

EVALUATING THE EFFECTIVENESS OF MILITARY DECISION  
SUPPORT SYSTEMS: GAME ENVIRONMENT SIMULATOR  
AND OPTIMIZATION ALGORITHM

REPORT NO. 345-2

Prepared for:

U.S. Army Research Institute  
5001 Eisenhower Avenue  
Alexandria, Virginia

MARCH 1982



---

INTEGRATED SCIENCES CORPORATION  
Santa Monica, California

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 345-2	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle)  Evaluating the Effectiveness of Military Decision Support Systems: Game Environment Simulator and Optimization Algorithm		5. TYPE OF REPORT & PERIOD COVERED Scenario Generator Design Report 11/81-1/82
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Antonio Leal, Efraim Shaket and Judea Pearl		8. CONTRACT OR GRANT NUMBER(s) MDA903-81-C-0449
9. PERFORMING ORGANIZATION NAME AND ADDRESS Integrated Sciences Corporation 1640 Fifth Street Santa Monica, CA 90401		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS  9026/581
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Research Institute 5001 Eisenhower Avenue, Sixth Floor Alexandria, Virginia 22333		12. REPORT DATE March 1982
		13. NUMBER OF PAGES 85
14. MONITORING AGENCY NAME & ADDRESS (If different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) <div style="display: flex; justify-content: space-between;"> <div> Disbursing Office DCASR Los Angeles  11099 S. LaCienega Blvd.  P.O. Box 45011  Los Angeles, CA 90045 (2 copies) </div> <div> U.S. Army Research Institute  Dr. S. Halpin  5001 Eisenhower Avenue, 6th Floor  Alexandria, Virginia 22333 (2 copies) </div> </div>		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  Expert systems, game, simulation, training aids, planning aids		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  <p>The main objective of this program is to construct a flexible test bed for the evaluation of the effectiveness of computer-based expert systems in military training and planning.</p> <p>The technical approach consists of simulating the characteristics of expert systems in a game-like environment. Such characteristics include (1) friendly and English-like (stylized) dialogue, (2) system explanations of</p>		



Block 20 continued.

rationale about decision recommendations, (3) an ability to make relevant suggestions and comments about situation assessments and about plans proposed by the user, and (4) the use of high level strategic concepts and terminology.

The required software for such a program includes (1) a game environment simulator, (2) a simulated expert system for the game, and (3) an evaluation program for recording execution histories and for summarization. The game simulator will contain provisions for the experimenter to adjust critical parameters so that a controlled environment can be maintained. The expert system will monitor the progress of the game and can be interrogated as the user sees fit. A facility will also be provided for evaluating the user's performance under different modes of consultation with the expert system.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Evaluating the Effectiveness of Military Decision  
Support Systems: Game Environment Simulator  
and Optimization Algorithm

Report 345-2

Prepared for:

U.S. Army Research Institute  
5001 Eisenhower Avenue  
Alexandria, Virginia

Prepared by:

Antonio Leal  
Efraim Shaket  
Judea Pearl

Integrated Sciences Corporation  
1640 Fifth Street  
Santa Monica, California 90401

March 1982

## TABLE OF CONTENTS

1.0	PROGRAM ABSTRACT. . . . .	1
1.1	OBJECTIVE. . . . .	1
1.2	APPROACH . . . . .	1
1.3	PROGRESS . . . . .	1
1.4	PLANS AND MILESTONES . . . . .	2
2.0	GAME ENVIRONMENT SIMULATOR. . . . .	3
2.1	MILITARY BREAKTHROUGH. . . . .	3
2.2	THE STATE TRANSITION MATRIX. . . . .	5
3.0	OPTIMIZATION PROCEDURE. . . . .	8
3.1	OPTIMIZATION . . . . .	8
4.0	OPTIMIZATION ALGORITHM. . . . .	14
4.1	OVERVIEW . . . . .	14
4.2	INITIAL INFORMATION. . . . .	17
4.3	PROBABILITY MATRICES . . . . .	17
4.4	UTILITY MATRICES . . . . .	29
5.0	THE DECISION MAPS . . . . .	44
	APPENDIX - THE PROGRAM CODE. . . . .	73

## LIST OF TABLES

Table		Page
1	State Transition Matrix and Probability of Win. . . . .	6

## LIST OF FIGURES

Figure		Page
1	State Transition Network. . . . .	7
2	Enemy Encampment Array . . . . .	9
3	Flow Diagram for Data and Decisions in the (i,j) Stage. The Triplet (F,i,j) Denotes the State of Entering the (i,j) Stage with Force F. . . . .	10
4	Influence-Diagram for Variables Affecting the Events and Observations in Each Stage. . . . .	11
5	Optimization Information Flow . . . . .	15
6	Formulation of $P(X_2/Z)$ . . . . .	19
7	Ways to get from Z to $X_2$ . . . . .	20
8	$P(X_2/Z)$ (divided by 27) . . . . .	21
9	Formulation of $P(X_1/Z)$ . . . . .	22
10	Ways to Get from Z to $X_1$ . . . . .	24
11	$P(X_1/Z)$ (divided by 729). . . . .	25
12	$P(X_1/Z) = \sum_Z P(X_1/Z)P(Z)$ . . . . .	27
13	$P(X_2/Z) = \sum_Z P(X_2/Z)P(Z)$ . . . . .	27
14	$U1(Z,F) = U(F_a(Z,F))PW(Z,F) + V(F_a(Z,F))(1-PW(Z,F))$ . . . . .	30
15	$UID(Z,F) = U(F_a(Z,F))PWD(Z,F) + V(F_a(Z,F))(1-PWD(Z,F))$ . . . . .	30
16	$U2A(X_1,F) = \sum_Z U1(Z,F)P(Z/X_1)$ . . . . .	32

# LIST OF FIGURES (Continued)

Figure		Page
17	$U2B(X_2, F) = \sum_Z U1(Z, F)P(Z/X_2)$	32
18	$U2BD(X_2, F) = \sum_Z U1D(Z, F)P(Z/X_2)$	33
19	$U3B(X_2, F) = \text{MAX}(U2B(X_2, F), V(F))$	35
20	$U3BD(X_2, F) = \text{MAX}(U2BD(X_2, F), V(F))$	35
21	$U3C(Z, F) = \text{MAX}(U1(Z, F), V(F))$	36
22	$U3CD(Z, F) = \text{MAX}(U1D(Z, F), V(F))$	36
23	$U4B(X_2, F) + U3B(X_2, F)(1-PDS) + U3BD(X_2, F)PDS$	37
24	$U4C(Z, F) = U3C(Z, F)(1-PDD) + U3CD(Z, F)PDD$	37
25	$U5B(X_1, F) = \sum_{X_2} U4B(X_2, F)P(X_2/X_1)$	38
26	$U5C(X_1, F) = \sum_Z U4C(Z, F)P(Z/X_1)$	40
27	$U6(X_1, F) = \text{MAX}(U5B(X_1, F), U5C(X_1, F))$	40
28	$U7(X_1, F) = \text{MAX}(U6(X_1, F), (U2A(X_1, F)))$	41
29	$U8(X_1, F) = \text{MAX}(U7(X_1, F), V(F))$	41
30	$V(F) = \sum_{X_1} U8(X_1, F)P(X_1)$	43

## 1.0 PROGRAM ABSTRACT

### 1.1 OBJECTIVE

The main objective of this program is to construct a flexible test bed for the evaluation of the effectiveness of computer-based expert systems in military training and planning.

### 1.2 APPROACH

The technical approach consists of simulating the characteristics of expert systems in a game-like environment. Such characteristics include (1) friendly and English-like (stylized) dialogue, (2) system explanations of rationale about decision recommendations, (3) an ability to make relevant suggestions and comments about situation assessments and about plans proposed by the user, and (4) the use of high level strategic concepts and terminology.

The required software for such a program includes (1) a game environment simulator, (2) a simulated expert system for the game, and (3) an evaluation program for recording execution histories and for summarization. The game simulator will contain provisions for the experimenter to adjust critical parameters so that a controlled environment can be maintained. The expert system will monitor the progress of the game and can be interrogated as the user sees fit. A facility will also be provided for evaluating the user's performance under different modes of consultation with the expert system.

### 1.3 PROGRESS

To date, the following tasks have been completed:

- (1) Design of the game scenario generator.
- (2) Preliminary implementation of the game for test and evaluation purposes.
- (3) Completion of the optimality algorithm for the game.
- (4) Technical report sections for optimality and game description.
- (5) Preparation of a demonstration video tape showing a typical game session.
- (6) Implementation of the optimality procedure.
- (7) Production of a complete set of decision maps for the game.



#### 1.4 PLANS AND MILESTONES

8/81 - 3/82: (see above)

- 3/82 - 7/82: (1) Complete detailed design of expert system.  
(2) Complete a preliminary implementation of the expert system.

- 8/82 - 7/83: (1) Design and implement performance monitor, complete final  
(second year) implementation of expert system, integrate expert system  
and performance monitor with scenario generator and  
optimization procedure, perform system tests and validation.

## 2.0 GAME ENVIRONMENT SIMULATOR

A preliminary version of the game environment simulator has been implemented. The game is based on the classical problem in Statistical Decision Theory of making a critical decision with available information or waiting until more reliable information can be obtained. Delaying the decision too long could result in lost opportunities. The following section contains the rules of the game as they are presented to the player by the computer. A complete demonstration of the game is available in a prepared video tape which is a separate appendix to this report.

### 2.1 MILITARY BREAKTHROUGH

You are trapped behind enemy lines and your objective is to break through the enemy forces and reach the ocean beyond. Each of the four enemy lines has seven encampments which may be attacked or skipped depending on prevailing conditions or available information. After a successful attack, you BREAKTHROUGH to face the next enemy line. However, an unsuccessful attack moves you to the next encampment to the right.

At the start of the game you will be given military forces made up of three components: Artillery (A), Infantry (I), and Tanks (T). Each enemy encampment has similar forces but the exact strength is not known.

The strength of each component of your forces is measured by one of four possible levels: high (HI), medium (MED), low (LOW), or depleted (NIL). The enemy commander always configures his forces into one of only four possible combinations: (1) HI-HI-HI, (2) MED-MED-MED, (3) LOW-LOW-LOW, or (4) NIL-LOW-NIL. These strengths refer to the three components Artillery, Infantry, and Tanks (A-I-T) in that order.

Your forces begin at HI-HI-HI. The enemy tries hard to conceal its real strength using camouflage and decoying techniques. When confronted with a new enemy encampment, a preliminary assessment of its strength will be available and displayed in the corresponding box. The initial assessment, however, may be unreliable.

Reconnaissance may be used to improve your information about the true enemy strength. By sending in "shallow" reconnaissance, the displayed assessment will be improved, but will still not be entirely accurate. •

By sending in "deep" reconnaissance, a true picture of the enemy strength may be obtained. However, the deeper the reconnaissance, the more chance you have of being detected by the enemy. If you are detected, you have lost the element of surprise and the battle is more difficult to win.

If you wish to avoid being detected altogether, you may attack without reconnaissance. Alternatively, if you think your chances of success are small, you may skip the encampment confronting you and move to the next one on the right. •

Once you reach the encampment on the extreme right (the 7th), you MUST attack. If such an attack fails, the game ends with defeat since you lost the chance of reaching the ocean.

After each battle your forces may be reduced in strength. There is no possibility of additional strength or replacements.

Occasionally, the weather will be poor. If it is raining, a battle is more difficult to win, the information is less reliable, and the probability of being detected is smaller. •

## 2.2 THE STATE TRANSITION MATRIX

The following Table 1 shows the state transitions that occur in the game as well as the probabilities of win in various game configurations. The friendly forces can assume one of only 12 combinations (states) ranging from HI-HI-HI to NIL-NIL-NIL. The enemy forces can assume one of only 4 possible states. For each match of friendly and enemy state, a particular probability of winning the battle (if it occurs) has been assigned along with the new state for the friendly forces. The enemy state is chosen at random at every confrontation. The probability of win and the new state are independent of each other. The forces will undergo state transition regardless of the outcome of the battle.

For example, if the friendly forces are currently at state number 3 (MED-HI-HI) and the enemy state is number 2 (MED-MED-MED), if a battle occurs, there is a .7 chance of the player winning and he will be left with forces of MED-HI-MED (state number 5) whether he wins or not. State number 12 (NIL-NIL-NIL) ends the game in defeat for the player since his forces are depleted.

Figure 1 shows the state transitions in the form of a network flow diagram. The arc labels refer to enemy states. Omitted arcs lead directly back to the same node.

	U(F):	9	8	8	7	7	6	6	5	5	4	2	1	
	A:	H	H	M	H	M	M	L	L	N	N	N	N	} Friendly Force Combination F
	I:	H	H	H	M	H	M	H	M	H	M	L	N	
	T:	H	M	H	M	M	M	M	M	M	M	L	N	
<u>AIT</u>		1	2	3	4	5	6	7	8	9	10	11	12	State
HHH	1	.5 2	.4 6	.4 7	.3 8	.3 9	.2 10	.2 10	.1 11	.1 11	0 12	0 12	0 12	Probability of Win Transition State (friendly)
MMM	2	.8 3	.7 4	.7 5	.6 6	.6 7	.5 8	.5 9	.4 10	.4 10	.3 11	.2 12	0 12	
LLL	3	.9 1	.9 5	.9 5	.8 6	.8 6	.7 8	.7 9	.6 10	.6 10	.5 11	.4 12	0 12	
NLN	4	1 1	1 2	1 3	1 4	1 5	.9 6	.9 7	.8 10	.8 10	.8 11	.6 12	0 12	
Enemy Force Combination Z	State													
		"Rain" subtracts .1 from P(win)												
		"Detection" subtracts .2 from P(win)												
		P(win) less then 0 is treated as 0												
		P(detection/shallow) = .4												
		P(detection/deep) = .8												

Table 1. STATE TRANSITION MATRIX AND PROBABILITY OF WIN

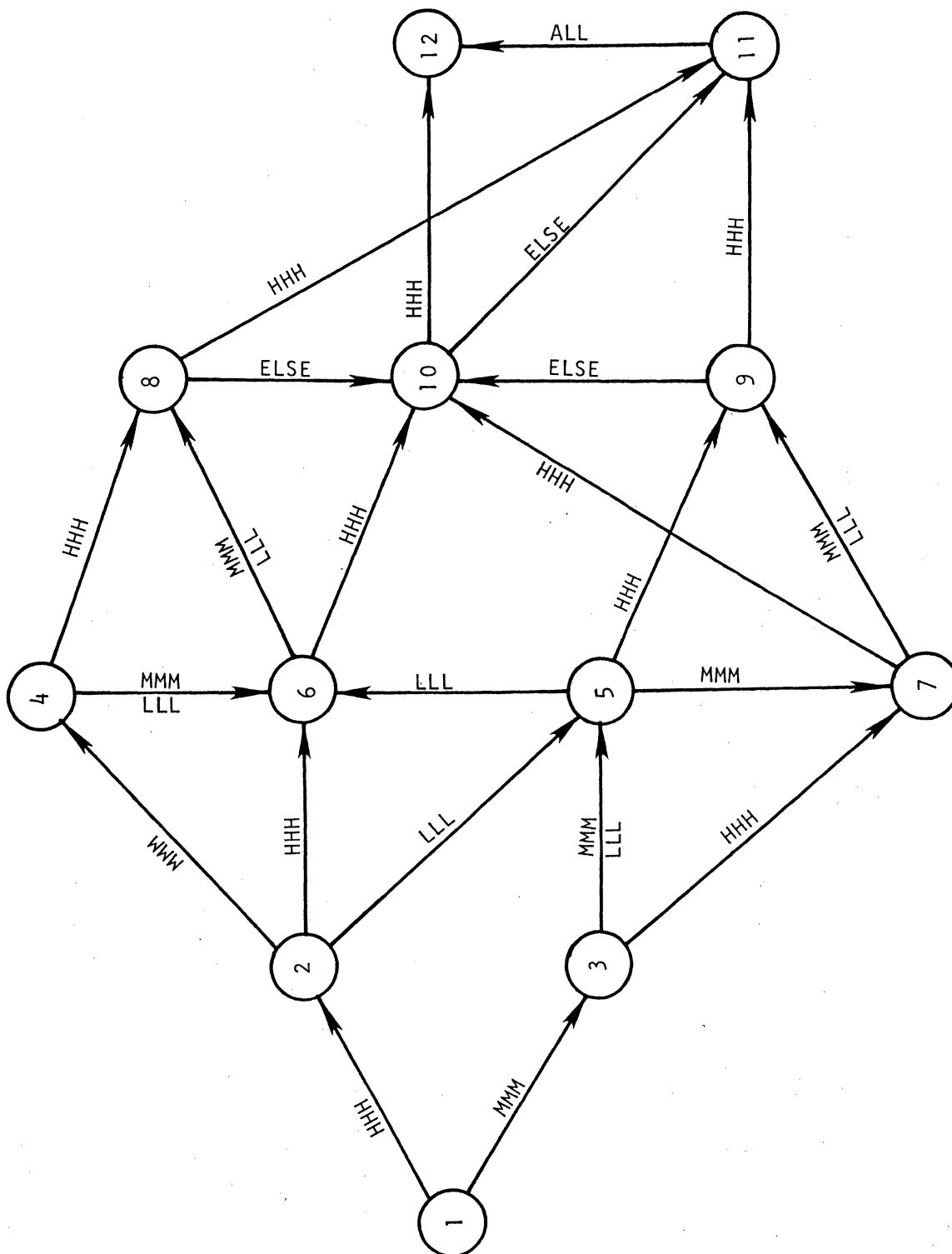


Figure 1. STATE TRANSITION NETWORK.



### 3.0 OPTIMIZATION PROCEDURE

In order to evaluate the performance of the player and to permit the expert system to generate relevant comments and recommendations about the game, an optimization procedure will exist which will have the capability to calculate the best game strategy at any point. The following section describes the optimality algorithm excluding the weather factor.

#### 3.1 OPTIMIZATION

The optimal decision at each decision junction as well as the utility associated with any given situation can be computed recursively using the expected utility maximization principle. Let the enemy encampments be arranged in a rectangular array as described in Figure 2. The game always starts with the  $i_m, j_m$  encampment.

From any given  $(i,j)$  cell the game scenario may proceed to only two other cells: 1) Cell  $(i, j-1)$ , if an attack is avoided or failed (and  $j > 1$ ), or 2) Cell  $(i-1, j_m)$  in case an attack is successful. As a result, the utilities and decisions connected with confronting the  $(i,j)$  cell can be computed from the utilities of entering  $(i-1, j_m)$  and  $(i, j-1)$ . This facilitates a row-by-row recursive procedure of calculating the optimal policy in the following order:  $(1,1) (1,2) \dots (i,j_m); (2,1) (2,2) \dots (2,j_m); (3,1) (3,2) \dots$ .

This role-back computation is space-efficient due to the fact that at any  $(i,j)$  stage of the computation only two utility vectors need be saved in memory: that characterizing the entry to the  $(i-1, j_m)$  stage and the one associated with the entry to the  $(i, j-1)$  stage. The details of this optimization procedure can be obtained from the flow chart of Figure 3 and the influence-diagram of Figure 4.

Let  $U_{i,j}(F)$  stand for the utility of entering stage  $(i,j)$  with force  $F$ . The utility of launching an attack at the  $(i,j)$  stage knowing the variable  $F, z$  and  $D$ , is given by:

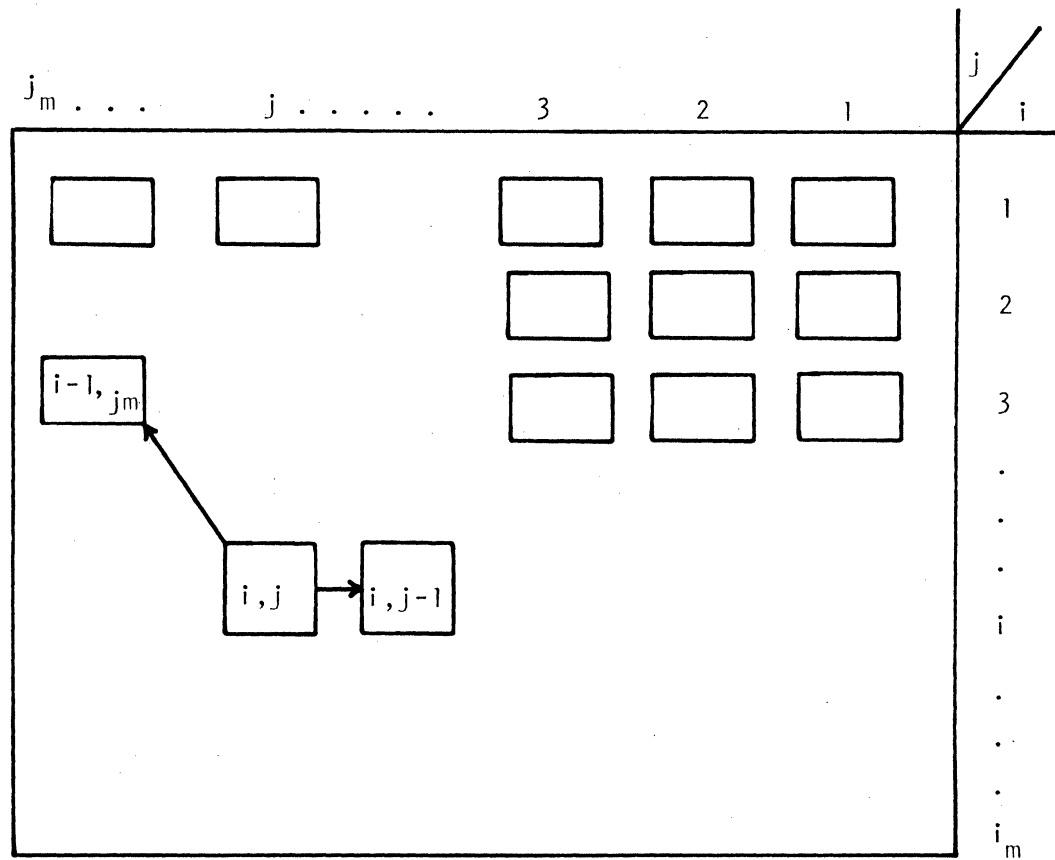


Figure 2. Enemy Encampment Array.

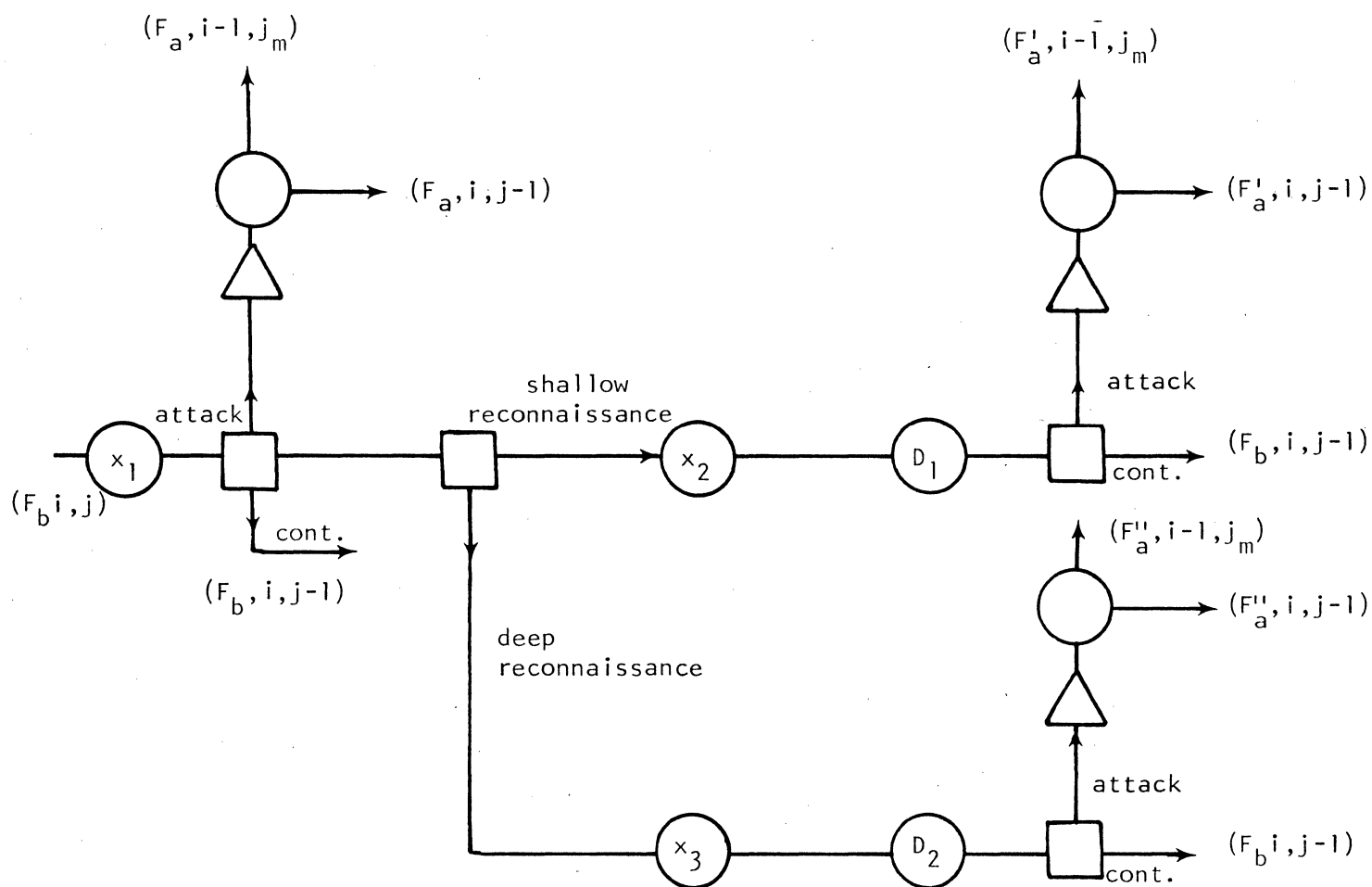


Figure 3. Flow-diagram for data and decisions in the  $(i, j)$  stage. The triplet  $(F, i, j)$  denotes the state of entering the  $(i, j)$  stage with force  $F$ .

#### Random Variables

$F_b$  - Own force on entry

$F_a$  - Own force after an attack

$x_1$  - Initial report regarding enemy strength

$x_2$  - Report obtained by shallow reconnaissance

$x_3$  - Report obtained by deep reconnaissance

$D_1$  - Being detected during shallow reconnaissance

$D_2$  - Being detected during deep reconnaissance

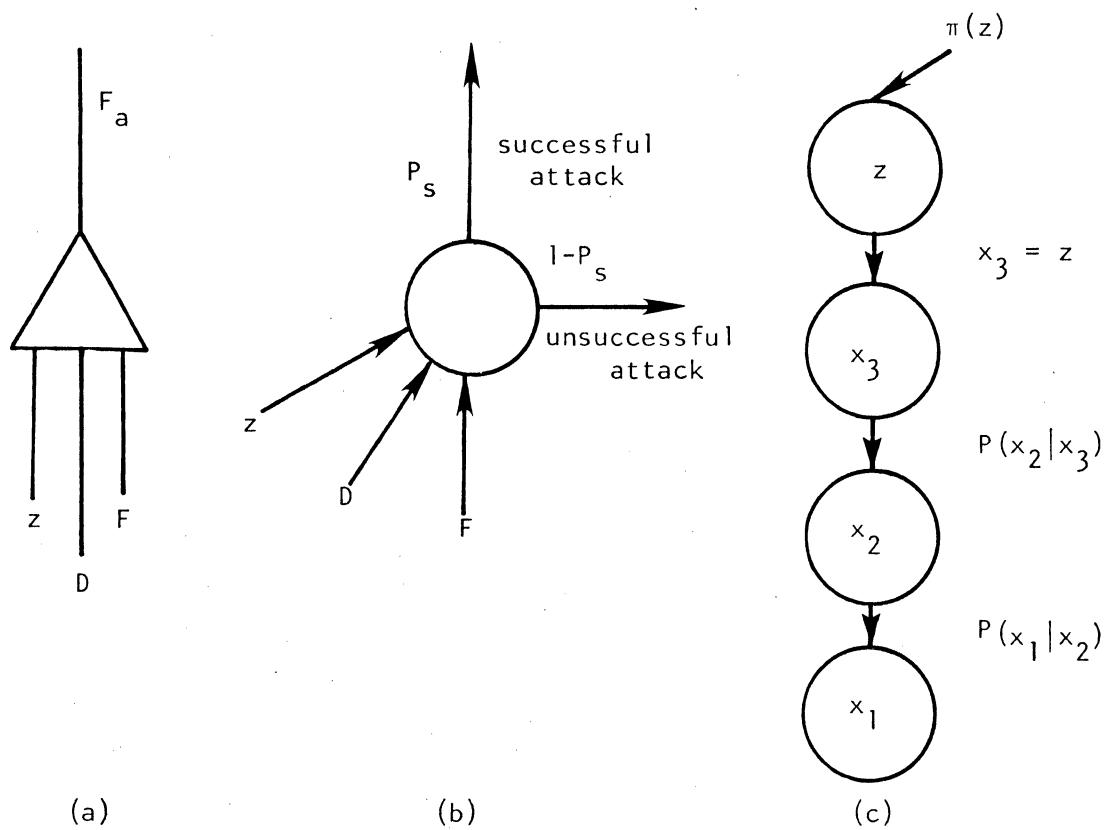


Figure 4. Influence-diagram for variables affecting the events and observations in each stage.

- 4a) The residual (after the attack) force  $F_a$  is a deterministic function of the initial force ( $F$ ), the enemy force  $z$  and whether the reconnaissance force has been detected ( $D$ ).
- 4b) The probability of an attack resulting in successful penetration ( $P_s$ ) is a deterministic function of  $F$ ,  $z$  and  $D$ .
- 4c) The reported levels of the enemy strength before reconnaissance ( $x_1$ ), after shallow reconnaissance ( $x_2$ ) and after deep reconnaissance ( $x_3$ ) are related to the true level ( $z$ ) by successive stages of noise corruption characterized by the conditional probability matrices  $P(x_i|x_{i-1})$ . Deep reconnaissance results in a noise-free report  $x_3=z$ :  $\pi(z)$  is the prior probability of  $z$ .

$$U(\text{attack } i, j \mid F, z, D) = P_s(F, z, D) U_{i-1, j_m} [F_a(F, z, D)] + [1 - P_s(F, z, D)] U_{i, j-1} [F_a(F, z, D)] \quad (1)$$

Likewise, if the level of enemy force ( $z$ ) is not accurately known, then based on a report  $x$  we have:

$$U(\text{attack } i, j \mid F, x, D) = E_{z|x} [U(\text{attack } i, j \mid F, z, D)] \quad (2)$$

where  $E_{z|x} [f(z)]$  stands for the conditional expectation of  $f(z)$  given  $x$

$$E_{z|x} [f(z)] = \sum_t f(z) p(z|x). \quad (3)$$

The utility of sending a reconnaissance mission given only the initial report  $x_1$ , is given by:

$$U(\text{shallow reconnaissance } i, i \mid x_1, F) = E_{x_2, D_1 | x_1} [\max U(\text{attack } i, j \mid F, x_2); U_{i, j-1}(F)] \quad (4)$$

with a similar expression ( $x_3$  replacing  $x_2$ ) for deep reconnaissance.

By comparing the magnitudes of the four terms:

- $U(\text{attack } i, j \mid F, x_1)$
  - $U(\text{shallow reconnaissance } i, j \mid F, x_1)$
  - $U(\text{deep reconnaissance } i, j \mid F, x_1)$
  - $U_{i, j-1}(F)$
- (5)

one can find the optimal choice among the four options available upon entering stage  $(i, j)$  with force  $F$  and upon obtaining an initial report  $x_1$ . The maximum of these four terms gives  $U(\text{entering } i, j \mid F, x_1)$  which, upon averaging, yields the entry utility  $U_{i, j}(F)$ :

$$U_{i,j}(F) = E_{x_1} [U(\text{entering } i,j|F,x_1)] \quad (6)$$

Equations (1) - (6) complete the calculation of the vector  $U_{i,j}(F)$  in terms of the two vectors  $U_{i-1,j}(F)$  and  $U_{i,j-1}(F)$ . The dimensionality of these vectors is equal to the number of levels that the variable  $F$  may assume. In our case,  $F$  may take 12 possible combinations of infantry, artillery and armour forces and so, the dimensionality of the entry-utility vector is 12.

The optimal decision policy should convey the following intuitive rule of behavior: When  $j$  is small and a low enemy force is reported (via  $x_1$ ), it does not pay to verify the accuracy of this report by sending a reconnaissance and risking detection. Reconnaissance would pay off only when  $j$  is large, since upon detection the player can still avoid confrontation and seek another encampment with low enemy force. The parameters defining the functions  $F_a(F,z,D)$ ,  $P_s(F,z,D)$ ,  $P(x_2|z)$  and  $P(x_3|x_2)$  should be chosen in such a way as to make the expected score highly sensitive to the violations of such common sense rules.



## 4.0 OPTIMIZATION ALGORITHM

Section 3.0 presented the optimization procedure in formal mathematical notation. This section describes the same procedure as a step-by-step computable algorithm.

### 4.1 OVERVIEW

Figure 2 shows the 28 possible positions (encampments) that could confront the player during a single game. They are arranged in 4 rows (enemy lines) and 7 columns. The start is at the lower left corner but since the computation occurs in reverse order, the encampments are numbered starting at the upper right corner. The optimality computation for each encampment depends on a number of pre-defined utility and probability matrices as well as on two state vectors that are passed from one encampment to the next. The U vector is, initially, the utility of each friendly force from 9 for HHH to 1 for NNN. (See Table 1). Thus,  $U(F)=(9,8,8,7,7,6,6,5,5,4,2,1)$ . The V vector is passed from each encampment to the next one on the left. It is initialized at -1 for each friendly force since a loss of a battle at the end of any enemy line results in a loss of the game. Thus, every encampment receives two vectors: (1) the U from the enemy line above and (2) the V from the encampment to the immediate right. When the optimality calculations are completed for one enemy line, a new U equal to the V of the left-most unit in the completed line, is passed to the next enemy line.

Figure 5 is a reproduction of Figure 3 but shows information flowing in the opposite direction. Each stage has been labelled for reference. Branch A is the player option to attack without reconnaissance. Branch B assumes that shallow reconnaissance has been chosen and branch C refers to deep reconnaissance. At each stage, a utility matrix is calculated

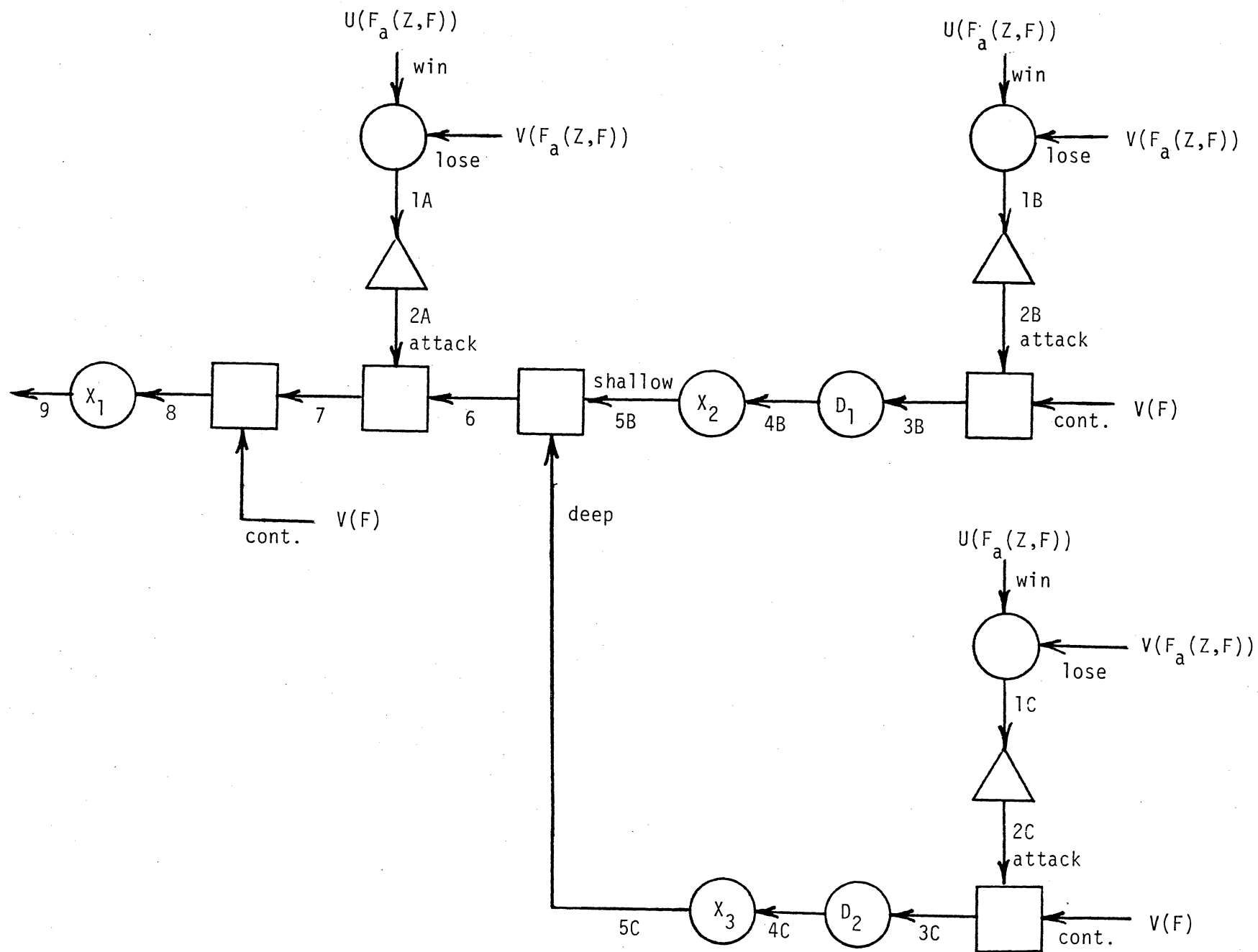


Figure 5. Optimization Information Flow

which reflects the information known at that time. It is then passed to the next stage. The first matrix is the utility of attacking knowing the true enemy strength  $Z$ . This matrix is the same for stages 1A, 1B, and 1C. It depends upon the passed vectors  $U$  and  $V$  and on the transition matrix  $F_a$  (See Table 1). Stage 2A represents the utility of attacking knowing only report  $X_1$ , the initial enemy strength report after having been passed through two noise filters. Stage 2B is the utility of attacking knowing report  $X_2$ , a single-filter enemy strength report given after shallow reconnaissance is chosen. Stage 2C is the same matrix as stage 1C since the true enemy strength is known after deep reconnaissance is chosen.

Stages 3B and 3C represent the maximum utility for either attacking or continuing to the next encampment (for shallow or deep respectively). 4B and 4C average over the situations of being detected or not detected after reconnaissance is selected. Stage 5B is the utility of taking shallow reconnaissance knowing report  $X_2$  and 5C is the utility of taking deep reconnaissance knowing report  $X_3$  (equivalent to  $Z$ ). At stage 6, branches B and C are combined to form the utility for selecting shallow or deep reconnaissance and this, in turn, is combined with branch A to form, at stage 7, a matrix which incorporates the utility for attacking without reconnaissance. Matrix 8 then incorporates the utilities for continuing to the next encampment immediately. Finally, matrix 8 combined with the possible initial reports  $X_1$  produce the new vector  $V$  to be transmitted to the next encampment on the left.

These calculations must be performed for each of the 28 encampments. They all require various probability matrices which are computed in advance. The final results are 5 decision maps corresponding to the 5 decision boxes in Figure 5 for each of the 28 encampments. These maps provide the optimal decisions for all possible situations encountered in any game. The decision maps are presented in Section 6.0 and the program code listing is in the Appendix.

## 4.2 INITIAL INFORMATION

Before the major utility matrices can be calculated, a number of probability matrices, some utility vectors, and the transition matrix must be defined. The initial utility of friendly forces  $U$  and the transmitted utility vector  $V$  were defined in the last section. The transition matrix  $F_a$  is in Table 1 and shows the reduction in forces after a battle regardless of win or loss. The probability of detection under shallow reconnaissance PDS is .4 and the probability of detection under deep reconnaissance PDD is .8 for the current game. The probability of win  $PW$  is also shown in Table 1 for every combination of friendly forces  $F$  and for every combination of enemy forces  $Z$ . The probability of win when detected is  $PWD(Z,F)=PW(Z,F)-.2$  with a lower bound of 0. The prior probability of enemy forces  $P(Z)$  is  $P(HHH)=2/7$ ,  $P(MMM)=2/7$ ,  $P(LLN)=2/7$ , and  $P(NLN)=1/7$ .

## 4.3 PROBABILITY MATRICES

From the information above, there are 3 initial required probability matrices: (1)  $PW(Z,F)$ , a  $4 \times 12$  matrix for the probability of win without detection, (2)  $PWD(Z,F)$ , a  $4 \times 12$  matrix for the probability of win when detected, and (3)  $P(Z)$ , a vector of 4 values for the probability of enemy forces.

### 4.3.1 Probability of Report $X_2$ given $Z$

$P(X_2/Z)$  is the probability of seeing report  $X_2$  given the true enemy force  $Z$ . Report  $X_2$  is displayed after selecting shallow reconnaissance and, thus, results from passing  $Z$  through one distortion filter. Each component of  $X_2$  (artillery, infantry, and tanks) could be at a level of high (H), medium (M), low (L), or nil (N) making 64 possible combinations in all. However, only 4 of them HHH, MMM, LLL, NLN are reserved for the initial enemy force. The filter randomly changes each component of  $Z$  by one step with equal probability either up, down, or no change. Thus, for

example, an initial Z of LLL could have its artillery component moved up to M while its tank component dropped to N producing an  $X_2$  report of MLN.  $P(X_2/Z)$ , then, is a 4x64 matrix showing the probability of every combination of  $X_2$  given a specific Z. For example,  $P(NNN/NLN)$  is 4/24. Some of these combinations are impossible since, for example, a report could not have an N if the initial corresponding component started out as an H.

Figure 6 shows the possible ways that a single component could be altered by one pass through the filter. For example, in Figure 6c, M could go to H, M, or L with equal probability. However, as shown in Figure 6a, N can only go to N or L, etc. Figure 7 is a table of the number of paths that each component can take to reach a final state. The probability is calculated by taking each of the possible 64 reports, multiplying the number of ways each component of Z can get to the component in  $X_2$  (see Figure 8), and dividing by 27 ( $3^3$ ). This forms  $P(X_2/Z)$ . Thus, the probability of report  $X_2$  given Z is the entry in the table in Figure 8 divided by 27.

#### 4.3.2 Probability of Report $X_1$ Given Z

Report  $X_1$  is displayed as soon as the player enters a new encampment and results from passing Z through the distortion filter twice.  $P(X_1/Z)$  is the probability that report  $X_1$  will show up given the enemy force Z. It is also a 4x64 matrix and is calculated the same way as  $P(X_2/Z)$ . Figure 9 shows the possible ways components of Z can be distorted to produce components of  $X_1$ . Figure 10 shows these combinations in tabular form. The matrix  $P(X_1/Z)$  is the square of the matrix  $P(X_2/Z)$  in Figure 7. Figure 11 is the result of multiplying the three components for each  $X_1$ . Thus,  $P(X_1/Z)$  can be obtained by dividing the entries in Figure 11 by 729 ( $9^3$ ). For example,  $P(NNN/NLN)$  is 75/729 or approximately 0.10288. Not all arrows are shown in Figures 9a or 9d. The arrows marked with "2" are doubled and should appear twice.

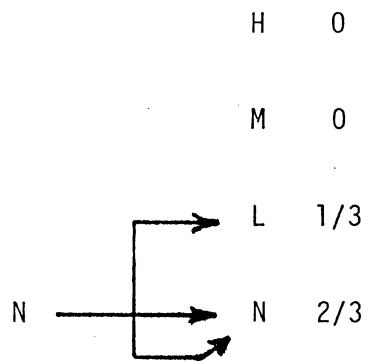


Figure 6a

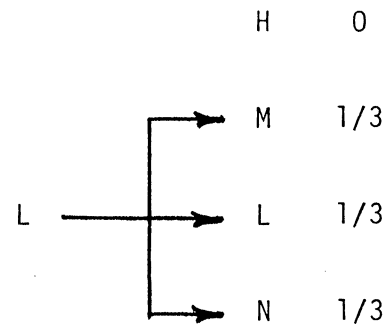


Figure 6b

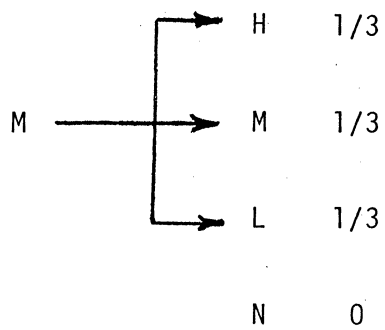


Figure 6c

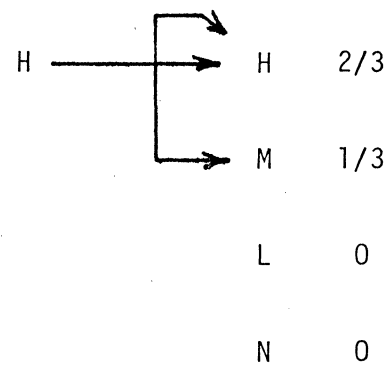


Figure 6d

Figure 6. Formulation of  $P(X_2/Z)$



		$x_2$			
		N	L	M	H
Z	N	2	1	0	0
	L	1	1	1	0
	M	0	1	1	1
	H	0	0	1	2

Figure 7. Ways to get from Z to  $x_2$

Z			Z		
H M L N			H M L N		
H M L L			H M L L		
H M L N			H M L N		
$X_2$			$X_2$		
1	NNN	0 0 1 4	33	NMH	0 0 0 0
2	NNL	0 0 1 2	34	NHM	0 0 0 0
3	NLN	0 0 1 4	35	MNH	0 0 0 0
4	LNN	0 0 1 2	36	MHN	0 0 0 0
5	NLL	0 0 1 2	37	HNM	0 0 0 0
6	LNL	0 0 1 1	38	HMN	0 0 0 0
7	LLN	0 0 1 2	39	LLH	0 1 0 0
8	NNM	0 0 1 0	40	LHL	0 1 0 0
9	NMN	0 0 1 4	41	HLL	0 1 0 0
10	MNN	0 0 1 0	42	LMM	0 1 1 0
11	LLL	0 1 1 1	43	MLM	0 1 1 0
12	NLM	0 0 1 0	44	MML	0 1 1 0
13	NML	0 0 1 2	45	NHH	0 0 0 0
14	LMN	0 0 1 0	46	HNH	0 0 0 0
15	LMN	0 0 1 2	47	HHN	0 0 0 0
16	MNL	0 0 1 0	48	LMH	0 1 0 0
17	MLN	0 0 1 0	49	LHM	0 1 0 0
18	NNH	0 0 0 0	50	MLH	0 1 0 0
19	NHN	0 0 0 0	51	MHL	0 1 0 0
20	HNN	0 0 0 0	52	HLM	0 1 0 0
21	LLM	0 1 1 0	53	HML	0 1 0 0
22	LML	0 1 1 1	54	MMM	1 1 1 0
23	MLL	0 1 1 0	55	LHH	0 1 0 0
24	NMM	0 0 1 0	56	HLH	0 1 0 0
25	MNM	0 0 1 0	57	HHL	0 1 0 0
26	MMN	0 0 1 0	58	MMH	2 1 0 0
27	NLH	0 0 0 0	59	MHM	2 1 0 0
28	NHL	0 0 0 0	60	HMM	2 1 0 0
29	LNH	0 0 0 0	61	MHH	4 1 0 0
30	LHN	0 0 0 0	62	HMH	4 1 0 0
31	HNL	0 0 0 0	63	HHM	4 1 0 0
32	HLN	0 0 0 0	64	HHH	8 1 0 0

Figure 8.  $P(X_2/Z)$  (divide by 27)

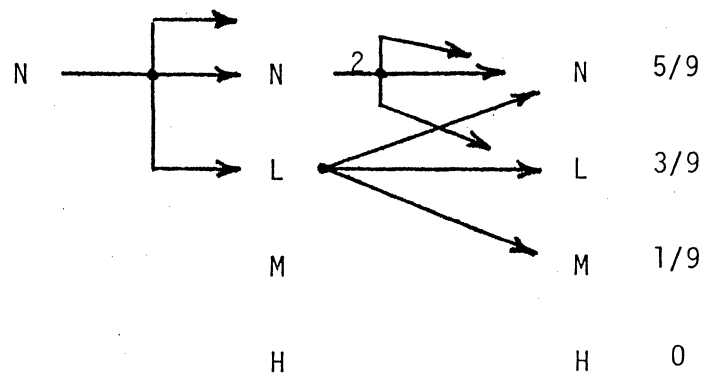


Figure 9a.

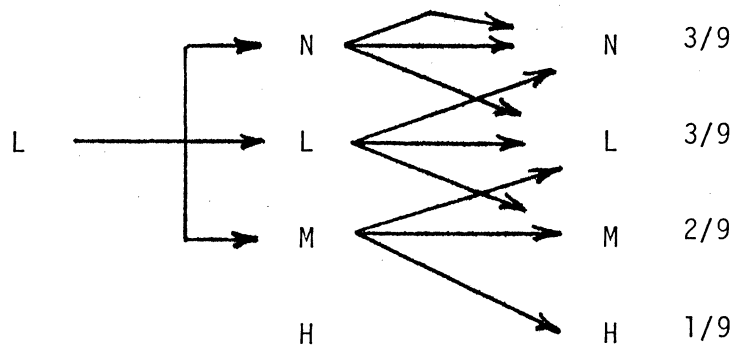


Figure 9b.

Figure 9. Formulation of  $P(X_1/Z)$

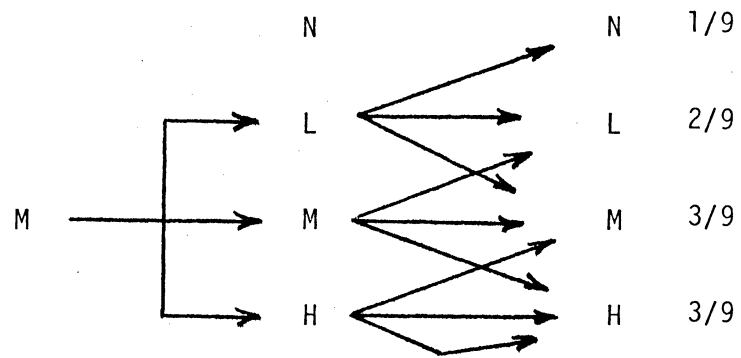


Figure 9c.

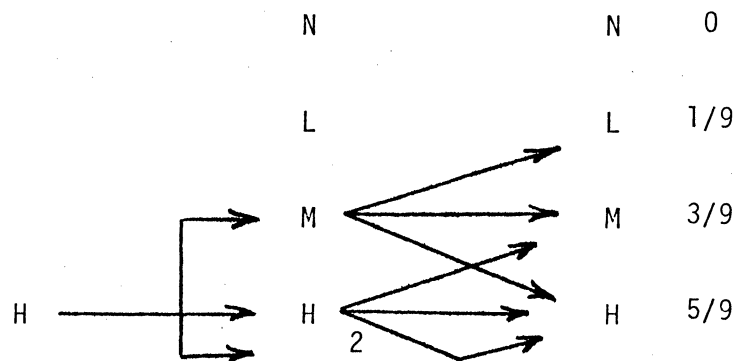


Figure 9d.

Figure 9. (Continued) Formulation of  $P(X_1/Z)$

		$X_1$			
		N	L	M	H
Z	N	5	3	1	0
	L	3	3	2	1
	M	1	2	3	3
	H	0	1	3	5

Figure 10. Ways to Get from Z to  $X_1$

		Z						Z			
		H	M	L	N			H	M	L	N
		H	M	L	L			H	M	L	L
		H	M	L	N			H	M	L	N
	$X_1$						$X_1$				
1	NNN	0	1	27	75	33	NMH	0	9	6	0
2	NNL	0	2	27	45	34	NHM	0	9	6	5
3	NLN	0	2	27	75	35	MNH	0	9	6	0
4	LNN	0	2	27	45	36	MHN	0	9	6	0
5	NLL	0	4	27	45	37	HNM	0	9	6	0
6	LNL	0	4	27	27	38	HMN	0	9	6	0
7	LLN	0	4	27	45	39	LLH	5	12	9	0
8	NNM	0	3	18	15	40	LHL	5	12	9	9
9	NMN	0	3	18	50	41	HLL	5	12	9	0
10	MNN	0	3	18	15	42	LMM	9	18	12	6
11	LLL	1	8	27	27	43	MLM	9	18	12	3
12	NLM	0	6	18	15	44	MML	9	18	12	6
13	NML	0	6	18	30	45	NHH	0	9	3	0
14	LMN	0	6	18	9	46	HNH	0	9	3	0
15	LMN	0	6	18	30	47	HHN	0	9	3	0
16	MNL	0	6	18	9	48	LMH	15	18	6	0
17	MLN	0	6	18	15	49	LHM	15	18	6	3
18	NNH	0	3	9	0	50	MLH	15	18	6	0
19	NHN	0	3	9	25	51	MHL	15	18	6	3
20	HNN	0	3	9	0	52	HLM	15	18	6	0
21	LLM	3	12	18	9	53	HML	15	18	6	0
22	LML	3	12	18	18	54	MMM	27	27	8	2
23	MLL	3	12	18	9	55	LHH	25	18	3	0
24	NMM	0	9	12	10	56	HLH	25	18	3	0
25	MNM	0	9	12	3	57	HHL	25	18	3	0
26	MMN	0	9	12	10	58	MMH	45	27	4	0
27	NLH	0	6	9	0	59	MHM	45	27	4	1
28	NHL	0	6	9	15	60	HMM	45	27	4	0
29	LNH	0	6	9	0	61	MHH	75	27	2	0
30	LHN	0	6	9	15	62	HMH	75	27	2	0
31	HNL	0	6	9	0	63	HHM	75	27	2	0
32	HLN	0	6	9	0	64	HHH	125	27	1	0

Figure 11.  $P(X_1/Z)$  (divide by 729)



#### 4.3.3 Unconditional Probability of Report $X_1$

$P(X_1)$  is the probability of report  $X_1$  showing up at the start of each encampment and is a vector of 64 entries. It can be computed directly from  $P(X_1/Z)$  and  $P(Z)$  as follows. (See Figure 12)

$$P(X_1) = \sum_Z P(X_1/Z)P(Z)$$

#### 4.3.4 Unconditional Probability of Report $X_2$

$P(X_2)$  is the probability of report  $X_2$  showing up after shallow reconnaissance is chosen and is a vector of 64 entries. It is computed from  $P(X_2/Z)$  and  $P(Z)$ . (See Figure 13)

$$P(X_2) = \sum_Z P(X_2/Z)P(Z)$$

#### 4.3.5 Probability of Report $X_2$ given Report $X_1$

$P(X_2/X_1)$  is the probability that the shallow reconnaissance report will show up given that one of the 64 possible initial reports has occurred (barring impossible initial reports). It is a 64x64 matrix. However,  $X_1$  is formed by running  $Z$  through two filters. Therefore,  $P(X_2/X_1)$  can be calculated by using Bayes' Rule and running  $X_2$  through one filter to produce  $X_1$ .

$$P(X_2/X_1) = \frac{P(X_1/X_2)P(X_2)}{P(X_1)}$$

Since  $P(X_1)$  and  $P(X_2)$  were calculated before, it is only necessary to form  $P(X_1/X_2)$ . This is accomplished using the same procedure as shown in Section 4.3.1 except that 64 combinations must be filtered rather than only 4. From this, it can be seen that  $P(X_1/Z)$  is a sub-matrix of  $P(X_1/X_2)$  having all 64 rows and 4 of the columns.

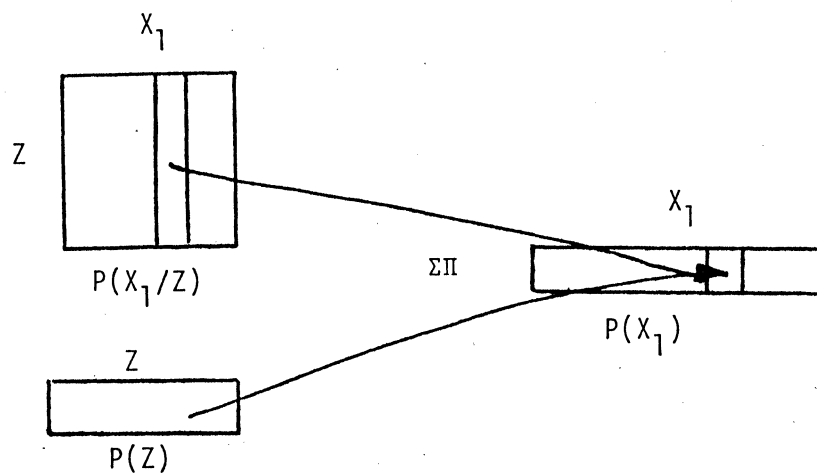


Figure 12.  $P(X_1) = \sum_Z P(X_1/Z)P(Z)$

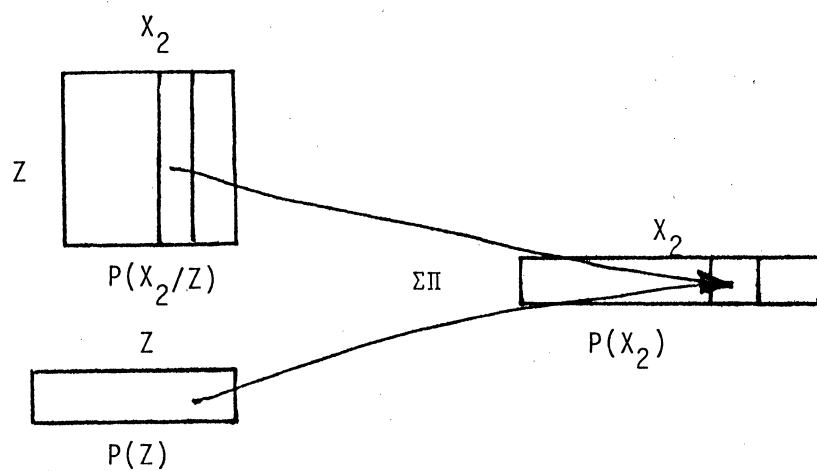


Figure 13.  $P(X_2/Z) = \sum_Z P(X_2/Z)P(Z)$

#### 4.3.6 Probability of Enemy Force Z given Report $X_1$

$P(Z/X_1)$  is the probability that Z will be the true enemy force given that report  $X_1$  has shown up in the game. It is  $4 \times 64$  in size and can be calculated from  $P(X_1/Z)$ ,  $P(Z)$ , and  $P(X_1)$  by Bayes' Rule.

$$P(Z/X_1) = \frac{P(X_1/Z)P(Z)}{P(X_1)}$$

#### 4.3.7 Probability of Enemy Force Z given Report $X_2$

$P(Z/X_2)$  is also  $4 \times 64$  and is calculated in the same way as  $P(Z/X_1)$ .

$$P(Z/X_2) = \frac{P(X_2/Z)P(Z)}{P(X_2)}$$

Strictly speaking, the information available after shallow reconnaissance is not  $X_2$  only, but the combination of  $X_1$  and  $X_2$ . However, since  $X_1$  was produced from  $X_2$  by an independent random process, it can be ignored in favor of its source  $X_2$ . Formally,  $P(X_1/Z, X_2) = P(X_1/X_2)$  implies  $P(Z/X_2, X_1) = P(Z/X_2)$ . This mechanism saves a substantial amount of computation since, otherwise, a  $64 \times 64$  matrix would be required to characterize all combinations of  $X_1$  and  $X_2$ .

#### 4.4 UTILITY MATRICES

At this point, the optimality calculations begin. The following utility matrices are computed for each of the 28 encampments. The 5 decision maps are produced as they are encountered and at the end of each enemy line (7 encampments) a new U is calculated to be used by the next enemy line. The computations are taken in parallel for each of the 3 branches in Figure 5. Most of the utility matrices must be duplicated for the detected and non-detected states.

##### 4.4.1 Utility of Attacking Knowing Z

Matrix U1 is the utility of attacking knowing the true enemy state Z and is 4x12 in size. Matrix U1D is the same for detected. It is found by averaging over the utility of winning U and the utility of losing V with the corresponding probabilities.

$$U1(Z,F) = U(F_a(Z,F))PW(Z,F) + V(F_a(Z,F))(1-PW(Z,F))$$

$$U1D(Z,F) = U(F_a(Z,F))PWD(Z,F) + V(F_a(Z,F))(1-PWD(Z,F))$$

The utility of winning is multiplied by the corresponding probability of winning and added to the utility of losing times the corresponding probability of losing. Since this represents an attack, the utilities must be obtained by referencing the transition matrix  $F_a$  to see what the remaining forces will be after the attack. Matrices U1 and U1D suffice for all 3 branches 1A, 1B, and 1C in Figure 5. (See Figures 14 and 15.)

##### 4.4.2 Utility of Attacking Knowing Report $X_1$

Stage 2A is the utility of attacking knowing only report  $X_1$  rather than the true state Z. Matrix U2A( $X_1$ ,F) is 64x12 in size and

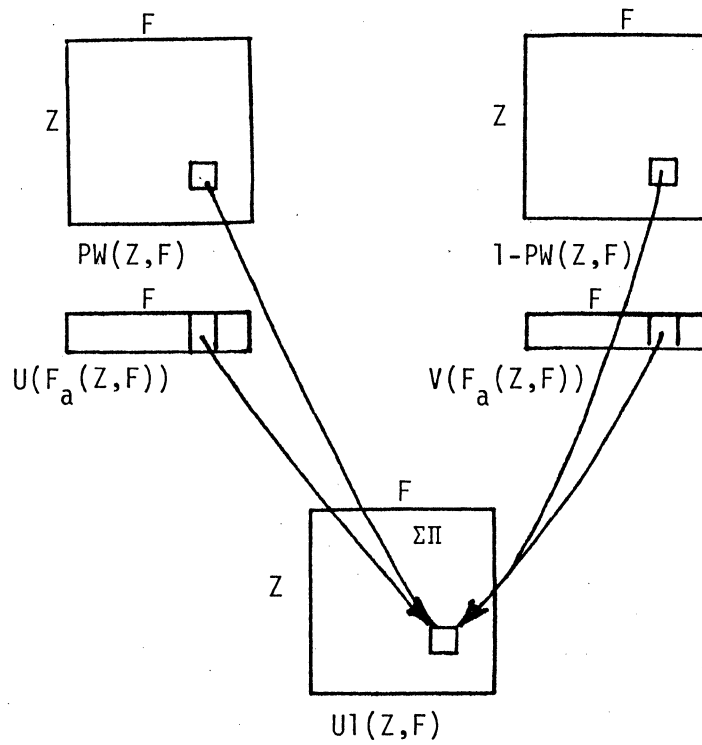


Figure 14.  $U_1(Z, F) = U(F_a(Z, F))PW(Z, F) + V(F_a(Z, F))(1-PW(Z, F))$

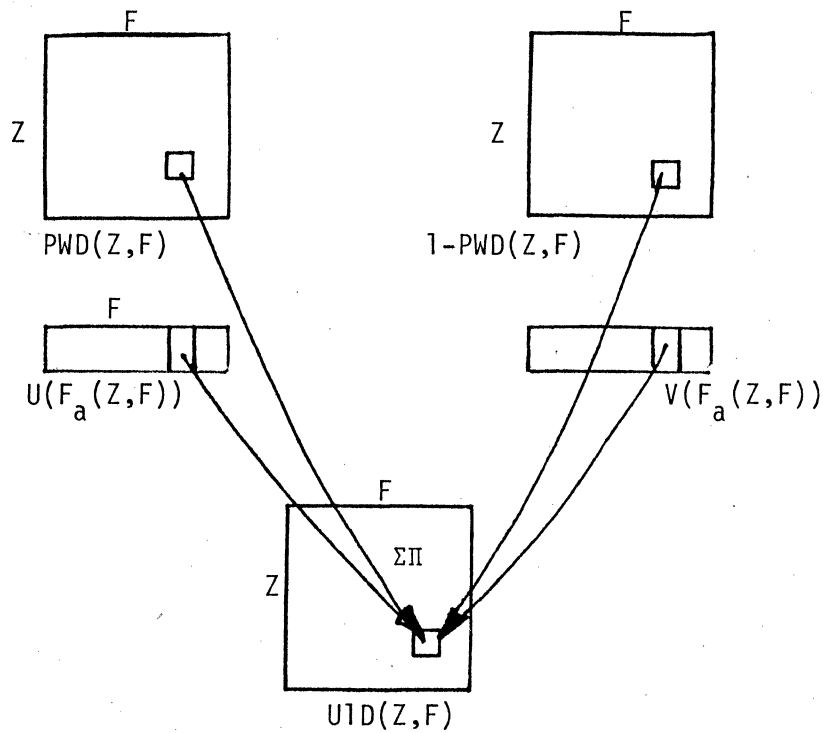


Figure 15.  $U_{1D}(Z, F) = U(F_a(Z, F))PWD(Z, F) + V(F_a(Z, F))(1-PWD(Z, F))$

can be calculated from  $U1(Z,F)$  and  $P(Z/X_1)$ .

$$U2A(X_1,F) = \sum_Z U1(Z,F)P(Z/X_1)$$

A corresponding matrix for detected is not required since branch A means that no reconnaissance was taken. (See Figure 16.)

#### 4.4.3. Utility of Attacking Knowing Report $X_2$

At stage 2B, the player has taken shallow reconnaissance and has decided to attack based on report  $X_2$ . This matrix,  $U2B(X_2,F)$  is  $64 \times 12$  and is calculated from  $U1$  and  $P(Z/X_2)$ . A corresponding matrix  $U2BD$  is based on  $U1D$  and is for detected. (See Figures 17 and 18.)

$$U2B(X_2,F) = \sum_Z U1(Z,F)P(Z/X_2)$$

$$U2BD(X_2,F) = \sum_Z U1D(Z,F)P(Z/X_2)$$

#### 4.4.4 Utility for Attacking or Continuing

Stages 3B and 3C represent the player's decision to attack or to continue to the next encampment given the report after choosing shallow or deep reconnaissance respectively.  $U3B(X_2,F)$  and  $U3BD(X_2,F)$  are the shallow reconnaissance matrices for not detected and detected. They are  $64 \times 12$  and computed by taking the maximum of  $U2B$  and  $V$ .  $U3C(Z,F)$  and  $U3CD(Z,F)$  are  $4 \times 12$  and are based on the maximum of  $U1$  and  $V$ .

$$U3B(X_2,F) = \text{MAX}(U2B(X_2,F), V(F))$$

$$U3BD(X_2,F) = \text{MAX}(U2BD(X_2,F), V(F))$$

$$U3C(Z,F) = \text{MAX}(U1(Z,F), V(F))$$

$$U3CD(Z,F) = \text{MAX}(U1D(Z,F), V(F))$$

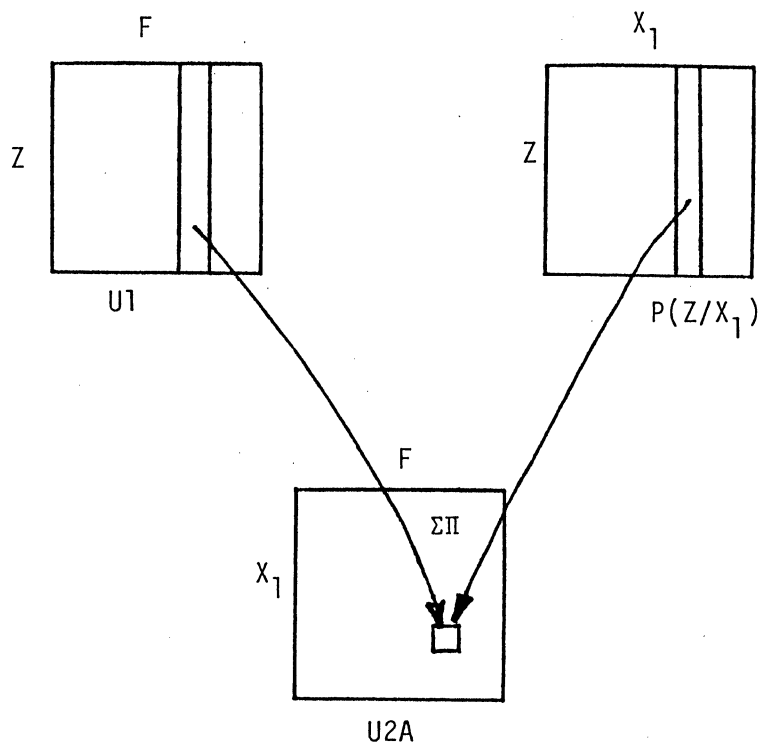


Figure 16.  $U2A(X_1, F) = \sum_Z U1(Z, F)P(Z/X_1)$

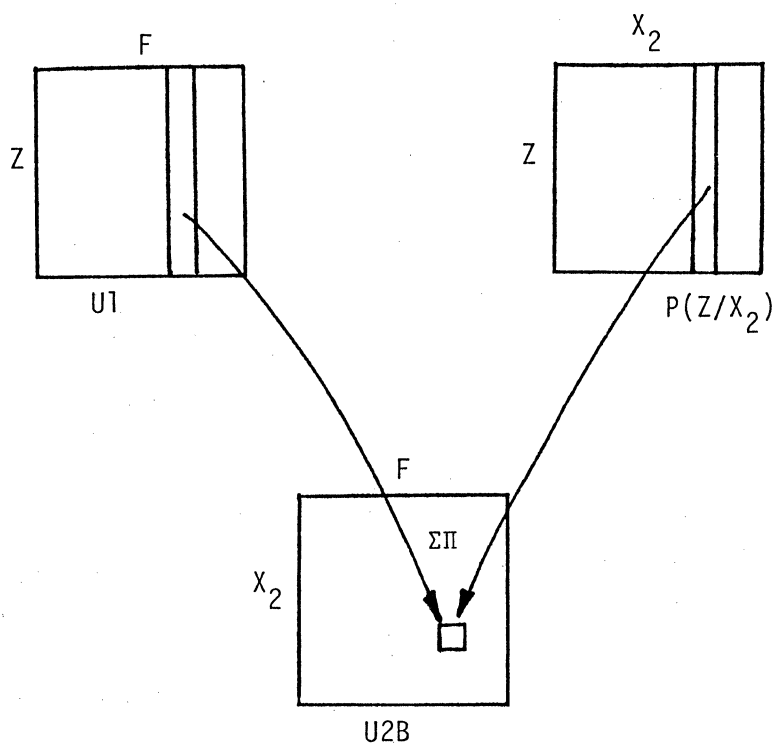


Figure 17.  $U2B(X_2, F) = \sum_Z U1(Z, F)P(Z/X_2)$

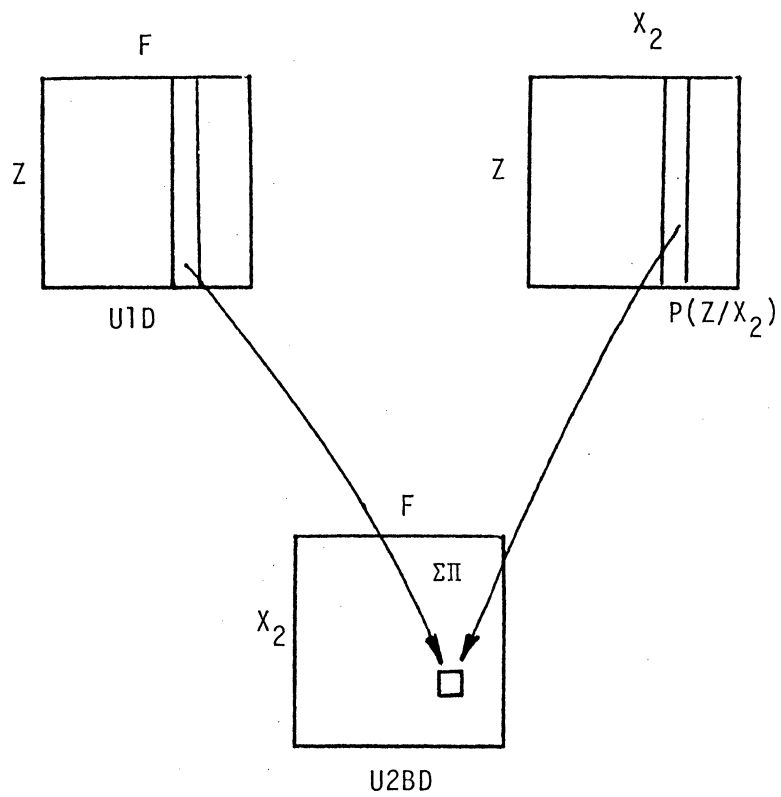


Figure 18.  $U2BD(X_2, F) = \sum_Z U1D(Z, F)P(Z/X_2)$



V is not passed through the transition matrix since this stage does not represent an attack, but continuing with the same forces. (See Figures 19, 20, 21, and 22.)

These 4 matrices form 4 of the major decision maps since they reflect the player's decision to attack or continue in a shallow/deep or detected/non-detected situation.

#### 4.4.5 Average Utility for Detected/Not Detected

At stage 4B and 4C, an average should be taken over the situations for detected and not detected using the corresponding probabilities for detection PDS and PDD. The results are the 64x12 matrix U4B for the shallow reconnaissance branch and the 4x12 matrix U4C for the deep reconnaissance branch. (See Figures 23 and 24.)

$$U4B(X_2, F) = U3B(X_2, F)(1-PDS) + U3BD(X_2, F)PDS$$

$$U4C(Z, F) = U3C(Z, F)(1-PDD) + U3CD(Z, F)PDD$$

#### 4.4.6 Utility of Taking Shallow or Deep Reconnaissance

Once an average has been taken over the possibility of being detected, the computation can progress to stages 5B and 5C which assume that either shallow or deep has been chosen, but the corresponding report has not yet been seen. Matrix U5B is a 64x12 array that captures the utility of taking shallow reconnaissance prior to knowing its outcome report  $X_2$ . It is found by combining U4B and  $P(X_2/X_1)$  and summing over  $X_2$ . (See Figure 25.)

$$U5B(X_1, F) = \sum_{X_2} U4B(X_2, F)P(X_2/X_1)$$

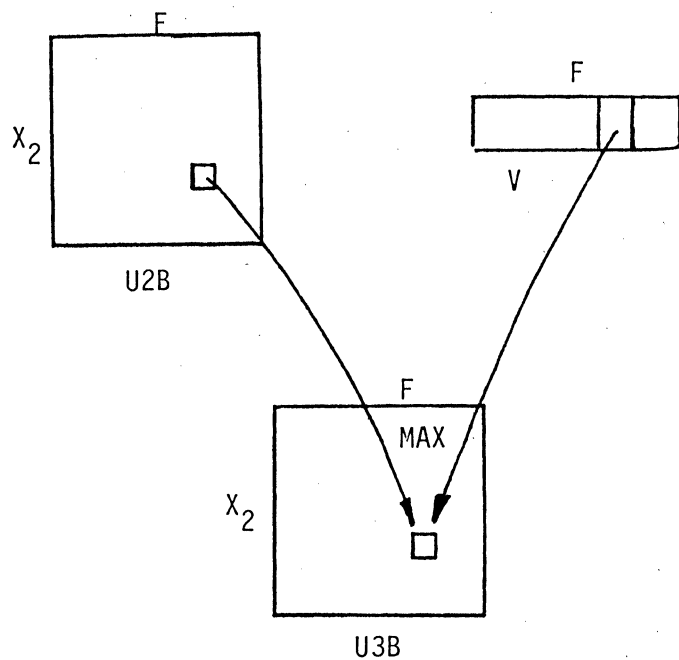


Figure 19.  $U3B(x_2, F) = \text{MAX}(U2B(x_2, F), V(F))$

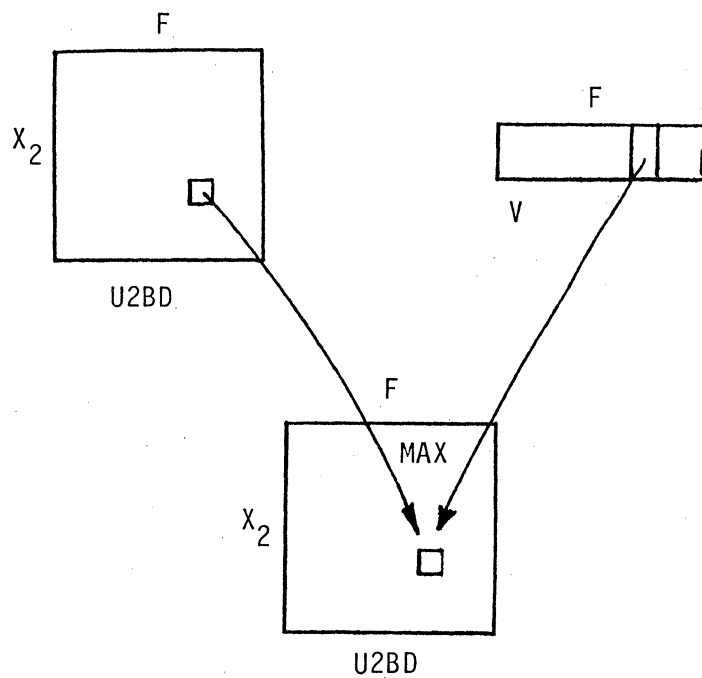


Figure 20.  $U3BD(x_2, F) = \text{MAX}(U2BD(x_2, F), V(F))$

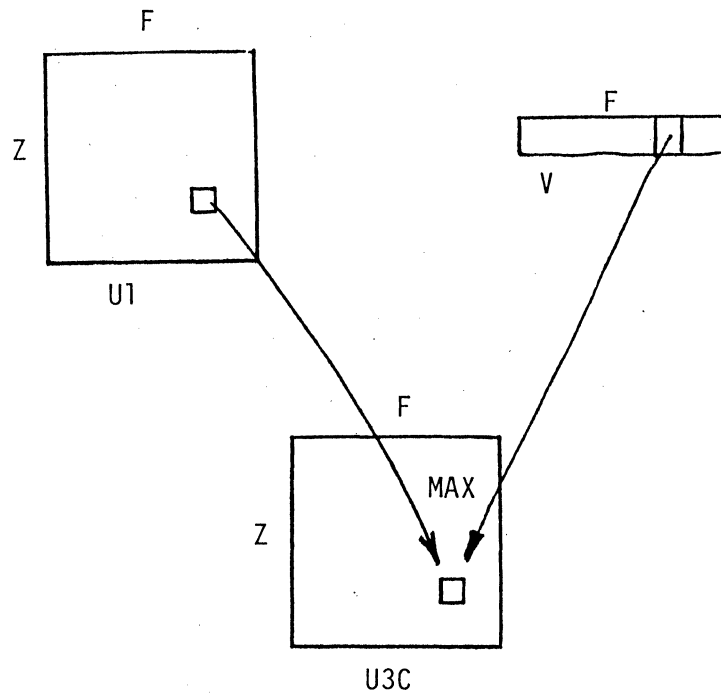


Figure 21.  $U3C(Z,F) = \text{MAX}(U1(Z,F), V(F))$

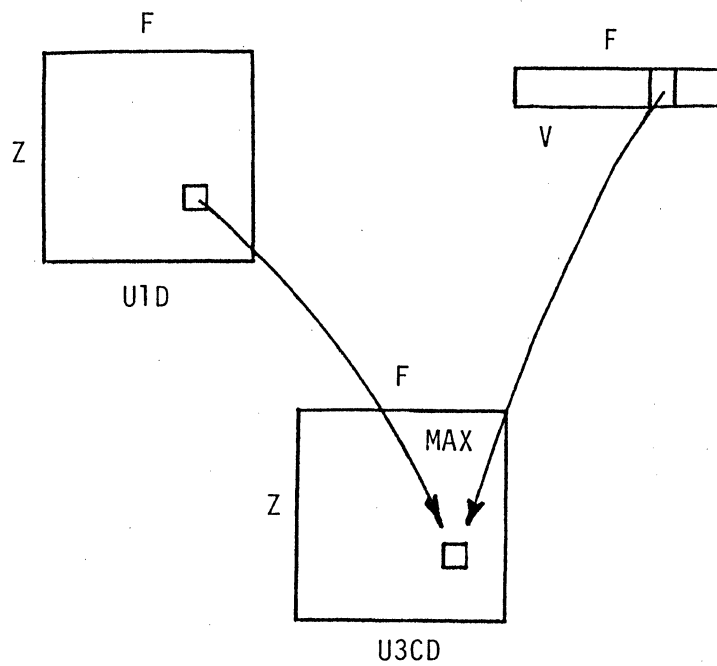


Figure 22.  $U3CD(Z,F) = \text{MAX}(U1D(Z,F), V(F))$

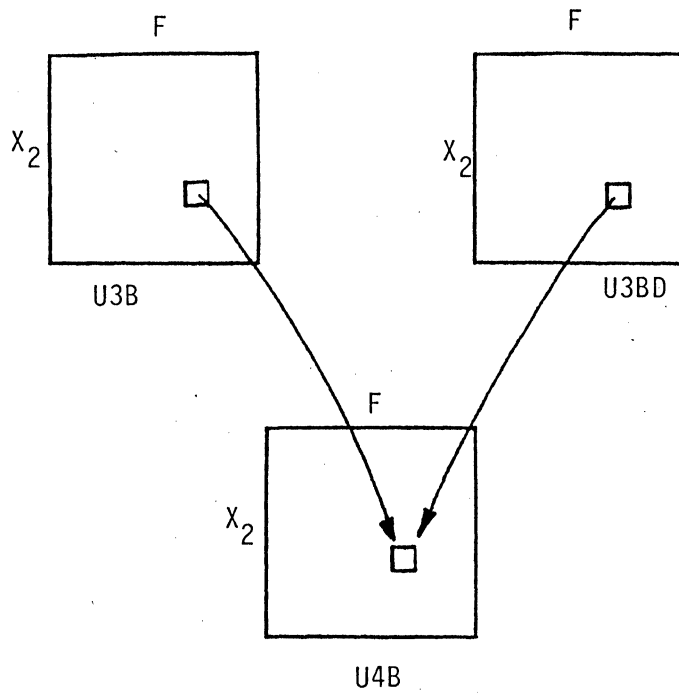


Figure 23.  $U4B(x_2, F) = U3B(x_2, F)(1-PDS) + U3BD(x_2, F)PDS$

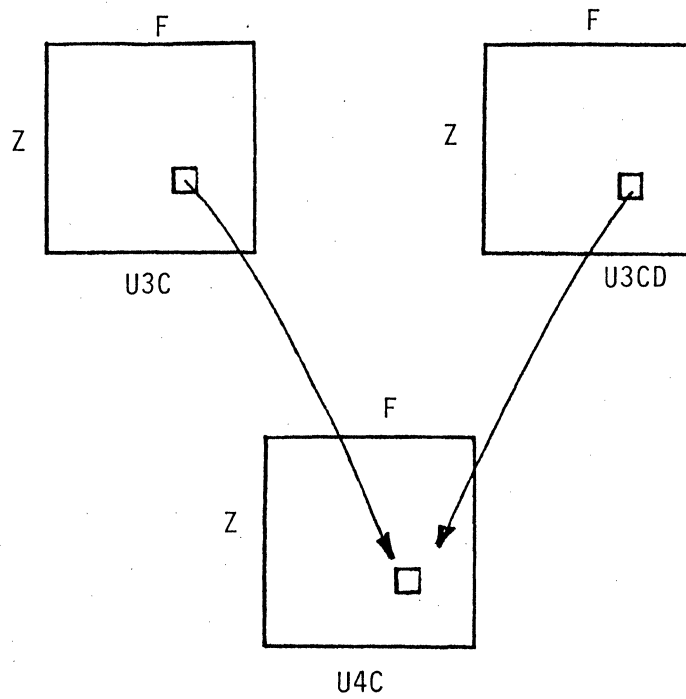


Figure 24.  $U4C(Z, F) = U3C(Z, F)(1-PDD) + U3CD(Z, F)PDD$

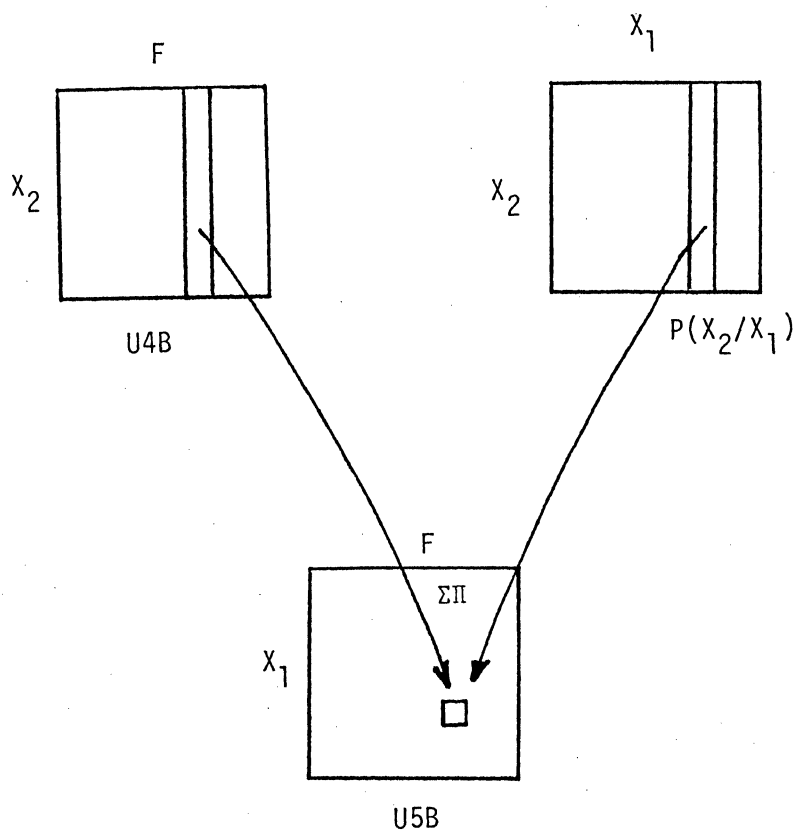


Figure 25.  $U5B(x_1, F) = \sum_{x_2} U4B(x_2, F) P(x_2/x_1)$

For stage 5C, a similar matrix  $U5C(X_1, F)$  is formed from  $U4C$  and  $P(Z/X_1)$  and is  $64 \times 12$  in size. (See Figure 26.)

$$U5C(X_1, F) = \sum_Z U4C(Z, F)P(Z/X_1)$$

Now, the maximum of these two matrices will form  $U6(X_1, F)$ , a  $64 \times 12$  matrix that contains the maximum utility (decision rule) for choosing shallow or deep reconnaissance once attack or continue have rejected. (See Figure 27.)

$$U6(X_1, F) = \text{MAX}(U5B(X_1, F), U5C(X_1, F))$$

#### 4.4.7 Utility of the Reconnaissance Option

Matrix  $U2A(X_1, F)$  can now be used and incorporated with  $U6$  to form  $U7(X_1, F)$ , a  $64 \times 12$  matrix that provides the decision rule for taking reconnaissance or attacking immediately assuming that continuing has been rejected. (See Figure 28.)

$$U7(X_1, F) = \text{MAX}(U6(X_1, F), U2A(X_1, F))$$

#### 4.4.8 Utility of the Attack, Continue, or Reconnaissance Option

$U7$  can now be compared to  $V$  in order to find out the utility of attacking or continuing.  $U8$  is simply the maximum of  $U7$  and  $V$ . Again,  $V$  is not passed through the transition matrix since continuing would cause the player to retain his current forces. (See Figure 29.)

$$U8(X_1, F) = \text{MAX}(U7(X_1, F), V(F))$$

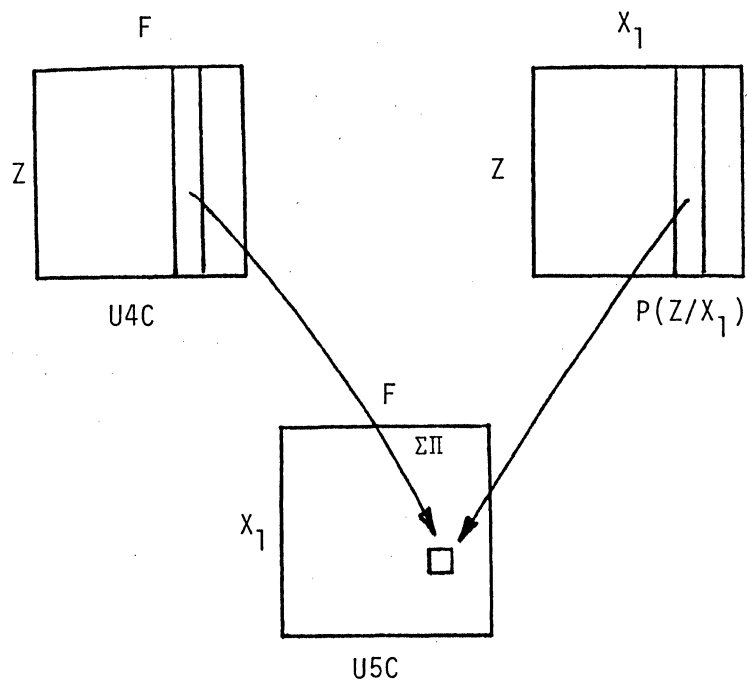


Figure 26.  $U5C(X_1, F) = \sum_Z U4C(Z, F)P(Z/X_1)$

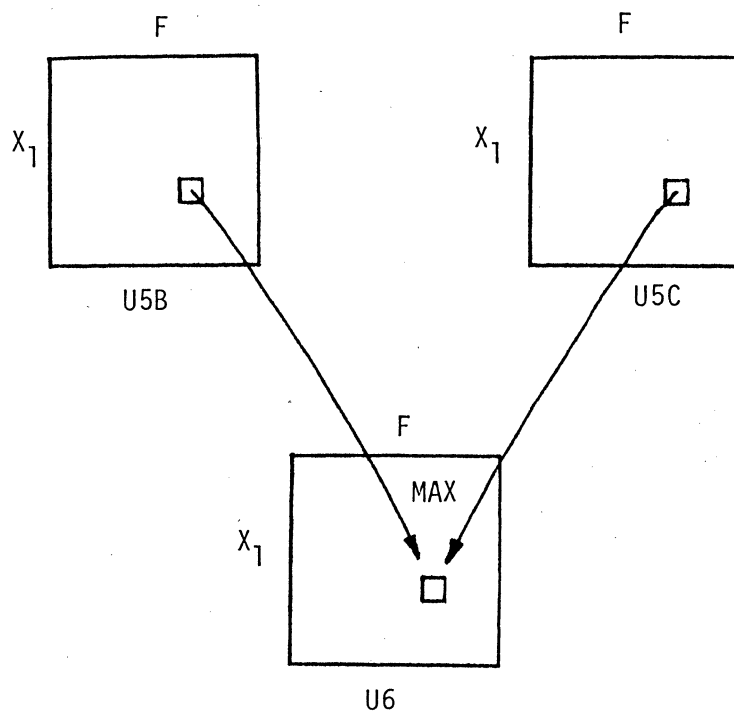


Figure 27.  $U6(X_1, F) = \text{MAX}(U5B(X_1, F), U5C(X_1, F))$

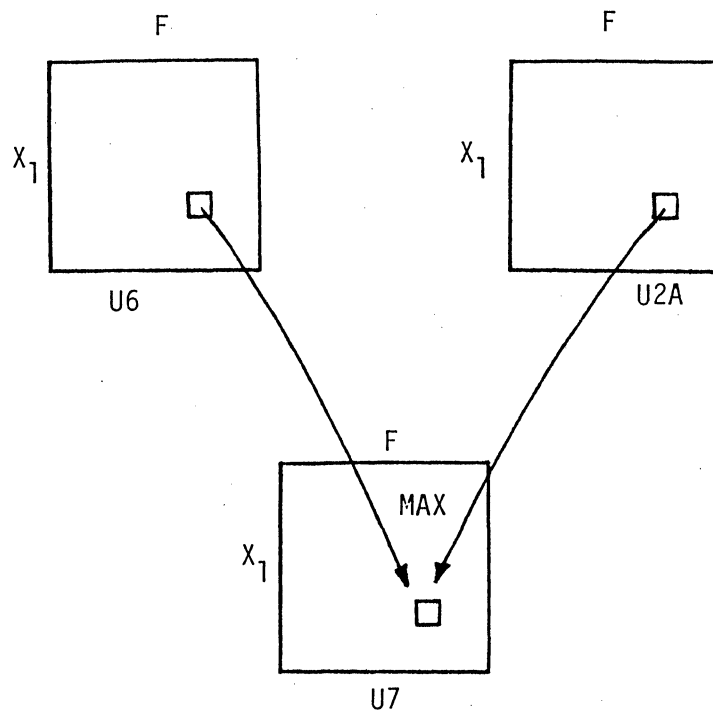


Figure 28.  $U7(X_1, F) = \text{MAX}(U6(X_1, F), (U2A(X_1, F)))$

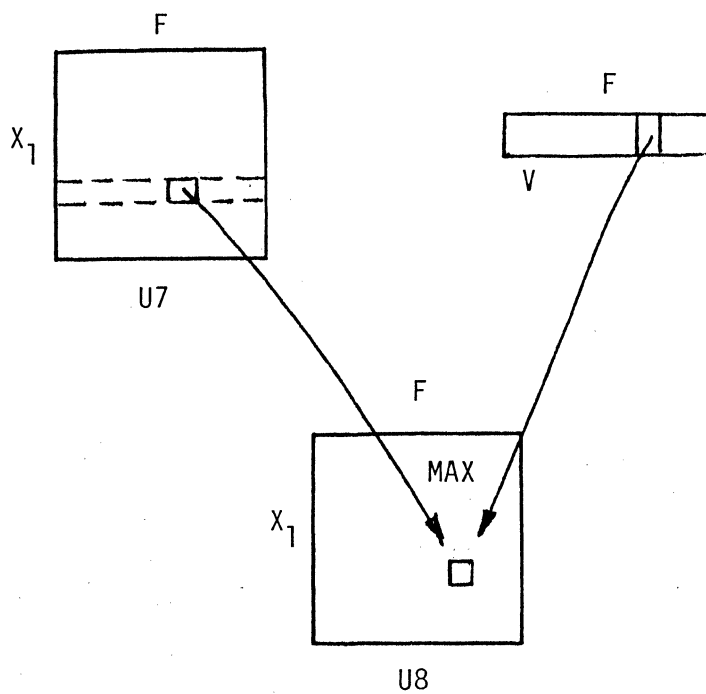


Figure 29.  $U8(X_1, F) = \text{MAX}(U7(X_1, F), V(F))$



#### 4.4.9 The Major Decision Map

The main decision map is formed from matrices U5B, U5C, U2A, and V. These feed into the production of U8 and, for each combination of friendly forces F and combination of reports  $X_1$ , give a highest value which is the decision to (1) attack immediately, (2) continue to the next encampment, (3) take shallow reconnaissance, or (4) take deep reconnaissance.

#### 4.4.10 The New Transmitted Vector

Once the main decision map is completed, a new vector V can be transmitted to the next encampment by using  $U8(X_1, F)$  and  $P(X_1)$ , and summing over  $X_1$ . The result is a 12-value vector. (See Figure 30.)

$$V(F) = \sum_{X_1} U8(X_1, F)P(X_1)$$

#### 4.4.11 The Next Enemy Line

When the current enemy line (7 encampments) is finished, a new utility vector  $U(F)$  is made from the previously transmitted V. The V vector is then set once again to -1 to start the next line.

$$U(F) = V(F)$$

$$V(F) = -1$$

The process continues until all 4 enemy lines have been completed. At this time, there are 140 decision maps which describe the optimal decision for every possible situation that could occur in the game.

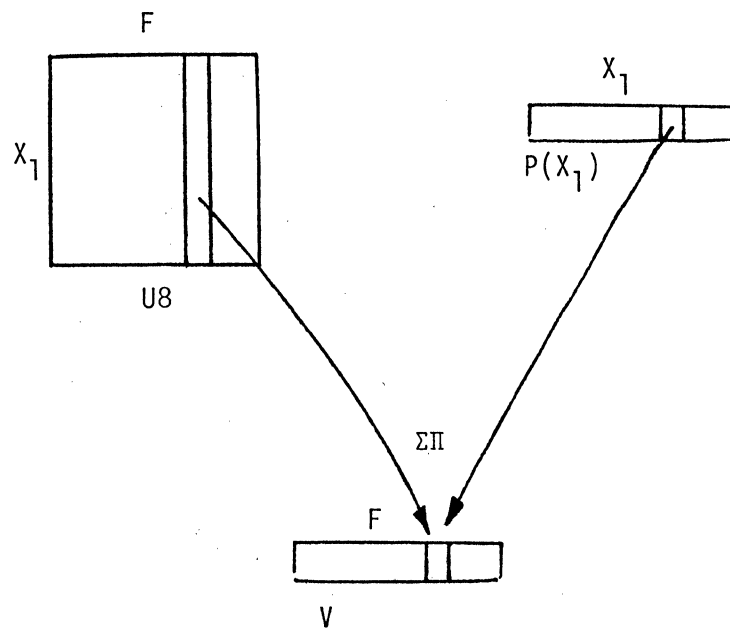


Figure 30.  $V(F) = \sum_{X_1} U8(X_1, F)P(X_1)$

## 5.0 THE DECISION MAPS

The following 140 decision maps show the results of the optimality procedure. They are in order from the first enemy line to the last (1-4) and from the first encampment to the last (1-7) although they were calculated in reverse. The main map is shown first and contains letters representing the four decisions:

- A - Attack immediately with no reconnaissance
- S - Take Shallow reconnaissance
- D - Take deep reconnaissance
- C - Continue directly to the next encampment

Only 11 of the 12 possible friendly forces  $F$  are shown since the last one (NNN) results in a lost game and no decisions could be made from it. The combinations are in order of artillery, infantry, and tanks from left-to-right. The columns are labelled with the possible reports  $X_1$  which initially show up when the encampment is first encountered. They are in order of artillery, infantry, and tanks from top-to-bottom.

The second map shows the A or C decisions that can be made providing that shallow was recommended in the main map. The same 64 column labels are used but now represent the results of report  $X_2$ . Some of the entries are missing since these combinations of  $X_2$  are impossible. This map is for not detected and the third map is for detected.

The last two maps are used when deep reconnaissance has been chosen. In these cases, the true enemy strength is known (report  $X_3$  is equivalent to Z) and, thus, there are only 4 columns. Again, the entries are either A for attack or C for continue.

DECISION MAP                  ENEMY LINE 4                  ENCAMPMENT 7                  (I=1, J=1)

NNNLLNLLNNMMLNNLLMMNNHLLMMNMNNLLHHNNMMHLLHLMNNHLLMMHHMLHHMMHMHMMH  
NNLNLNLNNLNNLMMNNLNNHNLMLMMNLHNNHMLHMLMHNHMLHLMMLHMLHMMHMHMMH  
NLNNLLMMNNLMLMNLNNHNNMLLMMNNHLLNNHMMHNMHLLMMLHNNHMLHMLHMLHMMHMH  
ATTACK/CONTINUE/SHALLOW/DEEP                  (REPORT X1)  
HHH                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
HHM                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
MHH                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
HMM                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
MHM                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
MMM                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
LHM                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
LMM                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
NHM                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
NMM                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
NLL                  AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED                  (REPORT X2)  
HHH                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
HHM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
MHH                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
HMM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
MHM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
MMM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
LHM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
LMM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
NHM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
NMM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
NLL                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED                  (REPORT X2)  
HHH                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
HHM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
MHH                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
HMM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
MHM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
MMM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
LHM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
LMM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
NHM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
NMM                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA  
NLL                  AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAA...AAAAAA

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED                  (REPORT X3)                  ATTACK/CONTINUE GIVEN DEEP, DETECTED  
HMLN                  HMLN  
HMLL                  HMLL  
HMLN                  HMLN  
HHH                  AAAA                  HHH                  AAAA  
HHM                  AAAA                  HHM                  AAAA  
MHH                  AAAA                  MHH                  AAAA  
HMM                  AAAA                  HMM                  AAAA  
MHM                  AAAA                  MHM                  AAAA  
MMM                  AAAA                  MMM                  AAAA  
LHM                  AAAA                  LHM                  AAAA  
LMM                  AAAA                  LMM                  AAAA  
NHM                  AAAA                  NHM                  AAAA  
NMM                  AAAA                  NMM                  AAAA  
NLL                  AAAA                  NLL                  AAAA

## DECISION MAP

ENEMY LINE 4

ENCAMPMENT 6

(I=1, J=2)

NNNLNLLNNMMLNMLMNNHLLMNMNNLLHNNNMHHLLHLMNNHLLMMHHMLHMMHMHMMHH  
 NNLNLLNMLNMLMNNHLLMNMNNLLHNNNMHHLLHLMNNHLLMMHHMLHMMHMHMMHH  
 NMLNLLNMLNMLMNNHLLMNMNNLLHNNNMHHLLHLMNNHLLMMHHMLHMMHMHMMHH  
 ATTACK/CONTINUE/SHALLOW/DEEP (REPORT X1)  
 HHH AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA  
 HHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDDDDDDDDD  
 MHH AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDDDDDDDDD  
 HMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDDDDDDDDD  
 MHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDDDSDDDDD  
 MMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDSSSDDDDD  
 LHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDSSSDDDDD  
 LMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDSSSDDDDD  
 NHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDSSSDDDDD  
 NMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDSDDDSSSDDDDD  
 NLL AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAASASASSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSDDDDD

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)  
 HHH AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 HHM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 MHH AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 HMM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 MHM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 MMM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 LHM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 LMM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 NHM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 NMM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 NLL AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... CCAAAA... CCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)  
 HHH AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 HHM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 MHH AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 HMM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 MHM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 MMM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 LHM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA... AAAAAA...  
 LMM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... CCAAAA... CCCCCCCCCCCCCCCCCC  
 NHM AAAAAAAAAAAAAAAAAAAAAA... AAAAAA... CCAAAA... CCCCCCCCCCCCCCCCCC  
 NMM AAAAAAAAAAAAAAAAAAAAAA... CACAAA... CCCCCC... CCCCCCCCCCCCCCCCCC  
 NLL AAAAAAACACCCACACC... CCCCCC... CCCCCC... CCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN  
 HMLL  
 HMLN  
 HHH AAAA  
 HHM CAAA  
 MHH CAAA  
 HMM CAAA  
 MHM CAAA  
 MMM CAAA  
 LHM CAAA  
 LMM CAAA  
 NHM CAAA  
 NMM CAAA  
 NLL CCAA

(REPORT X3)

HMLN  
 HMLL  
 HMLN  
 HHH CAAA  
 HHM CAAA  
 MHH CAAA  
 HMM CAAA  
 MHM CAAA  
 MMM CAAA  
 LHM CAAA  
 LMM CCAA  
 NHM CCAA  
 NMM CCAA  
 NLL CCAA

## DECISION MAP

ENEMY LINE 4

ENCAMPMENT 5

(I=1, J=3)

NNNLNLLNNMNLNNLLMMNNHLLMMNNMNLHNNNMHLLHLMNNHLLMMHMLHMMHMHMMHH  
 NNLNLLNLLNNMNLNNLLMMNNHLLMMNNMNLHNNNMHLLHLMNNHLLMMHMLHMMHMHMMHH  
 NLNNLLNMMNLHLLMMNNHLLMMNNMNLHNNNMHLLHLMNNHLLMMHMLHMMHMHMMHH

ATTACK/CONTINUE/SHALLOW/DEEP

(REPORT X1)

HHH AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDDDDDDDDDDDDDDDDDDDDDDD  
 HHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSDDDD  
 MHH AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSDDDD  
 HMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSDDDD  
 MHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSDDDD  
 MMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSDDDD  
 LHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSDDDD  
 LMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSSSSSD  
 NHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSSSSSD  
 NMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDDDAAADDDDDDDSDDDSSSSSSD  
 NLL AAAAAAAAAAAAAAAAAASSSSSSSSASSSSSSSSSSSSSSSSSSDSSSSSDSDSDDDSSDDDDDDDD

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

HHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 HHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCCCC  
 MHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCCCC  
 HMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCCCC  
 MHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCCCC  
 MMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCCCC  
 LHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCCCC  
 LMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCCCC  
 NHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCCCC  
 NMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 NLL AAAAAAAAAAAAAAAAAAAAAA...CACAAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

HHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 HHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 MHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 HMM AAAAAAAAAAAAAAAAAAAAAA...CACAAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC  
 MHM AAAAAAAAAAAAAAAAAAAAAA...CACAAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC  
 MMM AAAAAAAAAAAAAAAAAAAAAA...CACAAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC  
 LHM AAAAAAAAAAAAAAAAAAAAAA...CACAAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC  
 LMM AAAAAAAAAAAAAACAAAAAA...CCCCAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC  
 NHM AAAAAAAAAAAAAACAAAAAA...CCCCAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC  
 NMM AAAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC  
 NLL CCCCCCCCCCCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN

HMLL

HMLN

HHH CCAA  
 HHM CAAA  
 MHH CAAA  
 HMM CAAA  
 MHM CAAA  
 MMM CAAA  
 LHM CAAA  
 LMM CAAA  
 NHM CAAA  
 NMM CCAA  
 NLL CCAA

(REPORT X3)

HMLN

HMLL

HMLN

HHH CCAA  
 HHM CCAA  
 MHH CCAA  
 HMM CCAA  
 MHM CCAA  
 MMM CCAA  
 LHM CCAA  
 LMM CCAA  
 NHM CCAA  
 NMM CCAA  
 NLL CCAA

ENCAMPMENT 4

(I=1, J=4)

NNNNLNLNLNNMLNNLLMMNNHLLMMNNNNLLHHNNMMHHLLHLLMMNHLLMMHHMLHHMMHHMMHH  
NNLNLNLNLNNLLNNMNLNNHLLMLMMMLHHNNLMHHNNMLHLLMLMHHNNHLLHLLMMHLLHHMMHHMMHH  
NLNNLLNNNNLLMLNNLNNHNNMLMMNHLLNLNHMMHNNNNHLLMMLHHNNHMLMLMHHLLHHMMHHMMHH

ATTACK/CONTINUE/SHALLOW/DEEP

(REPORT X1)

[illegible]

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

(REPORT X2)

[illegible]

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED

(REPORT X2)

NAME	OVER	BARRELS	DELETED	REPORT	X27
HHH	AAAAAAAAAAAAAAAAAAAA	CACAAA	CCCCC	CCCCCCCCCCCCCCCC	
HHM	AAAAAAAAACACACACACC	CACCCC	CCCCC	CCCCCCCCCCCCCCCC	
MHH	AAAAAAAAACACACACACC	CACCCC	CCCCC	CCCCCCCCCCCCCCCC	
HMM	AAAAAAAAACACACACACC	CACCCC	CCCCC	CCCCCCCCCCCCCCCC	
MHM	AAAAAAAAACACACACACC	CACCCC	CCCCC	CCCCCCCCCCCCCCCC	
MMM	AAAAAAAAACACCCACACC	CCCCC	CCCCC	CCCCCCCCCCCCCCCC	
LHM	AAAAAAAAACACCCACACC	CCCCC	CCCCC	CCCCCCCCCCCCCCCC	
LMM	AAAAAAAAACACCCACACC	CCCCC	CCCCC	CCCCCCCCCCCCCCCC	
NHM	AAAAAAAAACACCCACACC	CCCCC	CCCCC	CCCCCCCCCCCCCCCC	
NMM	AAAAAACACACCCACACC	CCCCC	CCCCC	CCCCCCCCCCCCCCCC	
NLL	CCCCCCCCCCCCCCCC	CCCCC	CCCCC	CCCCCCCCCCCCCCCC	

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

FMN

HMI N

HILL

HMI 1

HMLN

(REPORT X3)

THREE  
HUMAN

HHH	CCAA
HHM	CCAA
MHH	CCAA
HMM	CCAA
MHM	CCAA
MMH	CCAA
LHM	CCAA
LMM	CCAA
NHM	CCAA
NMM	CCAA
NLL	CCAA

HHH	CCC
HHM	CCA
MHH	CCA
HMM	CCA
MHM	CCA
MMM	CCA
LHM	CCA
LMM	CCA
NHM	CCA
NMM	CCA
NLL	CCA





ENCAMPMENT 2

(I=1, J=6)

ATTACK/CONTINUE/SHA

(REPORT X1)

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

(REPORT X2)

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

(REPORT X2)

ATTACK/CONTINUE GIVEN. DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN

(REPORT X3)

HMLN

HHH	CCC
HHM	CCCA
MHH	CCCA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHH	CCCA
LMM	CCAA
NHM	CCAA
NMM	CCCA
NLL	CCCA

HHH	HHH
HMM	CCAA
HHH	CCCA
HMM	CCCA
HMM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCCA
NHM	CCCA
NMM	CCCA
NLL	CCCC



DECISION MAP

ENEMY LINE 3

ENCAMPMENT 7

(I=2, J=1)

NNNLNLLNMMNLLNLLMMNNHLLMMNNMNNLLHHNNMMHLLHLLMMNNHLLMMHHMLHHMMHMMHHH  
 NNLNLLNLLNMMNLLNMMNLLNHNLMMLMMNMLNHNLMHNNHNNMLHLLMMHNNHMLHLLMMHLLHMMHMMHH  
 NLNLLNMMNLLNMMNLLNHNLMMLMMNMLNHNLMHNNHNNMLHLLMMHNNHMLHLLMMHLLHMMHMMHH

ATTACK/CONTINUE/SHALLOW/DEEP

(REPORT X1)

HHH  
 HHM  
 MHH  
 HMM  
 MHM  
 MMM  
 LHM  
 LMM  
 NHM  
 NMM  
 NLL

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

HHH  
 HHM  
 MHH  
 HMM  
 MHM  
 MMM  
 LHM  
 LMM  
 NHM  
 NMM  
 NLL

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

HHH  
 HHM  
 MHH  
 HMM  
 MHM  
 MMM  
 LHM  
 LMM  
 NHM  
 NMM  
 NLL

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN  
 HMLL  
 HMLN

(REPORT X3)

HHH  
 HHM  
 MHH  
 HMM  
 MHM  
 MMM  
 LHM  
 LMM  
 NHM  
 NMM  
 NLL

HHH  
 HHM  
 MHH  
 HMM  
 MHM  
 MMM  
 LHM  
 LMM  
 NHM  
 NMM  
 NLL

HMLN  
 HMLL  
 HMLN

HHH  
 HHM  
 MHH  
 HMM  
 MHM  
 MMM  
 LHM  
 LMM  
 NHM  
 NMM  
 NLL

## DECISION MAP

ENEMY LINE 3

ENCAMPMENT 6

(I=2, J=2)

NNNLNLLNMLNLLMMNNHLLMMNNMLLHNNNMHLLHLMNNHLLMMHMLHMMHMHMMH  
 NNLNLLNMLNLLMMNNHLLMMNNMLLHNNNMHLLHLMNNHLLMMHMLHMMHMHMMH  
 NLLNLLNMLNLLMMNNHLLMMNNMLLHNNNMHLLHLMNNHLLMMHMLHMMHMHMMH

ATTACK/CONTINUE/SHALLOW/DEEP (REPORT X1)

HHH AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAASSSSSSD  
 HHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDSDDDDDDDDDDD  
 MHH AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDSDDDDDDDDDDD  
 HMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDSDDDSSSSDDDD  
 MHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDSDDDSSSSDDDD  
 MMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADADDDDAADDDDDSDDDSSSSDDDD  
 LHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADADDDDAADDDDDSDDDSSSSDDDD  
 LMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAASSSSSSAAASSSSSSSSSSSSSSSSDDDD  
 NHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAASSSSSSAAASSSSSSSSSSSSSSSSDDDD  
 NMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAASSSSSSSSSSSSSSSSSSSSSSSSSSSSD  
 NLL AAAAAAAAAAAAAAAAAAAAAAAAAASASASSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSD

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

HHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAAAAAACCCCCCCC  
 HHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAAAAAACCCCCCCC  
 MHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAAAAAACCCCCCCC  
 HMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAAAAAACCCCCCCC  
 MHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAAAAAACCCCCCCC  
 MMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 LHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 LMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 NHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 NMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 NLL AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

HHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 HHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 MHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 HMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 MHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 MMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 LHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 LMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 NHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...AAAAAA...AAAAAACAAACCCCCCCC  
 NMM AAAAAAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC  
 NLL AAAAAACACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN

HMLL

HMLN

HHH CAAA  
 HHM CAAA  
 MHH CAAA  
 HMM CAAA  
 MHM CAAA  
 MMM CAAA  
 LHM CAAA  
 LMM CAAA  
 NHM CAAA  
 NMM CCAA  
 NLL CCAA

(REPORT X3)

HMLN

HMLL

HMLN

HHH CCAA  
 HHM CAAA  
 MHH CAAA  
 HMM CCAA  
 MHM CCAA  
 MMM CCAA  
 LHM CCAA  
 LMM CCAA  
 NHM CCAA  
 NMM CCAA  
 NLL CCAA

(I=2, J=3)

ATTACK/CONTINUE/SHALLOW/DEEP

(REPORT X1)

[illegible]

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

(REPORT X2)

H H H	A A A A A A A A A A A A A A A A . . . . .	A A A A A A . . . . .	C C C A A A . . . . .	C C C C C C C C C C C C C C C C C C C C C C
H H M	A A A A A A A A A A A A A A A A . . . . .	A A A A A A . . . . .	A A A A A A . . . . .	A A A A A A C A A A C C C C C C C C C C C C
M H H	A A A A A A A A A A A A A A A A . . . . .	A A A A A A . . . . .	A A A A A A . . . . .	A A A A A A C A A A C C C C C C C C C C C C
H M M	A A A A A A A A A A A A A A A A . . . . .	A A A A A A . . . . .	C C C A A A . . . . .	C C C C C C C C C C C C C C C C C C C C C C
M H M	A A A A A A A A A A A A A A A A . . . . .	A A A A A A . . . . .	C C C A A A . . . . .	C C C C C C C C C C C C C C C C C C C C C C
M M M	A A A A A A A A A A A A A A A A . . . . .	C A C A A A . . . . .	C C C C C C . . . . .	C C C C C C C C C C C C C C C C C C C C C C
L H M	A A A A A A A A A A A A A A A A . . . . .	C A C A A A . . . . .	C C C C C C . . . . .	C C C C C C C C C C C C C C C C C C C C C C
L M M	A A A A A A A A A A A A A A A A . . . . .	A A A A A A . . . . .	C C C A A A . . . . .	C C C C C C C C C C C C C C C C C C C C C C
N H M	A A A A A A A A A A A A A A A A . . . . .	A A A A A A . . . . .	C C C A A A . . . . .	C C C C C C C C C C C C C C C C C C C C C C
N M M	A A A A A A A A A A A A A A A A . . . . .	C A C A A A . . . . .	C C C C C C . . . . .	C C C C C C C C C C C C C C C C C C C C C C
N L L	A A A A A A A C A C C C A C A C C . . . . .	C C C C C C . . . . .	C C C C C C . . . . .	C C C C C C C C C C C C C C C C C C C C C C

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

(REPORT X2)

[illegible]

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN

HMLN

HMLL

HMI 1

HMLN

HMI N

(REPORT X3)

HHH	CCAA
HHM	CAAA
MHH	CAAA
HMM	CCAA
MHM	CCAA
MMM	CCAA
LHM	CCAA
LMM	CCAA
NHM	CCAA
NMM	CCAA
NLL	CCCA

HHH	CCAA
HHM	CCAA
MHH	CCAA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCCA
NHM	CCCA
NMM	CCCA
NLL	CCCC

(I=2, J=4)

ATTACK/CONTINUE/SHALLOW/DEEP

(REPORT X1)

[illegible]

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

HHH	AAAAA	CACAA	CCCCC	CCCCCCCCCCCCCCCC
HHM	AAAAA	AAAAA	CCCAA	CCCCCCCCCCCCCCCC
MHH	AAAAA	AAAAA	CCCAA	CCCCCCCCCCCCCCCC
HMM	AAAAA	CACAA	CCCCC	CCCCCCCCCCCCCCCC
MHM	AAAAA	CACAA	CCCCC	CCCCCCCCCCCCCCCC
MMM	AAAAA	CACCC	CCCCC	CCCCCCCCCCCCCCCC
LHM	AAAAA	CACCC	CCCCC	CCCCCCCCCCCCCCCC
LMM	AAAAA	CACAA	CCCCC	CCCCCCCCCCCCCCCC
NHM	AAAAA	CACAA	CCCCC	CCCCCCCCCCCCCCCC
NMM	AAAAA	CCCAA	CCCCC	CCCCCCCCCCCCCCCC
NLL	CCCCC	CCCCC	CCCCC	CCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

REFERENCE	OVER	CHARACTER	DEFINITION	REPORT	KEY
HHH	AAAA	AAAAAAAC	AAAAAAAC	CCCCAA	CCCCCC
HHM	AAAA	AAAAAAAC	AAAAAAAC	CCCCCC	CCCCCC
MHH	AAAA	AAAAAAAC	AAAAAAAC	CCCCCC	CCCCCC
HMM	AAAA	AAAAAAAC	AAAAAAAC	CCCCCC	CCCCCC
MHM	AAAA	AAAAAAAC	AAAAAAAC	CCCCCC	CCCCCC
MMM	AAAA	AAAAAAAC	AAAAAAAC	CCCCCC	CCCCCC
LHM	AAAA	AAAAAAAC	AAAAAAAC	CCCCCC	CCCCCC
LMM	ACAC	CCCCAC	CCCCCCCC	CCCCCC	CCCCCC
NHM	ACAC	CCCCAC	CCCCCCCC	CCCCCC	CCCCCC
NMM	ACAC	CCCCAC	CCCCCCCC	CCCCCC	CCCCCC
NLL	CCCC	CCCCCCCC	CCCCCCCC	CCCCCC	CCCCCC

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

..... CCCCCC..... CCCCCCCCCCCCCCCCCCCC  
ATTACK/CONTINUE GIVEN DEEP, DETECTED

	HMLN
	HMLL
	HMLN
HHH	CCAA
HHM	CCAA
MHH	CCAA
HMM	CCAA
MHM	CCAA
MMM	CCCA
LHM	CCCA
LMH	CCAA
NHM	CCAA
NMM	CCAA
NLL	CCCA

(REPORT X3)

	HMLN
	HMLL
	HMLN
HHH	CCAA
HHM	CCCA
MHH	CCCA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCCA
NHM	CCCA
NMM	CCCA
NLL	CCCA

ENEMY LINE 3

ENCAMPMENT 3

 $(I=2, J=5)$ 

ATTACK/CONTINUE/SHALLOW/DEEP

(REPORT X1)

HHM  
MHH  
HMM  
MHH  
MMM  
LHM  
LMM  
NHM  
NMM  
NLL

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED

(REPORT X2)

HHH  
HHM  
MH4  
HMM  
MHM  
MMM  
LHM  
LMM  
NHM  
NMM  
NL4

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED

(REPORT X2)

HHH  
HHM  
MHH  
HMM  
MHM  
MMM  
LHM  
LMM  
NHM  
NMM  
NIL

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HHH  
HHM  
MHH  
HMM  
MHM  
MMM  
LHM  
LMM  
NHM  
NMM  
NLL

(REPORT X3)

HHH  
HHM  
MHH  
HMM  
MHH  
MMM  
LHM  
LMM  
NHM  
NMM  
NLL

(I=2, J=6)

(REPORT X1)

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

.....CCCCC.....CCCCCCCCCCCCCCCCCC  
ATTACK/CONTINUE GIVEN DEEP, DETECTED

(REPORT X3)

HHH	CCAA
HHM	CCCA
MHH	CCCA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCAA
NHM	CCAA
NMM	CCCA
NLL	CCCC

HHH	CCAA
HHM	CCCA
MHH	CCCA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCCA
NHM	CCCA
NMM	CCCA
NLL	CCCC



(I=2, J=7)

ATTACK/CONTINUE/SHALLOW/DEEP

(REPORT X1)

[illegible]

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

SECRET ORY REL

HHH	AAAAAAAAAACA	AAAAAA	CCCCAA	CCCCC	CCCCCCCCCCCCCCCCCCCC
HHM	AAAAAAACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
MHH	AAAAAAACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
HMM	AAAAAAACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
MHM	AAAAAAACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
MMM	AAAAACACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
LHM	AAAAACACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
LMM	AAAAAAACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
NHM	AAAAAAACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
NMM	AAAAAAACAC	CCACAC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC
NLL	CCCCCCCC	CCCCCCCC	CCCCC	CCCCC	CCCCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

(REPORT X2)

[illegible]

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

FIMLN

HMI N

HILL

FILED  
HMI

HMLN

HILL  
HILL N

(REPORT X3)

HHH	CCC
HHH	CCC
MHH	CCC
HMM	CCC
MHM	CCC
MMM	CCC
LHM	CCC
LMM	CCC
NHM	CCC
NMM	CCC
LLL	CCC

HHH	HHH
HHM	CCAA
MHH	CCCA
HMM	CCCA
MHM	CCCA
NMM	CCCA
LHM	CCCA
LMM	CCCC
NHM	CCCC
NMM	CCCC
NLL	CCCC

H H H  
H H M  
M H H  
H M M  
M H M  
M M M  
L H M  
L M M  
N H M  
N M M  
N L L

(I=3, J=2)

ATTACK/CONTINUE/SHALLOW/DEEP

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

ATTACK/CONTINUE GIVEN SHALLOW DETECTED (REPORT X2)

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

(REPORT X3)

HHH	HHH
HHM	CCAA
MHH	CAAA
HMM	CAAA
MHM	CCAA
MMM	CCAA
LHM	CCCA
LMM	CCCA
NHM	CCAA
NMM	CCAA
NLL	CCCA



ENEMY LINE 2

ENCAMPMENT 4

(I=3, J=4)

[illegible]

```

-62-
ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)
HHH AAAAAAAAAAAAAAAAAAAAAA CACAAA CCCCCC CCCCCCCCCCCCCCCCCCCC
HMM AAAAAAAAAAAAAAAAAAAAAA CACAAA CCCCCC CCCCCCCCCCCCCCCCCCCC
MHH AAAAAAAAAAAAAAAAAAAAAA CACAAA CCCCCC CCCCCCCCCCCCCCCCCCCC
HMM AAAAAAACACACACACACC CACCCC CCCCCC CCCCCCCCCCCCCCCCCCCC
MHM AAAAAAACACACACACACC CACCCC CCCCCC CCCCCCCCCCCCCCCCCCCC
MMM AAAAAAACACCCACACACC CCCCCC CCCCCC CCCCCCCCCCCCCCCCCCCC
LHM AAAAAAACACCCACACACC CCCCCC CCCCCC CCCCCCCCCCCCCCCCCCCC
LMM AAAAAAAAAAACAAAAAA CCAAAA CCCCCC CCCCCCCCCCCCCCCCCCCC
NHM AAAAAAAAAAACAAAAAA CCAAAA CCCCCC CCCCCCCCCCCCCCCCCCCC
NMM AAAAAAACACCCACACACC CCCCCC CCCCCC CCCCCCCCCCCCCCCCCCCC
NLL CCCCCCCCCCCCCCCCCC CCCCCC CCCCCC CCCCCCCCCCCCCCCCCCCC

```

```

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)
HHH AAAAAAAAAAAGAAAAAA . . . CCCAAA . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
HHM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
MHH AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
MMM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
MHM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
MMM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
LHM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
LMM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
NHM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
NMM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
NLL CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC

```

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED      ATTACK/CONTINUE GIVEN DEEP, DETECTED

HHH	CCAA
HHM	CCAA
MHH	CCAA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCAA
NHM	CCAA
NMM	CCCA
NLL	CCCA

(REPORT X3)

SENTENCE GIVEN	D
	HMLN
	HMLL
	HMLN
HHH	CCAA
HMM	CCCA
MHH	CCCA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCCA
NHM	CCCA
NMM	CCCA
NLL	CCCL

ENEMY LINE 2

(I=3, J=5)

```

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)
HHH AAAAAAAAAAACA AAAAAA. . . CCCAAA. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
HHM AAAAAAACACACACACC. . . CACCCC. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
MHH AAAAAAACACACACACC. . . CACCCC. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
HMM AAAAAAACACCCACACC. . . CCCCCC. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
MHM AAAAAAACACCCACACC. . . CCCCCC. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
MMM AAAAAAACACCCACACC. . . CCCCCC. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
LHM AAAAAAACACCCACACC. . . CCCCCC. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
LMM AAAAAAAAAAACA AAAAAA. . . CCCAAA. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
NHM AAAAAAAAAAACA AAAAAA. . . CCCAAA. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
NMM CCCCCCCCCCCCCCCCCC. . . CCCCCC. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC
NLL CCCCCCCCCCCCCCCCCC. . . CCCCCC. . . CCCCCC. . . CCCCCCCCCCCCCCCCCCCC

```

```

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)
HHH AAAAAAAAAAACAAAAAA . . . CCCAAA . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
HHM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
MHH AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
HMM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
MHM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
MMM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
LHM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
LMM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
NHM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
NMM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
NLL CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC

```

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED      ATTACK/CONTINUE GIVEN DEEP, DETECTED

HHH	HMLN		HMLN
HHH	HMLL	(REPORT X3)	HMLL
MHH	HMLN		HMLN
HMM	CCAA		CCAA
MHM	CCCA		CCCA
HMM	CCCA		CCCA
MHM	CCCA		CCCA
MMM	CCCA		CCCA
LHM	CCCA		CCCA
LMM	CCAA		CCCA
NHM	CCAA		CCCA
NMM	CCCC		CCCC
NLL	CCCC		CCCC

(I=3, J=6)

[illegible][illegible]

```

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)
HHH AAAAAAAAAAACA AAAAAA . . . CCCAAA . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
HHM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
MHH AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
HMM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
MHM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
MMM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
LHM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
LMM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
NHM AAAAAAACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
NMM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC
NLL CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCCCC

```

```

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)
HHH AAAAAAAAAAAGAAAAAA . . . CCCAAA . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
HHM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
MHH AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
HMM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
MHM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
MMM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
LHM AAAAAACACACCCACACC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
LMM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
NHM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
NMM CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC
NLL CCCCCCCCCCCCCCCCCC . . . CCCCCC . . . CCCCCC . . . CCCCCCCCCCCCCCCCCC

```

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED      ATTACK/CONTINUE GIVEN DEEP, DETECTED

HHH	HMLN
HHM	HMLL
MHH	HMLN
HHM	CCAA
MHM	CCCA
HHM	CCCA
MHM	CCCA
MHM	CCCA
LHM	CCCA
LHM	CCCA
NHM	CCCA
NHM	CCCC
NLL	CCCC

(REPORT X3)

HHH	HMLN
HHM	HMLL
MHH	CCAA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCCC
NHM	CCCC
NMM	CCCC
NLL	CCCC

## DECISION MAP

ENEMY LINE 2

ENCAMPMENT 1

(I=3, J=7)

```

NNLNLNLLNNMLNLLMMNNHLLMMNNMLLHNNMMHLLHLMNNHLLMMHHMLHMMHMHMMH
NNLNLNLLNNMLNLLMMNNHLLMMNNMLLHNNMMHLLHLMNNHLLMMHHMLHMMHMHMMH
NLLNLLNMMNMLLMMNHNHNNMLLMMNHLHNNHMMHMLLMLHNNHMMHMLLMMHMLHMMHMH
ATTACK/CONTINUE/SHALLOW/DEEP (REPORT X1)
HHH SSSSDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
HHM DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDSDSSSSD
MHH DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDSDSSSSD
HMM DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDSDSSSSD
MHM DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDSDSSSSD
MMM DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDSDSSSSD
LHM DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDSDSSSSD
LMM AAAAAASASASSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
NHM AAAAAASASASSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSSS
NMM DDDDDDDDDSDDDDDDDDDDDSDSSSSSSSSSSSSSDSDSSSSSDSDSDSSSSDDDDSSSSD
NLL DDDDDDDSSSSSDSDSDSSSSSDSDSDSSSSSSSSSSSSSDSDSSSSSDSDSDSDSSSSDDSSSSD

```

```

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)
HHH AAAAAAAAAACAAAAAA...CCCCAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC
HHM AAAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
MHH AAAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
HMM AAAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
MHM AAAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
MMM AAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
LHM AAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
LMM AAAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
NHM AAAAAAACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
NMM CCCCCCCCCCCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
NLL CCCCCCCCCCCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC

```

```

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)
HHH AAAAAAAAAACAAAAAA...CCCCAA...CCCCCC...CCCCCCCCCCCCCCCCCCCC
HHM AAAAAACACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
MHH AAAAAACACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
HMM AAAAAACACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
MHM AAAAAACACACCCACACC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
MMM ACACCCCCACCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
LHM ACACCCCCACCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
LMM CCCCCCCCCCCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
NHM CCCCCCCCCCCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
NMM CCCCCCCCCCCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC
NLL CCCCCCCCCCCCCCCCCC...CCCCCC...CCCCCC...CCCCCCCCCCCCCCCCCCCC

```

```

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED ATTACK/CONTINUE GIVEN DEEP, DETECTED

```

	HMLN		HMLN
	HMLL		HMLL
	(REPORT X3)		
HHH	CCAA	HHH	CCAA
HHM	CCCA	HHM	CCCA
MHH	CCCA	MHH	CCCA
HMM	CCCA	HMM	CCCA
MHM	CCCA	MHM	CCCA
MMM	CCCA	MMM	CCCA
LHM	CCCA	LHM	CCCA
LMM	CCCA	LMM	CCCC
NHM	CCCA	NHM	CCCC
NMM	CCCC	NMM	CCCC
NLL	CCCC	NLL	CCCC



(I=4, J=1)

ATTACK/CONTINUE/SLOW/DEEP

(REPORT X1)

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

.....  
ATTACK/CONTINUE GIVEN DEEP, DETECTED

(REPORT X3)

HMLN  
HMLL  
HMLN

HHH	HHH
HHH	HHH
MHH	HHH
HMM	HHH
MHM	HHH
MMM	HHH
LHM	HHH
LMM	HHH
NHM	HHH
NMM	HHH
Nil	HHH

## DECISION MAP

ENEMY LINE 1

ENCAMPMENT 6

(I=4, J=2)

NNNNLNNLNNMMLNNLLMMNNHLLMNMNMNLLHHNNMMHLLHLMNMNHLLMMHMLHMMHMHMMHH  
 NNNLNNLNNMMLNNMNLNNHLLMNMMLHNNHLLMNMNHMLHLLMNMNHMLHLLMMHMLHMMHMHMMHH  
 NNNLNNLNNMMLNNMNLNNHLLMNMMLHNNHLLMNMNHMLHLLMNMNHMLHLLMMHMLHMMHMHMMHH

ATTACK/CONTINUE/SHALLOW/DEEP (REPORT X1)

HHH AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADADADDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD  
 HHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADADDDDDAAADDDDDDDSDDDSSSDDDDD  
 MHH AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADADDDDDAAADDDDDSDDDSSSDDDDD  
 HMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDAAADDDDDSDDDSSSDSSSD  
 MHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDAAADDDDDSDDDSSSDSSSD  
 MMM AAAAAADADADDDDDDDDDADDDDDDDSDSDSSSDSDSSSDSDDDDDDDDDDDSSSDSSSDSSSD  
 LHM AAAAAADADADDDDDDDDDADDDDDDDSDSDSSSDSDSSSDSDDDDDDDDDDDSSSDSSSDSSSD  
 LMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAADDDDDAAADDDDDSDDDSSSDSSSDSSSDDDDD  
 NHM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAASAAAASSSSSSSSSSSSSSSDDDDD  
 NMM AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAASSSSSAAASSSSSSSSSSSSSSDDDDD  
 NLL AAAAAAAAAAAAAAAAAASASAAASASASSSSSSSSSSSSSSSSSSDSSSDDDDDDD

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

HHH AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . CCCAAA. . . . . CCCCCCACCCCCCCCCC  
 HHM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . AAAAAA. . . . . AAAAAACAAACCCCCC  
 MHH AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . AAAAAA. . . . . AAAAAACAAACCCCCC  
 HMM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . AAAAAA. . . . . AAAAAACAAACCCCCC  
 MHM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . AAAAAA. . . . . AAAAAACAAACCCCCC  
 MMM AAAAAAACACACACACC. . . . . CACCCC. . . . . CCCCCC. . . . . CCCCCCCCCCCCCCCCCC  
 LHM AAAAAAACACACACACC. . . . . CACCCC. . . . . CCCCCC. . . . . CCCCCCCCCCCCCCCCCC  
 LMM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . AAAAAA. . . . . AAAAAACAAACCCCCC  
 NHM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . AAAAAA. . . . . AAAAAACAAACCCCCC  
 NMM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . AAAAAA. . . . . AAAAAACAAACCCCCC  
 NLL AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . CCCAAA. . . . . CCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

HHH AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . CCCAAA. . . . . CCCCCCCCCCCCCCCCCC  
 HHM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . CCCAAA. . . . . CCCCCCCCCCCCCCCCCC  
 MHH AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . CCCAAA. . . . . CCCCCCCCCCCCCCCCCC  
 HMM AAAAAAAAAAAAAAAAAAAAAA. . . . . CACAAA. . . . . CCCCCC. . . . . CCCCCCCCCCCCCCCCCC  
 MHM AAAAAAAAAAAAAAAAAAAAAA. . . . . CACAAA. . . . . CCCCCC. . . . . CCCCCCCCCCCCCCCCCC  
 MMM AAAAAAACACACACACC. . . . . CACCCC. . . . . CCCCCC. . . . . CCCCCCCCCCCCCCCCCC  
 LHM AAAAAAACACACACACC. . . . . CACCCC. . . . . CCCCCC. . . . . CCCCCCCCCCCCCCCCCC  
 LMM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . CCCAAA. . . . . CCCCCCCCCCCCCCCCCC  
 NHM AAAAAAAAAAAAAAAAAAAAAA. . . . . AAAAAA. . . . . CCCAAA. . . . . CCCCCCCCCCCCCCCCCC  
 NMM AAAAAAAAAAAAAAAAAAAAAA. . . . . CACAAA. . . . . CCCCCC. . . . . CCCCCCCCCCCCCCCCCC  
 NLL AAAAAACACCCACACC. . . . . CCCCCC. . . . . CCCCCC. . . . . CCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN  
 HMLL  
 HMLN  
 HHH CCAA  
 HHM CAAA  
 MHH CAAA  
 HMM CAAA  
 MHM CAAA  
 MMM CCAA  
 LHM CCAA  
 LMM CAAA  
 NHM CAAA  
 NMM CAAA  
 NLL CCAA

(REPORT X3)

HMLN  
 HMLL  
 HMLN  
 HHH CCAA  
 HHM CCAA  
 MHH CCAA  
 HMM CCAA  
 MHM CCAA  
 MMM CCAA  
 LHM CCAA  
 LMM CCAA  
 NHM CCAA  
 NMM CCAA  
 NLL CCAA

## DECISION MAP

ENEMY LINE 1

ENCAMPMENT 5

(I=4, J=3)

NNNLLNLLNNMNLNLLMMNNHLLMMNNNLLHNNNMHHLLHLLMMNHLLMMHHMLHMMHMHMMHH  
 NNLNLLNLLNMNLLMMNMLNHNLMMLMNMMLHNNLMHNNHMLHMLMHNHMLHLLMMHLHMMHMHMMH  
 NLLNLLNMMNLNLLMNLNHNMMMLMMNHLNHLNHNMMNMLHLLMMLHNNHMLMMLHHLHMMHMHMMH

ATTACK/CONTINUE/SHALLOW/DEEP

(REPORT X1)

HHH AAAAAAAAAAADDADADDDADDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD  
 HHM AAAAAAAAAAAAAAAAAAAAAADDAAAAAAAAAAAAAAAAADDDDDDDDDDDDDDDDDDDDDDDDSDSDDDDD  
 MHH AAAAAAAAAAAAAAAAAAAAAADDAAAAAAAAAAAAAAAAADDDDDDDDDDDDDDDDDDDDDDDDSDSDDDDD  
 HMM AAAAAAAAAAADDADADDDADDDDDDDDDADADDDDDDDDDDDDDDDDDDDDDDDDDDDDDSDSSSSD  
 MHM AAAAAAAAAAADDADADDDADDDDDDDDDADADDDDDDDDDDDDDDDDDDDDDDDDDDDDDSDSSSSD  
 MMM DDDDDDDDDDDDDDDDDSDSDDDDDSDSDSSSDSDSSSDSDDDSSSDDDDDDDSSSDDDSSSSD  
 LHM DDDDDDDDDDDDDDDDDSDSDDDDDSDSDSSSDSDSSSDSDDDSSSDDDDDDDSSSDDDSSSSD  
 LMM AAAAAAAAAAAAAAAAAAAAAASASAAAAAAAAAAAAAAAAASSSSSSAAASSSSSSSSSSSSSSSD  
 NHM AAAAAAAAAAAAAAAAAAAAAASASAAAAAAAAAAAAAAAAASSSSSSAAASSSSSSSSSSSSSSSD  
 NMM AAAAAAAAAAAAAAAAAAAAAASASSSSASASASASSSSSSSSSSSSSDSSSSSDSDSDDDDDDDDDDDDD  
 NLL AAAAAASASSSSSSSSSSSSASSSSSSSSSSSSSSSSSSSSSDSSSSSDSDSDDDSSSDSSSSD

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

HHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 HHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 MHH AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 HMM AAAAAAACACACACACC...CACCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 MHM AAAAAAACACACACACC...CACCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 MMM AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 LHM AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 LMM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 NHM AAAAAAAAAAAAAAAAAAAAAA...AAAAAA...CCCCAA...CCCCCCCCCCCCCCCCCCCC  
 NMM AAAAAAAAAAAAAAAAAAAAAA...CACAAA...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 NLL AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED (REPORT X2)

HHH AAAAAAAAAAAAAAAAAAAAAA...CACAAA...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 HHM AAAAAAACACACACACC...CACCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 MHH AAAAAAACACACACACC...CACCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 HMM AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 MHM AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 MMM AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 LHM AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 LMM AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 NHM AAAAAAACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 NMM AAAAAACACACCCACACC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC  
 NLL CCCCCCCCCCCCCCCC...CCCCC...CCCCC...CCCCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN

HMLL

HMLN

HHH

HHM

MHH

HMM

MHM

MMM

LHM

LMM

NHM

NMM

NLL

CCAA

CCAA

CCAA

CCCA

CCCA

CCCA

CCCA

CCCA

CCAA

CCAA

CCCA

(REPORT X3)

HMLN

HMLL

HMLN

HHH

HHM

MHH

HMM

MHM

MMM

LHM

LMM

NHM

NMM

NLL

CCAA

CCCA

CCCA

CCCA

CCCA

CCCA

CCCA

CCCA

CCCA

CCCA

CCCC





ENCAMPMENT 2

 $(I=4, J=6)$ 

NNNNLNLNLMMLNNLLMMNNHLLLMMMMNNLLHHNNMMHHLLHLMMNHLLMMHHMLHHMHHHHH  
NNLNLLNLNLMLLNNMNLNHNLCMLMMMLHHNNLMHHNNMLLMLMLMHNNHMLHLMLMHLHMMHMMHH  
NLNNLLNMNNNLMLNMLNHHNNMLLMMNHLLNLLNHHMMNNHLLMLLHHNHMLMLPHHLHMMHHMH

ATTACK/CONTINUE/SALLOW/DEEP

(REPORT X1)

[illegible]

ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED (REPORT X2)

(REPORT X2)

[illegible]

ATTACK/CONTINUE GIVEN SHALLOW, DETECTED

(REPORT X2)

HHH	AAAAAAAAAACA	AAAAAA.	CCCCAAA.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
HMM	AAAAACACACCC	CACACC.	CCCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
MHH	AAAAACACACCC	CACACC.	CCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
HMM	AAAAACACACCC	CACACC.	CCCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
MHM	AAAAACACACCC	CACACC.	CCCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
MMM	ACACCCCCCACC	CCCCCCCC.	CCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
LHM	ACACCCCCCACC	CCCCCCCC.	CCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
LMM	CCCCCCCCCCCC	CCCCCCCC.	CCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
NHM	CCCCCCCCCCCC	CCCCCCCC.	CCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
NMM	CCCCCCCCCCCC	CCCCCCCC.	CCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC
NLL	CCCCCCCCCCCC	CCCCCCCC.	CCCCCCC.	CCCCCCC.	CCCCCCCCCCCCCCCCCCCC

ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED

ATTACK/CONTINUE GIVEN DEEP, DETECTED

HMLN

HMLN

HMLL

HMLL

HMLN

HMLN

HHH	CCAA
HHH	CCCA
HHH	CCCA
HMM	CCCA
MHH	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCCC
NHH	CCCC
NMM	CCCC
NLL	CCCC

(REPORT X3)

HHH	CCAA
HMM	CCCA
MHH	CCCA
HMM	CCCA
MHM	CCCA
MMM	CCCA
LHM	CCCA
LMM	CCCC
NHM	CCCC
NMM	CCCC
NLL	CCCC



## APPENDIX. THE PROGRAM CODE

The optimality program was written in the BASIC programming language and is shown in full along with numeric input data to initialize some of the vectors and matrices. The following variable translation table will show the correspondence between the names used in the description and the variables used in the program.

$U(F)$	U	12
$V(F)$	V	12
$F_a(Z,F)$	F1	4x12
PR	Q1	(PR = probability reduction for detected and is .2)
PDS	Q2	
PDD	Q3	
$PW(Z,F)$	P1	4x12
$PWD(Z,F)$	P2	4x12
$P(X_1/Z)$	P3	4x64
$P(X_2/Z)$	P4	4x64
$P(Z)$	P5	4
$P(Z/X_1)$	P6	4x64
$P(Z/X_2)$	P7	4x64
$P(X_1)$	P8	64
$P(X_2)$	P9	64
$P(X_2/X_1)$	P0	64x64
$U1(Z,F)$	U1	4x12
$U1D(Z,F)$	D1	4x12
$U2A(X_1,F)$	A2	64x12
$U2B(X_2,F)$	B2	64x12
$U2BD(X_2,F)$	D2	64x12



$U3B(X_2, F)$	B3	64x12
$U3BD(X_2, F)$	D3	64x12
$U3C(Z, F)$	C3	4x12
$U3CD(Z, F)$	E3	4x12
$U4B(X_2, F)$	B4	64x12
$U4C(Z, F)$	C4	4x12
$U5B(X_1, F)$	B5	64x12
$U5C(X_1, F)$	C5	64x12
$U6(X_1, F)$	U6	64x12
$U7(X_1, F)$	U7	64x12
$U8(X_1, F)$	U8	64x12

```

100 REM PREPARE PROBABILITY MATRICES
110 MARGIN 120
120 DIM F1(4,12),U(12),V(12),P1(4,12),P2(4,12),P3(4,64),P4(4,64)
130 DIM P5(4),P6(4,64),P7(4,64),P8(64),P9(64),P0(64,64)
140 DIM U1(4,12),D1(4,12),A2(64,12),B2(64,12),D2(64,12),B3(64,12)
150 DIM D3(64,12),C3(4,12),E3(4,12),B4(64,12),C4(64,12)
160 DIM B5(64,12),C5(64,12),U6(64,12),U7(64,12),U8(64,12)
170 DIM M$(64,12),M1$(64,12),M2$(64,12),M3$(4,12),M4$(4,12)
180 DIM G1$(12),G$(3),T(3)
190 REM PROBABILITY REDUCTION FOR DETECTED
200 Q1=.2
210 REM PROBABILITY OF DETECTION GIVEN SHALLOW
220 Q2=.4
230 REM PROBABILITY OF DETECTION GIVEN DEEP
240 Q3=.8
250 REM TRANSITION OF FORCES: FA
260 FOR Z=1 TO 4
270 FOR F=1 TO 12
280 READ F1(Z,F)
290 NEXT F
300 NEXT Z
310 REM UTILITY OF FORCES: U, V
320 FOR F=1 TO 12
330 READ V(F)
340 NEXT F
350 REM PROBABILITY OF WIN: PW, PWD
360 FOR Z=1 TO 4
370 FOR F=1 TO 12
380 READ P1(Z,F)
390 P2(Z,F)=P1(Z,F)-Q1
400 IF P2(Z,F)<0 THEN P2(Z,F)=0
410 NEXT F
420 NEXT Z
430 REM PROBABILITY OF ENEMY FORCES: P(Z)
440 FOR Z=1 TO 4
450 READ P5(Z)
460 NEXT Z
470 REM PROBABILITY OF REPORT X1 GIVEN Z: P(X1/Z)
480 FOR X1=1 TO 64
490 READ P3(4,X1)
500 NEXT X1
510 FOR Z=3 TO 2 STEP -1
520 FOR X1=1 TO 32
530 READ P3(Z,X1)
540 P3(5-Z,65-X1)=P3(Z,X1)
550 NEXT X1
560 NEXT Z
570 FOR X1=1 TO 64
580 READ P3(1,X1)
590 NEXT X1
600 FOR X1=1 TO 64
610 FOR Z=1 TO 4
620 P3(Z,X1)=P3(Z,X1)/729

```

OPTIMALITY March 6, 1982

```
630 NEXT Z
640 NEXT X1
650 REM PROBABILITY OF REPORT X2 GIVEN Z: P(X2/Z)
660 FOR X2=1 TO 32
670 FOR Z=1 TO 4
680 P4(Z,X2)=0
690 NEXT Z
700 NEXT X2
710 FOR X2=1 TO 7
720 READ P4(4,X2)
730 NEXT X2
740 FOR X2=9 TO 15 STEP 2
750 READ P4(4,X2)
760 NEXT X2
770 P4(4,22)=1
780 P4(2,11)=1
790 P4(2,21)=1
800 P4(2,22)=1
810 P4(2,23)=1
820 FOR X2=1 TO 17
830 P4(3,X2)=1
840 NEXT X2
850 FOR X2=21 TO 26
860 P4(3,X2)=1
870 NEXT X2
880 FOR X2=33 TO 64
890 FOR Z=1 TO 4
900 P4(Z,X2)=P4(5-Z,65-X2)
910 NEXT Z
920 NEXT X2
930 P4(1,64)=8
940 P4(1,63)=4
950 P4(1,61)=4
960 P4(1,59)=2
970 P4(1,56)=0
980 P4(1,52)=0
990 P4(1,50)=0
1000 P4(1,43)=0
1010 FOR X2=1 TO 64
1020 FOR Z=1 TO 4
1030 P4(Z,X2)=P4(Z,X2)/27
1040 NEXT Z
1050 NEXT X2
1060 REM READ REPORT LABELS
1070 READ G$(1)
1080 READ G$(2)
1090 READ G$(3)
1100 FOR F=1 TO 12
1110 READ G1$(F)
1120 NEXT F
1130 REM PROBABILITY OF REPORTS X1 AND X2: P(X1), P(X2)
1140 FOR X=1 TO 64
1150 S1=0
1160 S2=0
1170 FOR Z=1 TO 4
1180 S1=S1+P5(Z)*P3(Z,X)
```

```

1190 S2=S2+P5(Z)*P4(Z,X)
1200 NEXT Z
1210 IF S1=0 THEN S1=-1E20
1220 IF S2=0 THEN S2=-1E20
1230 P8(X)=S1
1240 P9(X)=S2
1250 NEXT X
1260 REM PROBABILITY OF Z GIVEN X1 AND X2: P(Z/X1), P(Z/X2)
1270 FOR X=1 TO 64
1280 FOR Z=1 TO 4
1290 P6(Z,X)=P3(Z,X)*P5(Z)/P8(X)
1300 P7(Z,X)=P4(Z,X)*P5(Z)/P9(X)
1310 NEXT Z
1320 NEXT X
1330 REM PROBABILITY OF X2 GIVEN X1: P(X2/X1)
1340 FOR X1=1 TO 64
1350 FOR X2=1 TO 64
1360 FOR K=1 TO 3
1370 T(K)=1
1380 Y1$=MID(G$(K),X1,1)
1390 Y2$=MID(G$(K),X2,1)
1400 IF (Y1$='H' AND Y2$='H')OR(Y1$='N' AND Y2$='N') THEN T(K)=2
1410 IF Y1$='N' AND (Y2$='M' OR Y2$='H') THEN T(K)=0
1420 IF Y1$='H' AND (Y2$='N' OR Y2$='L') THEN T(K)=0
1430 IF (Y1$='L' AND Y2$='H')OR(Y1$='M' AND Y2$='N') THEN T(K)=0
1440 NEXT K
1450 P0(X2,X1)=T(1)*T(2)*T(3)*P9(X2)/P8(X1)/27
1460 NEXT X2
1470 NEXT X1
1480 REM ***** START ENEMY LINE LOOP *****
1490 FOR I=1 TO 4
1500 REM TRANSMIT V TO U
1510 FOR F=1 TO 12
1520 U(F)=V(F)
1530 V(F)=-1
1540 NEXT F
1550 REM START ENCAMPMENT LOOP
1560 FOR J=1 TO 7
1570 REM INITIALIZE ALL MAPS
1580 FOR F=1 TO 12
1590 FOR X=1 TO 64
1600 M$(X,F)='S'
1610 M1$(X,F)='A'
1620 M2$(X,F)='A'
1630 NEXT X
1640 FOR Z=1 TO 4
1650 M3$(Z,F)='A'
1660 M4$(Z,F)='A'
1670 NEXT Z
1680 NEXT F
1690 REM UTILITY OF ATTACKING KNOWING ENEMY FORCE Z: U1, U1D
1700 FOR F=1 TO 12
1710 FOR Z=1 TO 4
1720 U1(Z,F)=P1(Z,F)*U(F1(Z,F))+(1-P1(Z,F))*V(F1(Z,F))
1730 D1(Z,F)=P2(Z,F)*U(F1(Z,F))+(1-P2(Z,F))*V(F1(Z,F))
1740 NEXT Z

```

OPTIMALITY March 6, 1982

```
1750 NEXT F
1760 REM UTILITY OF ATTACKING KNOWING X1 OR X2: U2A, U2B, U2BD
1770 FOR F=1 TO 12
1780 FOR X=1 TO 64
1790 S1=0
1800 S3=0
1810 S4=0
1820 FOR Z=1 TO 4
1830 S1=S1+U1(Z,F)*P6(Z,X)
1840 S3=S3+U1(Z,F)*P7(Z,X)
1850 S4=S4+D1(Z,F)*P7(Z,X)
1860 NEXT Z
1870 A2(X,F)=S1
1880 B2(X,F)=S3
1890 D2(X,F)=S4
1900 NEXT X
1910 NEXT F
1920 REM MAX UTILITY FOR CONTINUING OR ATTACKING: U3B, U3BD, U3C, U3CD
1930 FOR F=1 TO 12
1940 FOR X2=1 TO 64
1950 B3(X2,F)=B2(X2,F)
1960 IF B2(X2,F)>=V(F)-1E-10 GOTO 1990
1970 B3(X2,F)=V(F)
1980 M1$(X2,F)='C'
1990 D3(X2,F)=D2(X2,F)
2000 IF D2(X2,F)>=V(F)-1E-10 GOTO 2030
2010 D3(X2,F)=V(F)
2020 M2$(X2,F)='C'
2030 IF X2<18 OR (X2>20 AND X2<27) OR (X2>38 AND X2<45) OR X2>47 GOTO 2060
2040 M1$(X2,F)='.'
2050 M2$(X2,F)='.'
2060 NEXT X2
2070 FOR Z=1 TO 4
2080 C3(Z,F)=U1(Z,F)
2090 IF U1(Z,F)>=V(F)-1E-10 GOTO 2120
2100 C3(Z,F)=V(F)
2110 M3$(Z,F)='C'
2120 E3(Z,F)=D1(Z,F)
2130 IF D1(Z,F)>=V(F)-1E-10 GOTO 2160
2140 E3(Z,F)=V(F)
2150 M4$(Z,F)='C'
2160 NEXT Z
2170 NEXT F
2180 REM WEIGHTED AVERAGE FOR DETECTED/NON-DETECTED: U4B, U4C
2190 FOR F=1 TO 12
2200 FOR X2=1 TO 64
2210 B4(X2,F)=B3(X2,F)*(1-Q2)+D3(X2,F)*Q2
2220 NEXT X2
2230 FOR Z=1 TO 4
2240 C4(Z,F)=C3(Z,F)*(1-Q3)+E3(Z,F)*Q3
2250 NEXT Z
2260 NEXT F
2270 REM UTILITY OF RECON NOT KNOWING REPORT: U5B, U5C
2280 FOR F=1 TO 12
2290 FOR X1=1 TO 64
2300 S=0
```

```

2310 FOR X2=1 TO 64
2320 S=S+B4(X2,F)*P0(X2,X1)
2330 NEXT X2
2340 B5(X1,F)=S
2350 S=0
2360 FOR Z=1 TO 4
2370 S=S+C4(Z,F)*P6(Z,X1)
2380 NEXT Z
2390 C5(X1,F)=S
2400 NEXT X1
2410 NEXT F
2420 REM MAX UTILITY OF SHALLOW AND DEEP RECON: U6
2430 FOR X1=1 TO 64
2440 FOR F=1 TO 12
2450 U6(X1,F)=B5(X1,F)
2460 IF B5(X1,F)>=C5(X1,F) GOTO 2490
2470 U6(X1,F)=C5(X1,F)
2480 M$(X1,F)='D'
2490 NEXT F
2500 NEXT X1
2510 REM MAX UTILITY OF RECON AND NO RECON: U7
2520 FOR X1=1 TO 64
2530 FOR F=1 TO 12
2540 U7(X1,F)=U6(X1,F)
2550 IF U6(X1,F)>A2(X1,F) GOTO 2580
2560 U7(X1,F)=A2(X1,F)
2570 M$(X1,F)='A'
2580 NEXT F
2590 NEXT X1
2600 REM MAX UTILITY OF ATTACK OR CONTINUE: U8
2610 FOR X1=1 TO 64
2620 FOR F=1 TO 12
2630 U8(X1,F)=U7(X1,F)
2640 IF U7(X1,F)>=V(F)-1E-10 GOTO 2670
2650 U8(X1,F)=V(F)
2660 M$(X1,F)='C'
2670 NEXT F
2680 NEXT X1
2690 REM PRINT ALL MAPS
2700 PRINT 'DECISION MAP          ENEMY LINE '5-I;
2710 PRINT '          ENCAMPMENT 'B-J; '          (I='I'; J='J; '))
2720 PRINT
2730 PRINT TAB(20);G$(1)
2740 PRINT TAB(20);G$(2)
2750 PRINT TAB(20);G$(3)
2760 PRINT 'ATTACK/CONTINUE/SALLOW/DEEP          (REPORT X1)'
2770 FOR F=1 TO 11
2780 PRINT TAB(10);G1$(F);TAB(20);
2790 FOR X=1 TO 64
2800 PRINT M$(X,F);
2810 NEXT X
2820 PRINT
2830 NEXT F
2840 PRINT 'ATTACK/CONTINUE GIVEN SHALLOW, NOT DETECTED          (REPORT X2)'
2850 FOR F=1 TO 11
2860 PRINT TAB(10);G1$(F);TAB(20);

```

```

2870 FOR X=1 TO 64
2880 PRINT M1$(X,F);
2890 NEXT X
2900 PRINT
2910 NEXT F
2920 PRINT 'ATTACK/CONTINUE GIVEN SHALLOW, DETECTED' (REPORT X2)
2930 FOR F=1 TO 11
2940 PRINT TAB(10);G1$(F);TAB(20);
2950 FOR X=1 TO 64
2960 PRINT M2$(X,F);
2970 NEXT X
2980 PRINT
2990 NEXT F
3000 PRINT 'ATTACK/CONTINUE GIVEN DEEP, NOT DETECTED';SPA(7);
3010 PRINT 'ATTACK/CONTINUE GIVEN DEEP, DETECTED'
3020 PRINT TAB(20);'HMLN';SPA(43);'HMLN'
3030 PRINT TAB(20);'HMLL';SPA(16);'(REPORT X3)';SPA(16);'HMLL'
3040 PRINT TAB(20);'HMLN';SPA(43);'HMLN'
3050 FOR F=1 TO 11
3060 PRINT TAB(10);G1$(F);TAB(20);
3070 FOR Z=1 TO 4
3080 PRINT M3$(Z,F);
3090 NEXT Z
3100 PRINT SPA(32);G1$(F);SPA(8);
3110 FOR Z=1 TO 4
3120 PRINT M4$(Z,F);
3130 NEXT Z
3140 PRINT
3150 NEXT F
3160 REM COMPUTE NEW V TO BE TRANSMITTED
3170 FOR F=1 TO 12
3180 S=0
3190 FOR X1=1 TO 64
3200 S=S+U8(X1,F)*P8(X1)
3210 NEXT X1
3220 V(F)=S
3230 NEXT F
3240 REM FINISH ENCAMPMENT LOOP
3250 NEXT J
3260 REM FINISH ENEMY LINE LOOP
3270 NEXT I
3280 REM ***** DATA *****
3290 REM F1(F,Z)
3300 DATA 2,6,7,8,9,10,10,11,11,12,12,12
3310 DATA 3,4,5,6,7,8,9,10,10,11,12,12
3320 DATA 1,5,5,6,6,8,9,10,10,11,12,12
3330 DATA 1,2,3,4,5,6,7,10,10,11,12,12
3340 REM U(F)
3350 DATA 9,8,8,7,7,6,6,5,5,4,2,1
3360 REM P(WIN/F,Z)
3370 DATA .5,.4,.4,.3,.3,.2,.2,.1,.1,0,0,0
3380 DATA .8,.7,.7,.6,.6,.5,.5,.4,.4,.3,.2,0
3390 DATA .9,.9,.9,.8,.8,.7,.7,.6,.6,.5,.4,0
3400 DATA 1,1,1,1,1,.9,.9,.8,.8,.8,.6,0
3410 REM P(Z)
3420 DATA .285714,.285714,.285714,.142857

```

OPTIMALITY March 6, 1982

```
3430 REM          P(X1/Z)
3440 DATA 75,45,75,45,45,27,45,15,50,15,27,15,30,9,30,9,15,0,25,0,9,18
3450 DATA 9,10,3,10,0,15,0,15,0,0,0,5,0,5,0,0,0,9,0,6,3,6,0,0,0,0,3,0
3460 DATA 3,0,0,2,0,0,0,0,1,0,0,0,0,0
3470 DATA 27,27,27,27,27,27,27,18,18,18,27,18,18,18,18,18
3480 DATA 9,9,9,18,18,18,12,12,12,9,9,9,9,9
3490 DATA 1,2,2,2,4,4,4,3,3,3,8,6,6,6,6,6,6
3500 DATA 3,3,3,12,12,12,9,9,9,6,6,6,6,6,6
3510 DATA 0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,3,3,3
3520 DATA 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,5,5,5,9,9,9
3530 DATA 0,0,0,15,15,15,15,15
3540 DATA 15,27,25,25,25,45,45,45,75,75,75,125
3550 REM          P(X2/Z)
3560 DATA 4,2,4,2,2,1,2
3570 DATA 4,1,2,2
3580 REM          REPORT LABELS
3590 DATA 'NNNLNLLNNMMLNNLLMMNNHLLMMNMNNLLHHNNMMHLLHLLMMNNHLLMMHHMLHHMMHMHMH'
3600 DATA 'NNLNLLNNMMLNNMMLNHNLMMLNMMLHNNHNLMMHNNHNLHMLMLHNNHMLHLLMMHLHMMHMHMH'
3610 DATA 'NLNNLLNNMMLMMLNHNHNMMLMMNHLHNLNHNHNMNNHLLMMLHNNHMLMLMHHLHMMHMHMH'
3620 DATA 'HHH', 'HHH', 'MHH', 'HMM', 'MHM', 'MMM', 'LHM', 'LMM', 'NHM', 'NMM'
3630 DATA 'NLL', 'NNN'
3640 END
```