AMSAA

TECHNICAL REPORT NO. 530

GROUNDWARS VERSION 5.0 - USER'S GUIDE

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AUGUST 1992

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U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ABERDEEN PROVING GROUND, MARYLAND

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Technical Report No. 530	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION U.S.Army Materiel Systems Analysis Activity 6b. OFFICE SYMBOL (If applicable) AMXSY-GC	7a NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) Aberdeen Proving Ground, Maryland 21005-5071	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U.S.Army Materiel Command 8b. OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) 5001 Eisenhower Avenue Alexandria, VA 22333-0001	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
GROUNDWARS 5.0 Reference Guide

12. PERSONAL AUTHOR(S)
Michael C. Schmidt

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Technical Report	FROM ______ TO ______	1993 January	

16. SUPPLEMENTARY NOTATION

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
GROUNDWARS, stochastic, event sequenced, effectiveness model, Monte Carlo, land duel, heterogeneous forces, TANKWARS, target acquisition, combat survivability

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

GROUNDWARS is a stochastic, two sided, event sequenced, weapon systems effectiveness model which provides the results of a land duel between two heterogeneous forces. The model simulates individual weapon systems and employs Monte Carlo probability theory as its primary solution technique. GROUNDWARS is an outgrowth of the BRL TANKWARS Model. The original model has been modified by AMSAA to include additional methodology improvements including multiple combat vehicles, dynamic target acquisition, artillery effects, line of sight enhancements, survivability enhancements (smoke grenades, active protection), statistical confidence and testing.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Michael C. Schmidt	22b. TELEPHONE (Include Area Code) (410) 278-7290 22c. OFFICE SYMBOL AMXSY-GC

DD Form 1473, JUN 86 Previous editions are obsolete. SECURITY CLASSIFICATION OF THIS PAGE

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I Introduction

Groundwars is a weapon systems effectiveness model which provides the results of a land duel between two forces. The model simulates individual weapon systems and employs Monte Carlo probability theory as its primary solution technique. The simulation is stochastic and event sequenced.

Groundwars is an outgrowth of the TANKWARS model (version II) originally written by Mr. Fred Bunn of the Army Research Laboratory (BRL), Aberdeen Proving Ground, Maryland.[1] The original model has been modified to include numerous enhancements and new methodologies. The current version of the model is Groundwars Version 5.0.

A total of 6 different platforms can be deployed between the two forces. The user determines the size of the two forces (maximum of 100 total systems), the range at which the battle will begin, the attack angle distribution to be used, and the terrain statistics to be used.

Intervisibility between combatants is determined by statistical terrain data. Groundwars allows the user to play many different terrains, provided the data is available. Three terrain distributions are within the model; they are Eschenbach, Hunfeld, and Peine and are located in Germany. Eshenbach is choppy terrain with limited opening range and in-view lengths. Peine is flat and has long opening range and in-view lengths. Hunfeld has moderate ranges. Table-top terrain, in which no limit exists on intervisibility, can also be played. The model also allows the user to input other terrain distributions if another is desired. Vehicles in overwatch and defenders always have line-of-sight to one another.

Given that intervisibility exists between two combatants, acquisition may occur. A observer can acquire a target either by normal search or by detection of a the target's firing signature. Normal acquisition is based on the Center for Night Vision and Electro-Optics (CNVEO) target detection routines, and is a function of the sensor, the atmosphere, the target, etc. An observer may also detect a target's firing signature. Whenever an enemy system fires, there is a probability that the observer will detect it. If this probability is met, the observer begins engagement of the target after a random period of time which is drawn from a

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[1] Bunn, Fred L., The Sustained Combat Model: Tankwars II, An Armored Combat Analysis Program, ARBRL-TR-09999, U.S. Army Ballistic Research Laboratory, APG, MD, December 1985

distribution generated from test data.

Four types of rounds can be played in the model: kinetic energy(KE), high explosive anti-tank(HEAT), anti-tank guided missiles(ATGM), and fire and forget missile missiles(FAF). For each weapon the model requires system characteristics (firing times, times of flight, reliability), accuracy data, and lethality data.

Three types of target engagement can be played in the model. The first is single target engagement in which a firer detects a target, begins engagement of the target, and discontinues all other actions. The second type allows the firer to detect a target and begin engaging, and to concurrently search for additional targets. Once the firer disengages the first target, he will select the next target from his list and begin engaging the next target. The third type of engagement can only be played with fire and forget missiles. In this type of engagement, the firer attempts to queue a number of targets, and then fire a single shot at each of the queued targets nearly simultaneously.

A number of countermeasures, such as on board smoke grenades can be simulated. When the grenade system detects an incoming round, it will launch grenades around the vehicle and form a cloud of smoke which may cause incoming missiles to abort. A second type of countermeasure is an active protection system. Similar to the smoke grenades, this system senses an incoming round and either destroys, jams, or degrades the incoming projectile. The user controls the level of effectiveness for these self-defense systems. Artillery delivered smoke can also be played on the battlefield which will degrade acquisition capabilities.

Limited artillery play is also implemented in the model. Each army can deploy one on-call mission during a battle, and the attacking force is given the option to have one preparatory artillery barrage. For each type of mission, there is an associated probability of kill which is assessed against all enemy vehicles desired. On-call artillery missions occur at random times in the battle.

Groundwars allows the user to choose from a couple of disengagement tactics. A firer will always disengage its target after it is catastrophically killed. The first optional tactic is to disengage a target after hitting it. A second optional tactic is to fire a certain number of rounds at a target and then disengage. For these optional tactics, the model allows a firer to return to a serviced target, if he hasn't found another target after a period of time.

The primary measures of effectiveness for the simulation are loss exchange ratio, mean casualties, system exchange ratios, and average losses as a function of time in the battle. The secondary measures include surviving force ratio, shots, hits, and kills for each weapon target pairing, and average detections by each sensor. The amount of output is directly controlled by the user, and can range from averages to a detailed break down of many facets of the battle.

Groundwars can provide a trade off analysis between major weapon system characteristics such as fire control, lethality, and accuracy. It can provide analysis for a number of combat related issues (i.e. terrain, atmospheric conditions, attack angles). The effects of changes in target acquisition, target disengagement policy, and ammunition storage can be shown relatively quickly and easily.

The main limitations are that there are no effects from suppression, and only direct fire line of sight weapon systems can be simulated. The model plays only ground to ground engagements with no helicopters. It does not play the effects of barriers nor does include a dismounted infantry model.

The main strong point of the model is its quick set up and run time which allows for examination of many situations and conditions. The model provides a basis for modelling system interactions and can enable an analyst to obtain a good understanding of these effects prior to large scale combined arms modelling.

II Input Data Requirements

The program has been released with certain limits on the number of units in a battle (100) and the number of different vehicle, weapon and sensor types which can be played (6). These limits may be modified as desired. If the user modifies these limits, some additional modifications may be needed within the program.

Groundwars requires a number of input files. There is a game control file in which the user determines the scenario, the terrain, and the level of output desired. This file also determines the attack angle distribution, the visibility conditions, etc.

For each army there is a unit deployment file in which the user sets the number of units, the starting locations of the units, and the function of the units in the battle. A miscellaneous information file which describes things such as disengagement tactic, artillery lethality, and decoys for each army. Each side has a file which describes its vehicles, one for its weapons, and one for its sensors. For each weapon system there is an accuracy file, and for each weapon-target pair there may be a lethality file.

If artillery delivered smoke or other obscurants are to be played, a file is required to characterize the periods and levels of obscuration.

With the inclusion of fratricide and combat identification (CID) in the current release version, additional files are required which describe engagement rules and CID effectiveness.

All files except for the Individual Unit Action(IUA) lethality files are free formatted. Comment lines may be added to the TOP of any input files by starting the line with an asterisk (*). Any lines shown in the documentation are there for clarity and the program expects them to be there. They may be changed, but cannot be deleted.

Data which are entered as character strings can be a maximum of seven letters long and can include capital or small letters (longer strings will be truncated to seven letters). All times which are entered into the data files are in seconds, and all linear measurements (dimensions, speed, etc.) are in meters.

The program looks for all of its input files in the current working directory. All input files which are needed for the battle which the user wishes to run must be assembled into the current directory prior to execution of the program. The program looks to use files with specific names. These names will be explained in the different input sections. A sample set of inputs and files is given later in this document.

II.A Game Control File

This file defines the scenario to be played and controls the level of output. The file must be named "game" in the current working directory for the program to read it. The general structure of the file is shown in Figure 1.

```
**  Comment Line(s)

Scenario: RED Attack, BLUE Attack, STATIONARY Engagement

Terrain: Peine, Hunfeld, Eschenbach, Table-top, or Other

Attack Angle Distribution: Cardioid, Frontal,
                           CV-CPOA, Close Combat

Atmospheric Visibility Range, Optical Attenuation, Thermal Attenuation

Output Control Flags (7)

Program Debug Flags (30)

Range Increment for Input

Maximum Battle Time

Increments for Output: Time, Range

Maximum Number of Replications, Initial Random Seed

Pinpoint Restriction

Statistical Confidence Level, Relative Width
```

Figure 1 Game Control File

The first three lines of the file set the type of engagement, the terrain, and the attack angle distribution. Each of these requires a character string for input. For line 1 the user inputs RED attack, BLUE attack, or STATIONARY engagement. In an attack scenario the attacking army can deliver a prep artillery barrage and possibly kill some enemies prior to the direct fire battle. Intervisibility is determined by the use of the terrain distribution selected on the next line. In the stationary engagement, no prep artillery kills are assessed. Intervisibility exists between all combatants, and the terrain statistics are not used.

Intervisibility between combatants for attack scenarios is determined by using statistical distributions which characterize a particular piece of terrain. The model contains the terrain distributions for three areas in Germany: Eschenbach, Hunfeld, and Peine. The user can also specify table-top terrain which ensures continuous line-of-sight between all combatants. If the user wishes to use a terrain which is not in the model, this can be done by setting the terrain to OTHER, and entering the appropriate distributions described later in this section.

The user defines the attack angle distribution to be used, and has choices of CARDIOID, FRONTAL, CV-CPOA, and CLOSE COMBAT. The attack angle distribution is used to determine the angle of impact for all rounds fired. See Appendix A for a graphical representation of the distributions.

The user then specifies the atmospheric conditions for the battle. The meteorologic visibility range is given first, and then the corresponding atmospheric attenuation coefficients for optical transmission and for thermal transmission, respectively. These inputs are used for the corresponding sensor types when acquisition capabilities are calculated during a battle.

The seven output control flags on line 4 determine the detail and amount of output that will be generated for a battle. If all flags are set to 0, the basic output will be generated. The output generated by setting the flags to non-zero are shown in the figure.

Flag	Input	Description
1	1	- normal output plus a one line summary of each replication
	2	- normal output plus a detailed account of all critical events in the battle (DO NOT run more than 1 replication)
2	1	- output of weapon system characteristics (round type, firing times, reliability, etc.)
	2	- sample of lethality data for each weapon-target pairing
3	1	- output of acquisition estimates for each sensor
	2	- output of acquisition estimates for every change in atmospherics caused by artillery smoke
4	1	- trace entry and exit from important routines (DO NOT run for more than 1 replication)
5	1	- output all events as they are scheduled and canceled (DO NOT run for more than 1 replication)
6	1	- output of killer victim scoreboards by range
7	1	- output of the distribution of shots for each weapon type

Figure 2 Output Control Flags

Flag 2 echoes some of the inputs to the output file so that the user can check for input errors. Analysis of acquisition capabilities is aided by printing acquisition probability and time estimates as a function of range for each sensor-target pairing (flag 3). The output generated by these two flags may be produced with or without running a battle. To produce this output without running a battle set the number of replications to 0.

The next line contains 30 flags which control output for program debugging. The flags should not be set > 0 for more than a single replication.

On line 6 the user enters the data-input range increment. This increment will be used when the model reads other inputs including lethality, accuracy, firing times, etc.

The maximum battle time is input on the next line. This time will be used to end the battle unless all combatants on one side are dead or non-functioning.

The next line controls the output of certain measures of effectiveness which are recorded and reported as a function of either time or range. Average RED and BLUE losses and exchange ratio are output as a function of battle time. The first number on this line is the time increment for this output. The second entry on the line is the range increment for the output of acquisitions, shots, hits, and kills as a function of range.

On line 9 the user sets the maximum number of replications to be played. This number will be used only if the desired level of statistical confidence has not been reached by this point. The second input on this line is the initial random number seed.

The ability of an observer to detect a target's firing signature (pinpoint) can be restricted by the next input. Entering a 0 allows observers to detect firing signatures regardless of the their ability to detect by normal search. By entering a 1 on this line the user restricts observers' capabilities to pinpoint. The observer can pinpoint only if he has P-infinity greater than 0.0 at the target range.

The last line of the file pertains to the confidence level of the output for RED dead, BLUE dead, and Exchange Ratio. These inputs are used to terminate the simulation if the desired level of confidence has been reached. The model records the results from each of the replications and calculates the mean and standard deviation for all preceding replications. If the results meet the statistical criteria which the user sets for all three of the above measures of effectiveness the model terminates execution. The user specifies the level of confidence (80, 90, 95, 98, or 99) and the relative width (usually between .05 and .15). For example, if the user specified 95 percent confidence and a .05 for the relative width, then he could be 95 percent confident that the true mean of the distribution is within 5 percent of the displayed mean.

If a user defined terrain is being used (<u>OTHER</u> was specified for the terrain), there is an additional section to the file. For intervisibility the model first finds the range at which line of

found, the model draws alternating in and out of view segments of varying lengths. The lengths of these segments are drawn from two additional distributions. The format for entering the three distributions, first opening range, in-view segment lengths, and out of view segment lengths, is shown below. Note the probability distributions are cumulative and the values for the longest ranges must be 1.0.

```
Number of Points in: Opening Range Dist.,
                     In and Out of View Segment Length Dist.'s

Range1  P(Open)   *** First Opening Range Distribution
Range2  P(Open)
  :        :
RangeN    1.0

Range1   P(In-view)   P(Out-of-view)
Range2   P(In-view)   P(Out-of-view)
  :          :              :
RangeN      1.0            1.0
```

Figure 3 Input of "OTHER" Terrain

II.B Unit Deployment File

In the unit deployment file the user defines the force size, the location, the exposure and the type of combatants for each army. Within this file, the user specifies the names of the vehicles, weapons, and sensors which will be used in the simulation. These names are important, as they will be used throughout the other data files. Each army has a unit deployment file which must be named bunit for BLUE and runit for RED. The structure of these files is shown below.

```
*** Comment Line(s)
*  unit      number   type of    exposure   location   vehicle  weapon   sensor
*  name                combatant                        name     name     name
   COMPANY   2         Defender   HD         4000.      BRAD     TOW2     ANTAS
   RECON     4         Defender   HD         4500.      HMMWV    COAX     ANTAS
```

Figure 4 Unit Deployment File

The first entry on each line is the unit name. This name is used to distinguish combatants in this unit from those in other units. All output will be shown in reference to these unit names. Following the unit name is the number combatants in this unit.

The next two entries are the type of combatant and the exposure. For the type of combatant there are three choices, Defender, Attacker, and Overwatch. The exposure of the units is either hull defilade(HD) or fully exposed(FE). Both defending and overwatch units are stationary, and can be either HD or FE. Defenders will begin firing upon detection whereas units in overwatch can deploy the tactic that they will not engage until an enemy vehicle has begun the battle (overwatch tactic is set in the army file). Attackers are moving, and should be fully exposed. For a stationary engagement both forces are stationary, one force will consist of all defenders, and the other will be all overwatch. For an attack scenario, the attacking force will consist of attacker units and overwatch units against defending units.

The next input is the location of the units on the battlefield in meters. Because of the way the model keeps track of the units, attackers move in the positive direction. For example, if the battle is a BLUE attack and the initial battle range is 4000 meters, the RED defense would be placed at 4000. and the BLUE attackers would be started at 0 meters. Overwatch units can be placed at any range.

The names of the vehicle, weapon and the sensor associated with the units are the last three inputs. These names will be used in the other input files and the names must match. The different vehicles, weapons, and sensors can be mixed between the different units as is shown in the example.

II.C Vehicle Description File

The vehicle description files contain the data which describe the platforms which will be simulated. The file describes such things as the physical size, and the speed of the vehicles. For each army there is one vehicle file which contains subunits for each vehicle for that army. The BLUE vehicle file is bveh, and the RED file is rveh. Each subunit has the same structure, and the subunits can be entered in the file in any order. The vehicle names used in this file must agree with those specified in the unit deployment file.

Figure 5 shows the structure of the vehicle subunit. Each subunit can begin with description or comment lines to denote what this vehicle is (ie. *** M1A1 *** or *** M1A1 with 20 percent signature reduction). The lines in the sample which begin with "--" must remain in the file or an error will result. They are included to help the user when entering the data.

```
** Comment Lines
Vehicle Name
 --Turret dimensions: Height   ½Width   Length: Front   Back
                        x.x      x.x             x.x     x.x
 --Hull dimensions:   Height   ½Width   Length: Front   Back
                        x.x      x.x             x.x     x.x
 --Target Acq. Data: Hull Defiladed, Fully Exposed
                        x.x             x.x    * Optical Contrast
                        x.x             x.x    * Thermal Contrast
                        x.x             x.x    * Critical Dimension
                        x.x             x.x    * Radar Cross Section
 --Movement: max speed, acceleration, deceleration
                 x.x          x.x          x.x
 --Times to Leave the Battle: Jockey, When Empty, When F-killed
                                xx.x     xx.x        xxx.x
 --Active Protection: Arc of Protection, Number of Launches
                              xx.x              xx
        Weapon Name
        --  P(det)  P(fire)/hit  P(fire)/miss  P(intercept)
             x.xx     x.xx          x.xx          x.xx
        --  Degradation Factors: 0°,30°,60°,90°,120°,150°,180°
                   x.xx  x.xx  x.xx  x.xx  x.xx  x.xx  x.xx
        END
 --Smoke Grenades: Ngren, P(Launch), alpha*CL's, Time to Deploy, Duration
                    xx       x.x       x.x  x.x  x.x     xx.x
 --Laser Warning Recvr: On/Off, P(det), Pop-smoke, Engage, Hide, Nfov, Tsearch
                          T/F     x.x      T/F       T/F    T/F   x.x   x.x
```

Figure 5 Vehicle Description File

The first data that are needed are box dimensions of the vehicle. The first line is for the turret and the second for the hull. The dimensions required are the height, ½ the width, the front length (from the center of the turret ring to the front of the vehicle), and the back length (all dimensions are in meters).

The second section of input is used for target acquisition and the characteristics entered describe the appearance of this vehicle to others. The data which are needed are the optical contrast, thermal contrast, critical dimension, and radar cross section. Each of these characteristics is entered for when this vehicle is hull defiladed and fully exposed. Optical contrast is used when a visual sensor is looking at this vehicle. It is defined as the difference between the average luminance of the vehicle and the average luminance of the background divided by the average luminance of the background. Thermal contrast is merely the difference between the average temperature of the vehicle and the average temperature of the background (°Celsius). The critical dimension is used for both visual and thermal sensors and is usually the presented height of the vehicle. Radar cross section is used when the opposing sensor is a radar acquisition device.

The user then enters the speed, the acceleration, and the deceleration of the vehicle. Even if the vehicle is to be stationary in the battle, the user should enter a non-zero speed. The last entry on this line controls the movement of attackers when engaging and is referred to as pause. If an attacker is engaging a target and line of sight is about to break, they would normally continue advancing and discontinue the engagement. Changing this variable to a 1 causes the attacker to continue the engagement by moving to a hull defiladed posture and not breaking line of sight.

During the battle certain situations may cause a vehicle to try to leave the battlefield. The first of these situations is when a defender or overwatch vehicle pops down to move to a new position or to reload a missile pod. The second is when a unit is depleted of ammunition and tries to move to a fully defiladed posture to avoid being killed. The third situation is when a unit has been fire-power killed and can no longer participate in the battle and tries to hide. A certain period of time to get to cover will be assessed for each of these situations. The times are entered on the next line for each of these situations, respectively. These are mean times; the model will draw from a normal distribution about these times to determine the exact time for a given point in the battle.

The last sections of the subunit define the survivability enhancements present on this vehicle. The first section is for an active protection system which detects, and possibly changes the effectiveness of an incoming projectile. The system protects an arc centered at the front of the vehicle and may be deployed a set number of times. The user defines the arc and the number of times it may activate on the first line. The system works in four stages: detection, fire, intercept, and degrade. Probabilities are used to define the first three stages.

If, and only if, the number of times the system may activate is greater than 0 the user needs to enter the additional information which defines the system. The first entry is the name of a weapon against which the APS will activate. The next line of data requires:

P(det) -prob. of detecting the incoming round
P(fire)/hit -prob. of firing at an incoming round that will hit
P(fire)/miss -prob. of firing at an incoming round that will miss
P(intercept) -prob. of intercepting the incoming round.

The last line defines the degradation factors for each 30 degree sector within the arc of protection. These factors are multiplied times the lethality of the incoming round (ie. if P(kill)=.6 and deg. factor=.2 the resultant P(kill)=.12). These three lines (weapon name, probabilities, and degradation) are duplicated for each weapon against which this system is effective. When all affected weapons have been entered, enter "END" as the next line.

The next survivability enhancement is an on board smoke grenade system. The system has the ability to detect an incoming round and to deploy a smoke cloud around the target vehicle which affects target acquisition by and of this vehicle. The first two inputs are the number of times the launcher can fire and the probability that the system will detect and deploy. The next three entries are the levels of smoke (alpha*CL) values which affect the three types of sensors: optical, thermal, and radar respectively. The next input on the line is the time from launch of the grenades to the effective formation of the smoke cloud around the vehicle. The last datum is the effective duration of the smoke cloud from the time it forms.

The last survivability enhancement is a laser warning receiver (LWR) system which may be activated when the vehicle gets lased prior to being engaged. For the LWR to react, the engaging weapon system must be using a laser range finder. The first entry determines if there is an LWR on board, either True or False(T/F). The next entry is the probability that the LWR will detect that it has been lased and that it will react. The first reaction is to pop smoke grenades. If popping smoke grenades is desired, the user needs to enter the appropriate values on the smoke grenade line. If only this warning receiver is to trigger smoke grenades, the probability of sensing on the smoke grenade line should be set to 0.0. The next reaction to being lased is to turn and engage the combatant who lased you. The last reaction is to try to hide. Any combination of these reactions can be played simultaneously. When the LWR reaction is to turn and engage, the LWR can give different levels of accuracy when pointing in the direction of the threat. If the LWR can give a precise location of the enemy, the entry for the next input is 1.0. Otherwise the user should enter the general area to search for the threat as a number of fields of view of the appropriate sensor. The last entry on the line is the time to search for this enemy before resuming normal search.

II.D Weapon Description File

As with the vehicle description file, there is a BLUE weapons file (bweap) and a RED weapons file (rweap). The file contains subunits which describe one weapon system each. For each weapon subunit the user defines firing times, reliability, times to reload, type of round etc. The general structure of the subunit is shown in Figure 6. The first data entry is the name of the weapon system (character string) which must agree with one of the weapon systems named in the unit deployment file.

```
** Comment Line(s)
Weapon Name
 --Type     Max. Range  Nrounds   Halt-fire  Tactic  Nrpt   LRF
   xx         xxxx.       xx          x        x      xx     x
 --Inputs by Range: P(sense), T(flight), T(first), T(fixed), Rel.
      x.xx  x.xx  x.xx  x.xx ....  x.xx  x.xx     ** P(sense)
      xx.x  xx.x  xx.x  xx.x ....  xx.x  xx.x     ** T(flight)
      xx.x  xx.x  xx.x  xx.x ....  xx.x  xx.x     ** T(first)
      xx.x  xx.x  xx.x  xx.x ....  xx.x  xx.x     ** T(fixed)
      x.xx  x.xx  x.xx  x.xx ....  x.xx  x.xx     ** Reliability
 --Jockeying:  IF-pop  N(jockey)  T(jockey)
                 x        xx         xx.x
 --Subsequent Firing:  T(median)   T(min)
                          x.x        x.x
 --Burst Fire:  Rate-Fire     Nrds/Burst
                  x.x            x
 --Missiles:  IF-dis  Nipods  Ntgts  T(reload)  Pabt/smk  Pabt/terr
                x       x       x      xx.x       x.xx      x.xx
 --Multiple Engagement:  IF-mult  T(mult)  N(mult)  Reload-part
                           x        xx.x      x          x
```

Figure 6 Weapon Description File

On the next line the user defines the type of round being fired. The table below shows the appropriate inputs for the four types of rounds. Next the user enters the maximum effective firing range of the weapon and the total number of rounds on board the vehicle. The last input on the line determines if this weapon system halts before firing. The system will halt before firing if the user enters a 1.

Kinetic Energy Round (KE)	1
High Explosive Anti-Tank (HEAT)	2
Fire and Forget Missile (FAF)	3
Command Line-of-Sight Missile (CLOS)	4

Table 1 Round Type Assignment Numbers

Disengagement policy is governed by the next input, tactic. The following table shows the different policies and their corresponding numerical inputs. The user should set tactic=1 to disengage only if the target is catastrophically killed. If the firer should disengage for one of the other reasons the appropriate number from the table should be used. If the firer is to disengage after a set number of shots, the number of shots to fire is the last input on the line.

Disengage After:	
Catastrophic Kill	1
Hitting the Target	2
Firing Nrpt Rounds at the Target	3

Table 2 Disengagement Tactics

The last entry on this line determines if this weapon system uses a laser range finder prior to its first round of an engagement. The play of the range finder does not change the way accuracy is played. The only effect of setting this input to True is that it will now activate laser warning receivers on target vehicles.

The next five lines are data which are input by range. These data are input in range increments as specified in the game control file. The first value on each line should be for range=increment, not for range=0 meters. There must be enough numbers on each line to cover up to and including the maximum firing range set on line 1. The first line is the probability that the firer will sense the impact location of a round that misses its target, P(sense). T(flight) is the time of flight of the round to the various ranges. The median time to fire the first round of an engagement, T(first), is next. T(fixed) is the fixed time between rounds when using an auto-loader. The last input which is a function of range is the reliability of the round.

Groundwars allows systems which are either in defense or overwatch to increase survivability by moving to a fully defiladed posture at certain points in the battle. A missile system which is reloading its missiles may pop down to complete this mission by setting if-pop = 1. A KE system may pop down and move to a new position (jockey) after firing a set number of shots, N(jockey). If N(jockey) is equal to 0 for a KE weapon, the unit will not jockey. The length of time a KE system remains fully defiladed is defined by the input T(jockey). Missile systems remain fully defiladed for the reload time, T(reload), mentioned later.

The next line characterizes the subsequent firing times for the system. The user inputs the median time to fire a subsequent round and a minimum time to fire. Before a subsequent round is fired, a random draw is made from a log-normal distribution about the median time to determine the random re-aiming time. This time is added to the fixed time between rounds if an auto-loader is being used. If this total time is less than the minimum time, then the minimum time to fire a subsequent round, T(min), will be used as the subsequent firing time.

The next line defines attributes for within burst rounds. The first input is the rate of fire in rounds per second. The second input is the number of rounds in a single burst.

A number of inputs are required for missile systems. For missile systems which remain exposed during reload (if-pop=0), there are two choices for continuing an engagement. The system may be able to keep its fix on its target and therefore resume the engagement of that target upon finishing reloading. On the other hand, some systems such as hand-held one person systems cannot maintain a fix on the target and must begin the acquisition process anew after reloading. If the system can maintain a fix on the target while reloading then if-dis should be set to 0, otherwise set it to 1 .

The next input is the number of missiles on board which are ready to fire. It is this number which will be reloaded when the ready rounds are depleted. Ntgts is the number of rounds which can be fired nearly simultaneously (should be set to 1 when not playing multiple engagement). T(reload) is the time required to reload the ready to fire missile pod. The next two data are probabilities that a missile will abort due to a change in the atmosphere (smoke), and to line of sight breaking between the firer and target during flight.

The last section of each subunit deals with a missile system's ability to queue targets and fire at them nearly simultaneously. A system may only play multiple engagement if the round type is a fire and forget missile. If multiple engagement is desired, if-mult should be set to 1. T(mult) is the time from initial detection to search for additional targets before beginning the engagement. After t(mult) has elapsed the firer will begin the engagement. N(mult) is the total number of targets to try to multiply engage. After n(mult) targets have been detected, the firer will fire a single shot at each target and disengage. When playing multiple engagement, a system is able to reload part of its missile pod so that it always has a full pod when engaging targets. Reload-part should be set to 1 if the system can reload part of the pod, and that is the desired tactic.

II.E Sensor Description File

Groundwars allows the user to play optical, thermal, or millimeter wave devices, with a total of 6 sensors for both sides. As with the vehicle and weapon files, the sensor file is a group of subunits, one for each sensor. The BLUE sensor file is named bsens, and the RED is rsens.

For optical and thermal devices, the model uses a form of the CCNVEO (CECOM Center for Night Vision and Electro-Optics) target acquisition methodology to approximate acquisition capability. The play of millimeter wave technology in the model is limited and the performance of this type of sensor is fixed except for changes in the atmosphere. The required data for optical and thermal devices is different from that for a radar device, so the structures of the subunits for the two types will be explained separately.

```
** Comment Line(s)
Sensor Name
 -- Sensor Type: VISUAL or THERMAL
 -- Data Type: TWENTY or NVLEXP
 -- Sensor Data
      If data type = TWENTY, enter 2 twenty point curves
        a. Minimum Resolvable Contrast or Temperature
        b. Spatial Frequency
      If data type = NVLEXP, enter 7 coefficients
 -- Horizontal and Vertical Fields of View and Search
     xx.x   xx.x    xx.x   xx.x
 -- Magnification and Level of Acquisition
     x.x      x.x    x.x
 -- N(dets), p(false) (HD,FE)
      x       x.xx   x.xx
 -- Pinpoint prob against all red weapons
     weapon1   x.xx
     weapon2   x.xx
     weapon3   x.xx
     END
```

Figure 7 VISUAL and THERMAL Sensor Subunit

The figure above shows the structure of the sensor performance subunit for optical and thermal sensors. The first four lines of data require character strings for input. The first line is the sensor name. On the first line of data the user specifies either <u>VISUAL</u> or <u>THERMAL</u>. The type of data for these types of sensors can be input in one of two ways with inputs of <u>TWENTY</u> and <u>NVLEXP</u>. For <u>TWENTY</u> the user enters two performance curves which contain twenty points each (apparent contrast and then spatial frequency). For <u>NVLEXP</u> the user enters seven coefficients to fit a sixth degree polynomial.

For the rest of the subunit, there will first be a description line and then a data line. As with the vehicle and weapon file,

the comment lines which are shown with "--" must remain in the file. On the next line, enter the horizontal and vertical fields of view and fields of search. The fields of view are characteristic of the sensor, and the fields of search are based on battlefield responsibility. The next line requires the magnification of the sensor and the level of acquisition desired against stationary targets, and against moving targets.

On the next line the user specifies the number of targets which may be detected concurrently (hunter-killer) by a system with this sensor, N(dets). If this system must remain fixed on the target while the gunner services the target, n(dets) should be set to 1. If other targets can be detected while the gunner is busy, n(dets) should be set > 1.

Also on this line are two probabilities of detecting false targets, P(false). When a target is first detected, a random draw is made against these probabilities to see if a false target will be randomly substituted for the real target. The first probability is for when the observer detects a hull defiladed target, and the second is for fully exposed targets.

The last section of the subunit defines the probabilities of this sensor detecting the firing signatures of other weapons in the battle. On each line enter the opposing weapon name and the probability of detection given the weapon fires. When all desired weapon have been input, enter "END" to end the section.

The figure to the right shows the structure of the sensor subunit for a radar sensor. The user specifies RADAR as the sensor type. Only rain and clutter affect radar acquisition. If there is no rain, the input is a 0, else it is a 1. On the same line, the level of clutter is specified, and can be either low clutter (1.0), or higher clutter (>1.0). The final section of the subunit is the same as for visual and thermal, from the number of detections to the end of the subunit.

```
** Comment Line(s)
Sensor Name
 -- Sensor Type: RADAR
 -- IF-rain,  Clutter
      x         x.x
 -- N(dets), P(false)
      x        x.xx    x.xx
 -- Fire-signature prob.'s
    weapon1     x.xx
    weapon2     x.xx
    weapon3     x.xx
    END
```

Figure 8 RADAR Sensor Subunit

II.F Weapon Accuracy File

For each weapon system defined in the two unit deployment files, there must be a file which contains weapon system delivery accuracies. BLUE accuracy files have the form bacc? where ? starts at 1 and ends at the number of blue weapon systems. The same structure holds for all RED accuracy files (racc?). Each file has the structure shown in Figure 9. The model requires biases and errors for three situations: stationary firer against a stationary target, a stationary firer against a moving target, and a moving firer against a stationary target. The model does not require errors for a moving firer against a moving target.

The file is free formatted, and all lines which begin with an "*" are comment lines included for clarity; comment lines may be added or removed between groups of data, but not within a group of data. All ranges are in meters, and all biases and errors are in mils (1/6400 of a circle).

There exist three types of errors which are read into the model and can be classified according to how long they persist. Fixed biases are those which persist over many engagements. Variable biases are caused by transient effects such as cross wind. Random errors are those which change from round to round and are caused by differences in individual rounds, wind gusts, etc.

The first two lines of each file must contain a weapon name and the number of range increments which will be input. The range input must account for all ranges from 0 up to and including the maximum firing range of the weapon.

The first section of the file is for a stationary firer against a stationary target. For this situation data is required for the first round fired and for subsequent rounds. For first rounds, fixed bias, variable bias and random error are required. For subsequent rounds only random error is needed. This error varies depending on whether the previous shot was a hit, a lost miss, or a sensed miss. Misses are either lost or sensed depending on the value of p(sense) in the weapon description file. For the number of ranges to be input, the user will enter a range and its corresponding errors for first and subsequent rounds.

The second section of the file is for a stationary firer against a moving target. This section has only two types of error: fixed bias and total error. These errors are required for four different attack angles: 0, 30, 60, and 90 degrees as is shown in the figure.

The third section is for a moving firer against a stationary target. Only fixed bias and total error are required at each range.

```
** Comment Line(s)
Weapon Name
6 ranges
**** STATIONARY FIRER vs STATIONARY TARGET ****
*      -------- 1st Round ---------   --------sub. rounds -------
*                                        h/h      h/lm       h/sm
*      fix bias   var bias   ran err   ran err   ran err   ran err
*rang   H    V    H    V    H    V    H    V    H    V    H   V
 rng1  .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx
  |     |    |    |    |    |    |    |    |    |    |    |    |
  |     |    |    |    |    |    |    |    |    |    |    |    |
 rngN .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx .xxx
*
**** STATIONARY FIRER vs MOVING TARGET ****
*    0 degrees     fixed bias                total error
*   rg (m)       H            V            H            V
      rng1     .xxx         .xxx         .xxx         .xxx
       |         |            |            |            |
       |         |            |            |            |
      rngN     .xxx         .xxx         .xxx         .xxx
*
*   30 degrees     fixed bias                total error
*   rg (m)       H            V            H            V
      rng1     .xxx         .xxx         .xxx         .xxx
       |         |            |            |            |
       |         |            |            |            |
      rngN     .xxx         .xxx         .xxx         .xxx
*
*   60 degrees     fixed bias                total error
*   rg (m)       H            V            H            V
      rng1     .xxx         .xxx         .xxx         .xxx
       |         |            |            |            |
       |         |            |            |            |
      rngN     .xxx         .xxx         .xxx         .xxx
*
*   90 degrees     fixed bias                total error
*   rg (m)       H            V            H            V
      rng1     .xxx         .xxx         .xxx         .xxx
       |         |            |            |            |
       |         |            |            |            |
      rngN     .xxx         .xxx         .xxx         .xxx
*
**** MOVING FIRER vs STATIONARY TARGET ****
*                   fixed bias            total error
*   rg (m)            H        V            H        V
      rng1          .xxx     .xxx         .xxx     .xxx
       |              |        |            |        |
       |              |        |            |        |
      rngN          .xxx     .xxx         .xxx     .xxx
```
Figure 9 Weapon Accuracy File

II.G Lethality Files

The lethality files contain probability of kill information which can be entered as either the Probability of Kill given a Hit (PKH) or as the Probability of Kill given a Shot (PKS). Probabilities of kill are generated by the Vulnerability/Lethality Division of the Ballistic Research Laboratory (BRL). The names of these files in the current working directory are similar to those for the accuracy files. BLUE files have the prefix bpk, and RED files begin with rpk. The BLUE files will be named: bpk1, bpk2, ..., bpk10, bpk11, ... PK files must exist for every combination of weapon system and vehicle which the user wishes to have fight. The model checks to see if all combinations of weapons vs. vehicles have been entered (including BLUE vs. BLUE and RED vs. RED). For those that do not exist, the model will give a warning message. The user should check these warnings for the first runs of the study to be sure that no desired combination has be missed.

The model recognizes four levels of kill: mobility kill, fire-power kill, mobility and fire-power kill, and catastrophic kill. The four levels of kill have the following results in the model. A mobility kill renders an attacker unable to continue the attack; the combatant remains at its current exposure and range, and can still engage. For a defender or overwatch unit, a mobility kill means that it no longer may pop down to reload or jockey to an alternate position. A fire-power kill leaves the combatant unable to fire, and he attempts to reach cover to avoid being killed further. For a mobility and fire-power kill, the combatant can no longer function, but it is not totally destroyed. Vehicles which have sustained one of these levels of damage continue to draw fire, and may be killed at a higher level. A catastrophically killed combatant no longer functions, and all units know that it no longer is a threat.

The first section of every file contains the same information, whether the user uses PKH or PKS. On the first line the weapon name and the target vehicle name are given; these must agree with those input in the unit deployment files. On the second line two flags are set which dictate the form of the lethality data. The first flag determines if the data is entered as PKH or PKS data. If the flag is set to a 0 or a 2 the data is PKS data. If the flag is a 1 the data is PKH. The forms of these data will be described shortly.

The second flag on the line determines if the data is independent of range to the target. For some weapons the lethality of the weapon is the same at all ranges. A 0 designates lethality which is a function of range and a 1 designates range independent lethality.

The first two forms of data are probability of kill given a shot. The data for both forms are independent of target aspect angle and round dispersion. The two forms require the same data, but are entered in a different order. For both forms, the data should begin with range of 0 meters. If the first lethality flag is set to a 0, the data needs to be in the form shown in Figure 10. When the flag is set to a 2, the data needs to be in the form shown in Figure 11. When P(k/s) data is being used, the probability of hit is forced to be 1.0 within the model, since the probability of hit was factored into the calculation of the P(k/s).

```
** Comment Line(s)
Weapon Name      Target Name
 0   x     lethality flags
**  0 m    rng2  rng3  rng4        rngN  | Kill Type     | Exposure
*******************************************************************
    x.xx   x.xx  x.xx  x.xx  ...   x.xx  | M Kill        |    HD
    x.xx   x.xx  x.xx  x.xx  ...   x.xx  | F Kill        |    HD
    x.xx   x.xx  x.xx  x.xx  ...   x.xx  | M & F Kill    |    HD
    x.xx   x.xx  x.xx  x.xx  ...   x.xx  | Catastrophic  |    HD
    x.xx   x.xx  x.xx  x.xx  ...   x.xx  | M Kill        |    FE
    x.xx   x.xx  x.xx  x.xx  ...   x.xx  | F Kill        |    FE
    x.xx   x.xx  x.xx  x.xx  ...   x.xx  | M & F Kill    |    FE
```

Figure 10 PKS Lethality File (flag=0)

```
** Comment Line(s)
Weapon Name      Target Name
 2   x     lethality flags
**   M      F      M&F     K    |  Range     |  Exposure
*********************************************************
    x.xx   x.xx   x.xx   x.xx   |  0 meters  |    HD
    x.xx   x.xx   x.xx   x.xx   |  range 2   |    HD
    x.xx   x.xx   x.xx   x.xx   |  range 3   |    HD
    x.xx   x.xx   x.xx   x.xx   |  range 4   |    HD
     :      :      :      :     |     :      |     :
    x.xx   x.xx   x.xx   x.xx   |  range N   |    HD
                                |            |
    x.xx   x.xx   x.xx   x.xx   |  0 meters  |    FE
    x.xx   x.xx   x.xx   x.xx   |  range 2   |    FE
    x.xx   x.xx   x.xx   x.xx   |  range 3   |    FE
    x.xx   x.xx   x.xx   x.xx   |  range 4   |    FE
     :      :      :      :     |     :      |     :
    x.xx   x.xx   x.xx   x.xx   |  range N   |    FE
```

Figure 11 PKS Lethality File (flag=2)

The third form to enter the data is the Individual Unit Action (IUA) file as produced by the BRL. For this type of input data, the first lethality flag should be set to 1. The data is a function of target, aspect angle, target exposure, round dispersion and kill criteria. The figure below shows the general structure of this file. This file is formatted, and should be received from the BRL in the proper format.

For each range there is a group of 88 lines of Pkh data. For lethality which is independent of range, there will be only one set of 88 lines. In each group of 88 lines there are 44 lines against a hull defiladed target followed by 44 lines for fully exposed targets. In each group of 44 lines there are 11 sets of 4 lines. The first 10 sets of lines correspond to 10 linear dispersions (1-10 feet) and the 11th set is for a uniform distribution of shots on the target. Each of the four lines corresponds to one of the four kill categories.

```
** Comment Line(s)
Weapon Name   Target Name
 1   x    ** lethality flags
***  range E  D K    0      30     60     90    120    150    180    Avg
*****************************************************************************
      rng1 1  1 1  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  1 2  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  1 3  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  1 4  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  2 1  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  2 2  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  2 3  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  2 4  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rng1 1  3 1  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
        |  |  | |    |     |     |     |     |     |     |     |
        |  |  | |    |     |     |     |     |     |     |     |
        |  |  | |    |     |     |     |     |     |     |     |
      rngN 2 10 3  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 10 4  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 11 1  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 11 2  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 11 3  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
      rngN 2 11 4  x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx x.xxx
```

Definitions

rng1 - 0 meters
rngN - last range for data
E - Target Exposure
D - Dispersion of the round, 1-10 ft., 11 is random disp.
K - Kill type (1-mkill, 2-fkill, 3-mfkill, 4-kkill)
Target Aspect Angle - 0, 30, 60, 90, 120, 150, 180 degrees

Figure 12 IUA Lethality File

II.H Army Miscellaneous File

The next file is the army miscellaneous file which contains information that isn't specific to any one unit type. An army file is required for each army. The names of the two files are barmy and rarmy. The general structure of the file is shown in the figure.

```
** Comment Line(s)
--Tactics:  Priority  T(relook)    N(bump)  T(bump)    Over-eng
               x        xx.x          x       xx.x        x
--Communications: If-comm   P(pass)  T(pass)    T(search)
                    x        x.xx      xx.x       xx.x
--Decoys:  NAME      N(flash)  T(start)  T(flash)
          Unit Name     x         xx.x      xx.x
--IF Artillery
     x
   Target1
   --Prep. Artil.  m f m&f k
                    x.xx  x.xx  x.xx  x.xx
   --On-call Artil.  m f m&f k
                    x.xx  x.xx  x.xx  x.xx
   Target2
   --Prep. Artil.  m f m&f k
                    x.xx  x.xx  x.xx  x.xx
   --On-call Artil.  m f m&f k
                    x.xx  x.xx  x.xx  x.xx
   END
```

Figure 13 Army Miscellaneous File

The first line of the file requires inputs for various tactical decisions. The first entry is for target priority. If a unit is able to detect more than one target concurrently, the firer will pick older targets over new if this is set to 1, and newer targets over old if this is set to 2. If the unit cannot detect more than one target, this input will have no effect.

The second input is the time a firer will search for other targets before going back to a previously serviced target and renewing the engagement (only if the target is still in line of sight and is not k-killed).

The next two inputs are used when a target vehicle is mobility and firepower killed, and is no longer functioning. A firer will recognize a target in this condition as non-threatening, and will disengage it. The firer will disengage the target after firing N(bump) rounds at it or after waiting T(bump) seconds. When either of these conditions is met, the target is "bumped up" to an inactivity killed vehicle, and all units will disengage it.

The last input on this line governs the play of overwatch vehicles in the simulation. As was mentioned in the unit

deployment file section, overwatch vehicles can either fire as soon as they acquire a target, or they may stay quiet until the enemy begins to fire. If the overwatch should fire upon acquiring a target, this input is a 1, else it is a 0.

The next line of input governs the play of communications between friendly vehicles. When one unit detects an enemy unit, it may pass the enemy unit's location to others. If the location is received, the receiver will conduct a field of view search in the area and attempt to detect the target. Enter a 1 for If-comm to give this army communications. The next value is the probability that the others will receive the transmission of the target's location. Next is the time to wait before the receiving vehicle will conduct its search. The final entry is the length of time the receiving vehicle will search in the field of view before renewing normal search. To have no others engage this same vehicle, the time to wait before searching should be set to a large number. To have friendly units gang up on the detected target, set this wait time to 0.0 .

The information necessary for the play of decoys is on the next line. Decoys are entered as any other unit type in the unit deployment file. However, the vehicle, weapon, and sensor names should be set to "NULL". When the army file is read, the name of the decoy which is entered here is used to make all units of this type decoys. When only normal decoys are played, the remaining inputs on this line should be set to 0. When flashing decoys are played, the number of flashing decoys is entered next, which is a subset of the total number of decoys. The next two inputs determine the "when to start flashing" and "how often to flash" for the decoys. Two inputs determine the 'when' and 'where' for decoys flashing. Both of these numbers are in seconds. The first is the time in the battle when the decoys should begin to flash. When flashing decoys are played the user must enter the probability of detecting the flashes in the opposing sensor file.

The rest of the file is for the play of artillery. If artillery is not desired, a 0 can be input on the next line and no other entry need be made. If artillery is played, for each enemy vehicle which is to be hit, there must be entered probabilities of kill. The names of all affected units must be entered.

II.I Obscuration File

This file defines changes in the atmospheric conditions during the battle. These changes affect all combatants across the battlefield. Smoke in the model starts at a certain time, and has a finite duration. Both of these parameters are set by the user. Any number of smoke events can be played in the model, but the more smokes which are played the slower the run time will be since all probabilities of acquisition and engagements are reassessed when the atmosphere changes. The file has the name smkfile. If no smoke is desired in the battle, this file can be ignored, and should not be left in the present working directory. The figure below shows the format of the file. The first two entries on each line are the starting time for the smoke and the duration of the smoke. The next three entries are the attenuations of transmission for optical, thermal, and radar sensors respectively.

```
***** Comment Line(s)
** start  duration  optic  therm  radar
   300.     400.     8.0    1.0    0.0  * smoke lasts from 300 to 700 sec.
   100.      50.     2.1    .74    0.3  * smoke 2 lasts from 100 to 150 sec.
```

Figure 14 Battlefield Obscuration File

II.J Engagement Control File

With the inclusion of fratricide into the model, a new file is used to describe which units can engage one another. This file eliminates the need for the simulation to calculate all of the engagement interactions that would take place between two units which would never realistically engage one another.

There is only one file, engfile, which describes the actions of both RED and BLUE units. If fratricide is not desired, this file can be ignored, and the model will revert to normal play with units engaging only enemy units; no friendly losses will occur. This file is complicated and the user should be sure of his/her changes.

Engagement is governed in the model by three parameters. The first parameter is a yes or no switch which determines if the engaging unit engages units of each of the other types. Given that an observer acquires a target, a check is then made to determine if he is able to identify the target through his sensor as either friendly or enemy. If he is able to identify the target as friendly, he will break off the engagement. If he identifies as an enemy, he will engage the target as normal. If he is not able to identify the target one way or the other, he must make some decision whether he should engage this "grey" target. This decision is characterised in the model by the last two parameters, the probability of engagement, and a time delay associated with the decision.

```
******** Engagement Table *******
Engaging Unit's Name
-- Target names,  Is-It-A-Tgt,    P(engage)    T(engage)
   Engagee 1          x              x.xx         xx.x
   Engagee 2          x              x.xx         xx.x
   'END'
```

Figure 15 Engagement Control File - structure

The engagement file contains a subunit for each unit type in the battle. The general structure of a single subunit is shown in the figure above. The first entry in each subunit is the engaging unit's name. After the next comment line, there is a single line entry for all units which the engaging unit may consider as a target. On each line are the engaged unit's name and the three parameters mentioned previously. For the yes or no decision, enter a 1 or 0 for yes and no, respectively. For the probability of engaging given that the engaging unit is unable to identify, and the time delay for the decision enter the appropriate numbers. Instead of listing all of the units in the battle, and entering a 0 for the ones not to be engaged, the user can enter only those wanted, and end the subunit by entering END as the unit name.

A sample engagement file is shown below. The first subunit is for unit type BUNIT1. BUNIT1 will engage both BUNIT2 and RUNIT1. However, when he cannot identify a target which he has detected, he will engage BUNIT2 only 40% of the time, but he will engage RUNIT1 100% of the time. This may be because RUNIT1 may be further away or in an area where BUNIT1 knows there are no friendly units, and BUNIT2 may be in an area where there is a good chance that friendly vehicles may be located. BUNIT2 has the location of BUNIT1 and will only engage RUNIT1. RUNIT1 will engage both BLUE units, and he will always engage on detection since his probabilities of engaging are 1.0.

```
******** Engagement Table *******
  'BUNIT1'
   -- Target name, is-it-a-tgt, p(engage), t(engage)
     'BUNIT2'          1           0.4          5.
     'RUNIT1'          1           1.0          0.
     'END'
****
  'BUNIT2'
   -- Target name, is-it-a-tgt, p(engage), t(engage)
     'RUNIT1'          1           1.0          5.
     'END'
***
  'RUNIT1'
   -- Target name, is-it-a-tgt, p(engage), t(engage)
     'BUNIT1'          1           1.0          0.
     'BUNIT2'          1           1.0          0.
     'END'
```

Figure 16 Engagement Control File - sample

II.K Combat Identification File 1

Only if the engagement file exists can the user play combat identification. The first type of combat identification is a system which has all friendly vehicles constantly emitting a CID signal (CID1) which friendly units, and sometimes enemy units, can detect. When a unit with this type of CID is detected by a friendly observer, there is a probability associated with the CID that the observer will then know that the CID host is friendly and if this probability is met, the observer will disengage the target. The CID signal being emitted can also aid others in detecting the host units. This aspect of the CID is modelled as a probability of detection in a given time period. If the time period were 30 seconds, for example, a random draw is done every 30 seconds to determine if any of the searching units will detect the host because of its signal.

The information to characterize these events is entered in the input file "cidfill". If this file is not included in the current working directory this part of the code will be ignored. The file contains a subunit for each different unit type in the battle which has a CID1 on board; the figure below shows a single subunit.

```
**** Comment Line(s) ****
 --CID Host Name, Time for Detection check
     'BUNIT1'          30.
   -- Probability of these observers CIDing host vehicle
      'BUNIT2'  x.xx  x.xx  x.xx  x.xx  x.xx  x.xx  x.xx ...
      'END'
   -- Probability of these observers detecting host vehicle's CID signal
      'BUNIT2'  x.xx  x.xx  x.xx  x.xx  x.xx  x.xx  x.xx ...
      'RUNIT1'  x.xx  x.xx  x.xx  x.xx  x.xx  x.xx  x.xx ...
      'END'
```

Figure 17 Combat Identification File 1 - structure

The first entry is the name of the CID1 host unit. On the same line, the user enters the time between CID detection attempts. The information in the first section is the probability of the friendly units being able to CID the host unit upon detection. Each line will contain the name of the observer unit, and the probabilities that this observer will CID1 as a function of range. In the next section enter the probabilities of friendly and enemy units detecting this CID1 host because of its CID signal. These probabilities are based on the time specified previously. The user enters the name of the observer unit, and the probabilities of detection as a function of range. Both sections are ended by entering an 'END' in place of the unit name.

```
*** Ranges: 500, 1000, 1500, ...
--CID Host Name, Time for Detection check
    'BUNIT1'         30.
  -- Probability of these observers CIDing host vehicle
     'BUNIT2'  1.00  0.98  0.90  0.80  0.65  0.40  0.20  0.00
     'END'
  -- Probability of these observers detecting host vehicle's CID signal
     'BUNIT2'  0.50  0.30  0.20  0.10  0.05  0.01  0.00  0.00
     'RUNIT1'  0.30  0.15  0.07  0.03  0.01  0.005  0.00  0.00
     'END'
--CID Host Name, Time for Detection check
    'BUNIT2'         30.
  -- Probability of these observers CIDing host vehicle
     'BUNIT1'  1.00  0.98  0.90  0.80  0.65  0.40  0.20  0.00
     'END'
  -- Probability of these observers detecting host vehicle's CID signal
     'BUNIT1'  0.50  0.30  0.20  0.10  0.05  0.01  0.00  0.00
     'RUNIT1'  0.30  0.15  0.07  0.03  0.01  0.005  0.00  0.00
     'END'
```

Figure 18 Combat Identification File 1 - sample

The figure above shows an example of a CID1 file. From the sample engagement file, there are two BLUE unit types, BUNIT1 and BUNIT2, and 1 RED unit type, RUNIT1. The first subunit in the sample CID1 file is for BUNIT1 as a CID1 host. The first section shows that BUNIT2 has a 0.50 probability of CIDing BUNIT1 at 500 m. and that probability drops to 0.20 at 3500 m. The next section describes BUNIT2 and RUNIT1's probabilities of detecting BUNIT1's CID1 signal every 30 seconds. So if RUNIT1 were 2000 m. away from BUNIT1, RUNIT1 would have a 3% chance of detecting BUNIT1 every 30 seconds. If an observer from BUNIT2 detects BUNIT1's CID1 signal, he automatically CIDs BUNIT1 as friendly.

The second subunit in the figure shows the probabilities when BUNIT2 has a CID1 type system on board. Again the probabilities are given for correct CID and for detection of the CID signal. There is no subunit for RUNIT1 because RUNIT1 does not have a CID1 on board in this battle.

II.L Combat Identification File 2

The second type of combat identification device which can be played is a query-response type system. This type of CID is used after an observer detects a target and decides to fire at the target. Just prior to firing at the target, the firer queries the target, and tries to elicit a response from the target. If the target receives the signal and returns a response, the firer will discontinue the firing sequence, disengage the target, and begin looking for new targets.

Associated with this query and response are four probabilities and a time delay. The diagram below shows the meaning of each of these inputs. P1 is the probability that when the host queries a target, the signal will reach the target. P3 is the probability that the target's response will get back to the host vehicle. P2 and P4 are the probabilities that the target and then the host vehicle will correctly interpret the query and response, respectively. The time delay is simply the time from the initial query to the observer interpreting the response. What the diagram does not show is that when the target sends out its response, there may be some chance that the response will be detected by enemy units, which may then engage that target.

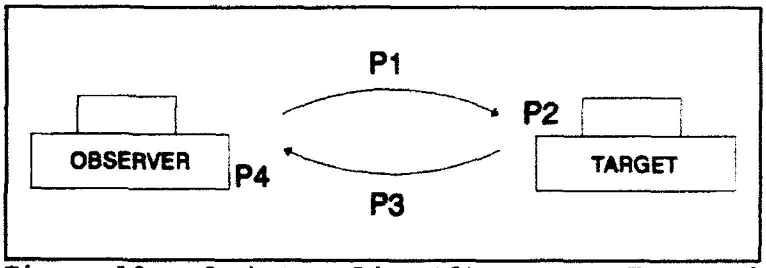

Figure 19 Combat Identification Type 2 Methodology

The input file for this type of CID is named "cidfil2". This file is divided into subunits for each unit type in the battle. The structure of the subunit is shown in the next figure. For the CID1 subunit the inputs described what others could do to the host vehicle. For CID2 the user inputs the probabilities which describe what the host vehicle can do to others.

The next figure shows the structure of the CID2 subunit. After the name of the host or querying unit, the first input is the number of times this unit will query a target before engaging it. If the firer receives a positive response from any query he will disengage the target, and not query again. If this unit has no CID then the input is 0. On the next two lines enter the time delay associated with the CID2, and P1 as described above, as a function of range between firer and target. Next there is a subsection for each unit type to be queried by the CID. Within each subsection the user enters the target unit's name, and P2 through P4. The section must be ended with an 'END' as the target name. The last section in the subunit defines the chance for the host vehicle to

```
---- CID Host Unit
 Host Name
    x                                            *** Number of CID Attempts
    x.xx  x.xx  x.xx  x.xx  ...                  *** CID Time Delay
    x.xx  x.xx  x.xx  x.xx  ...                  *** P1
  --- Probability of CID2 Against These Targets
     Target1 Name
       x.xx  x.xx  x.xx  x.xx  x.xx ...    *** P2
       x.xx  x.xx  x.xx  x.xx  x.xx ...    *** P3
       x.xx  x.xx  x.xx  x.xx  x.xx ...    *** P4
     Target2 Name
       x.xx  x.xx  x.xx  x.xx  x.xx ...    *** P2
       x.xx  x.xx  x.xx  x.xx  x.xx ...    *** P3
       x.xx  x.xx  x.xx  x.xx  x.xx ...    *** P4
     'END'
  --- Probability of Detecting These Targets' Responses
      Target1   x.xx  x.xx  x.xx  x.xx  x.xx ...     *** P(detect)
     'END'
```

Figure 20 Combat Identification File 2 - structure

detect a target when it responds to a CID2 query. For each appropriate target unit type, enter the target name and the probability as a function of range that the host unit will detect it.

The next figure shows a sample of a CID2 file. BUNIT1 has a CID2 type device on board and will query a target 1 time before engaging it. The time delay associated with its CID varies from 1 second at 500 m. to 5 seconds at 3500 m., and its probabilities of CID are very high. BUNIT1 is only able to CID BUNIT2 since there is no entry for RUNIT1. BUNIT1 is also able to detect BUNIT2 when it responds to a query. If a firer from BUNIT1 queries a unit from BUNIT2, other observers from BUNIT1 have a 0.1 probability of detecting that response at 2000 m.

The same is true when BUNIT2 is the host platform. Its time delay also ranges from 1 to 5 seconds, but it will try to query a target twice before engaging. Its probabilities of CID are a bit lower than BUNIT1's.

RUNIT does not have a CID on board, but is able to detect both BUNIT1 and BUNIT2's CID responses. These probabilities of detection are entered in the last section in the figure. For example, when BUNIT1 queries BUNIT2, RUNIT1 has a probability of detecting that response of .2 at 500 m.

```
*** Comment Line(s) ***
 BUNIT1
    1                                          *** Number of CID Attempts
    1.0 1.2 1.5 2.0 2.5 3.5 5.0                *** CID Time Delay
    1.0 1.0 1.0 1.0 1.0 1.0 0.85               *** P1
  --- Probability of CID2 Against These Targets
     BUNIT2
       1.0 1.0 1.0 1.0 1.0 1.0 1.0               *** P2
       1.0 1.0 1.0 1.0 1.0 1.0 0.85              *** P3
       1.0 1.0 1.0 1.0 1.0 1.0 1.0               *** P4
     'END'
  --- Probability of Detecting These Targets' Responses
      BUNIT2 0.2 0.2 0.2 0.1 0.1 0.0 0.0
     'END'
*** Comment Line(s) ***
 BUNIT2
    2                                          *** Number of CID Attempts
    1.0 1.0 1.0 1.0 1.0 3.0 5.0                *** CID Time Delay
    0.5 0.5 0.3 0.3 0.2 0.1 0.00               *** P1
    --- Probability of CID2 Against These Targets
     BUNIT1
       1.0 1.0 1.0 1.0 1.0 1.0 1.0               *** P2
       1.0 1.0 1.0 1.0 1.0 1.0 0.85              *** P3
       1.0 1.0 1.0 1.0 1.0 1.0 1.0               *** P4
     'END'
  --- Probability of Detecting These Targets' Responses
     'END'
*** Comment Line(s) ***
 RUNIT1
    0                                          *** Number of CID Attempts
    7*0.0                                      *** CID Time Delay
    7*0.0                                      *** P1
  --- Probability of CID2 Against These Targets
     'END'
  --- Probability of Detecting These Targets' Responses
     BUNIT1 1.0 1.0 1.0 1.0 1.0 1.0 1.0           *** P(detect)
     BUNIT2 0.2 0.2 0.2 0.1 0.0 0.0 0.0           *** P(detect)
     'END'
```

Figure 21 Combat Identification File 2 - sample

III RELEASE AUTHORITY

The Groundwars Model is the property of the Federal Government. The model may be released to any government agency which has a use for it. However, release to a government agency does not give authority for that agency to release the model to other agencies or contractors.

Contractors are permitted use of the model if there exists a contract with the government which requires its use. Contractors are required to have their government point of contact provide this office with a letter of request. Upon receipt of this request, AMSAA will provide the contractor with a Memorandum of Agreement for the use and modification of the model. Upon execution of this agreement, AMSAA will provide the model to the government POC, who in turn provides it to the contractor.

Any modifications which are made to the model should be provided to this office. Any errors in the model should be addressed to one of the points of contact in the next section. Requests for the model should be sent to:

Director
US Army Materiel Systems Analysis Activity
ATTN: AMXSY-GC (L. Harrington)
Aberdeen Proving Ground, MD 21005-5071

IV POINTS OF CONTACT

The following list provides points or places of contact for questions pertaining to the Groundwars Model and required input data.

Subject Area	Point(s) of Contact
GROUNDWARS Model	Mr. Gary Comstock (DSN 298-2079) Mr. Barry Burns (DSN 298-7289) Ms. Lilly Harrington (DSN 298-3239) Mr. Michael Schmidt (DSN 298-7290) Combined Arms and Barrier Warfare Analysis Branch (CABWAB), AMXSY-GC Ground Warfare Division, AMSAA
Vulnerability Data	Vulnerability/Lethality Div (VLD), BRL
Terrain Data	Mr. Danny Champion (DSN 258-5891), TRAC, White Sands Missile Range, NM
Firing Cycle Times Delivery Accuracy	Mr. Jesse Brewer (DSN 298-3374), Armored Warfare Analysis Branch Mr. Edward Walker (DSN 298-5356), Infantry Warfare Analysis Branch
Target Acquisition	Mr. Richard Mezan (DSN 298-2274) Mr. Jeff Matthews (DSN 298-7287) CABWAB, GWD, AMSAA

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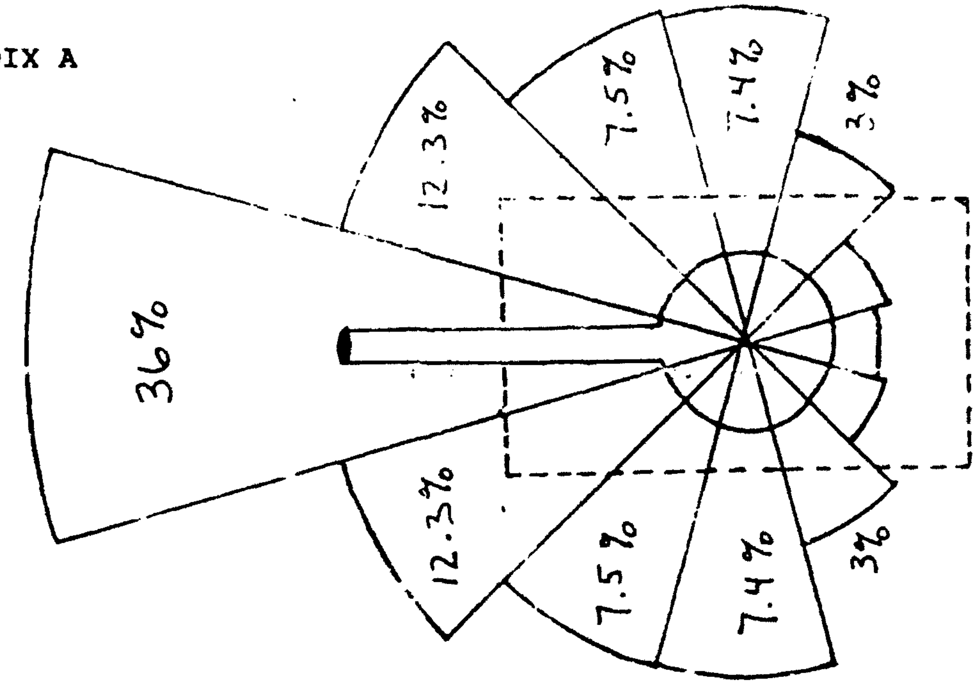
APPENDIX A

CV-CPOA



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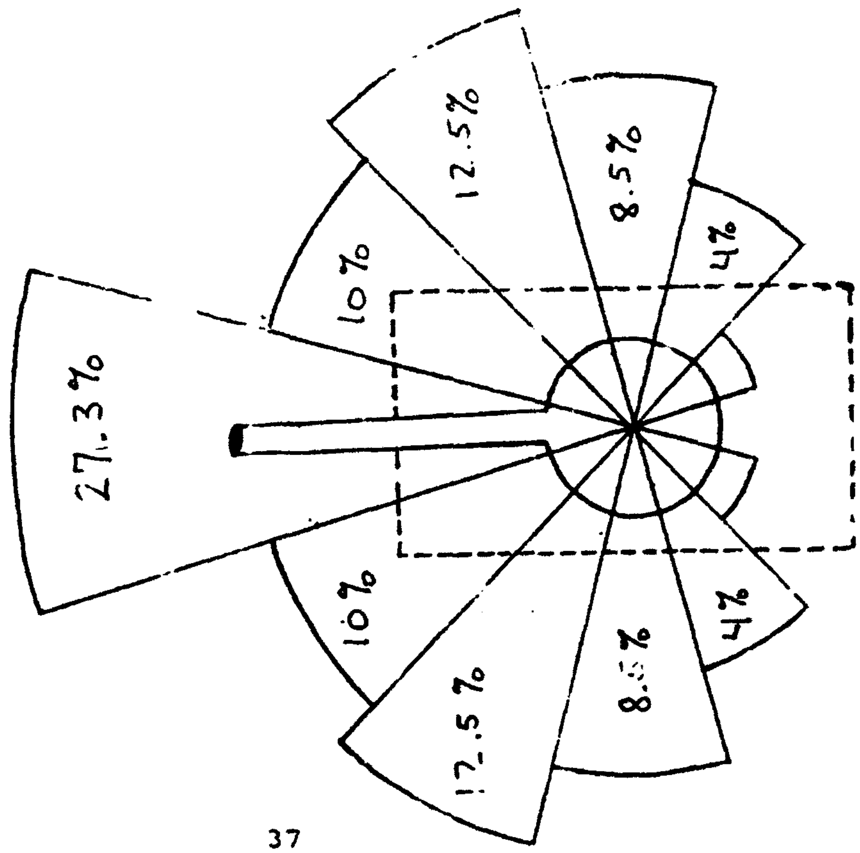

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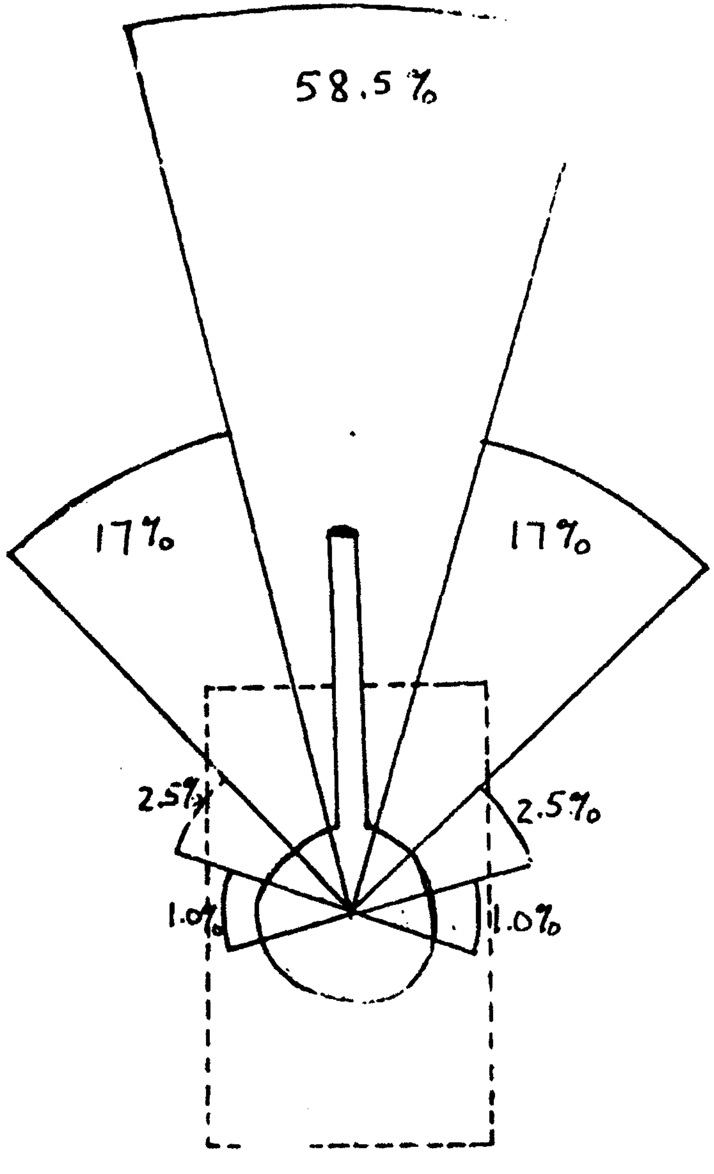
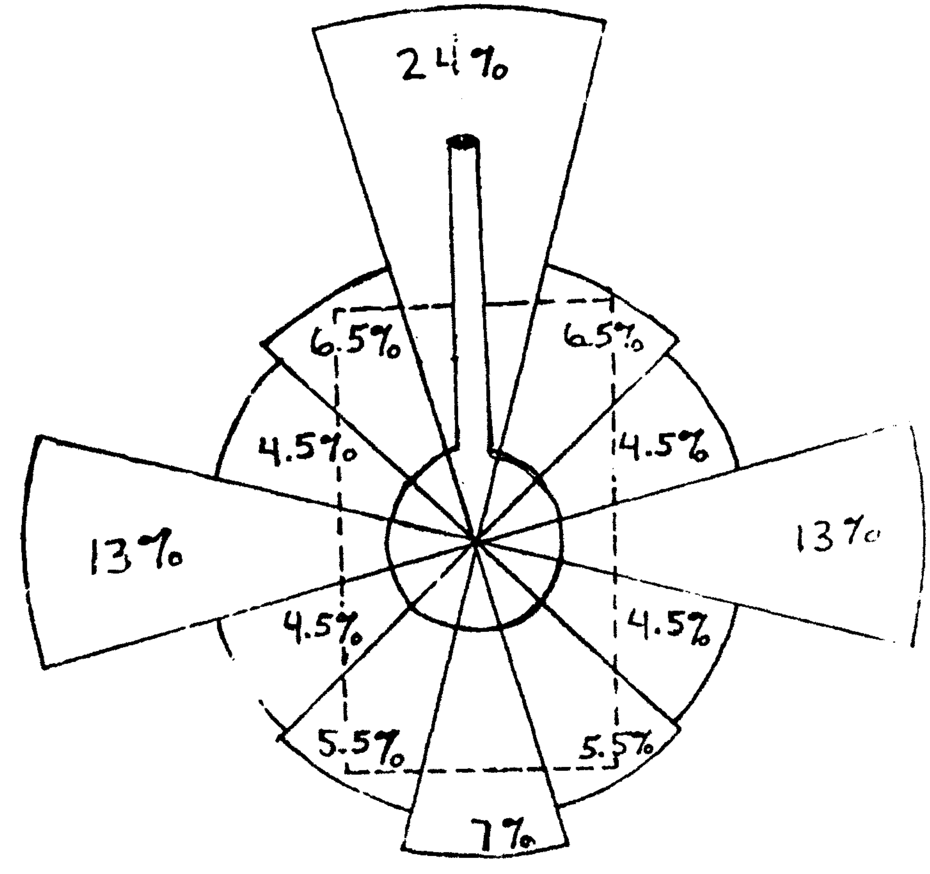


CLOSE QUARTER COMBAT



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1	SURVIAC Satellite Office ATTN: M. McGinnis Ste. 1610 1300 North Seventeenth Street Rosslyn, VA 22209

AMXSY-GC **GIST**

In-House Analysis

SUBJECT: Technical Report 530, Groundwars Version 5.0 - User's Guide

PRINCIPAL FINDINGS: NA

MAIN ASSUMPTIONS: NA

PRINCIPAL LIMITATIONS: NA

SCOPE OF THE EFFORT: Groundwars Combat Simulation. Ground to ground combat simulation of a two sided battle between heterogeneous forces.

OBJECTIVE: To document the input requirements of the model and to inform the user of the requirements and capabilities of the model.

BASIC APPROACH: The simulation is based on Monte Carlo probability theory for simulating randomness. Combat simulation standard approaches are used for simulating combat.

REASON FOR PERFORMING THE EFFORT: To document the input requirements of the model for user execution at other government sights and at appropriate contractors.

IMPACT OF THE EFFORT: NA

SPONSOR: U.S. Army Materiel Systems Analysis Activity

PRINCIPAL INVESTIGATOR: Michael C. Schmidt

COMMENTS AND QUESTIONS:

AMXSY-GC Attn(M. Schmidt)
Aberdeen Proving Ground, MD 21005-5071
DSN 298-4413, Comm. 1-410-278-4413

DTIC/DLSIE ACCESSION NUMBER: Report sent to DTIC (number not available). Report available by contacting AMSAA's Reports Processing Center, DSN 298-4661.

WHO COULD BENEFIT FROM THIS REPORT: Numerous outside government agencies use the Groundwars model to conduct weapon systems analyses. Also defense contractors which use the model need this report to format input data.