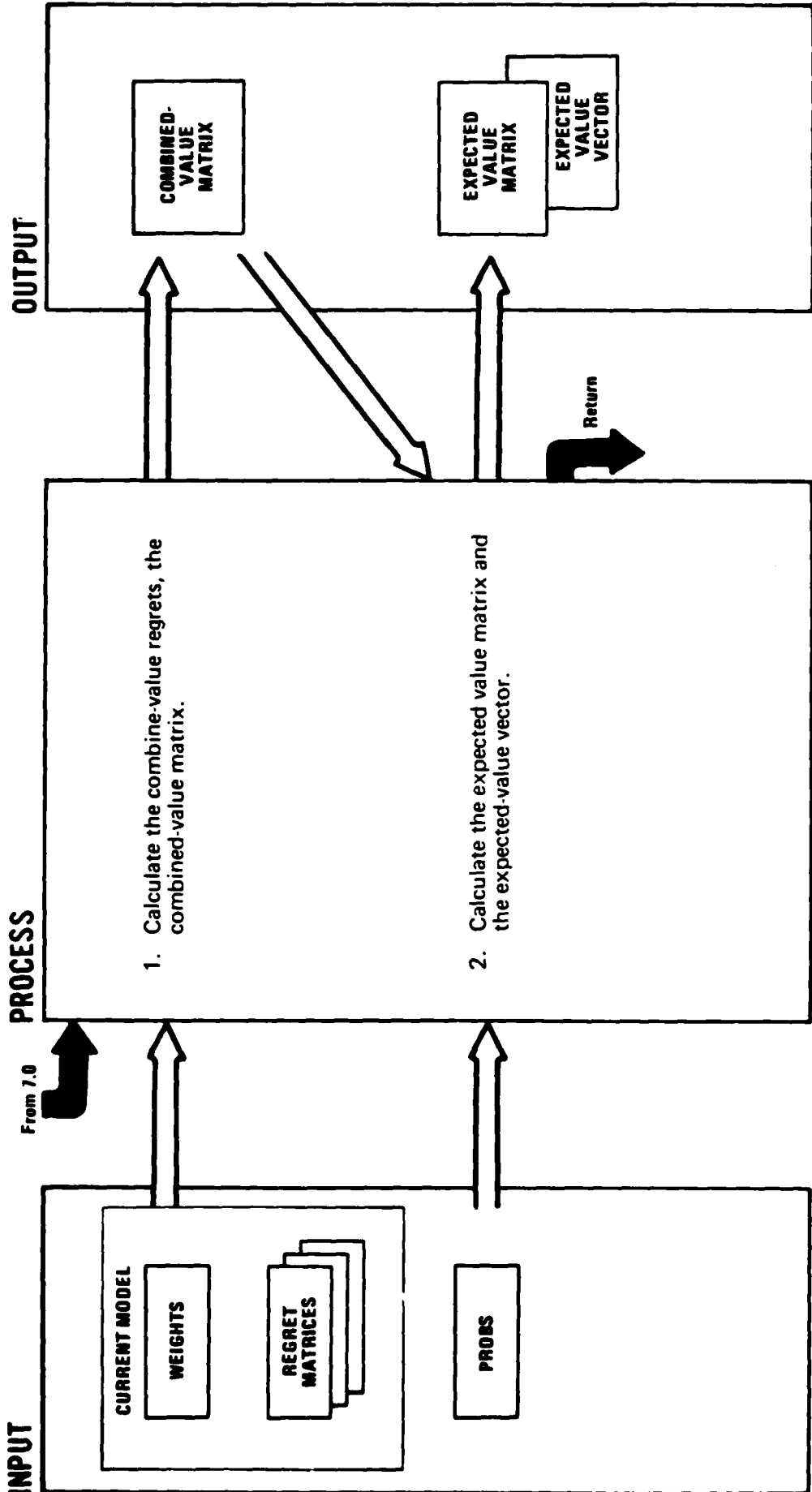
System Program: OPINT Name: _____
 Diagram ID: 7.4 Description: Set Criteria Weights Page: _____ of _____



1. Create a vector of weights containing an element = 1 for each criterion.
2. Prompt the user for integer input values -- a value for each criterion matrix. A conversion routine can check character to numeric translation to ensure valid input. (NUMS -- Chart 8.6)
3. Take the relative weights input from the keyboard and normalize these so that the sum of the weights is 100. (NORMALIZE Chart 8.7)



1. Create a vector of probabilities so that an element (= 1) exists in the vector for each event outcome.
2. Prompt the user for numerical input values — integers between 0 and 100. Check for validity of input and conversion to numerical data. (NUMS, Chart 8.6)
3. Invoke the normalization routine to ensure that the probabilities sum to 100 and have the same relative value as the keyboard input values. (NORMALIZE,



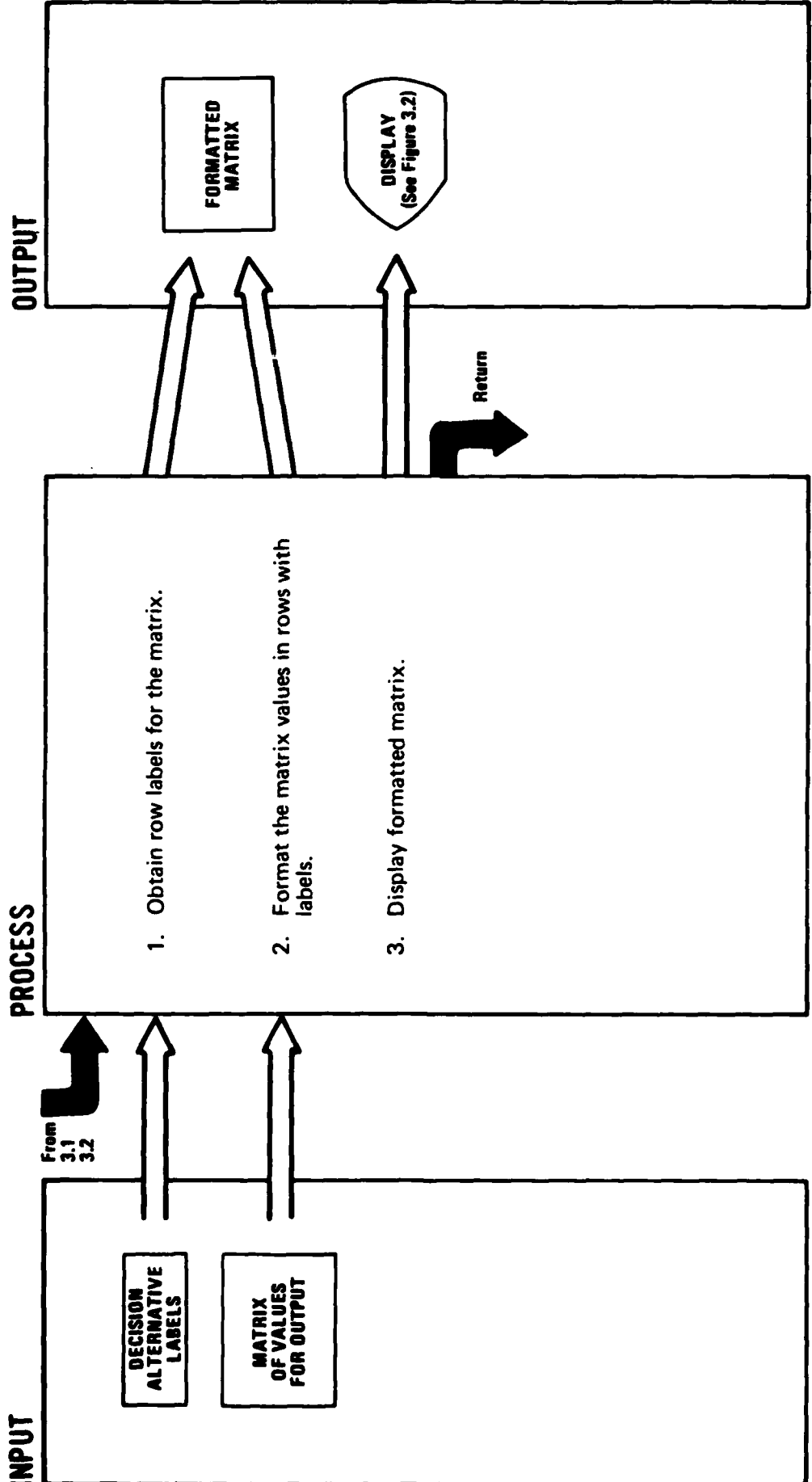
1. The combined-value matrix is formed by multiplying the weight for each criterion times the regret matrix for the criterion and then summing the position elements over each criterion.

A single array is formed which is a combination of all the regrets weighted (Ref. CALCCV, Chart 8.4)

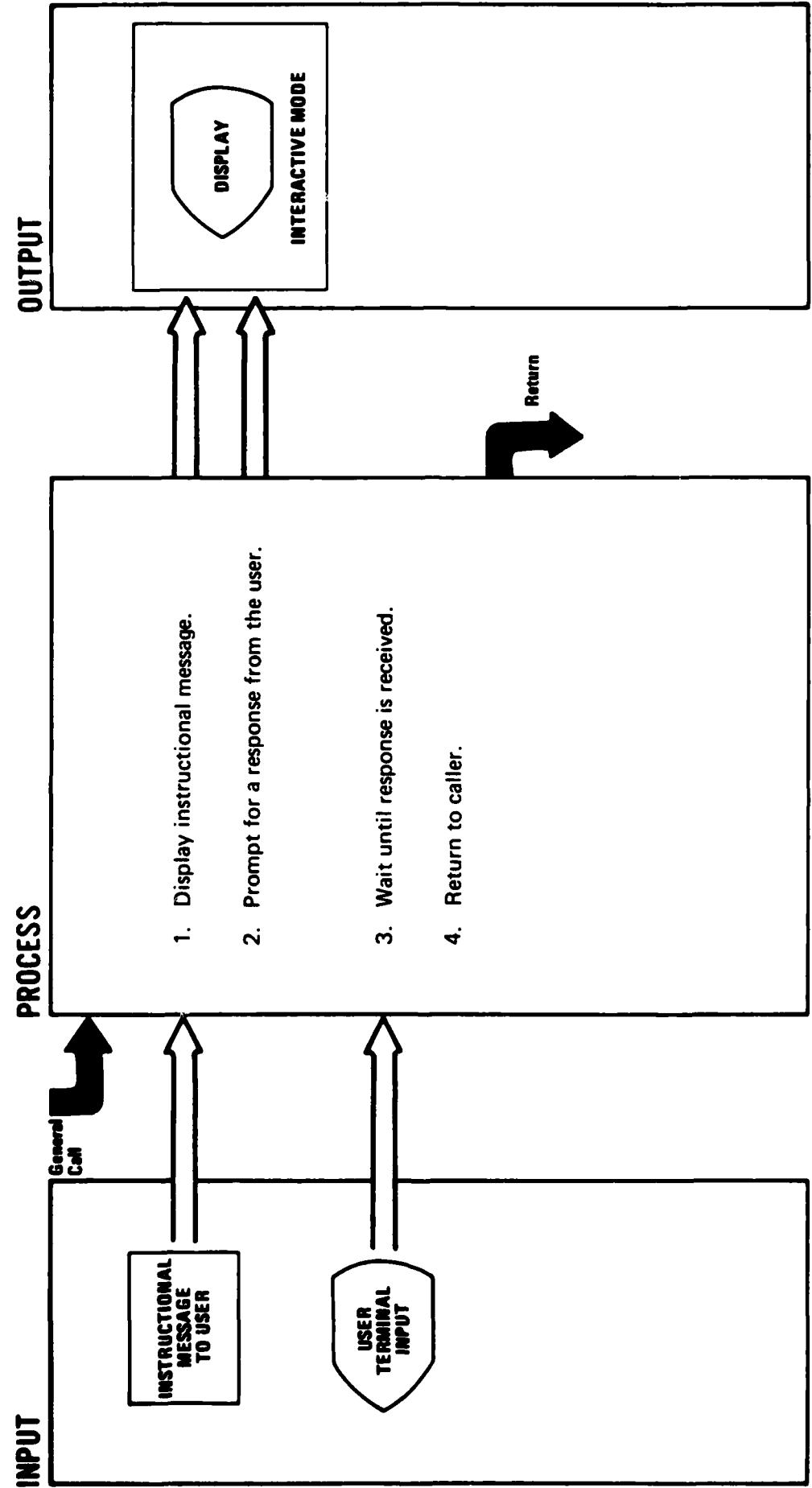
2. The weighted expected-value matrix is formed by multiplying each column of the combined-value regret matrix by the appropriate probability value for that outcome column.

The expected value vector is simply the row totals of this resulting matrix (Ref. CALCEV, Chart 8.3)

The following charts 8.1 - 8.7 describe generalized service routines for functions that are within the hierarchical structure of OPINT.

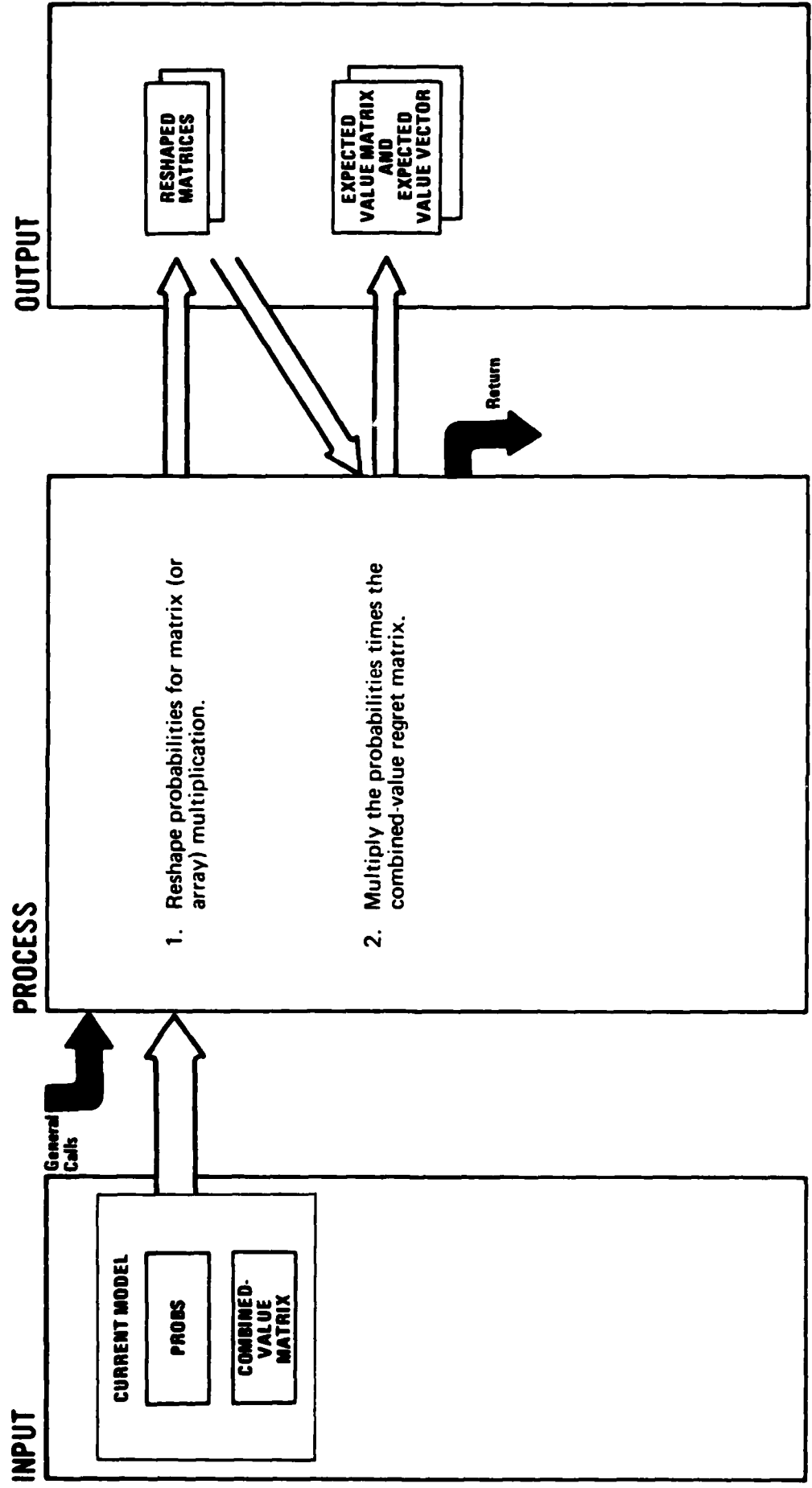


1. Matrix row labels and matrix values (usually an array) are passed as input to this routine. Alternative names are the row labels usually.
2. Formatting the Matrix for display requires the concatenation of character and numerical values into character or display output.



This routine is used for display purposes to enhance user control over changing displays.

3. Any keyboard input or a specific response may be requested of the user before processing can continue.



1. If matrix multiplication cannot occur in the system language by immediate instruction, then this step is omitted and step 2 is an iterative procedure — multiplying the appropriate probability times elements in the respective outcome column of the combined-value matrix.

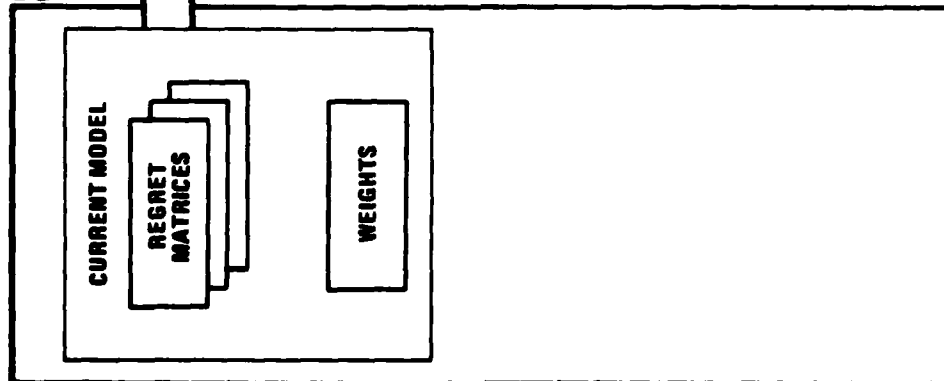
System/Program: QPINT

Name: CALCCV

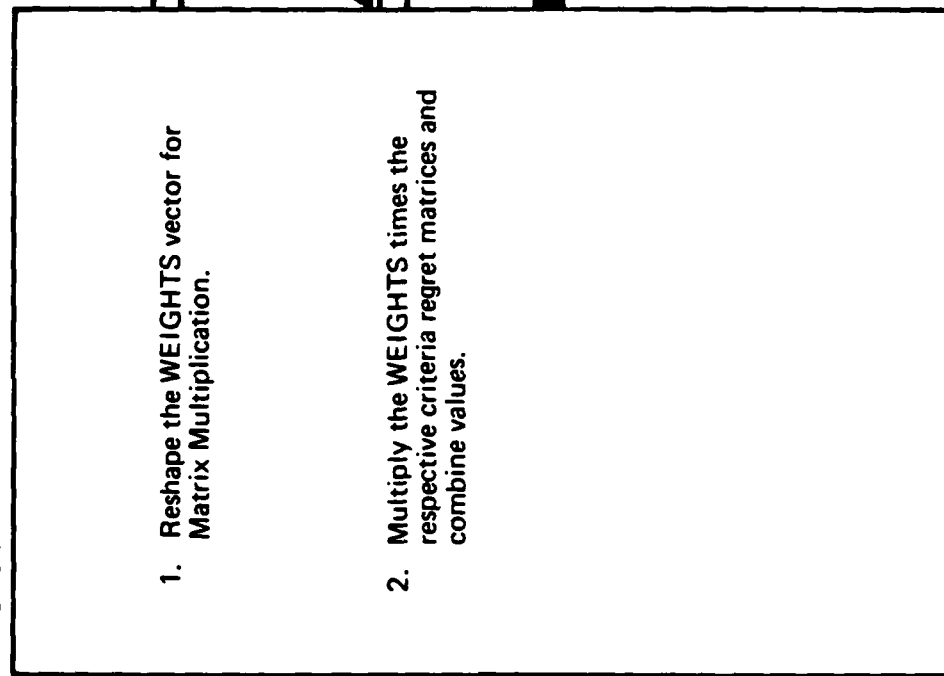
Diagram ID: 8.4 Description: Calculate Combined-Value Regrets

Page: of

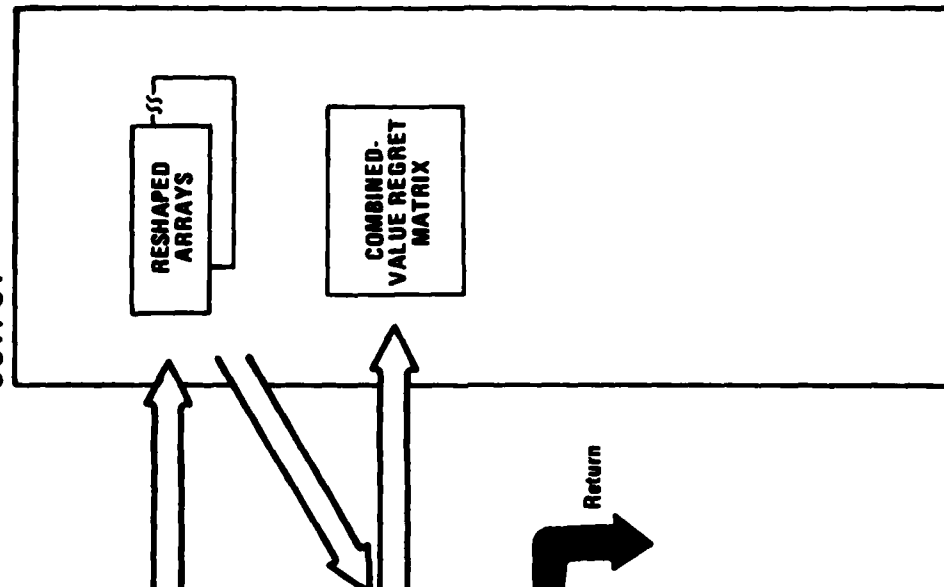
INPUT



PROCESS



OUTPUT

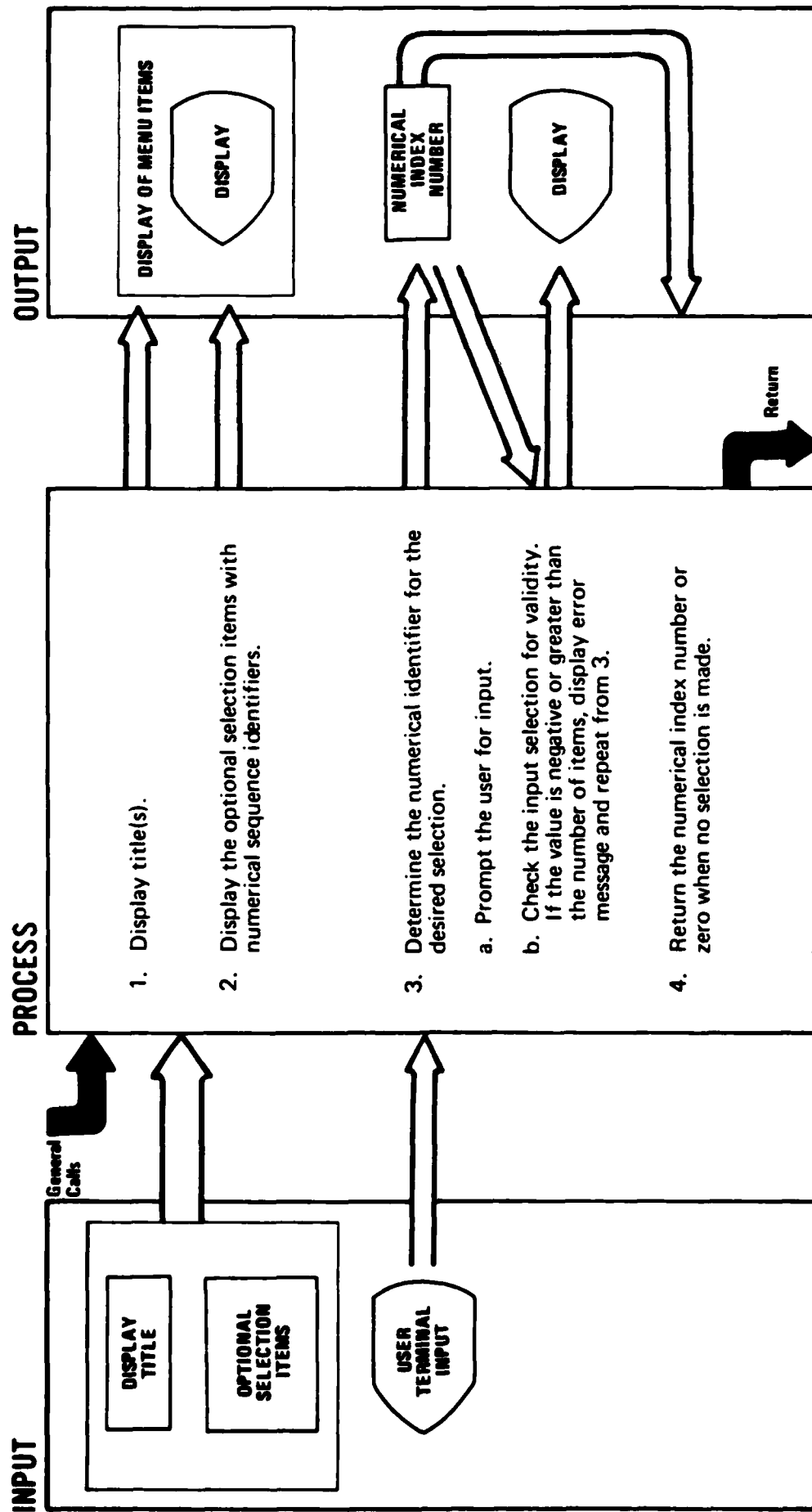


General Calls

Return

1. This step is required only for systems which allow single instruction matrix multiplication. Otherwise, step 2 is an iterative step.

2. The elements in each criterion Matrix are multiplied by the respective criterion weight. Then the cell values are added so that the (i,j) - th elements of all criteria matrices are added together for a particular alternative i and event outcome j .



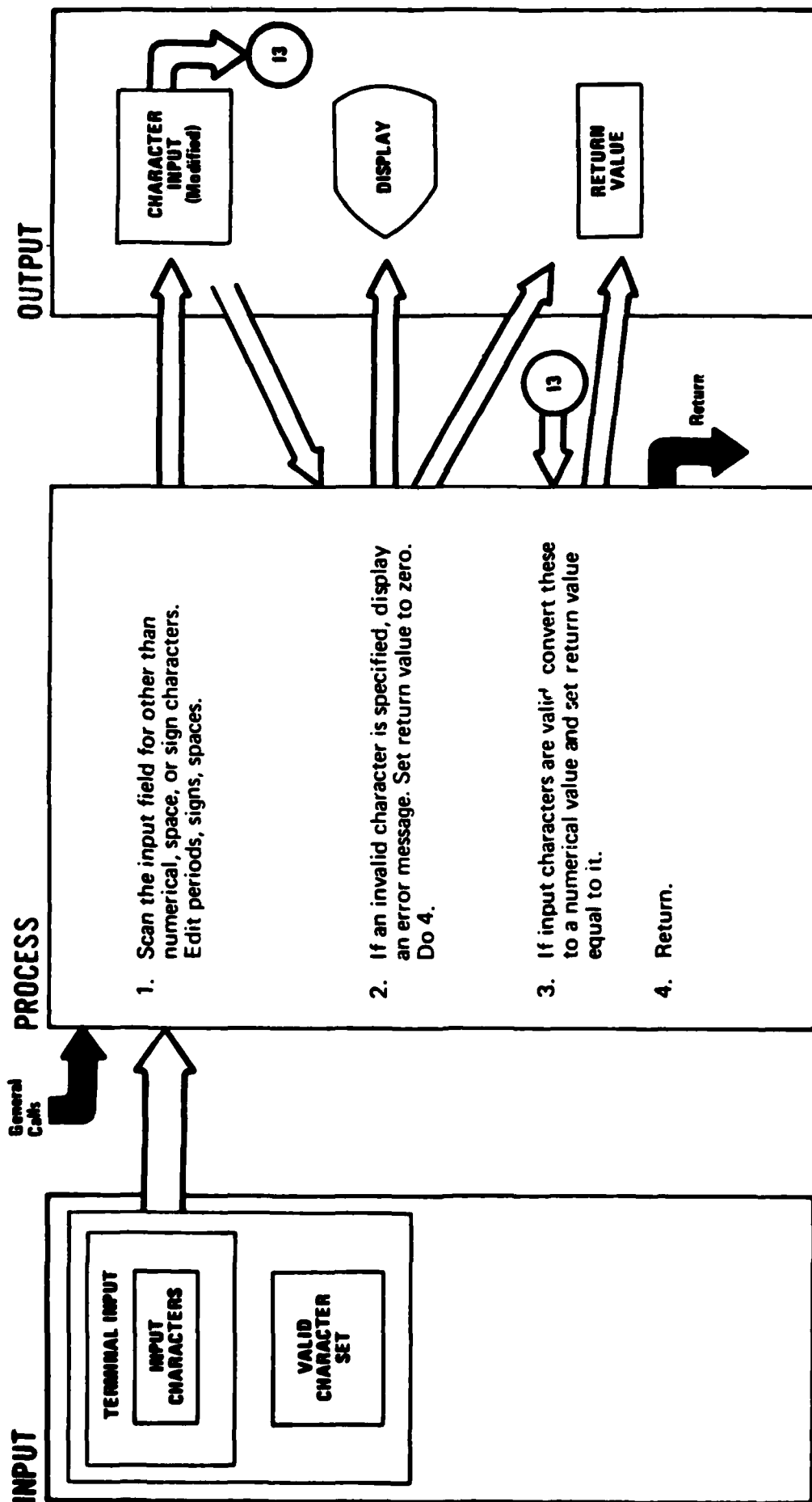
3. Prompt the user for the item sequence number of the choice selection. Check the validity of the user input. (Ref. NUMS Chart 8.6)

1. The title is passed to this routine so that the display will remain in context with the processing function. For example, a title may be 'DISPLAY RESULTS ... REGRET MATRICES'.

2. The selections that describe what is optimal are passed as input and are displayed in a list or cookbook MENU format along with item sequence numbers.

System/Program: OPINT Name: NUMS Page: of

Diagram ID: 8.6 Description: Number Input Checking Routine



This routine will not be required if system error checking routines interface with the standard keyboard-display input.

System/Program: QPINT

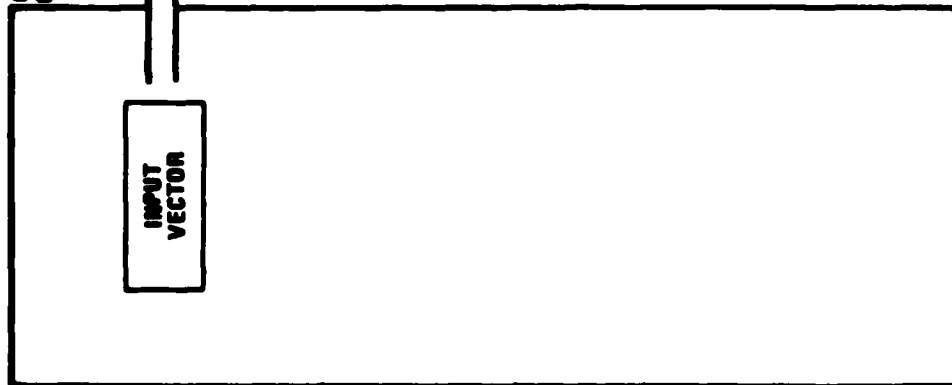
Name: NORMALIZE

Diagram ID: 8.7

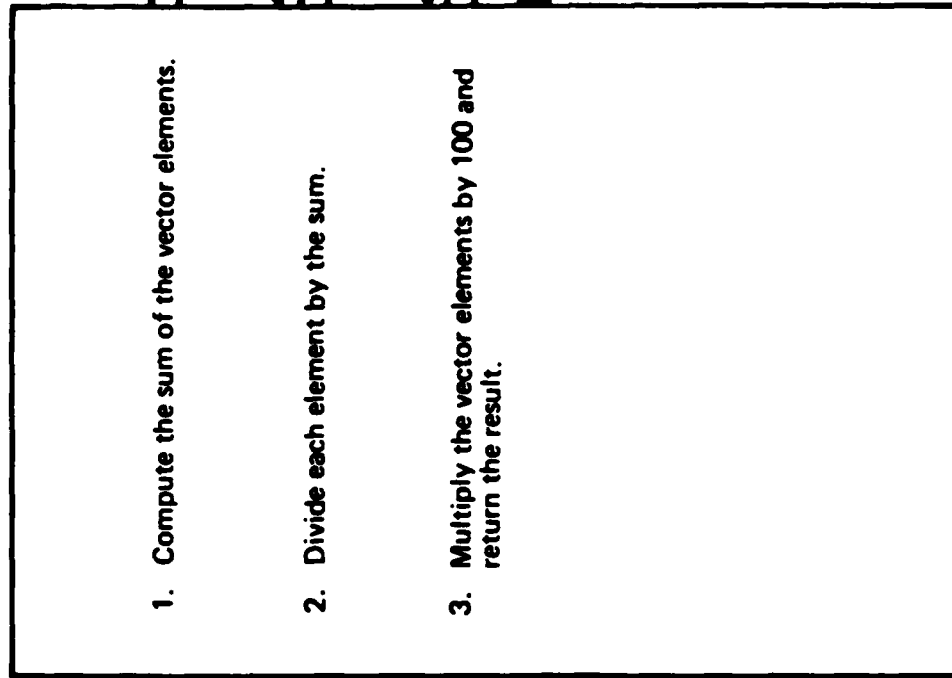
Description: Normalize Vector Values

Page: of

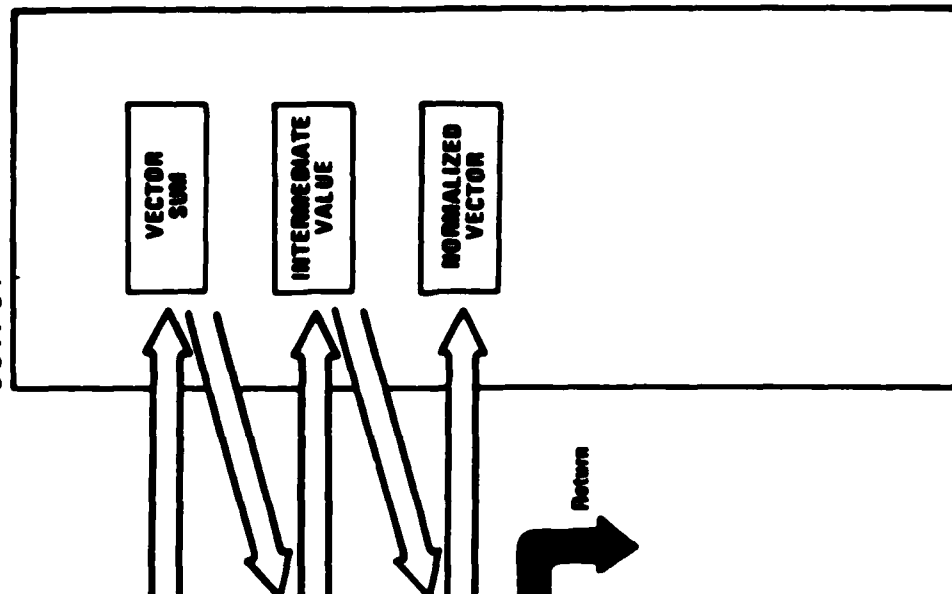
INPUT



PROCESS



OUTPUT



1. The input to this routine is a vector or row of numbers (otherwise, input will be converted to a numerical string of values). The sum of all the numbers in the vector is computed.

2. This step rescales all of the values to their percentage of the sum.

3. The normalized result from step 2 is typically multiplied by 100 to preserve percentage figures for output to the calling routines.