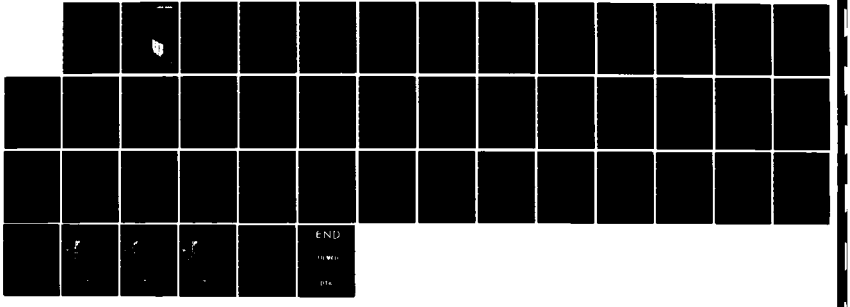
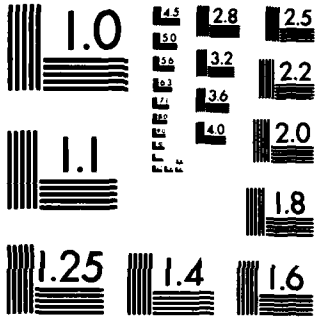
AD-A155 244 OBSTACLE PLANNING SIMULATION VERSION 11: DESIGN AND PERFORMANCE ANALYSIS(U) CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL J M DEPONAI ET AL. 1/1

UNCLASSIFIED APR 85 CERL-TR-P-85/10 F/G 15/3 NL





US Army Corps
of Engineers
Construction Engineering
Research Laboratory

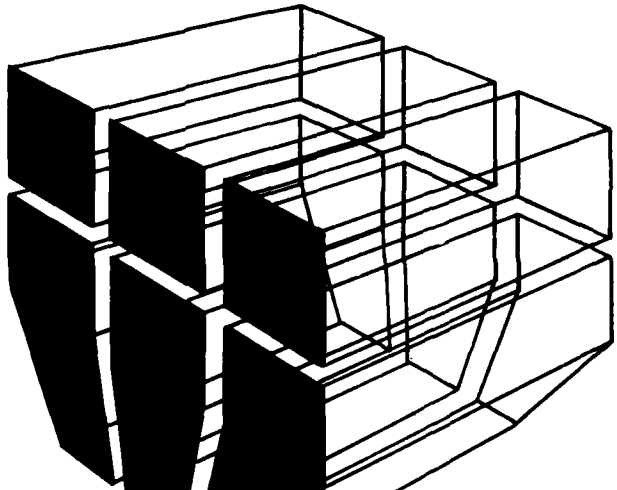
TECHNICAL REPORT P-85/10
April 1985



# OBSTACLE PLANNING SIMULATION, VERSION 1.1: Design and Performance Analyses

by
John M. Deponai III
James E. Snellen

Obstacle Planning Simulation (OPS) Version 1.1 is a pilot model developed to show the advantages of using simulation programs on PLATO to teach combat engineer tactics. Players in phase 1 of the game specify and implement an obstacle plan; in phase 2, players are passive observers as enemy mechanized infantry attack the friendly defensive position. The OPS design of Version 1.1 is described and its performance is analyzed. Recommendations are made on how to improve the model's performance and capabilities.



UNCLASSIFIED

URITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

## REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

| | |
|---|---|
| EPORT NUMBER<br>RL-TR-P-85/10 | 2. GOVT ACCESSION NO.<br>AD-A155 244 |
| 3. RECIPIENT'S CATALOG NUMBER | |
| TITLE *(and Subtitle)*<br>BSTACLE PLANNING SIMULATION, VERSION 1.1:<br>ESIGN AND PERFORMANCE ANALYSES | 5. TYPE OF REPORT & PERIOD COVERED<br>Final |
| | 6. PERFORMING ORG. REPORT NUMBER |
| AUTHOR(s)<br>)hn M. Deponai III<br>ames E. Snellen | 8. CONTRACT OR GRANT NUMBER(s) |
| PERFORMING ORGANIZATION NAME AND ADDRESS<br>.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY<br>.O. BOX 4005, CHAMPAIGN, IL 61820 | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>4A162731AT41-E-048 |
| CONTROLLING OFFICE NAME AND ADDRESS | 12. REPORT DATE<br>April 1985 |
| | 13. NUMBER OF PAGES<br>39 |
| MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)* | 15. SECURITY CLASS. *(of this report)*<br>Unclassified |
| | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

DISTRIBUTION STATEMENT *(of this Report)*

)proved for public release; distribution unlimited.

DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

SUPPLEMENTARY NOTES

opies are available from the National Technical Information Service
Springfield, VA 22161

KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

bstacle Planning Simulation
bstacles
LATO
raining devices

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

Obstacle Planning Simulation (OPS) Version 1.1 is a pilot model developed to show
ie advantages of using simulation programs on PLATO to teach combat engineer tac-
cs. Players in phase 1 of the game specify and implement an obstacle plan; in phase 2,
layers are passive observers as enemy mechanized infantry attack the friendly defensive
osition. The OPS design of Version 1.1 is described and its performance is analyzed.
ecommendations are made on how to improve the model's performance and capabilities.

FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

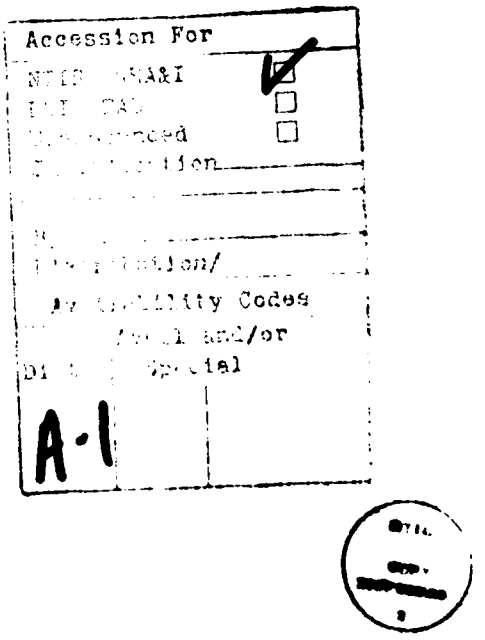
UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

## FOREWORD

This work was done for the Assistant Chief of Engineers, Office of the Chief of Engineers (OCE), under Project 4A162731AT41, "Design, Construction, and Operation and Maintenance Technology for Military Facilities"; Task E, "Military Engineering"; Work Unit 048, "Computer Based Education Support." The applicable STO is 82-5:8. The OCE Technical Monitor was Dr. Clemens Meyer, DAEN-ZCM. The work was performed by the Facility Systems Division (FS) of the U.S. Army Construction Engineering Research Laboratory (USA-CERL). James E. Snellen and Steven L. Murray of the Microcomputer Systems Laboratory, University of Illinois, designed and programmed the MALOS simulation driver. The driver is the product of many years' experience by Dr. Snellen and was inspired by "Panzerkring," another PLATO-based war game which Dr. Snellen developed with David G. Anderer. James E. Snellen, Andrew S. Lavis, and Thomas E. Olson designed and developed the incremental/hidden movement system. Frank J. Mabry contributed significantly to the data base design and provided invaluable support to the MALOS project. Military subject matter consultation for the Obstacle Planning Simulation scenario was provided by experts at the U.S. Army Engineer School and by John Deponai and CPT Lynn Wahlgren of USA-CERL.

E. A. Lotz is Chief, USA-CERL-FS. COL Paul J. Theuer is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.



CONTENTS

## TABLES

## FIGURES

# OBSTACLE PLANNING SIMULATION, VERSION 1.1: DESIGN AND PERFORMANCE ANALYSES

## 1 INTRODUCTION

### Background

Obstacle Planning Simulation (OPS) Version 1.1 was developed as a pilot model to demonstrate the benefits of using simulation programs on PLATO to teach combat engineer tactics. OPS 1.1 is an interactive, map-based, two-phase video game for a single player that models the effects of combat engineer modifications to terrain via a limited set of obstacles. In phase 1, the player specifies and implements an obstacle plan of his/her own design in two to four blocks of time, each block representing 4 hr of real time in which to work on a barrier plan. In phase 2, the player becomes a passive observer as an enemy mechanized infantry division attacks the friendly reinforced mechanized infantry brigade defensive position the player has fortified. Combat outcomes are probabilistic and are influenced by the player-emplaced obstacles. Survivor numbers for each force type are displayed at the end of the game. A more complete description of the game is in the USACERL Technical Report *Obstacle Planning Simulation (OPS): Introduction and User Instructions.*[1]

### Objective

Objectives of this report are to analyze the performance of OPS 1.1 and to recommend changes that would improve the model's usefulness as a teaching tool.

### Approach

A description of the model's basic design was drawn from developmental work with the OPS 1.1. Twenty different attack/defend plans were run on the model and statistical results were assessed to find ways of improving this version.

### Mode of Technology Transfer

OPS 1.1 is installed on the U.S. Army Engineer School (USAES) and University of Illinois (UI) PLATO systems. A MALOS simulation driver is being developed on the UI system as a vehicle for designing and running many different scenarios. Instructors at the USAES will design the different scenarios to support a variety of teaching points. This report identifies the changes to be made to the OPS 1.1 pilot model to achieve this capability. The OPS scenario will then become a single scenario residing in the MALOS simulation driver environment. The prototype MALOS simulation driver will be installed on the USAES system by September 1985.

## 2 DATA BASES REQUIRED

### Terrain Definition

This data base assigns terrain attributes to each of 61 possible map cell displays. Twelve terrain attributes are modeled--three describing relative elevation (ground, slope, and hilltop) and nine describing terrain features (road, gully, woods, town, swamp, ford, water, clear, and bridge). Each map cell definition includes one elevation attribute and may also include one or

[1] John M. Deponai III and James E. Snellen, *Obstacle Planning Simulation (OPS): Introduction and User Instructions*, Technical Report P-85/08/ADA149468 (U.S. Army Construction Engineering Research Laboratory, January 1985).

more feature attribute(s). If a bridge or a town attribute is part of a map cell definition, a road attribute also must be included. Table 1 shows the attribute combinations allowed and the code numbers for each. Corresponding graphic symbols are shown in Table 2.

**Movement Factor**

MALOS assigns to each "piece type" (i.e., vehicle or person) a single "movement factor" value from a range of values, 0 through 12. This value determines the speed of the piece relative to other piece types. Movement factor values relate to a 12-increment, sequential, cyclical game clock. If a vehicle is assigned a movement factor of 12, it is credited with a "move impulse" in each of the 12 time increments per clock cycle (turn). If it is assigned a movement factor of 6, the vehicle is credited with a move impulse in each of 6 time increments per clock cycle. A piece assigned a factor of zero would not move at all. The movement factor data base identifies the clock increments in which move impulses are allowed for each movement factor value. The effect is a "top road speed" associated with each movement factor. For each movement factor, the Xs in Table 3 show during which clock increment a move impulse is allowed. In OPS Version 1.1, only vehicles assigned movement factors of 12 are used. Movement factors less than 12 would describe the movement characteristics of slower vehicles and people.

**Movement Costs**

For a piece to move from one map cell to another requires payment of a "base cost" of one move impulse. Additional move impulses are charged depending on the terrain attributes' cumulative effect, i.e., effects of the map cell from which the piece is moved plus those of the map cell to which the piece moved. Only move impulses defray movement costs, not all clock time increments. Movement cost data bases store the information needed to compute the additional cost, as measured in move impulses to move from one map cell to another due to terrain constraints. A separate table is required for each piece type since the terrain attributes' delay effect will vary with the type of piece being moved. Table 4 shows example movement cost values for the pieces used in OPS Version 1.1.

Thus, to move from a map cell with attributes (ground, woods, road) to a map cell with attributes (ground, ford, woods) would require a base cost of one move impulse plus three to move from woods to ford, plus five more to move from woods to woods, for a total of nine move impulses. The other attribute combinations result in "irrelevant" combinations that MALOS disregards. A piece with a movement factor of 9 could negotiate the move in one full clock cycle or turn, but a piece with a movement factor of 3 would require three full turns to negotiate the move. Similarly, to move from a map cell with attributes (ground, woods, road) to a map cell also with an attribute (slope) would require a total cost of 11 move increments, one for the base cost, five to move from ground to slope, and five to move from woods to slope. The other attribute combinations are irrelevant. If both map cells (i.e., those moved from and to) have a good attribute, only the base cost of one move impulse is required to move from the one cell to the other. However, if the cell being moved into has a from-to attribute combination rated "not allowed" in the movement cost table, MALOS does not permit such a move.

**Engineer Reusable Asset Types**

In OPS 1.1, six engineer reusable assets are defined. Table 5 lists codes for these assets. Certain assets types are assigned as having a "blade" capability.

**Engineer Expendable Asset Types**

In OPS 1.1 seven engineer expendable assets are defined. Table 6 lists the codes for these assets.

**Engineer Task Types**

Nine engineer task types are defined in OPS 1.1. Table 7 shows task codes for each and Table 8 shows corresponding resource requirements for each task.

### Engineer Assets Available

Table 9 gives the total number of each type of engineer asset available, reusable and expendable, as used in OPS 1.1.

### Weapons Types

One data base defines blue weapons systems and one defines red weapons systems. In OPS 1.1, three weapons systems are defined for the blue team: 105 mm, 25 mm, and TOW. Five weapons systems are defined for the red team: 125 mm, 73 mm, 14.5 mm, 12.7 mm, and AT-3.

### Weapons Effectiveness

Probabilities of hitting a target (piece) in the open or in defilade and of killing each target, given that the target has been hit, are defined for each weapons system for multiples of some range increment up to a maximum range. The range increment is equal to the map cell length in meters. In OPS 1.1, for example, the range increment is 200 m. For each target type, MALOS computes a probability to kill a target as the product of the probability to hit the target and of the probability to kill the target given a hit for each firing weapons system, target type, exposure condition, and range. Table 10 gives the p(Hit) and p(Kill, given Hit) data bases for blue weapons against red targets. Table 11 lists resulting p(Kill) values computed by MALOS for the blue weapons systems; respective data for red weapons systems against blue targets are in Tables 12 and 13.

### Piece Types

There is one data base for blue units and one for red units. Pieces can consist of people, wheeled or track vehicles, and artillery pieces. For each piece, a piece name is designated, both primary and secondary weapons systems may be assigned, a basic load for the primary weapons system is specified, and a movement factor is assigned. Table 14 shows the piece definition data used in OPS 1.1.

### Orders of Battle

The order of battle data bases for the blue and red forces identify a collection of units. Each unit consists of three to seven subordinate units which, in turn, consist of 2 to 14 pieces. Each subordinate unit is identified by a letter image the size of a map cell on the screen display. All subordinate units belonging to the same parent have the same letter designation. Blue force units are companies with subordinate "sections" of two pieces each. Table 15 defines the blue order of battle used in OPS 1.1. Red force units are battalions with subordinate "companies" of 10 to 14 pieces each. Table 16 defines the red order of battle used in OPS 1.1.

### Parameters

The following parameter values are used in OPS 1.1:

maxspd = 30 = max speed of piece with movement factor of 12, in km/hr

mpmc = 200 = meters per map cell

sbfr = 30 = seconds between firing rounds, minimum required

minrnd = 2 = minimum number of engineer work rounds

maxrnd = 4 = maximum number of engineer work rounds

minkp = 5 = minimum kill probability (percent) for a piece to fire on a target

ekp = 10 = enhanced kill probability; percentage added to kill probability when a target is in a stopped state

resar =2500 = reserve activation range; range in meters at which a red unit will trigger activation of a blue reserve unit

vebo = 3 = vehicles engaged by obstacle; number of vehicles subtracted from number of vehicles available to fire when unit is engaged in negotiating an obstacle

kpml = 4 = kills per mine level; number of enemy vehicles killed to reduce minefield by one AT-mine-density level if the minefield is coverd by fire (only one vehicle is killed, regardless of minefield density, if the minefield is not covered by fire)

minedly = 288 = base delay per AT-mine-density level, in seconds

atddly = 168 = base delay per antitank ditch, in seconds

rcdly = 144 = base delay per road crater, in seconds

abtdly = 888 = base delay per abatis, in seconds

urdly =1200 = base delay per urban rubble obstacle, in seconds.

In addition to the base amount of delay attributed to the various obstacles, the following "fire enhancement" additional delays also are counted as long as a particular obstacle is covered with fire:

fedm = 120 = fire-enhanced delay due to mines, in seconds

fedd = 120 = fire-enhanced delay due to ditch, in seconds

feda = 408 = fire-enhanced delay due to abatis, in seconds

fedu = 600 = fire-enhanced delay due to urban rubble, in seconds

fedc = 48 = fire-enhanced delay due to crater, in seconds.

# 3 TWENTY RUNS OF OPS 1.1: STATISTICAL ANALYSES

## Attack Plans

Figure 1 shows the red force organization for combat. Five enemy attack plans are programmed into OPS 1.1. In all of the attacks, the enemy force first echelon consists of two BTR regiments that attack on line across a 10-km front. The enemy second echelon forces attack either in company columns or in companies on line. The scheme of each attack is represented in Figures 2 through 6 by a matrix that shows approximately where each enemy company enters the game board and its simulated time of arrival. In general, the strategy of each attack is as follows:

Attack A: heavy T-64 attack at the center; T-64s attack in column along two axes in center; BMPs attack in column at top of map.

Attack B: even pressure across whole front; T-64s attack on line at center and bottom; BMPs attack on line at top.

Attack C: same as Attack A, with one T-64 battalion shifted from center to bottom.

Attack D: heavy T-64 attack at top; T-64s attack in column at top part of map; BMPs attack in column at center; and a BMP battalion and two T-64 battalions attack in column at south.

Attack E: extremely heavy armor attack at center; T-64s and BMPs attack in column; light BMP and T-64 attack in the north and south.

## Defense Plan

Figure 7 shows the blue force organization for combat and Figure 8 shows the blue force deployment for combat. Approximately two companies of mechanized infantry (M2s) are distributed evenly across the front in a picket line. Two companies of mechanized infantry

are distributed evenly down the left side of the map and are designated as reserve forces. (Reserve forces are not activated until all friendly forces in the same sector of fire are destroyed and/or enemy forces advance to within 2500 m of the reserves' position.) The balance of the friendly force--two companies of mechanized infantry, two companies of tanks (M1s) and two companies of ITVs--are distributed evenly across a defensive line west of the river. The M1s are deployed directly in front of the likely avenues of approach.

### Levels of Engineer Effort

Four levels of engineer effort were used in statistical analysis of the game. The three barrier plans, designed by USA-CERL, should by no means be considered an "approved solution." They were created only for testing the model's performance on a representative set of data.

Level 1: base condition--no engineer effort expended.

Level 2: two engineer work periods--11 minefields (1-0-0 density), 6 antitank ditches, 9 blown bridges, 3 abatis, 4 road craters, and 10 M2 fighting positions on the picket line. Figure 9 shows the barrier and fortification locations for Level 2.

Level 3: three engineer work periods--Level 2 plus 6 minefields (1-0-0 density), 3 antitank ditches, 2 road craters, 3 M2 fighting positions on the picket line, and 2 M1 fighting positions on the main line of defense. Figure 10 shows the barrier and fortification locations for Level 3.

Level 4: four engineer work periods--Level 3 plus 6 minefields (1-0-0 density), 3 antitank ditches, 2 road craters, and 5 M1 fighting positions on the main line of defense. Figure 11 shows the barrier and fortification locations for Level 4.

### Statistical Analysis

Using special programs to execute runs, gather data, and generate statistics, 100 runs of each attack plan/barrier plan combination were executed and the killed and survived data for each piece type were collected. Mean values and standard deviations for the data were computed and are shown in Tables 17 through 19. Table 20 shows the mean simulated time for running each attack against each barrier plan. Each table shows the percentage change from the base condition, i.e., no engineer effort expended. The results were somewhat surprising at first glance. For a particular attack plan, the number of blue force pieces killed would be expected to decrease as the level of engineer effort increases; however, this was not true in all cases. In Attack Plan A, the number of M2s killed increases with higher levels of engineer effort. The same is true of ITVs for Attack Plan B, barrier level 2. This result probably was produced when the barriers allowed temporary and local massings of enemy units that gave the enemy local fire superiority much greater than its average 4 to 1 overall superiority.

Some anomalies also appeared in the red force killed statistics. The number of red forces killed would be expected to increase as the level of engineer effort increases, but the number of T-64s killed actually declines for all levels of engineer effort in attack plan A, levels 2 and 3 of attack plan B, level 3 of attack plan C, and level 2 of attack plan E. The cause is similar to that stated above; i.e., by achieving a very high fire superiority at a given obstacle, the enemy probably neutralized the blue forces covering the obstacle and, therefore, the obstacle ceased to be effective. MALOS provides that minefields do not kill if they are not covered by friendly fire.

### Performance Standards

For each piece type, blue and red, Table 21 presents the maximum number of kills for blue and the minimum number of kills for red expected for a particular engineer defense plan to be rated as having a significant impact on the battle's outcome. The numbers represent kills at 2.23 standard deviations from the mean kill figures for the "no engineer activity" level in Table 17.

# 4 FUTURE IMPROVEMENTS

## Data Base Organization

As a demonstration model, OPS 1.1 is not set up to run a variety of scenarios. To be a useful teaching tool, the MALOS simulation driver must be constructed to allow the running of multiple scenarios designed to instill specific teaching points. Thus, OPS 1.1 represents use of the computer at one end of the teaching spectrum: at one end is a big "capstone" exercise, and on the other end are very simple "5-on-1" type scenarios designed to show the efficacy of using fighting positions, the utility of minefields, and so on. These would be run in a minute or two, versus the 15 to 20 min required to run OPS 1.1.

In OPS 1.1, the scenario map definition, the number of engineer assets available, the blue and red orders of battle, and the blue and red deployments are part of the scenario definition. All other data bases are part of the MALOS driver. In the future, for more flexibility in designing families of scenarios, only the data bases for terrain types definition, movement factor, and movement cost will reside as "givens" in the MALOS driver. All other data will be stored as part of the scenario definition.

Provision also will be made to design scenarios to run at different map scales. The OPS 1.1 scenario and the logic behind it are designed for scale 1:50,000. The weapons effectiveness tables will be reprogrammed to describe the ranges and probabilities as a series of coordinates describing only points on the probability graph at which significant changes in probabilities occur. This method will replace the current method that records the probabilities at fixed-range increments. This change will allow more efficient processing of the probability data and will permit MALOS to generate probability-to-kill data from one data set for scenarios designed for different scales.

A library of standard scenario mapsheets, orders of battle (both red and blue), reusable and expendable asset types, task types, numbers of engineer assets available, piece types, and parameters will ultimately be provided for use by scenario designers as starting points for a particular scenario design. These data bases will be scale-dependent, but scenario designers will be able to edit them to satisfy particular demands.

Only one data base for each weapon type and weapons effectiveness data (probability tables) will be available in the library. Data in these bases will be unchangeable since they are not independent of the MALOS driver software. Thus, scenario designers can neither invent new weapons types nor redefine the probabilites to hit and/or kill. Scenario designers can, however, elect to use only a subset of the weapon types available to them.

No attack or defense plans will be stored in the library. The designer of each scenario will create these plans as part of the scenario design process.

## Map Editor

A map editor module will be designed to help scenario designers create and modify maps more easily than is now possible. In OPS 1.1, the map creation process is laborious and requires the designer to specify individually the type of terrain to be assigned to each of 1800 map cells. The improved map editor will allow designers to assign a certain terrain type to a map area by specifying the terrain type to be assigned and then moving the cursor around on the map sheet. Road trace definition will be done similarly, and the map editor will use a simple assignment algorithm to assign a certain road symbol to a particular map cell. For example, if the road trace is drawn through a wooded area, the map editor would assign a symbol of a "road in woods." It would also decide the correct road intersection symbol to be shown. The designer would then edit the road trace to the specific design.

## Scenario Assembler

A scenario assembler/editor is needed that will enable a scenario designer to create space for a new scenario, delete old scenarios, and create and name a new scenario from data in the MALOS library.

### Access Control

An access system is needed to control who can do what in creating/deleting/editing maps and scenarios. The access system will have one or more directors who will have full access to all features of the map/scenario generation system, i.e., they will be able to create, edit, delete any data base in any of the libraries and assign which features of the scenario/map generation system will be available to all other system users. When a user, to whom the director has given map create/edit capabilities, creates a map, he/she will be able to specify who will be able to edit/delete that map. The director(s) will have override authority and will be able to edit or delete any map or scenario.

### Statistical Reports

In addition to the current statistics reported in OPS 1.1, the following statistics would be helpful to lesson designers: amount of blue primary weapons system ammunition destroyed before it could be fired; number of red vehicles destroyed by fire while not engaged by an obstacle; number of red vehicles destroyed by fire while engaged by an obstacle; and number of red vehicles killed by mines. Statistics will be reported by vehicle type and when appropriate, by obstacle type, as well as summary totals.

### Scenario Replay

The ability to permit an "instant reply" of a given scenario will be provided by storing the initial state variables and a pseudorandom seed equal to the seed used in a particular scenario. The option to run the scenario in a "step mode," with the player deciding the size of the time increment step, also will be provided, i.e., the player will be able to specify how many fire rounds to run before pausing to let the player (or instructor) analyze what is happening on the screen.

### Game Performance Standards

A feature will be provided that will enable scenario designers to do multiple runs of a given scenario automatically and generate means and standard deviations for the enhanced statistical set described above. This will let scenario designers define a baseline standard against which student performance in obstacle placement can be measured.

### Calibration

The weapons effectiveness data must be improved to reflect approved probabilities to hit and to kill given a hit for each of the weapons systems. In OPS 1.1, representative data are used and have not been validated. Although the current data will be improved during the model development phase, the data validation and improvement should continue into the operation and maintenance phase. Moreover, since the model is primarily a teaching tool and not an operations research tool, instructors may, in the future, wish to bias the data somewhat to emphasize a particular teaching point.

### Troop Deployments

The attack plans and friendly troop deployments programmed into OPS 1.1 were examples only and, in the future, should be modified to reflect more realistic offensive and defensive deployments.

## 5 CONCLUSIONS AND RECOMMENDATIONS

### Conclusion

The OPS 1.1 pilot model has shown that computer simulation is a feasible way of teaching obstacle employment principles. However, pilot model's current capabilities do not include the scenario development infrastructure that instructors need to exploit this tool--that is, to allow them to deliver a particular teaching point. The OPS 1.1 scenario itself can be used in only a limited role in the overall course of instruction. A lesson development "tool kit" is needed to allow instructors to custom-design scenarios in support of specific teaching objectives. A scenario management system also is needed to control the simulation development process.

**Recommendations**

Based on results of this study, the following steps are recommended for improving OPS 1.1 capabilities:

1. Develop a scenario generation and management system to be used with the MALOS simulation driver that will enable individual instructors to custom-design scenarios easily.

2. Improve the MALOS driver to allow a reasonable range of map scales to be modeled and multiple scenarios to be run.

3. Develop a library of data bases that instructors can use as starting points for their scenario designs.

4. Improve the map editor to allow faster and easier creation of original maps and editing of existing maps.

5. Provide for a wider variety of statistical data to be collected during the simulation run.

6. Develop an enhanced version of MALOS that will allow the player to maneuver blue forces in response to the red attack.

7. Provide a scenario replay capability and an option to make the action pause after so many fire increments have transpired.

8. Evaluate the cost and benefits of developing enhanced versions of MALOS that will permit both red and blue forces to be played interactively. On one end of the spectrum would be a two-player (two-screen) game in which one red player challenges one blue player. On the other end of the spectrum would be a multiplayer game in which "m" red players challenge "n" blue players using "m+n" screens to display the game results. In any of these versions, each player would "see" on the screen only those enemy forces within his/her line of sight, not the entire battlefield situation.

**Table 1**

**Allowable Terrain Types**

| Code | Elevation | Features |
|---|---|---|
| 0 | ground | clear |
| 1 | ground | gully |
| 2 | ground | gully |
| 3 | ground | gully |
| 4 | ground | gully |
| 5 | ground | gully |
| 6 | ground | gully |
| 7 | ground | gully |
| 8 | ground | gully |
| 9 | ground | gully |
| 10 | ground | gully |
| 11 | slope | |
| 12 | hilltop | clear |
| 13 | ground | road, clear |
| 14 | ground | road, clear |
| 15 | ground | road, clear |
| 16 | ground | road, clear |
| 17 | ground | road, clear |
| 18 | ground | road, clear |
| 19 | ground | road, clear |
| 20 | ground | road, clear |
| 21 | ground | road, clear |
| 22 | ground | road, clear |
| 23 | ground | road, town |
| 24 | ground | woods |
| 25 | hilltop | woods |
| 26 | hilltop | road, town |
| 27 | hilltop | road, woods |
| 28 | hilltop | road, woods |
| 29 | hilltop | road, clear |
| 30 | hilltop | road, clear |
| 31 | hilltop | road, clear |
| 32 | hilltop | road, clear |
| 33 | slope | road |
| 34 | slope | road |
| 35 | ground | woods, road |
| 36 | ground | woods, road |
| 37 | ground | woods, road |
| 38 | ground | clear, ford |
| 39 | ground | clear, ford |
| 40 | ground | woods, road |
| 41 | ground | swamp |
| 42 | ground | road, swamp |
| 43 | ground | road, swamp |
| 44 | ground | gully, woods |
| 45 | ground | gully, woods |
| 46 | ground | ford, woods |
| 47 | ground | ford, woods |
| 48 | ground | ford, woods |
| 49 | ground | ford, woods |
| 50 | hilltop | clear, road |
| 51 | hilltop | clear, road |
| 52 | hilltop | clear, road |
| 53 | hilltop | clear, road |
| 54 | hilltop | clear, road |
| 55 | hilltop | clear, road |
| 56 | ground | water |
| 57 | ground | woods, road |
| 58 | ground | woods, road |
| 59 | ground | road,bridge,clear,water |
| 60 | ground | road,bridge,clear,water |

**Table 2**

**Graphic Terrain Symbols by Code Number**

| | | | | | |
|---|---|---|---|---|---|
| 1 | " " | 21 | " " | 41 | " " |
| 2 | " " | 22 | " " | 42 | " " |
| 3 | " " | 23 | " " | 43 | " " |
| 4 | " " | 24 | " " | 44 | " " |
| 5 | " " | 25 | " " | 45 | " " |
| 6 | " " | 26 | " " | 46 | " " |
| 7 | " " | 27 | " " | 47 | " " |
| 8 | " " | 28 | " " | 48 | " " |
| 9 | " " | 29 | " " | 49 | " " |
| 1Ø | " " | 3Ø | " " | 5Ø | " " |
| 11 | " " | 31 | " " | 51 | " " |
| 12 | " " | 32 | " " | 52 | " " |
| 13 | " " | 33 | " " | 53 | " " |
| 14 | " " | 34 | " " | 54 | " " |
| 15 | " " | 35 | " " | 55 | " " |
| 16 | " " | 36 | " " | 56 | " " |
| 17 | " " | 37 | " " | 57 | " " |
| 18 | " " | 38 | " " | 58 | " " |
| 19 | " " | 39 | " " | 59 | " " |
| 2Ø | " " | 4Ø | " " | 6Ø | " " |

## Table 3

## Movement Factor Chart

| Movement Factor | Clock Increment 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | X | X | X | X | X | X | X | X | X | X | X | X |
| 11 | X | X | X | X | X | . | X | X | X | X | X | X |
| 10 | X | X | X | X | X | . | X | X | X | X | X | . |
| 9 | X | X | X | . | X | X | X | . | X | X | X | . |
| 8 | X | X | . | X | X | . | X | X | . | X | X | . |
| 7 | X | X | . | X | . | X | . | X | X | . | X | . |
| 6 | . | X | . | X | . | X | . | X | . | X | . | X |
| 5 | . | X | . | X | . | . | X | . | X | . | . | X |
| 4 | . | . | X | . | . | X | . | . | X | . | . | X |
| 3 | . | . | . | X | . | . | . | X | . | . | . | X |
| 2 | . | . | . | . | . | X | . | . | . | . | . | X |
| 1 | . | . | . | . | . | X | . | . | . | . | . | . |
| 0 | . | . | . | . | . | . | . | . | . | . | . | . |

## Table 4

## Movement Costs for Vehicles in OPS 1.1

| FROM | TO Ground | Slope | Hilltop | Clear | Woods | Road | Bridge | Town | Gully | Swamp | Ford | Water |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ground | - | 5 | X | - | - | - | - | - | - | - | - | - |
| Slope | - | 5 | 4 | 2 | 3 | - | - | 2 | 3 | 3 | 3 | 11 |
| Hilltop | X | 3 | - | - | - | - | X | - | X | X | X | X |
| Clear | - | 3 | - | 1 | 2 | - | - | 1 | 2 | 2 | 2 | 11 |
| Woods | - | 5 | - | 2 | 5 | - | 2 | 2 | 3 | 3 | 3 | 11 |
| Road | - | - | - | - | - | 0 | 0 | - | - | - | - | - |
| Bridge | - | - | - | 1 | 2 | 0 | 0 | - | X | - | - | - |
| Town | - | 3 | - | 1 | 2 | - | - | - | 2 | 2 | 2 | 11 |
| Gully | - | 11 | X | 11 | 9 | - | X | 11 | 4 | 11 | 3 | 11 |
| Swamp | X | X | X | X | X | - | X | X | X | X | X | X |
| Ford | 2 | 5 | X | 2 | 2 | | - | 2 | 2 | 2 | 2 | 11 |
| Water | - | 11 | X | 11 | 11 | - | X | 11 | 11 | 11 | 11 | 11 |

"-" means such a move is irrelevant
"X" means such a move is not allowed

**Table 5**

**Engineer Reusable Assets Defined for OPS 1.1**

| Code | Display Description | Feature | Explanation |
|---|---|---|---|
| ces | Engineer Squads | | |
| ace | M9 ACE | Blade | ACE=Armored Combat Earthmover |
| cev | M728 CEV | Blade | CEV=Combat Engineer Vehicle |
| ebl | Bucket Loader | Blade | |
| see | Sm. Empl. Excavator | Blade | |
| gemss | M128 Mine Layer | | |

**Table 6**

**Engineer Expendable Assets Defined for OPS 1.1**

| Code | Display Description | Explanation |
|---|---|---|
| m15atm | M15 AT mines | AT=Anti-tank |
| m75atm | M75 GEMSS minefield | Ground Emplaced Mine Scattering System |
| raams | RAAMS volleys | volley: six gun battery |
| m180 | M180 Kit | Road cratering system |
| sc40 | Shape Charge (40lb) | |
| cc40 | Crater Charge (40lb) | |
| tnt | TNT | In pounds |

**Table 7**

**Engineer Task Types Defined for OPS 1.1**

| Task Code | Task Description |
|---|---|
| mfj | One 200m x 50m conventional, 1-0-0 density minefield |
| mfg | Four 200m x 50m GEMMS emplaced 1-0-0 density minefields |
| mfa | One 200m long RAAMS emplaced 1-0-0 density minefield |
| atd | One 200m long anti-tank ditch |
| brb | Demolish one primary two-lane highway bridge |
| rcm | One relieved face road crater, 30 ft x 18 ft |
| aam | One abatis, 75m long |
| urr | One urban rubble obstacle, 100 ft long, two sides |
| fp | Two each fighting positions for each of two vehicles |

## Table 8

## Engineer Asset Requirements per Task for OPS 1.1

| Asset Code | Task Codes mfj | *mfg | mfa | atd | brb | rcm | aam | urr | fp |
|---|---|---|---|---|---|---|---|---|---|
| ces | 3 | 1 | | | 1 | 1 | 1 | 4 | |
| ace | | | | 2 | | | | | |
| gemss | | 1 | | | | | | | |
| (blade) | | | | | | | | | 1 |
| m15atm | 222 | | | | | | | | |
| m75atm | | 800 | | | | | | | |
| raams | | | 6 | | | | | | |
| m180 | | | | | | 5 | | | |
| sc40 | | | | | 5 | | | | |
| cc40 | | | | | 5 | | | | |
| tnt | | | | | 160 | | 100 | 850 | |

*Distributed over 4 map cells, same or adjacent

## Table 9

## Total Engineer Assets Used for OPS 1.1

| Expendable Asset Code | Number Of Units | Renewable Asset Code | Number Of Units |
|---|---|---|---|
| m15atm | 2000 | ces | 9 |
| m75atm | 3200 | ace | 6 |
| m180 | 100 | cev | 2 |
| sc40 | 125 | ebl | 1 |
| cc40 | 70 | see | 2 |
| tnt | 15000 | gemss | 1 |
| raams | 18 | | |

| ********** Weapon: BLUE TOW ********** | | | | | | |
|---|---|---|---|---|---|---|
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 |
| P(hit),open: | 20 | 60 | 60 | 60 | 60 | 60 |
| P(kill) target in open, given hit: | | | | | | |
| trgt:T64 | 100 | 85 | 85 | 85 | 85 | 85 |
| trgt:BMP | 100 | 85 | 85 | 85 | 85 | 85 |
| trgt:BTR60 | 100 | 85 | 85 | 85 | 85 | 85 |
| P(h),defilade: | 10 | 40 | 40 | 40 | 40 | 40 |
| P(kill) target in defilade, given hit: | | | | | | |
| trgt:T64 | 100 | 50 | 50 | 50 | 50 | 50 |
| trgt:BMP | 100 | 63 | 63 | 63 | 63 | 63 |
| trgt:BTR60 | 100 | 63 | 63 | 63 | 63 | 63 |

| ********** Weapon: BLUE 105mm ********** | | | | | | |
|---|---|---|---|---|---|---|
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 |
| P(hit),open: | 50 | 50 | 50 | 45 | 40 | 35 |
| P(kill) target in open, given hit: | | | | | | |
| trgt:T64 | 100 | 90 | 80 | 78 | 75 | 71 |
| trgt:BMP | 100 | 100 | 100 | 100 | 100 | 100 |
| trgt:BTR60 | 100 | 100 | 100 | 100 | 100 | 100 |
| P(h),defilade: | 40 | 35 | 30 | 25 | 20 | 15 |
| P(kill) target in defilade, given hit: | | | | | | |
| trgt:T64 | 100 | 85 | 83 | 80 | 75 | 67 |
| trgt:BMP | 100 | 100 | 100 | 100 | 100 | 100 |
| trgt:BTR60 | 100 | 100 | 100 | 100 | 100 | 100 |

| ********** Weapon: BLUE 25mm ********** | | | | | |
|---|---|---|---|---|---|
| range(m) | 200 | 400 | 600 | 800 | 1000 |
| P(hit),open: | 40 | 20 | 10 | 5 | 5 |
| P(kill) target in open, given hit: | | | | | |
| trgt:T64 | 3 | 0 | 0 | 0 | 0 |
| trgt:BMP | 25 | 25 | 25 | 20 | 15 |
| trgt:BTR60 | 25 | 25 | 25 | 20 | 15 |
| P(h),defilade: | 6 | 4 | 3 | 2 | 1 |
| P(kill) target in defilade, given hit: | | | | | |
| trgt:T64 | 0 | 0 | 0 | 0 | 0 |
| trgt:BMP | 3 | 0 | 0 | 0 | 0 |
| trgt:BTR60 | 3 | 0 | 0 | 0 | 0 |

**********

1 of 3

**Table 10**

**Blue Weapon Probability Values Used in OPS 1.1**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| apon: BLUE TOW ********** | | | | | | | | |
| 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 |
| 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 55 |
| 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 35 |
| t: | | | | | | | | |
| 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 | 63 |
| apon: BLUE 105mm ********** | | | | | | | | |
| 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 |
| 50 | 45 | 40 | 35 | 30 | 30 | 25 | 20 | 15 |
| 80 | 78 | 75 | 71 | 67 | 67 | 60 | 50 | 33 |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 30 | 25 | 20 | 15 | 10 | 10 | 5 | 5 | |
| t: | | | | | | | | |
| 83 | 80 | 75 | 67 | 50 | 50 | 20 | 20 | |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |
| 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | |
| apon: BLUE 25mm ********** | | | | | | | | |
| 600 | 800 | 1000 | | | | | | |
| 10 | 5 | 5 | | | | | | |
| 0 | 0 | 0 | | | | | | |
| 25 | 20 | 15 | | | | | | |
| 25 | 20 | 15 | | | | | | |
| 3 | 2 | 1 | | | | | | |
| it: | | | | | | | | |
| 0 | 0 | 0 | | | | | | |
| 0 | 0 | 0 | | | | | | |
| 0 | 0 | 0 | | | | | | |

**********

of 3

1.1

| 2200 | 2400 | 2600 | 2800 | 3000 | 3200 | 3400 | 3600 |
|---|---|---|---|---|---|---|---|
| 55 | 50 | 50 | 50 | 50 | 45 | 40 | 40 |
| 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| 85 | 85 | 85 | 85 | 85 | 85 | 85 | 85 |
| 35 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| 50 | 50 | 50 | 50 | 33 | 33 | 20 | 15 |
| 63 | 63 | 63 | 63 | 50 | 33 | 33 | 33 |
| 63 | 63 | 63 | 63 | 50 | 33 | 33 | 33 |

| 2200 | 2400 | 2600 | 2800 | 3000 | 3200 | 3400 | 3600 |
|---|---|---|---|---|---|---|---|
| 15 | 10 | 5 | | | | | |
| 33 | 30 | 15 | | | | | |
| 100 | 50 | 50 | | | | | |
| 100 | 50 | 50 | | | | | |

2 of 3

| ********** Weapon: BLUE TOW ********** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | 140 |
| P(kill),target in open: | | | | | | | |
| trgt:T64 | 20 | 51 | 51 | 51 | 51 | 51 | 5 |
| trgt: BM | 20 | 51 | 51 | 51 | 51 | 51 | 5 |
| trgt:BTR | 20 | 51 | 51 | 51 | 51 | 51 | 5 |
| P(kill),target in defilade: | | | | | | | |
| trgt:T64 | 10 | 20 | 20 | 20 | 20 | 20 | 2 |
| trgt:BMP | 10 | 25.2 | 25.2 | 25.2 | 25.2 | 25.2 | 25. |
| trgt:BTR | 10 | 25.2 | 25.2 | 25.2 | 25.2 | 25.2 | 25. |

| ********** Weapon: BLUE 105mm ********** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | 140 |
| P(kill),target in open: | | | | | | | |
| trgt:T64 | 50 | 45 | 40 | 35.1 | 30 | 24.85 | 20. |
| trgt:BMP | 50 | 50 | 50 | 45 | 40 | 35 | 3 |
| trgt:BTR | 50 | 50 | 50 | 45 | 40 | 35 | 3 |
| P(kill),target in defilade: | | | | | | | |
| trgt:T64 | 40 | 29.75 | 24.9 | 20 | 15 | 10.05 | |
| trgt:BMP | 40 | 35 | 30 | 25 | 20 | 15 | 1 |
| trgt:BTR | 40 | 35 | 30 | 25 | 20 | 15 | 1 |

| ********** Weapon: BLUE 25mm ********** | | | | | |
|---|---|---|---|---|---|
| Range(m): | 200 | 400 | 600 | 800 | 1000 |
| P(kill),target in open: | | | | | |
| trgt:T64 | 1.2 | 0 | 0 | 0 | 0 |
| trgt:BMP | 10 | 5 | 2.5 | 1 | .75 |
| trgt:BTR | 10 | 5 | 2.5 | 1 | .75 |
| P(kill),target in defilade: | | | | | |
| trgt:T64 | 0 | 0 | 0 | 0 | 0 |
| trgt:BMP | .18 | 0 | 0 | 0 | 0 |
| trgt:BTR | .18 | 0 | 0 | 0 | 0 |

**********

1 of 3

**Table 11**

**Blue Fire Kill Probabilities Computed by MALOS**

| 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 260 |
|---|---|---|---|---|---|---|---|---|
| 51 | 51 | 51 | 51 | 51 | 51 | 46.75 | 42.5 | 42. |
| 51 | 51 | 51 | 51 | 51 | 51 | 46.75 | 42.5 | 42. |
| 51 | 51 | 51 | 51 | 51 | 51 | 46.75 | 42.5 | 42. |
| 20 | 20 | 20 | 20 | 20 | 20 | 17.5 | 15 | 1 |
| 25.2 | 25.2 | 25.2 | 25.2 | 25.2 | 25.2 | 22.05 | 18.9 | 18. |
| 25.2 | 25.2 | 25.2 | 25.2 | 25.2 | 25.2 | 22.05 | 18.9 | 18. |

| 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 260 |
|---|---|---|---|---|---|---|---|---|
| 30 | 24.85 | 20.1 | 20.1 | 15 | 10 | 4.95 | 3 | .7 |
| 40 | 35 | 30 | 30 | 25 | 20 | 15 | 5 | 2. |
| 40 | 35 | 30 | 30 | 25 | 20 | 15 | 5 | 2. |
| 15 | 10.05 | 5 | 5 | 1 | 1 | | | |
| 20 | 15 | 10 | 10 | 5 | 5 | | | |
| 20 | 15 | 10 | 10 | 5 | 5 | | | |

| 1000 |
|---|
| 0 |
| .75 |
| .75 |
| 0 |
| 0 |
| 0 |

| 2400 | 2600 | 2800 | 3000 | 3200 | 3400 | 3600 |
|---|---|---|---|---|---|---|
| 42.5 | 42.5 | 42.5 | 42.5 | 38.25 | 34 | 34 |
| 42.5 | 42.5 | 42.5 | 42.5 | 38.25 | 34 | 34 |
| 42.5 | 42.5 | 42.5 | 42.5 | 38.25 | 34 | 34 |
| 15 | 15 | 15 | 9.9 | 9.9 | 6 | 4.5 |
| 18.9 | 18.9 | 18.9 | 15 | 9.9 | 9.9 | 9.9 |
| 18.9 | 18.9 | 18.9 | 15 | 9.9 | 9.9 | 9.9 |

| 2400 | 2600 |
|---|---|
| 3 | .75 |
| 5 | 2.5 |
| 5 | 2.5 |

## Table 12

## Red Weapon Probability Values Used in OPS 1.1

| ********** Weapon: RED AT3 ********** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| range(m) | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 2600 |
| P(hit),open: | 60 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 40 | 30 | 25 | 20 | 20 |
| P(kill) target in open, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| trgt:M2 | 80 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| trgt:ITV | 80 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| P(h),defilade: | 40 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 20 | 10 | 5 | 5 | 5 |
| P(kill) target in defilade, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 50 | 50 | 50 | 50 | 33 | 33 | 33 | 33 | 25 | 25 | 25 | 10 | 10 |
| trgt:M2 | 50 | 50 | 50 | 50 | 33 | 33 | 33 | 33 | 25 | 25 | 25 | 10 | 10 |
| trgt:ITV | 50 | 50 | 50 | 50 | 33 | 33 | 33 | 33 | 25 | 25 | 25 | 10 | 10 |
| ********** Weapon: RED 125mm ********** | | | | | | | | | | | | | |
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 2600 |
| p(h),open: | 60 | 50 | 50 | 45 | 40 | 35 | 30 | 30 | 25 | 20 | 15 | 10 | 5 |
| P(kill) target in open, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 67 | 60 | 60 | 55 | 55 | 55 | 50 | 33 | 33 | 25 | 25 | 10 | 10 |
| trgt:M2 | 83 | 80 | 80 | 78 | 75 | 71 | 67 | 67 | 60 | 50 | 33 | 33 | 33 |
| trgt:ITV | 83 | 80 | 80 | 78 | 75 | 71 | 67 | 67 | 60 | 50 | 33 | 33 | 33 |
| P(h),defilade: | 30 | 30 | 30 | 25 | 25 | 20 | 15 | 15 | 10 | 10 | | | |
| P(kill) target in defilade, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 67 | 67 | 67 | 60 | 60 | 50 | 33 | 33 | 10 | 10 | | | |
| trgt:M2 | 83 | 83 | 83 | 80 | 80 | 80 | 80 | 80 | 80 | 50 | | | |
| trgt:ITV | 83 | 83 | 83 | 80 | 80 | 80 | 80 | 80 | 80 | 50 | | | |
| ********** Weapon: RED 73mm ********** | | | | | | | | | | | | | |
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | | | | | | | |
| P(hit),open: | 30 | 25 | 20 | 10 | 5 | 1 | | | | | | | |
| P(kill) target in open, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 67 | 60 | 50 | 50 | 20 | 10 | | | | | | | |
| trgt:M2 | 83 | 80 | 75 | 60 | 40 | 20 | | | | | | | |
| trgt:ITV | 83 | 80 | 75 | 60 | 40 | 20 | | | | | | | |
| P(h),defilade: | 25 | 20 | 15 | 5 | | | | | | | | | |
| P(kill) target in defilade, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 40 | 30 | 25 | 10 | | | | | | | | | |
| trgt:M2 | 60 | 60 | 60 | 40 | | | | | | | | | |
| trgt:ITV | 60 | 60 | 60 | 40 | | | | | | | | | |
| ********** Weapon: RED 14.5mm ********** | | | | | | | | | | | | | |
| Range(m): | 200 | 400 | 600 | 800 | 1000 | | | | | | | | |
| P(hit),open: | 40 | 35 | 30 | 25 | 20 | | | | | | | | |
| P(kill) target in open, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 13 | 3 | 3 | 0 | 0 | | | | | | | | |
| trgt:M2 | 25 | 15 | 15 | 15 | 15 | | | | | | | | |
| trgt:ITV | 25 | 15 | 15 | 15 | 15 | | | | | | | | |
| P(h),defilade: | 30 | 25 | 20 | 15 | | | | | | | | | |
| P(kill) target in defilade, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 3 | 0 | 0 | 0 | | | | | | | | | |
| trgt:M2 | 15 | 8 | 8 | 8 | | | | | | | | | |
| trgt:ITV | 15 | 8 | 8 | 8 | | | | | | | | | |
| ********** Weapon: RED 12.7mm ********** | | | | | | | | | | | | | |
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | | | | | | |
| P(hit),open: | 30 | 25 | 20 | 10 | 10 | 5 | 5 | | | | | | |
| P(kill) target in open, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 16 | 10 | 5 | 0 | 0 | 0 | 0 | | | | | | |
| trgt:M2 | 33 | 30 | 25 | 25 | 20 | 10 | 5 | | | | | | |
| trgt:ITV | 33 | 30 | 25 | 25 | 20 | 10 | 5 | | | | | | |
| P(h),defilade: | 20 | 15 | 10 | 5 | 5 | | | | | | | | |
| P(kill) target in defilade, given hit: | | | | | | | | | | | | | |
| trgt:M1 | 10 | 10 | 5 | 5 | 0 | | | | | | | | |
| trgt:M2 | 15 | 15 | 10 | 5 | 5 | | | | | | | | |
| trgt:ITV | 15 | 15 | 10 | 5 | 5 | | | | | | | | |

## Table 13

## Red Fire Kill Probabilities Computed by MALOS

| Weapon: RED AT3 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 2600 |
| P(kill),target in open: | | | | | | | | | | | | | |
| trgt:M1 | 30 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 20 | 15 | 12.5 | 10 | 10 |
| trgt:M2 | 52.8 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 24 | 18 | 15 | 12 | 12 |
| trgt:ITV | 52.8 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 24 | 18 | 15 | 12 | 12 |
| P(kill),target in defilade: | | | | | | | | | | | | | |
| trgt:M1 | 20 | 15 | 15 | 15 | 9.9 | 9.9 | 9.9 | 9.9 | 5 | 2.5 | 1.25 | .5 | .5 |
| trgt:M2 | 20 | 15 | 15 | 15 | 9.9 | 9.9 | 9.9 | 9.9 | 5 | 2.5 | 1.25 | .5 | .5 |
| trgt:ITV | 20 | 15 | 15 | 15 | 9.9 | 9.9 | 9.9 | 9.9 | 5 | 2.5 | 1.25 | .5 | .5 |
| **Weapon: RED 125mm** | | | | | | | | | | | | | |
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | 1600 | 1800 | 2000 | 2200 | 2400 | 2600 |
| P(kill),target in open: | | | | | | | | | | | | | |
| trgt:M1 | 40.2 | 30 | 30 | 24.75 | 22 | 19.25 | 15 | 9.9 | 8.25 | 5 | 3.75 | 1 | .5 |
| trgt:M2 | 49.8 | 40 | 40 | 35.1 | 30 | 24.85 | 20.1 | 20.1 | 15 | 10 | 4.95 | 3.3 | 1 |
| trgt:ITV | 49.8 | 40 | 40 | 35.1 | 30 | 24.85 | 20.1 | 20.1 | 15 | 10 | 4.95 | 3.3 | 1 |
| P(kill),target in defilade: | | | | | | | | | | | | | |
| trgt:M1 | 20.1 | 20.1 | 20.1 | 15 | 15 | 10 | 4.95 | 4.95 | 1 | 1 | | | |
| trgt:M2 | 24.9 | 24.9 | 24.9 | 20 | 20 | 16 | 12 | 12 | 8 | 5 | | | |
| trgt"ITV | 24.9 | 24.9 | 24.9 | 20 | 20 | 16 | 12 | 12 | 8 | 5 | | | |
| **Weapon: RED 73mm** | | | | | | | | | | | | | |
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | | | | | | | |
| P(kill),target in open: | | | | | | | | | | | | | |
| trgt:M1 | 20.1 | 15 | 10 | 5 | 1 | .1 | | | | | | | |
| trgt:M2 | 24.9 | 20 | 15 | 6 | 2 | .2 | | | | | | | |
| trgt:ITV | 24.9 | 20 | 15 | 6 | 2 | .2 | | | | | | | |
| P(kill),target in defilade: | | | | | | | | | | | | | |
| trgt:M1 | 10 | 6 | 3.75 | .5 | | | | | | | | | |
| trgt:M2 | 15 | 12 | 9 | 2 | | | | | | | | | |
| trgt:ITV | 15 | 12 | 9 | 2 | | | | | | | | | |
| **Weapon: RED 14.5mm** | | | | | | | | | | | | | |
| Range(m): | 200 | 400 | 600 | 800 | 1000 | | | | | | | | |
| P(kill),target in open: | | | | | | | | | | | | | |
| trgt:M1 | 5.2 | 1.05 | .9 | 0 | 0 | | | | | | | | |
| trgt:M2 | 10 | 5.25 | 4.5 | 3.75 | 3 | | | | | | | | |
| trgt:ITV | 10 | 5.25 | 4.5 | 3.75 | 3 | | | | | | | | |
| P(kill),target in defilade: | | | | | | | | | | | | | |
| trgt:M1 | .9 | 0 | 0 | 0 | | | | | | | | | |
| trgt:M2 | 4.5 | 2 | 1.6 | 1.2 | | | | | | | | | |
| trgt:ITV | 4.5 | 2 | 1.6 | 1.2 | | | | | | | | | |
| **Weapon: RED 12.7mm** | | | | | | | | | | | | | |
| Range(m): | 200 | 400 | 600 | 800 | 1000 | 1200 | 1400 | | | | | | |
| P(kill),target in open: | | | | | | | | | | | | | |
| trgt:M1 | 4.8 | 2.5 | 1 | 0 | 0 | 0 | 0 | | | | | | |
| trgt:M2 | 9.9 | 7.5 | 5 | 2.5 | 2 | .5 | .25 | | | | | | |
| trgt:ITV | 9.9 | 7.5 | 5 | 2.5 | 2 | .5 | .25 | | | | | | |
| P(kill),target in defilade: | | | | | | | | | | | | | |
| trgt:M1 | 2 | 1.5 | .5 | .25 | 0 | | | | | | | | |
| trgt:M2 | 3 | 2.25 | 1 | .25 | .25 | | | | | | | | |
| trgt:ITV | 3 | 2.25 | 1 | .25 | .25 | | | | | | | | |

## Table 14

## Piece Definition Data

| Team: | Blue | Blue | Blue | Red | Red | Red |
|---|---|---|---|---|---|---|
| Piece name: | M1 | M2 | ITV | T-64 | BTR-60 | BMP |
| Primary Weapon: | 105mm | TOW | TOW | 125mm | 14.5mm | AT-3 |
| Secondary Weapon: | none | 25mm | none | 12.7mm | none | 73mm |
| Primary Basic Load: | 55 | 12 | 12 | 40 | 127 | 4 |
| Movement Factor: | 12 | 12 | 12 | 12 | 12 | 12 |

## Table 15

## Blue Force Order of Battle

| Unit No. | Unit Name | Number of Pieces By Type In Each Discrete Subordinate Unit | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M2 | M2 | M2 | M2 | M2 | M2 | M2 | M1 | M1 | M1 | M1 | M1 | M1 | M1 | ITV | ITV | ITV | ITV | ITV | ITV |
| 116 | Co. "A" | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | |
| 117 | Co. "B" | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | |
| 118 | Co. "C" | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | |
| 119 | Co. "D" | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | |
| 120 | Co. "E" | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | |
| 121 | Co. "F" | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | |
| 122 | Co. "M" | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | |
| 123 | Co. "N" | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | |
| 124 | Co. "X" | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 |
| 125 | Co. "Y" | | | | | | | | | | | | | | | 2 | 2 | 2 | 2 | 2 | 2 |

## Table 16

## Red Force Order of Battle

| Unit No. | Unit Name | Number of Pieces By Type In Each Discrete Subordinate Unit | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | BTR-60 | BTR-60 | BTR-60 | T-64 | T-64 | T-64 | BMP | BMP | BMP |
| 101 | Bn. "A" | 11 | 11 | 11 | | | | | | |
| 102 | Bn. "B" | 11 | 11 | 11 | | | | | | |
| 103 | Bn. "C" | 11 | 11 | 11 | | | | | | |
| 104 | Bn. "D" | 11 | 11 | 11 | | | | | | |
| 105 | Bn. "E" | 11 | 11 | 11 | | | | | | |
| 106 | Bn. "F" | 11 | 11 | 11 | | | | | | |
| 107 | Bn. "M" | | | | 14 | 13 | 13 | | | |
| 108 | Bn. "N" | | | | 14 | 13 | 13 | | | |
| 100 | Bn. "O" | | | | 14 | 13 | 13 | | | |
| 110 | Bn. "P" | | | | 11 | 10 | 10 | | | |
| 111 | Bn. "Q" | | | | 11 | 10 | 10 | | | |
| 112 | Bn. "R" | | | | 11 | 10 | 10 | | | |
| 113 | Bn. "X" | | | | | | | 11 | 11 | 11 |
| 114 | Bn. "Y" | | | | | | | 11 | 11 | 11 |
| 115 | Bn. "Z" | | | | | | | 11 | 11 | 11 |

## Table 17

## End of Battle Kill Statistics for 20 Runs of OPS 1.1

| Attack Plan | Level of Engineer Effort | Mean Number Killed, Blue Force | | | | %Change (of Total) | Mean Number Killed, Red Force | | | | %Change (of Total) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ITV | M1 | M2 | TOTAL | | BMP | BTR-60 | T-64 | TOTAL | |
| A | 0 | 17 | 24 | 60 | 100 | Base | 9 | 198 | 157 | 364 | Base |
| | 2 | 15 | 23 | 66 | 104 | 4 | 11 | 198 | 146 | 355 | -3 |
| | 3 | 15 | 20 | 66 | 101 | 1 | 11 | 198 | 144 | 353 | -3 |
| | 4 | 15 | 20 | 64 | 99 | -1 | 16 | 198 | 153 | 367 | 1 |
| B | 0 | 10 | 27 | 63 | 100 | Base | 6 | 198 | 160 | 365 | Base |
| | 2 | 13 | 26 | 60 | 99 | -1 | 11 | 198 | 159 | 368 | 1 |
| | 3 | 10 | 22 | 59 | 91 | -9 | 10 | 198 | 159 | 367 | 1 |
| | 4 | 10 | 20 | 57 | 87 | -13 | 15 | 198 | 163 | 376 | 3 |
| C | 0 | 13 | 23 | 63 | 99 | Base | 9 | 198 | 157 | 365 | Base |
| | 2 | 13 | 23 | 56 | 92 | -7 | 11 | 198 | 158 | 368 | 1 |
| | 3 | 12 | 20 | 56 | 88 | -11 | 11 | 198 | 156 | 365 | 0 |
| | 4 | 12 | 20 | 55 | 87 | -12 | 16 | 198 | 163 | 378 | 4 |
| D | 0 | 24 | 24 | 67 | 115 | Base | 92 | 198 | 88 | 378 | Base |
| | 2 | 23 | 24 | 64 | 111 | -3 | 97 | 198 | 103 | 398 | 5 |
| | 3 | 19 | 23 | 59 | 101 | -12 | 99 | 198 | 117 | 414 | 10 |
| | 4 | 18 | 23 | 59 | 101 | -12 | 99 | 198 | 122 | 419 | 11 |
| E | 0 | 24 | 28 | 83 | 135 | Base | 71 | 198 | 117 | 386 | Base |
| | 2 | 24 | 28 | 82 | 133 | -1 | 75 | 198 | 114 | 387 | 0 |
| | 3 | 23 | 26 | 74 | 123 | -9 | 78 | 198 | 136 | 413 | 7 |
| | 4 | 15 | 23 | 66 | 105 | -22 | 84 | 198 | 158 | 440 | 14 |

## Table 18

## End of Battle Survivor Statistics for 20 Runs of OPS 1.1

| Attack Plan | Level of Engineer Effort | Mean Number of Survivors, Blue Force | | | | | Mean Number of Survivors, Red Force | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ITV | M1 | M2 | TOTAL | %Change (of Total) | BMP | BTR-60 | T-64 | TOTAL | %Change (of Total) |
| A | 0 | 7 | 4 | 24 | 36 | Base | 90 | 0 | 56 | 146 | Base |
| | 2 | 9 | 5 | 18 | 32 | -11 | 88 | 0 | 67 | 155 | 6 |
| | 3 | 9 | 8 | 18 | 35 | -3 | 88 | 0 | 69 | 157 | 8 |
| | 4 | 9 | 8 | 20 | 37 | 3 | 83 | 0 | 60 | 143 | -2 |
| B | 0 | 13 | 1 | 21 | 36 | Base | 93 | 0 | 53 | 145 | Base |
| | 2 | 11 | 2 | 24 | 37 | 3 | 88 | 0 | 54 | 142 | -2 |
| | 3 | 14 | 6 | 25 | 45 | 25 | 89 | 0 | 54 | 143 | -1 |
| | 4 | 14 | 8 | 27 | 49 | 36 | 84 | 0 | 50 | 134 | -8 |
| C | 0 | 11 | 5 | 21 | 37 | Base | 90 | 0 | 56 | 145 | Base |
| | 2 | 11 | 5 | 28 | 44 | 19 | 88 | 0 | 55 | 142 | -2 |
| | 3 | 12 | 8 | 28 | 48 | 30 | 88 | 0 | 57 | 145 | 0 |
| | 4 | 12 | 8 | 29 | 49 | 32 | 83 | 0 | 50 | 132 | -9 |
| D | 0 | 0 | 4 | 17 | 21 | Base | 7 | 0 | 125 | 132 | Base |
| | 2 | 1 | 4 | 20 | 25 | 19 | 2 | 0 | 110 | 112 | -15 |
| | 3 | 5 | 5 | 25 | 35 | 67 | 0 | 0 | 96 | 96 | -27 |
| | 4 | 6 | 5 | 25 | 35 | 67 | 0 | 0 | 91 | 91 | -31 |
| E | 0 | 0 | 0 | 1 | 1 | | 28 | 0 | 96 | 124 | |
| | 2 | 0 | 0 | 2 | 3 | | 24 | 0 | 99 | 123 | |
| | 3 | 1 | 2 | 10 | 13 | | 21 | 0 | 77 | 97 | |
| | 4 | 9 | 5 | 18 | 31 | | 15 | 0 | 55 | 70 | |

## Table 19

### Standard Deviations for Numbers Killed and Survived

| Attack Plan | Level of Engineer Effort | Blue Force Standard Deviations | | | | Red Force Standard Deviations | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ITV | M1 | M2 | TOTAL | BMP | BTR-60 | T-64 | TOTAL |
| A | 0 | 2 | 2 | 4 | 6 | 3 | 0 | 6 | 8 |
| | 2 | 2 | 2 | 3 | 5 | 4 | 0 | 10 | 12 |
| | 3 | 1 | 1 | 2 | 2 | 4 | 0 | 10 | 12 |
| | 4 | 1 | 0 | 4 | 4 | 7 | 0 | 9 | 13 |
| B | 0 | 3 | 1 | 3 | 6 | 3 | 0 | 6 | 8 |
| | 2 | 3 | 1 | 3 | 6 | 7 | 0 | 8 | 11 |
| | 3 | 2 | 0 | 2 | 4 | 8 | 0 | 7 | 12 |
| | 4 | 2 | 0 | 2 | 3 | 10 | 0 | 6 | 14 |
| C | 0 | 1 | 1 | 5 | 6 | 3 | 0 | 6 | 8 |
| | 2 | 2 | 1 | 4 | 6 | 4 | 0 | 8 | 10 |
| | 3 | 0 | 0 | 3 | 3 | 3 | 0 | 7 | 8 |
| | 4 | 1 | 0 | 2 | 2 | 8 | 0 | 6 | 13 |
| D | 0 | 0 | 0 | 3 | 4 | 7 | 0 | 10 | 13 |
| | 2 | 1 | 1 | 3 | 4 | 6 | 0 | 12 | 16 |
| | 3 | 3 | 1 | 3 | 7 | 0 | 0 | 9 | 9 |
| | 4 | 4 | 1 | 3 | 7 | 0 | 0 | 10 | 10 |
| E | 0 | 0 | 1 | 2 | 3 | 7 | 0 | 12 | 17 |
| | 2 | 1 | 0 | 3 | 5 | 5 | 0 | 13 | 16 |
| | 3 | 2 | 1 | 3 | 5 | 6 | 0 | 10 | 13 |
| | 4 | 5 | 1 | 5 | 10 | 7 | 0 | 8 | 13 |

## Table 20

## Mean Run Times and Standard Deviation of 20 Runs

| Attack Plan | Levels of Engineer Effort | Mean Simulation Time (Seconds) | %change | Standard Deviation (Seconds) |
|---|---|---|---|---|
| A | 0 | 4344 | Base | 0 |
| | 2 | 5089 | 17 | 5 |
| | 3 | 5088 | 17 | 2 |
| | 4 | 5096 | 17 | 36 |
| B | 0 | 4152 | Base | 0 |
| | 2 | 4960 | 19 | 30 |
| | 3 | 4988 | 20 | 39 |
| | 4 | 4968 | 20 | 94 |
| C | 0 | 4344 | Base | 0 |
| | 2 | 5088 | 17 | 0 |
| | 3 | 5088 | 17 | 0 |
| | 4 | 5094 | 17 | 27 |
| D | 0 | 3432 | Base | 0 |
| | 2 | 4886 | 42 | 27 |
| | 3 | 4908 | 43 | 42 |
| | 4 | 4895 | 43 | 29 |
| E | 0 | 3765 | Base | 426 |
| | 2 | 5257 | 40 | 211 |
| | 3 | 5439 | 44 | 105 |
| | 4 | 5437 | 44 | 133 |

## Table 21

## Standards for Judging Efficiency of Engineer Effort

| | Max Blue Killed If Engineer Effort Is Significant | | | Min Red Killed If Engineer Effort Is Significant | | |
|---|---|---|---|---|---|---|
| Attack Plan | ITV | M1 | M2 | BMP | BTR-60 | T-64 |
| A | 13 | 20 | 51 | 16 | 198 | 170 |
| B | 3 | 25 | 56 | 13 | 198 | 173 |
| C | 11 | 21 | 52 | 16 | 198 | 170 |
| D | 24 | 34 | 60 | 108 | 198 | 110 |
| E | 24 | 26 | 79 | 87 | 198 | 144 |

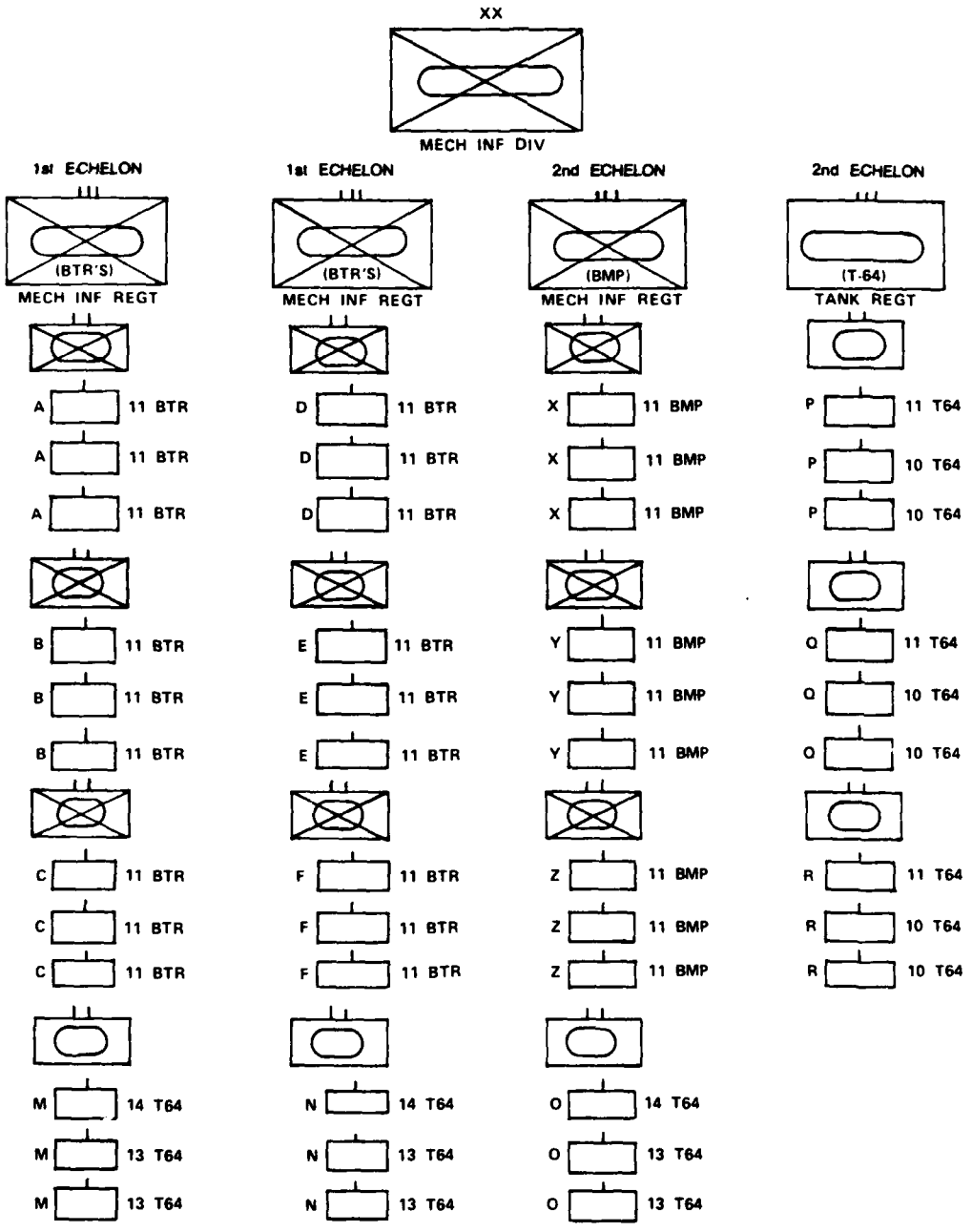



**Figure 1.** Enemy force organization for combat.

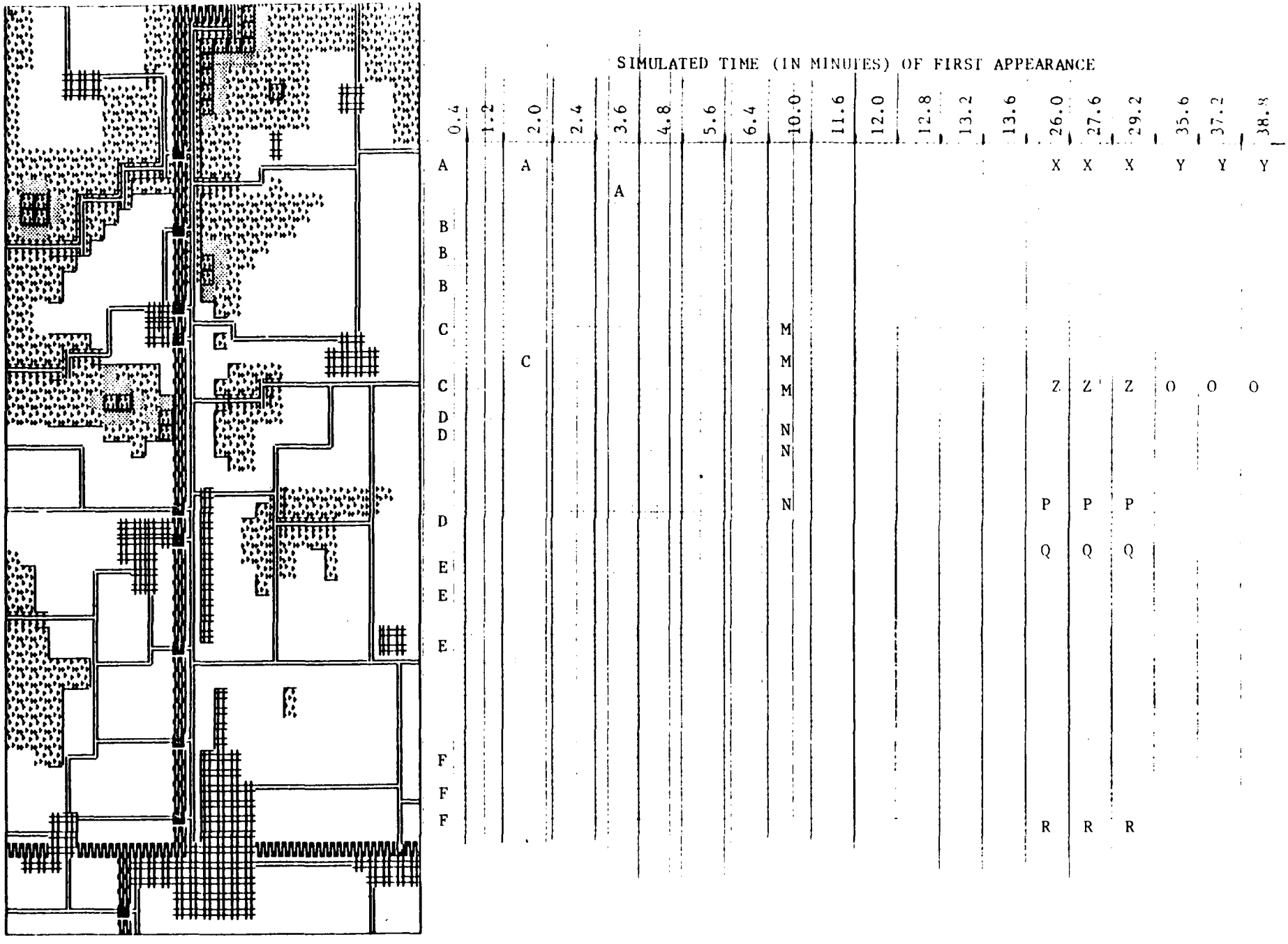



**Figure 2.** Enemy attack formation "A."

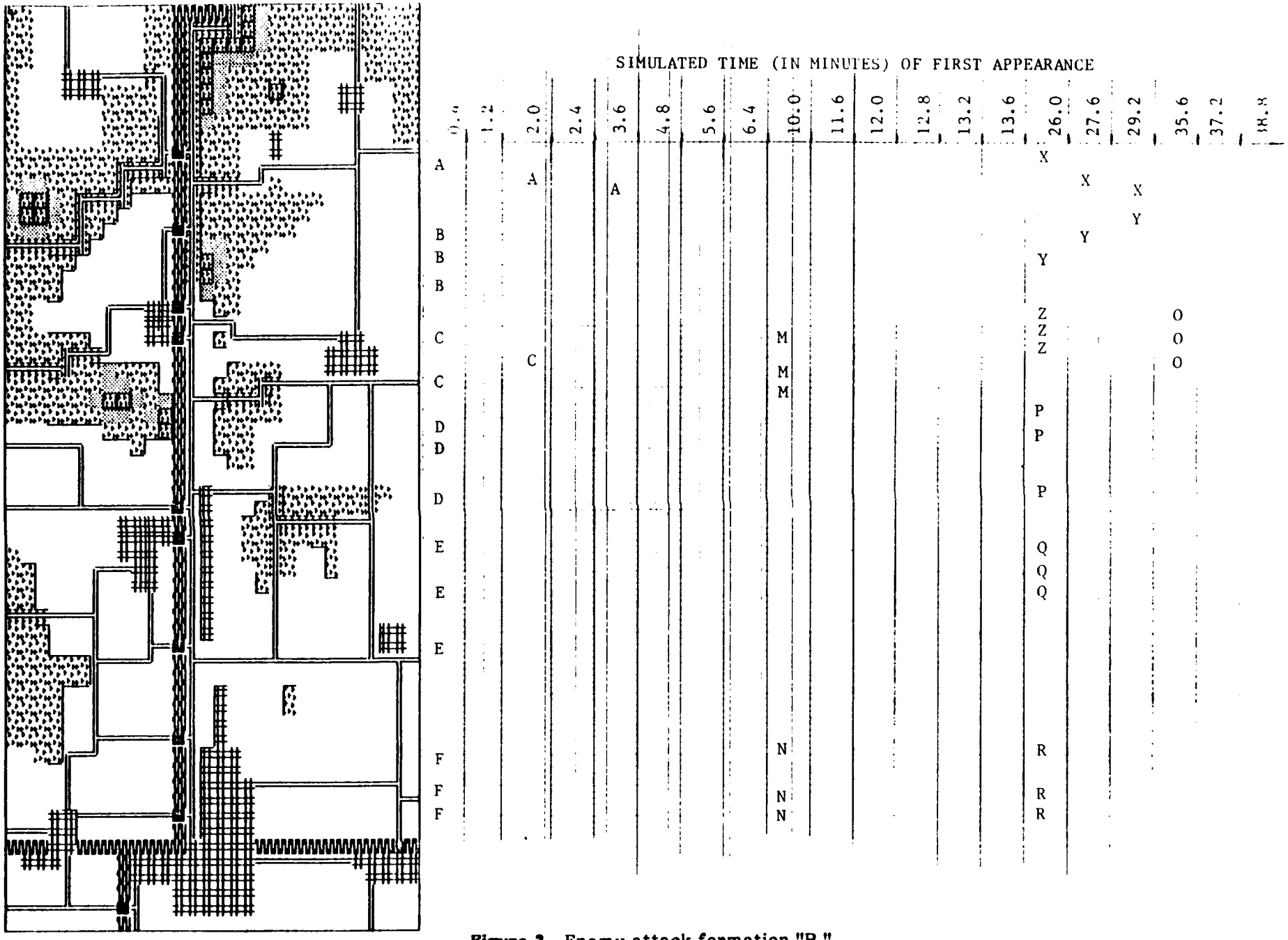



**Figure 3.** Enemy attack formation "B."

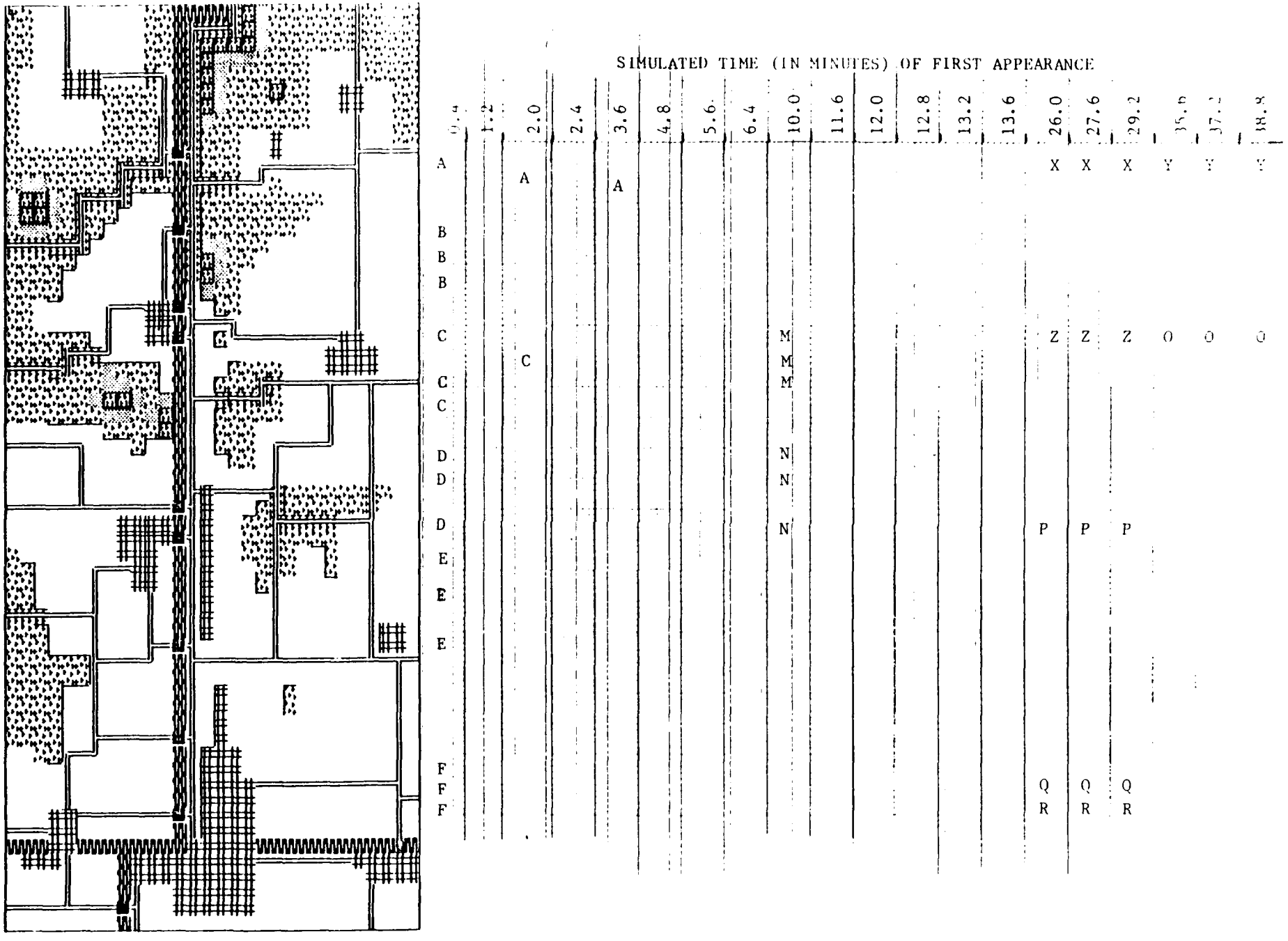
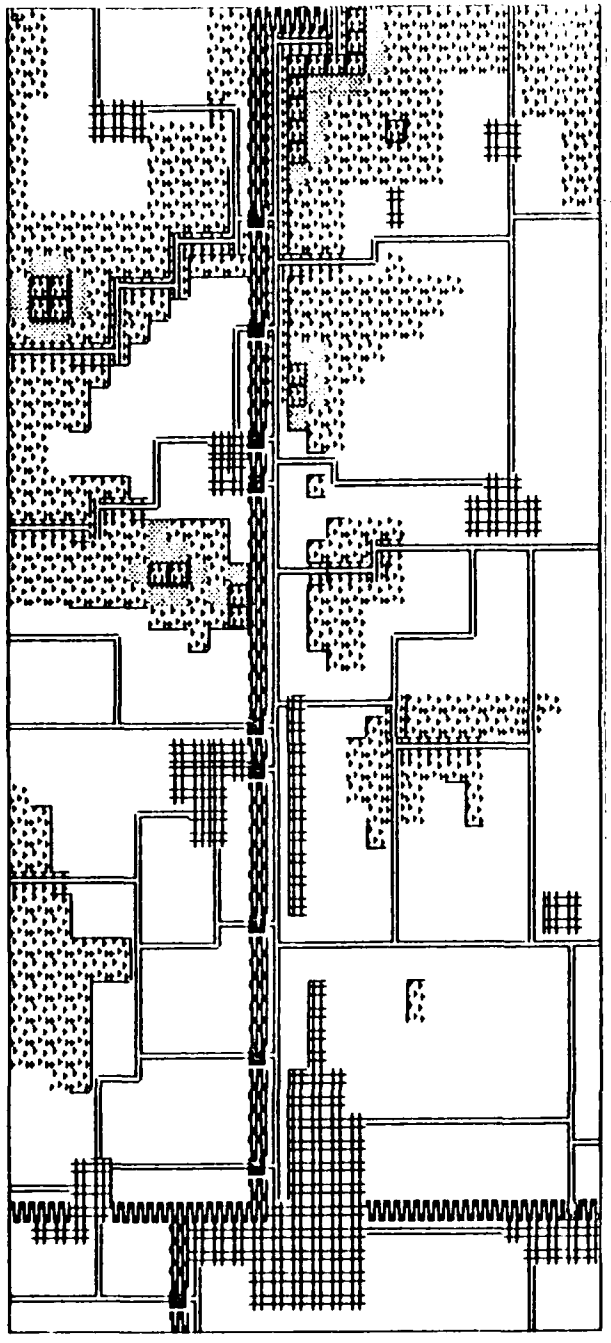



**Figure 4.** Enemy attack formation "C."



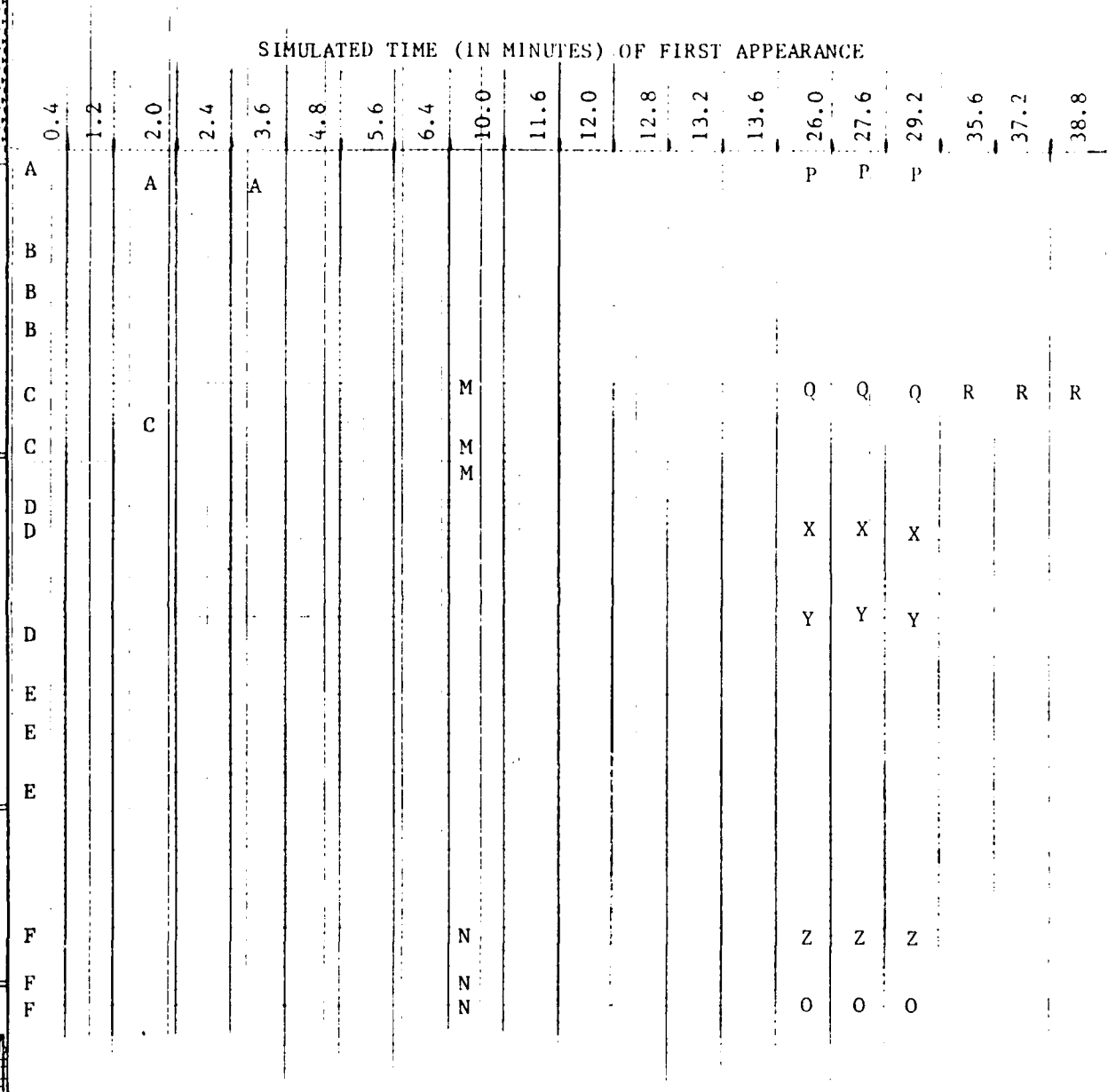
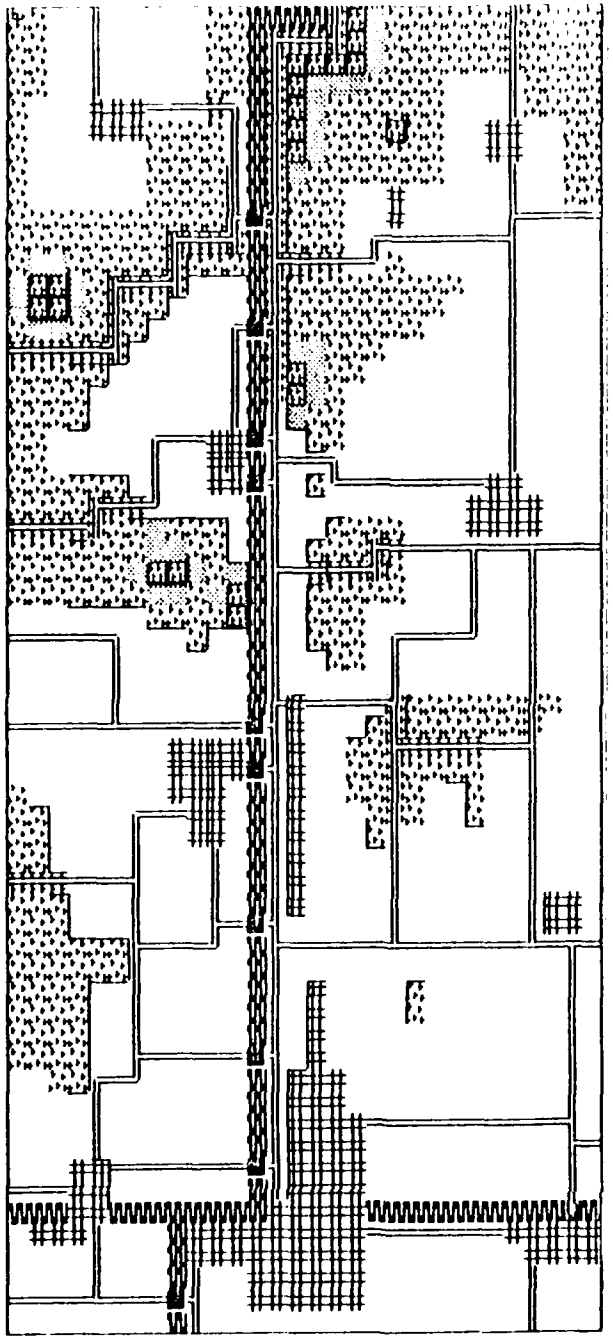



**Figure 5.** Enemy attack formation "D."



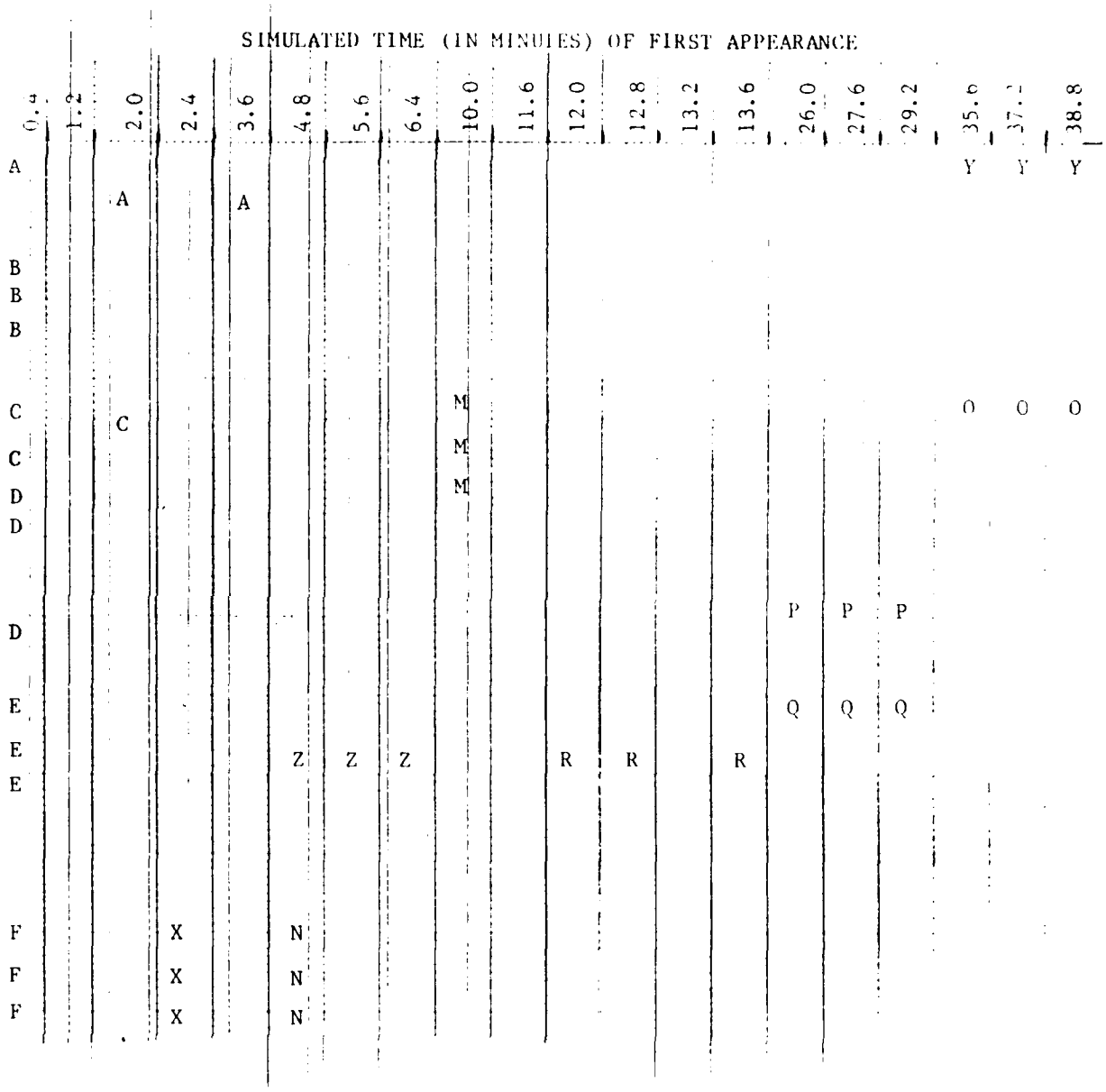



**Figure 6.** Enemy attack formation "E."

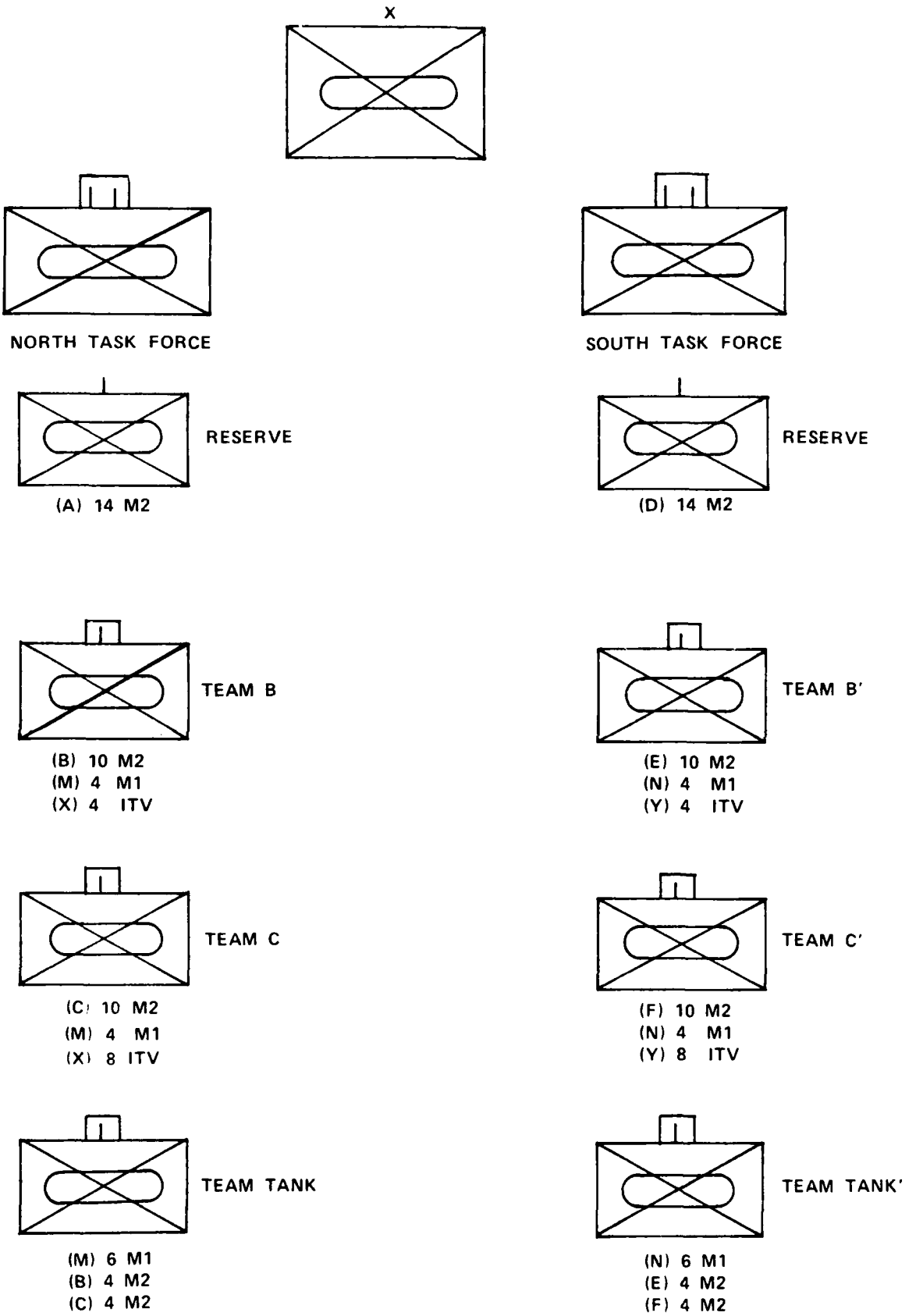



**Figure 7.** Friendly force organization for combat.

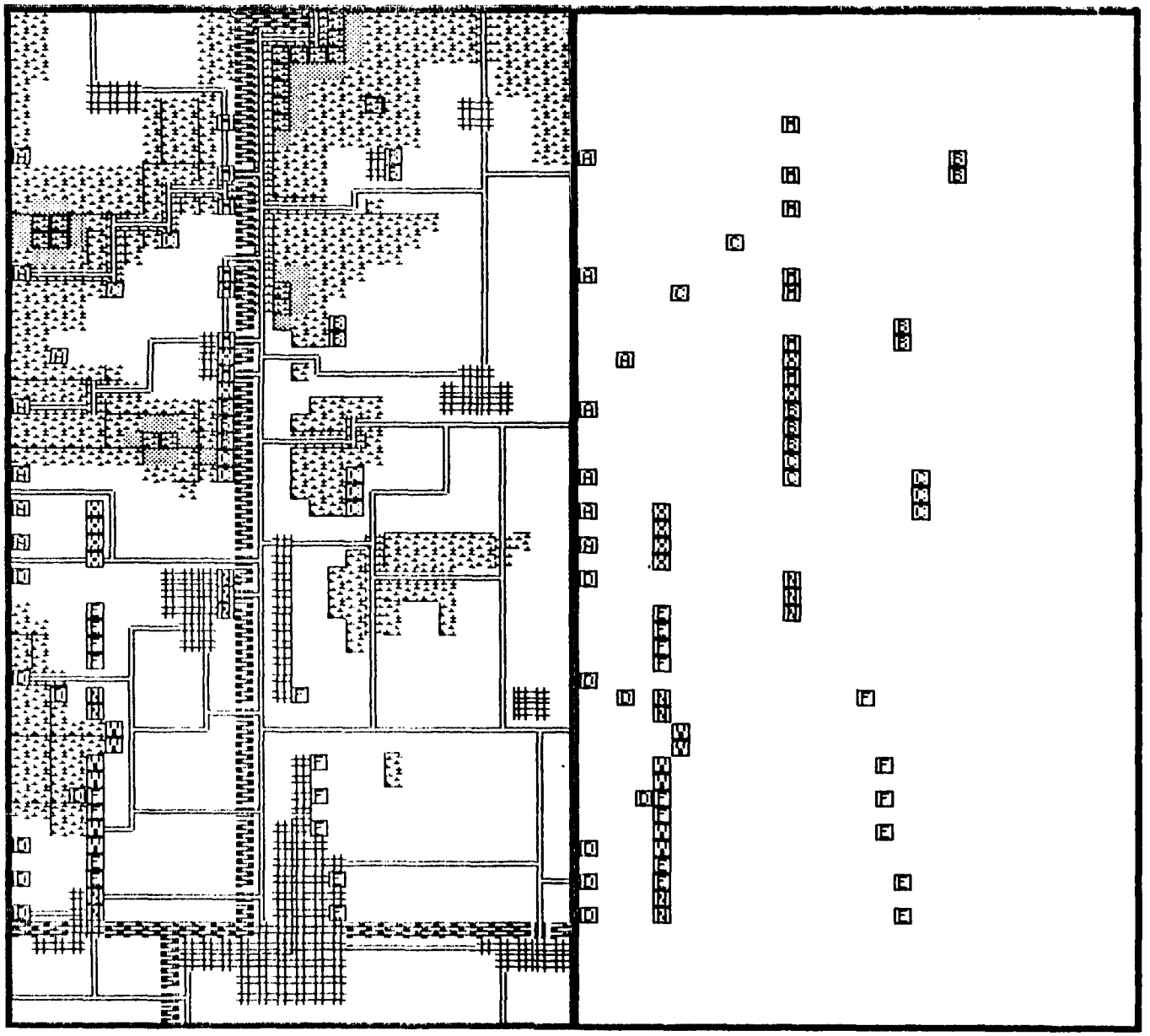


**Figure 8.** Friendly force deployment for combat.

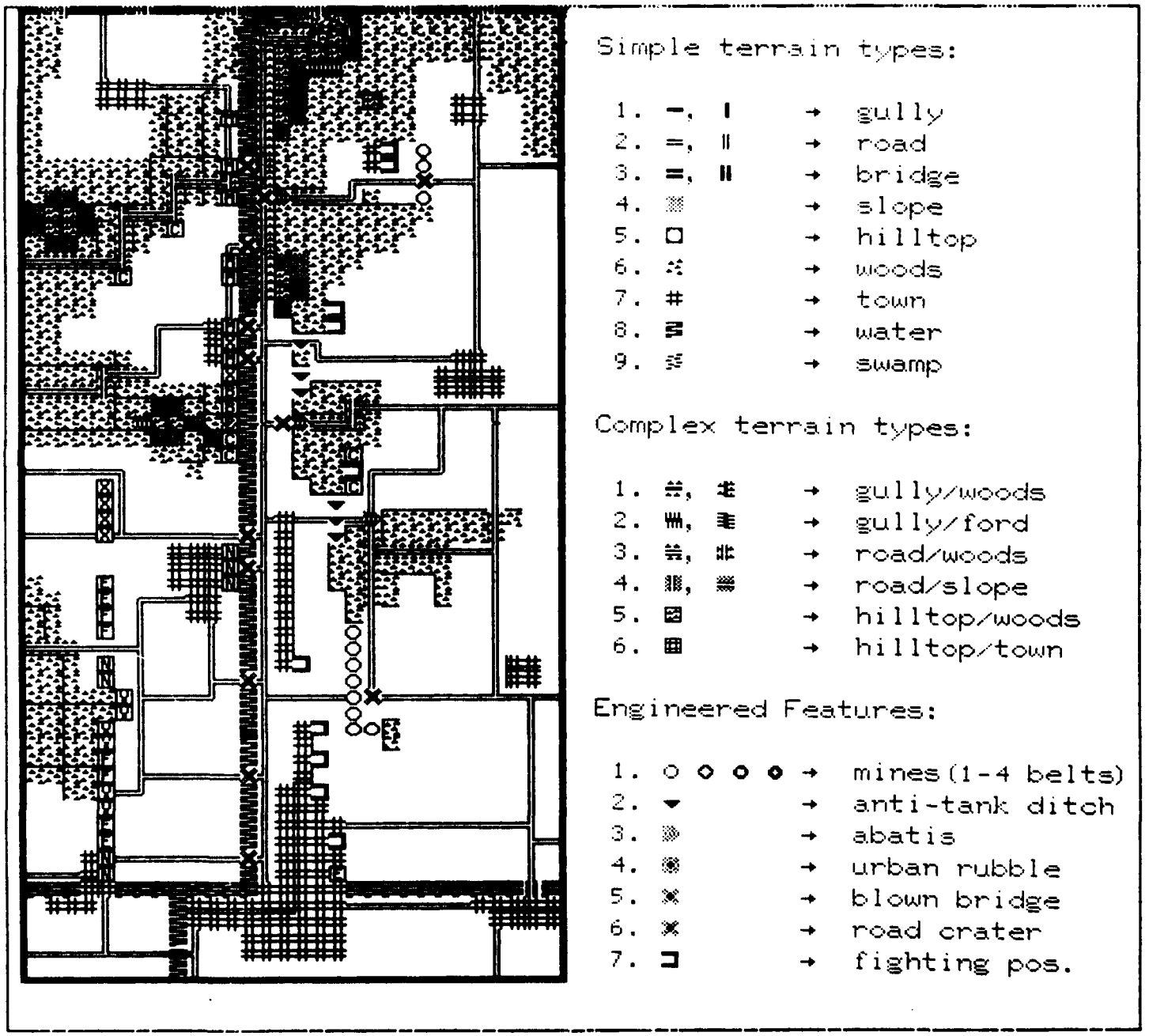
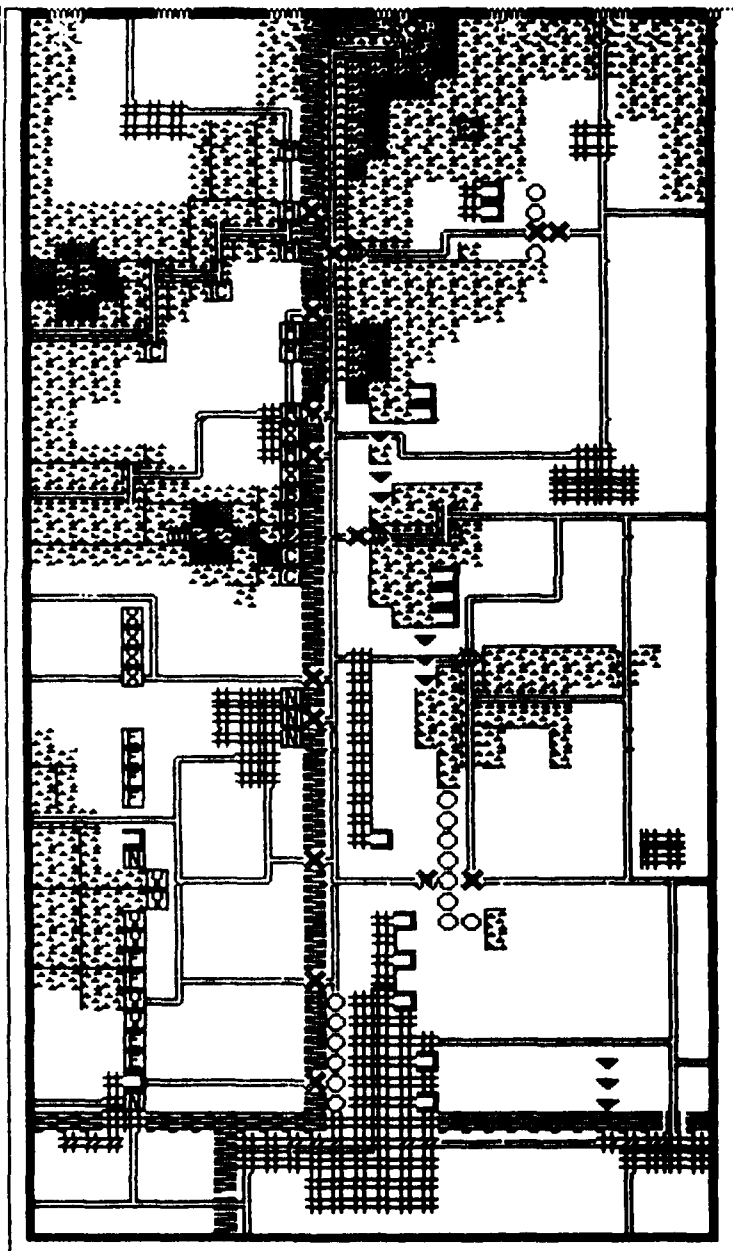



**Figure 9.** Engineer barriers and fortifications, Level 2.



Simple terrain types:

1. —, | → gully
2. =, ‖ → road
3. ≡, ‖ → bridge
4. ▒ → slope
5. □ → hilltop
6. ⁂ → woods
7. # → town
8. ≋ → water
9. ▒ → swamp

Complex terrain types:

1. ⁂, ⁂ → gully/woods
2. ≡, ≡ → gully/ford
3. ⁂, ⁂ → road/woods
4. ▒, ▒ → road/slope
5. ▣ → hilltop/woods
6. ▦ → hilltop/town

Engineered Features:

1. ○ ○ ○ ◆ → mines(1-4 belts)
2. ▼ → anti-tank ditch
3. ▨ → abatis
4. ▩ → urban rubble
5. ✕ → blown bridge
6. ✕ → road crater
7. ⊐ → fighting pos.

**Figure 10.** Engineer barriers and fortifications, Level 3.

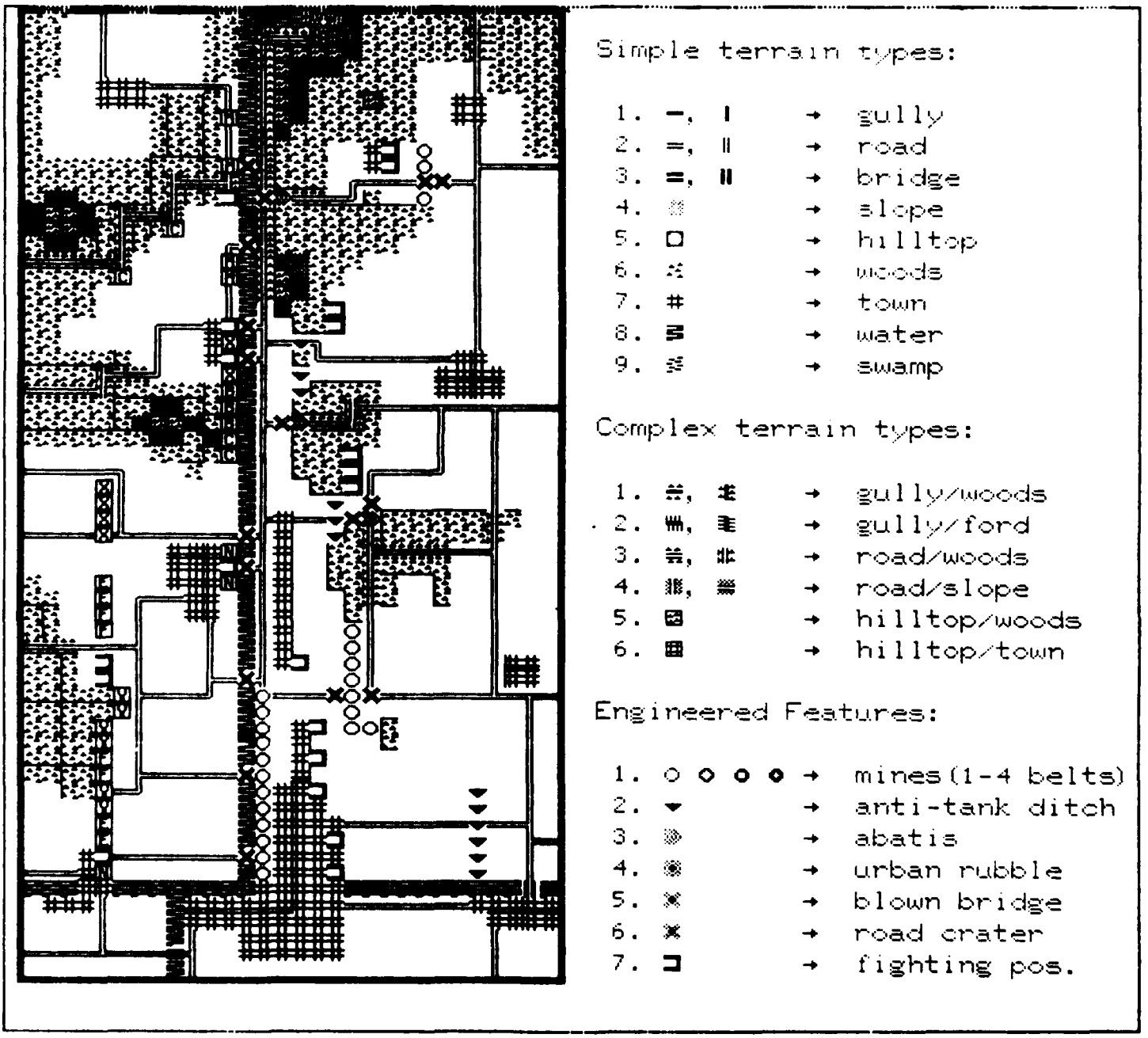



**Figure 11.** Barriers and fortifications, Level 4.

# MILITARY CORE DISTRIBUTION

Chief of Engineers
ATTN: Tech Monitor
ATTN: DAEN-ASI-L (2)
ATTN: DAEN-CCP
ATTN: DAEN-ZCF
ATTN: DAEN-RD
ATTN: DAEN-RDM
ATTN: DAEN-ZCZ
ATTN: DAEN-ZCM

U.S. Army Engineer Divisions
ATTN: Library (14)

U.S. Army Engineer Schools
ATTN: Combat Developments
ATTN: Dir. of Trng and Doctrine
ATTN: Dir. Trng Development
ATTN: Engr Training Center

All Active Brigades, Groups and Battalions (62)

All Reserve Commands, Brigades, Groups, Div Battalions (43)

HQ FORSCOM 30330
HQ TRADOC ATTN: ATEN-AD 23651

Engineer Studies Center 22060

U.S. Military Academy 10996

ROK/US Combined Forces Command
ATTN: EUSA-HHC-CFC 96301

U.S. Army Europe and 7th Army
ATTN. ODCS/Engr 09403

US CEMTCOM 33608

U.S. Marine Corps
ATTN: Mobility and Logistics 22134

U.S. Army, Fort Belvoir 22060
ATTN: ATZA-DTE-EM
ATTN: Engr Library
ATTN: Canadian Liaison Officer
ATTN: British Liaison Officer
ATTN: Australian Liaison Officer
ATTN: French Liaison Officer
ATTN: German Liaison Officer

Cold Regions Research Engr Lab 03755
ATTN: Library

ETL ATTN: 22060

Waterways Experiment Station
ATTN: Library 39180

Air Force Engr Servs Center 32403

Defense Technical Info. Center 22314 (12)

National Guard Bureau
ATTN: NBG-ARI 20310

Naval Civil Engr Lab
ATTN: Library 93041

U.S. Government Printing Office
Receiving/Depository (2)

U.S. Army CAORA
ATTN: ATOR-CAT 66027
ATTN: ATOR-CAW 66027
ATTN: ATOR-CAS 66027

END

FILMED

7-85

DTIC