# AMSAA

TECHNICAL REPORT NO. 514

## GROUNDWARS 4.2 REFERENCE GUIDE

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DECEMBER 19[illegible]



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U.S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
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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 homogeneous 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 dynamic target acquisition, near-simultaneous engagements, artillery effects, line-of-sight enhancements, survivability enhancements (smoke grenades, active protection), statistical confidence and testing.

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# GROUNDWARS 4.2 REFERENCE GUIDE

## I. INTRODUCTION

Groundwars is a weapon systems effectiveness model which provides the results of a land duel between two homogeneous forces. The model simulates individual weapon systems and employs Monte Carlo probability theory as its primary solution technique. Typically 300 replications are sufficient for a 95 percent confidence level for the primary measures of effectiveness (MOE).

Groundwars is an outgrowth of the TANKWARS model (version II) originally written by Mr. Fred Bunn of the Ballistic 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 4.2.

The simulation is stochastic and event sequenced. The battle is between two forces, one BLUE and one RED. Each side has one type of vehicle, sensor and round. Three scenarios can be played in the model, RED attack, BLUE attack, or meeting engagement. In the attack scenarios, the attackers are fully exposed and moving while the defenders are hull defiladed and stationary. In a meeting engagement, both sides are fully exposed and stationary. The user determines the size of the two forces (maximum of 20 total systems), the range at which the battles will begin, the attack angle distribution to be used, and the terrain data 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. Terrain distributions for three areas in Germany are indigenous to the model. Eschenbach is choppy terrain with short opening ranges and short in view segments. Peine is characterized by long opening ranges and in view segment lengths. The Hunfield area has moderate in view segments. Additional terrains may be input to the model if the data exists. The format for the data will be shown in the game file description.

Given that intervisibility exists between two combatants, acquisition may occur. A firer can acquire a target either by regular detection or by detection of a 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. Detection by firing signature is driven by a probability and a delay time. Whenever a system fires, all enemies which have line of sight to the firer draw against the probability. If detection occurs a time delay is assessed before the target can be engaged.

Groundwars allows the user to play one of four types of weapons: kinetic energy, high explosive anti-tank, guided missile, and fire and forget missile. For each type of round the model requires system characteristics(firing times, vehicle size, speed), accuracy data, and lethality data. The model also allows the user to play either single shot or burst fire.

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

A number of counter measures, such as on board smoke grenades can be simulated. When an incoming round is detected by the grenade system, it will launch grenades around the vehicle and form a cloud of smoke which will cause an incoming missile to abort. A second type of counter measure is an active protection system. Similar to the smoke grenades, this system senses an incoming round and either destroys or jams the projectile. The user controls the level of effectiveness for these self-defense systems. Also, one or both of the armies can deploy smoke on the battlefield which will degrade acquisition capabilities.

Limited artillery play is also implemented in the model. One mission can be deployed by an army during a battle. The attacking force is given the option to have a preparatory artillery barrage. For each type of mission, there is an associated probability of kill which is assessed against all enemy vehicles, all of which are assumed to be in the target area. 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 has not found another target after a period of time which is a user input.

The primary measures of effectiveness for the simulation are exchange ratio, mean casualties, and mean rounds per firer. The secondary measures include surviving force ratio, mean rounds fired per kill, numbers of detections, number of times vehicles were depleted of ammunition, and others. (See Section III.A) 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 limitation of the simulation is that it models only one weapon, round, and sensor per army. There are no effects from suppression, and it models only direct fire line of sight weapon systems. The main strong point of the model is its quick set up and run time which allows for examination of many situations and conditions. While the simulation of a realistic battlefield may be somewhat limited, the model does provide a basis for modelling system interaction and can enable an analyst to obtain a good understanding of these effects prior to combined arms modelling.

## II. INPUT DATA REQUIREMENTS

Groundwars requires nine input files. There is a scenario description file in which the user determines the scenario, the numbers of combatants, the terrain, and the level of output desired. For each army there is a system characteristics file, an accuracy file, a lethality file, and a target acquisition file. Figure II.1 shows the required filenames and the file descriptions.

| File Description | File Name |
|---|---|
| Scenario | game |
| BLUE Weapon File | bmis |
| BLUE Accuracy | bacc |
| BLUE Lethality | bpk |
| BLUE Acquisition | bacq |
| RED Weapon File | rmis |
| RED Accuracy | racc |
| RED Lethality | rpk |
| RED Acquisition | racq |

Figure II.1 Groundwars File Structure.

The file names shown must be used to match with the file names in the code. File names are all lower case letters for operating systems which are case sensitive. All files except for IUA lethality files are free formatted.

** Description Line **

1. Scenario: RED attack, BLUE attack, Meeting engagement
2. Terrain: Peine, Hunfeld, Eschenbach, other
3. Attack Angle Distribution: Cardioid, Frontal, CV-CPOA, Close Combat
4. Number of BLUE Combatants: start, end, increment
5. Number of RED Combatants: start, end, increment
6. Output control flags (7)
7. Debug flags (30)
8. Opening range: start, end, increment
9. Range increment for data input
10. End range, Output range inc. *only for attack scenario
11. Max time, Output time inc. *only for meeting scenario
12. Number of replications, Initial seed
13. Pinpoint restriction: 0=none, 1=pinfinity
14. BLUE: maximum firing range, lethality flags (2)
15. RED: maximum firing range, lethality flags (2)
16. Number of points in the group distribution
17. Group distribution
18. Ranges at which alphacl changes

---

This section is required if "other" terrain was used.

1. Number of points in the terrain distribution (lterr)
   Number of points in the opening range distribution
2. For lterr lines: Segment Length P(In) P(Out)
3. For lopen lines: Opening Range P(Opening)

Figure II.A.1 Scenario Description File.

## II.A SCENARIO DESCRIPTION FILE

The scenario file defines many aspects of the scenario to be played. The file is free-formatted, and the structure is shown in Figure II.A.1. Any number of description lines may be placed at the top of the file and are designated as comments by preceding asterisks.

The first three lines of the file require character strings as input. Line 1 sets the scenario to be played, with choices of RED attack, BLUE attack, and meeting engagement. The desired terrain is specified on line 2. The model contains the terrain distributions for three areas in Germany: Eschenbach, Hunfeld, and Peine. Other terrains can be played by entering "other." If other is specified, three cumulative distributions are required: the initial opening range, the length of the in view segments, and the length of the out of view segments. These distributions will be entered as shown after line 18. The attack angle distribution is the required input on line 3. The user chooses from the four listed in the figure.

The model allows the user to loop through the number of combatants on each side. On lines 4 and 5 the user inputs the number of BLUE and RED forces respectively. The model uses these numbers as the following loops show.

```
Loop nblue = start, end, increment
  Loop nred = start, end, increment
      call submodel
  End loop
End loop
```

If the user wishes to play a single number of combatants on the same side, the same number should be entered for "start" and "end" and any positive increment.

The next two lines control the level of output from the model. Line 6 is for the ordinary user of the model and has seven flags which can be set to control the level of output. The seven flags and the output which they control are shown in the table below. For each of the flags, the normal input is a 0. For a more detailed analysis, flag 1 can be set to a one which produces a one line summary for each replication of the battle. Flag 1 should only be set >1 if the number of replications is 1 or 2. The output produced by flag 2 is helpful in finding errors in input data. The output from setting flag 3 to a one is helpful in analyzing results, since acquisition can be a major driver in the simulation. If flag 3 is set to one, the output range increment (described later in this file) must be >0. The output from flags 2 or 3 can be produced without running a battle by setting the number of replications to 0. The output from setting either flag 4 or 5 to a one is large, and should only be done for one replication.

| Flag | Value | Result |
|---|---|---|
| 1 | 0 | - two page summary of all replications |
| | 1 | - 0 plus a one line summary of each replication |
| | 2 | - 1 plus all critical events in the battle |
| | 3 | - 2 plus a breakdown of the line of sight segments |
| 2 | 0 | - no additional output |
| | 1 | - three page output of miscellaneous system description firing times, tactics, disengagement policy, etc. |
| | 2 | - one page sample of lethality data |
| 3 | 0 | - no additional output |
| | 1 | - one page output of acquisition estimates for each army (p-infinity, tbar, atmospheric conditions) |
| 4 | 0 | - no additional output |
| | 1 | - trace entry and exit from important routines |
| 5 | 0 | - no additional output |
| | 1 | - output all events as they are scheduled and canceled |
| 6 | 0 | - two page output of some measures of effectiveness by range or time (*detections*, *shots*, *kills*, missile aborts) |
| | 1 | - no additional output |
| 7 | 0 | - no additional output |
| | 1 | - one page output of the distribution of shots |

The second line of output control flags are meant to be used by the programmer. They are for debugging purposes, and correspond to specific events in the battle.

On line 8 the user specifies the initial separation between the two armies. This input can be looped as the number of combatants can be. Many data are input as a function of range, and must be entered at a set range increment which is specified on line 9. The next two lines control the desired length of the battle. Line 10 controls attack scenarios which are ended when attackers are within a set range of the defenders; this ending range and the range increment for output by range are required on this line. Meeting engagements end after a specified length of time. For meeting engagements the detailed output is done in time increments instead of range. Lines 10 and 11 must both be included regardless of the scenario played. Line 12 requires the number of replications desired and the initial random number seed.

The ability to detect a target's firing signature (pinpoint) can be restricted by the next input. By entering a 1 on line 13, the user allows a

system to pinpoint only if it has P-infinity greater than 0.0 at that range. Otherwise, an input of 0 allows a system to pinpoint regardless of P-infinity.

The next two lines are critical features of the weapon systems for each army, BLUE then RED. The user specifies the maximum tactical firing range of the system and two flags related to the lethality files. The first flag determines the type of probability of kill data to be used, either probability of kill given a hit or probability of kill given a shot. The values to play for this flag are described in Section II.D Lethality Files. A value of 0, 1, or 2 must be used for this flag. Probability of kill can be either a function of range, or can be independent of range. For systems with range independent lethality the second flag on line 14 or 15 should be set to 1; systems with range dependent lethality require a 0 input.

Lines 16 and 17 in the file pertain to the group distribution. Attackers are placed into groups of varying size. The group distribution determines the size of these groups. The first line of input is the number of points to read as the distribution, which is the second line.

On the last line the user specifies two ranges at which the level of smoke on the battlefield changes. If the user wishes to have smoke deployed at the beginning of the battle, the user should NOT make the first value on this line the same as the opening range. These ranges are where the atmosphere changes, not where smoke begins or ends. For example, if the user wishes to have smoke deployed for 1,000 meters at the beginning of the battle with a beginning range of 4,000 meters, the line would read:

3000. 0.

```
** DESCRIPTION LINE(S) **
 1. Turret dimensions:        d1      d2      d3      d4
                             x.x     x.x     x.x     x.x
 2. Hull dimensions:          d1      d2      d3      d4
                             x.x     x.x     x.x     x.x
3-7  Inputs by Range:  Psense, ToF, Tfirst, Tfixed, Reliab
     x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx ...
     x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx ...
     x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx ...
     x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx ...
     x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx x.xx ...
 8. Movement:                 speed   accel   decel
                               x.x     x.x     x.x
 9. Weapon Character's:       kindrd  nrounds ishalt  ndets
                                x       x       x       x
10. Times to Hide:            tblosj  tlempt  tlfkil
                              xx.x    xx.x    xx.x
11. Jockeying:                ifpop   ntfjoc  timjoc
                                x       x      xx.x
12. Subsequent Firing:        timsub  tmin
                               x.x     x.x
13. Tactics:          tactic  nrpt    nbump   tbump   pause
                        x       x       x      xx.x     x
14. Firing Priorities:        recrng  tlook   nprior
                              xx.x    xx.x      x
15. Burst Fire Inputs:        rof     nrpb
                              x.x       x
16. Missile System: nipods    ntgts   trelod  pabtsm  pabterr
                      x         x      xx.x    x.xx    x.xx
17. Decoy Inputs:             ndecoy  nfldec  tflash  rngfla
                                x       x      xx.x    xx.x
18. Potpourri:                pinpnt  pfalhd  pfalfe  if_art
                              x.xx    x.xx    x.xx      x
19. Multiple Engagement:      ifmult   tmult  nmult   irldpt
                                x      xx.x     x       x
20. Artillery Prep:           mkill   fkill   m&fkill kkill
                              x.xx    x.xx    x.xx    x.xx
21. Artillery Oncall:         mkill   fkill   m&fkill kkill
                              x.xx    x.xx    x.xx    x.xx
22. Active Protection: arcdeg p(det) p(f/h) p(f/m) p(int) nrds
                       xx.x   x.xx   x.xx   x.xx   x.xx   x
23. Active Protection: Deg. Factors  0,30,60,90,120
                              x.xx  x.xx  x.xx  x.xx  x.xx
24. Smoke Grenades:  ngrens  p-pop  alphacl 1 & 2  duration
                       x      x.xx    xx.x   xx.x    xx.x
25. Communications:           ifcomm  pcomm   tcomm   tsearch
                                x     x.xx    xx.x    xx.x
```

Figure II.B.1 System Characteristics File.

## II.B MISCELLANEOUS SYSTEM CHARACTERISTICS FILE

This file contains weapon system characteristic data which describe vehicle size, weapon performance, movement rates and tactics, etc. Figure II.B.1 presents the structure of the file with the comment lines which MUST remain in the file to prevent input errors. Variables shown with a decimal point (x.xx) are real numbers, and those without (x) are integers. While the file is free formatted, integers should be entered as integers and reals as reals to avoid any input errors which may occur with strict FORTRAN compilers. Each army requires a system file.

| Line Number | Input Requirement | Description |
|---|---|---|
| 1-2 | d1-d4 | physical dimensions (meters) of the system (turret, hull) |
| | d1 | height |
| | d2 | 1/2 width |
| | d3 | distance from center of turret ring to front edge |
| | d4 | distance from center of turret ring to back edge |
| 3 | psense | Probability that the firer will sense the impact location of a round that misses its target. ** |
| 4 | tof | Time of flight for the round. ** |
| 5 | tfirst | Median time to fire the first round of an engagement. ** |
| 6 | tfixed | Fixed time between rounds for an auto-loader. ** |
| 7 | reliab | Round reliability. ** |

** These variables are dependent on range and are input at range increments specified in the scenario file. The first value on each line should be for range = increment range, not zero. There must be enough values on each line to cover ranges up to this system's maximum firing range.

| | | |
|---|---|---|
| 8 | Movement: | |
| | speed | Maximum speed (m/s) at which the system can move regardless of whether the system is attacking or defending, a positive value must be entered. |
| | accel | Acceleration of the vehicle (m/s2). |
| | decel | Deceleration of the vehicle (m/s2). |

| Line Number | Input Requirement | Description |
|---|---|---|
| 9 | | Weapon Characteristics: |
| | kind rd | Type of ballistic projectile.<br>1 - Kinetic Energy (KE)<br>2 - High Explosive Anti-Tank (HEAT)<br>3 - Fire and Forget Missile<br>4 - Command Line of Sight Missile |
| | nrounds | Number of rounds on board the vehicle. |
| | ishalt | Is the system halt to fire.<br>0 - the system can fire on the move<br>1 - the system must halt to fire |
| | ndets | Number of targets which can be detected by the system. |
| 10 | | Times to Leave the battlefield: |
| | tblosj | Time to leave when jockeying, or popping down to reload. |
| | tlempt | Time to leave when the system runs out of ammunition. |
| | tlfkil | Time to leave when the system has been fire power killed. |
| 11 | | Jockey Inputs: |
| | ifpop | Does this system go to a fully defiladed position to reload its missile pod?<br>(pertains only to missile systems in defense)<br>0 - system remains exposed to reload<br>1 - system pops down to reload |
| | ntfjoc | Number of rounds fired before disengaging and moving to a new position.<br>(pertains only to KE or HEAT systems in defense)<br>0 - system will never jockey |
| | timjoc | Time to jockey (sec).<br>(For multiple engagement timjoc is added to the time to reload to get the full time that the system is fully defiladed.) |
| 12 | | Subsequent Firing Times: |
| | timsub | Median time to fire a subsequent round at the same target in this engagement. |
| | tmin | Minimum time to fire a subsequent round at the same target in this engagement. |

| Line Number | Input Requirement | Description |
|---|---|---|
| 13 | Disengagement Tactics: | |
| | tactic | Target disengagement criterion (firer will always disengage after a k-kill)<br>1 - disengage after a k-kill<br>2 - disengage after a hit on the target<br>3 - disengage after firing a set number of rounds at the target (variable nrpt) |
| | nrpt | Number of rounds to fire at a target before disengaging. (only if tactic=3) |
| | nbump | Number of rounds to fire at a target after it has been m&f killed. After firing this number of rounds, the target is made inactive, and will no longer be a target for anyone. |
| | tbump | A period of time to fire at a target after it has been m&f killed. After waiting this period of time, the target has been inactive and is assumed out of commission. |
| | pausdf | Attacker continuing engagement tactic.<br>0 - attacker will disengage a target if line of sight is closing between it and the target<br>1 - attacker will move to a hull defiladed posture and continue engaging a target instead of losing line of sight to the target |
| 14 | Firing Priorities: | |
| | recrng | Range in meters within which an enemy system can be recognized. Targets within recrng carry a higher priority than those outside this range. |
| | tlook | Time to look for additional targets before re-engaging a previous target. |
| | nprior | Selection of targets for engagement<br>1 - older targets have higher priority<br>2 - newer targets have higher priority |
| 15 | Burst Fire Systems: | |
| | rof | Rate of fire in rounds per second in a burst. |
| | nrpb | Number of rounds per burst. If IUA lethality files are being used, nrpb must be no greater than 3. If pks lethality is played nrpb can be any number. |

| Line Number | Input Requirement | Description |
|---|---|---|
| 16 | Missile Systems: | |
| | nipods | Number of missiles in a missile pod. Only these missiles are ready to fire without reloading. |
| | ntgts | Number of targets which can be fired on simultaneously by a missile system. |
| | trelod | Time required to reload a missile pod. |
| | pabtsm | Probability that a missile will abort if the alpha*CL level increases during missile flight. |
| | pabttr | Probability that a missile will abort if line of sight between the firer and target ends during missile flight. |
| 17 | Decoys: | |
| | ndecoy | Total number of decoys (non-flashing and flashing). The model adds this number to the number of systems on this army's force. They are included in the 20 maximum number of systems played. |
| | nfldec | Number of flashing decoys (subset of ndecoy). Flashing decoys have the same firing signature as their fighting counterparts. |
| | tflash | Time between flashes for flashing decoys. |
| | rflash | Range at which flashing decoys begin flashing. Decoys will not flash if this is left at 0.0 |
| 18 | Potpourri: | |
| | pinpnt | Probability that this system will detect the firing signature of an enemy. |
| | pfalhd | Probability that a detected hull defiladed target will turn out to be false. |
| | pfalfe | Probability that a detected fully exposed target will turn out to be false. |
| 18 | if_art | Is this army deploying artillery?<br>0 - this army does not play artillery<br>1 - this army does play artillery |

| Line Number | Input Requirement | Description |
|---|---|---|
| 19 | Multiple Engagement: | |
| | ifmult | Is this army capable of multiple engagement?<br>0 - no multiple engagement capability<br>1 - multiple engagement is played (only with fire and forget systems) |
| | tmult | Time to search for subsequent targets before beginning the engagement. After tmult has passed, the firer will begin the engagement, provided he has not lost all of his targets. |
| | nmult | Number of targets to search for and engage. Engagement will begin as soon as nmult targets are detected. If nmult targets are not detected within tmult, engagement will begin anyway. Nmult must be <= ntgts <= ndets. |
| | irldpt | If desired, the system will reload part of its pod.<br>0 - system will only reload entire pod<br>1 - system will reload part of its pod as part of each jockey maneuver. (trelod is the time to reload a single missile) |
| 20 | Preparatory Artillery Probabilities of Kill: Artillery prep. fire is assessed prior to the start of the direct fire battle. Only attackers can deliver prep. artillery. Artillery pk's are assessed against every system on the opposing side. A single pk is required for each of four kill types: mkill, fkill, mfkill, and kkill. | |
| 21 | On-call Artillery Probabilities of Kill: Each side has one on-call mission per battle. This mission is placed at a time in the battle by a random number draw. The pk's are assessed as above, and are needed for the four kill types. | |
| 22 | Active Protection: System Performance | |
| | arcdeg | Frontal arc within which incoming rounds may be detected. The arc specified covers + and - arcdeg degrees on the front of the vehicle. |
| | p(det) | Probability that the active protection sensor will detect the incoming round given that it is within arcdeg. |
| | p(f/h) | If the incoming round will be a hit, this is the probability that the active protection will fire at it. |

| Line Number | Input Requirement | Description |
|---|---|---|
| | p(f/m) | If the incoming round will be a miss, this is the probability that the active protection will fire at it. |
| | p(int) | Probability that the active protection will intercept the incoming round. |
| | naprd | Number of times the active protection can activate per vehicle per replication. |
| 23 | Active Protection: Degradation factors: Factors must be entered for thirty degree sectors within the arc of protection. These numbers are the fractions of the enemies' probability of kill that will remain after interception. | |
| 24 | Smoke Grenades: | |
| | ngrens | Number of smoke grenades on board the vehicle. |
| | p-pop | Probability that the smoke grenades will deploy when an incoming round is detected. |
| | alpha*cl-1 | Level of smoke through which this system is trying to see when smoke grenades are deployed. |
| | alpha*cl-2 | Level of smoke through which enemies are trying to see when smoke grenades are deployed. |
| | duration | Duration (sec) of the smoke cloud when grenades are launched. |
| 25 | Communications: | |
| | ifcomm | Does this army have limited communications between individual systems?<br>0 - no communications<br>1 - limited communications |
| | pcomm | Probability that the communication of a target location will reach each friend of the system which first detects a target. |
| | tcomm | Time waited after reception of target location before attempting to detect that target. |
| | tsearch | Time to search for the received target before giving up and returning to normal search. |

## II.C SYSTEM ACCURACY FILES

This file contains weapon system delivery accuracies as shown in Figure II.C.1. 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. At this time 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 which may be deleted; more comments may be included. All ranges are in meters, and all angular measurements are in mils (1/6400 of a circle). BLUE and RED accuracy files have identical input requirements.

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 section of the file is for a stationary firer against a stationary target. For this situation two sets of data are required, that for the first round fired and that 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 psense in the system description file.

After the description line, the first input is a label to describe which errors are being input. The user then needs to enter the number of ranges to be read. The next few lines shown are comment lines which make the file easier to understand. On each of the next N lines 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. The user needs to enter the description or label and the number of ranges. 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.

The third section is for a moving firer against a stationary target. Only fixed bias and total error are required; this data is for only one attack angle.

Figure II.C.2 shows the situations in which each type of error will be used.

```
** DESCRIPTION LINE(S) **
Stationary firer vs stationary target
N ranges
*          ------- 1st round --------    --- sub. rounds
*          fixed   variable  random          lost     sens
*           bias    bias      error     hit    miss     miss
*          -------  --------  ---------  -------- ------ --------
* rg(m)    H   V    H    V    H    V     H    V   H  V   H    V
* -----    --- ---  ---  ---  ---  ---   ---  --- -- --  --   --
  rangel  x.x x.x  x.x  x.x  x.x  x.x   x.x  x.x x.x x.x x.x  x.x
    :      :   :    :    :    :    :     :    :   :  :   :    :
    :      :   :    :    :    :    :     :    :   :  :   :    :
  rangeN  x.x x.x  x.x  x.x  x.x  x.x   x.x  x.x x.x x.x x.x  x.x
*
Stationary firer vs moving target
N ranges
*                 fixed bias              total error
*  rg (m)      horiz.      vert.         horiz.      vert.
*  ------      -----       -----         -----       -----
*  0 degrees
   rangel       x.xx        x.xx          x.xx        x.xx
     :            :           :             :           :
     :            :           :             :           :
   rangeN       x.xx        x.xx          x.xx        x.xx
* 30 degrees
   rangel       x.xx        x.xx          x.xx        x.xx
     :            :           :             :           :
     :            :           :             :           :
   rangeN       x.xx        x.xx          x.xx        x.xx
* 60 degrees
   rangel       x.xx        x.xx          x.xx        x.xx
     :            :           :             :           :
     :            :           :             :           :
   rangeN       x.xx        x.xx          x.xx        x.xx
* 90 degrees
   rangel       x.xx        x.xx          x.xx        x.xx
     :            :           :             :           :
     :            :           :             :           :
   rangeN       x.xx        x.xx          x.xx        x.xx
Moving firer vs stationary target
N ranges
*                 fixed bias              total error
*  rg (m)      horiz.      vert.         horiz.      vert.
*  ------      -----       -----         -----       -----
   rangel       x.xx        x.xx          x.xx        x.xx
     :            :           :             :           :
     :            :           :             :           :
   rangeN       x.xx        x.xx          x.xx        x.xx
```

Figure II.C.1 System Accuracy File Structure.

```
Stationary vs Stationary:
      Meeting Engagement
      Halt-to-Fire Attackers  <---> Defenders
      Mobility Killed Attackers  <--->  Defenders

 Stationary vs Moving:
      Defenders ----> Moving Attackers

Moving vs Stationary:
      Moving Attackers ----> Defenders
```

Figure II.C.2 Situational Use of Various Aiming Errors.

As was mentioned in the miscellaneous file description, the maximum number of rounds per burst is limited to three when IUA lethality is being played. For burst fire systems, the numbers in the accuracy file are used as is shown in Figure II.C.2. Only the numbers in the stationary-stationary section will be used. The first two columns are the fixed bias, horizontal and vertical, for the first round of each burst. The random error for the first round is entered in columns 7 and 8. Columns 3 and 4 are the fixed bias for the second round in a burst,and columns 5 and 6 for the third round. The random errors for the second and third rounds in the burst are entered in columns 9 and 10.

```
** DESCRIPTION LINE(S) **
Stationary firer vs stationary target
N ranges
         1st rnd  2nd rnd  3rd rnd    1st rnd  sub rnd  all
*         fixed    fixed    fixed      var.     var.   round
*         bias     bias     bias       bias     bias   disper.
*        -------  -------- ---------  -------- ------ --------
* rg(m)   H   V    H   V    H   V      H   V    H  V   H    V
* -----  --- ---  --- --- --- ---    --- ---  -- -- --   --
  rangel x.x x.x  x.x x.x x.x x.x    x.x x.x  x.x x.x x.x  x.x
    :     :   :    :   :   :   :      :   :    :   :   :    :
    :     :   :    :   :   :   :      :   :    :   :   :    :
  rangeN x.x x.x  x.x x.x x.x x.x    x.x x.x  x.x x.x x.x  x.x
*
Stationary firer vs moving target
    : : : : Same format as Figure II.C.1
    : : : :
```

Figure II.C.3 System Accuracy File Structure - Burst Fire.

## II.D SYSTEM LETHALITY FILE

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). An aim point near the center of mass of the target is assumed. The model recognizes four levels of kill: mobility kill, fire power kill, mobility and fire power kill, and catastrophic kill. The form in which the data is entered into this file is determined by the lethality flags in the scenario definition file. The first flag determines whether the data is PKH or PKS, and in what form it will be entered. The second lethality flag determines the dependence of the lethality on range.Lethality can either vary with range or be independent of range. A 0 designates range dependent PK and a 1 designates range independent PK. The first of three forms 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, exposure, round dispersion and kill criteria. Figure II.D.1 shows the general structure of this file. This file is formatted, and will be received from the BRL in the proper format.

| | | | | | | Target Aspect Angle | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Targ | Rnd | Rnge | E | D | K | 0 | 30 | 60 | 90 | 120 | 150 | 180 | Avg |
| Header Line | | | | | | | | | | | | | |
| xxxx | xxx | 000 | 1 | 1 | 1 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | 000 | 1 | 1 | 2 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | 000 | 1 | 1 | 3 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | 000 | 1 | 1 | 4 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | 000 | 1 | 2 | 1 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | 000 | 1 | 2 | 2 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | : | : | : | : | : | : | : | : | : | : | : | : |
| | | : | : | : | : | : | : | : | : | : | : | : | : |
| | | : | : | : | : | : | : | : | : | : | : | : | : |
| | | rngN | 2 | 10 | 3 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | rngN | 2 | 10 | 4 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | rngN | 2 | 11 | 1 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | rngN | 2 | 11 | 2 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | rngN | 2 | 11 | 3 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |
| | | rngN | 2 | 11 | 4 | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx | x.xx |

Figure II.D.1 Sample of a BRL PKH file.

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 ft) 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.

The other 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 different order. For both forms, the data should begin with range of 0 meters and the files are free formatted. If the first lethality flag is set to a 0, the data will be in the form shown in Figure II.D.3. When the flag is set to a 2, the data will be in the form shown in Figure II.D.4.

| 0 m | rng1 | rng2 | rng3 | rng4 | | rngN | Kill Type | Expos |
|---|---|---|---|---|---|---|---|---|
| x.xx | x.xx | x.xx | x.xx | x.xx | ... | x.xx | M Kill | HD |
| x.xx | x.xx | x.xx | x.xx | x.xx | ... | x.xx | F Kill | HD |
| x.xx | x.xx | x.xx | x.xx | x.xx | ... | x.xx | M & F Kill | HD |
| x.xx | x.xx | x.xx | x.xx | x.xx | ... | x.xx | Catastrophic | HD |
| x.xx | x.xx | x.xx | x.xx | x.xx | ... | x.xx | M Kill | FE |
| x.xx | x.xx | x.xx | x.xx | x.xx | ... | x.xx | F Kill | FE |
| x.xx | x.xx | x.xx | x.xx | x.xx | ... | x.xx | M & F Kill | FE |
| x.xx | x.xx | x.xx | x.xx | x.xx | ... | x.xx | Catastrophic | FE |

Figure II.D.3 Probability of Kill Given a Shot (flag = 0).

| 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 II.D.4 Probability of Kill Given a Shot (flag = 2).

## II.E TARGET ACQUISITION DATA

The acquisition data file is free formatted and contains two major sections: sensor performance and vehicle description. Groundwars allows the user to play optical, thermal, or millimeter wave devices, but only one sensor for each side can be played at a time. For optical and thermal devices, the model uses a reduced form of the C2NVEO (CECOM Center for Night Vision and Electro-Optics) target acquisition methodology to approximate acquisition capability. Only a generic radar can be played in the model. The performance of this type of sensor is fixed except for fluctuations due to changes in the atmosphere. Since the required data for optical and thermal devices is so different from that for a radar device, the sensor performance section will be explained for each of these two.

Figure II.E.1 shows the structure of the sensor performance section for optical and thermal sensors. Any number of comments can be included at the top of this file provided they are preceded by asterisks. The first two lines of data requires character strings for input. The user specifies either"VISUAL" or "THERMAL". Data for these sensors can be input in one of two ways. The newer and more accurate way is to enter two performance curves which contain twenty points each. The second way is to enter seven coefficients to fit a sixth degree polynomial. It is recommended that the twenty point curves be used, but in some instances the data does not exist. The strings "TWENTY" and "NVLEXP" should be entered for each of these forms respectively, on line 2. The next line(s) are either the two curves or the sixth degree polynomial. On the next five lines, the user inputs the horizontal and vertical fields of view of the sensor, the horizontal and vertical fields of search of the observer, and the magnification of the sensor.

On line 9 the user specifies the level of acquisition to be played. This input determines the amount of data about the target which a system would want before engaging. Some often used levels and their corresponding values are shown below with a short description of the level of acquisition.

| Acq. Level | Optical | Thermal | Description |
|---|---|---|---|
| Detection | 1.0 | 1.0 | - there is a vehicle in sight |
| Classification | 2.0 | 2.0 | - is it tracked or wheeled? |
| Recognition | 3.0 | 4.0 | - it is an enemy vehicle |
| Identification | 6.0 | 8.0 | - it is a T72 |

The user inputs the visibility range and the atmospheric attenuation coefficient on line 10. The attenuation coefficient is a parameter used to calculate the transmission of the signal through the atmosphere, and is a function of sensor type, visibility range, and other variables in the atmosphere.

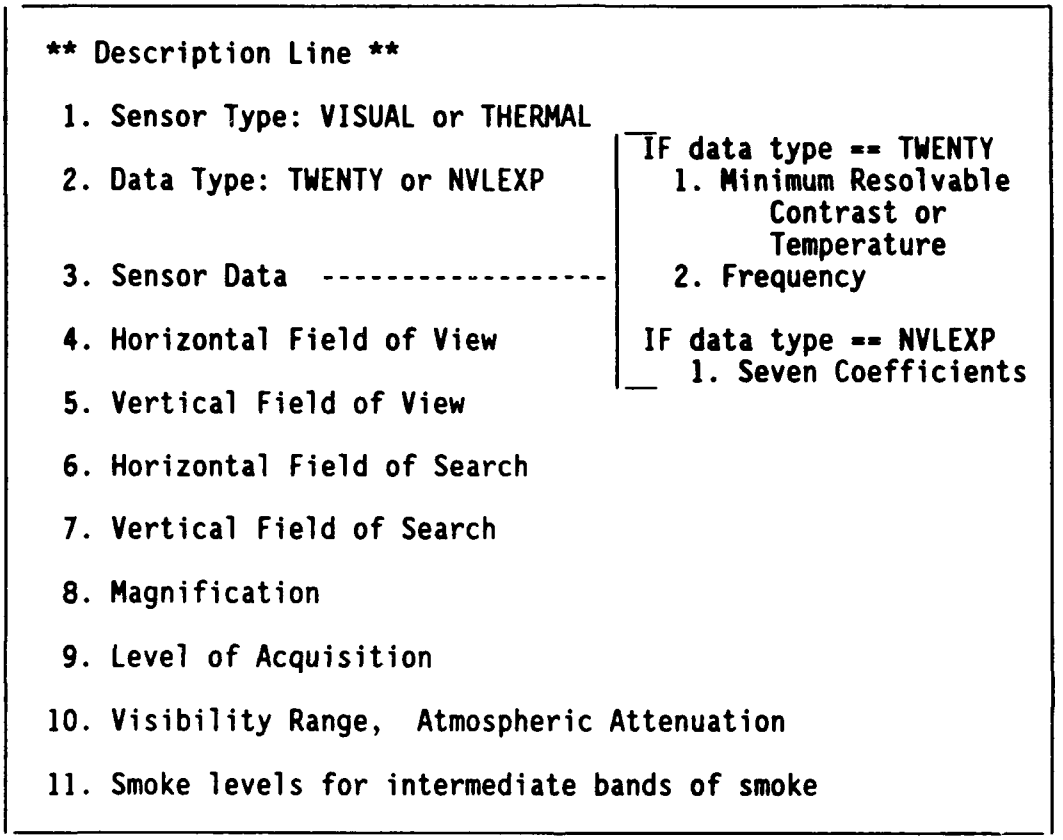


Figure II.E.1 Optical or Thermal Sensor Data.

The last inputs of this section specify levels of smoke on the battlefield. Three bands of different levels of smoke can be played. The ranges at which the smoke level changes are in the scenario description file. If smoke is desired at the beginning of the battle, this smoke should be entered as the first value on this line.

Figure II.E.2 shows the structure of the sensor performance section for a radar sensor. This section is very small because the modelling of radar is basically hard-wired. Again comments can be entered at the top with preceding asterisks, and the user specifies "RADAR" as the sensor type. Two factors effect the performance of the radar. The first is whether or not there is rain on the battlefield. If there is rain, the second input is a 1, else it is a 0. Two levels of clutter can also be specified, high clutter (clutter>1.0) and low clutter (clutter=1.0). There is no specification of acquisition level for radars; the level is approximately that of detection as was explained before. The final line in this section requires the smoke levels for bands of smoke as explained in the previous section.

```
* Generic Radar file
Sensor Type: RADAR
Rain
Clutter Level
Smoke levels for intermediate bands of smoke
```

Figure II.E.2 Radar Sensor Data.

Figure II.E.3 shows the platform description section. This section must be included regardless of the sensor type being played. This section is the last part of the acquisition file, and describes the platform on which the previously described sensor resides (i.e., if this file describes a BLUE sensor, this platform is the BLUE vehicle). The header line must be included in the file, and helps the user distinguish between the two major sections. Each required value must be given for both a hull defiladed and a fully exposed platform. The first line is the optical contrast, and the second line is the thermal contrast. These will be used when the opposing army deploys an optical or thermal sensor, respectively. The critical dimension of the vehicle is used for both types of sensors and is usually defined as the height of the vehicle. The final input is the radar cross section and is used only against radar sensors.

| * Platform Description | HD | FE |
|---|---|---|
| Optical Contrast | x.xx | x.xx |
| Thermal Contrast | x.xx | x.xx |
| Critical Dimension | x.xx | x.xx |
| Radar Cross Section | x.xx | x.xx |

Figure II.E.3 Platform Description.

## II.F SAMPLE INPUT FILES

```
RED attack
hunfeld          * Hunfeld terrain
cardioid distribution
2 4 2            * play 2 BLUE vehicles, then 4 BLUE vehicles
9 9 9            * play only 9 RED vehicles
0 0 1 0 0 0 1    *output control flags
0 0 0 0 0 0 0
4000 4000 4000    * play starting range of 4000m
500.             * range increment for data input
100.  500.       * end game at 100m, output at 500m
0.  0.           * used only for meeting engagements
300  11111111    * 300 replications
0                * no pinpoint restriction
3000.    1  0
3000.    1  0
7.0              * visibility range
0.0 0.0
9                *length of group distribution
.2 .36 .64 .75 .83 .87 .92 .94 1.     *group distribution
```

Figure II.F.1 Sample RED Attack File.

```
Meeting Engagement
hunfeld
Close combat distribution
9 9 9            * 9 BLUE vehicles
9 9 9            * 9 RED vehicles
0 0 1 0 0 0 1    *output control flags
0 0 0 0 0 0 0
4000 4000 4000    * play starting range of 4000m
500.             * range increment for data input
0.  500          * used only for attack scenarios
400.  40.    * end game after 400 s., output at 40 s.
300  11111111    * 300 replications
0                * no pinpoint restriction
3000.    1  0
3000.    1  0
7.0              * visibility range
0.0 0.0
9                *length of group distribution
.2 .36 .64 .75 .83 .87 .92 .94 1.     *group distribution
```

Figure II.F.2 Sample Meeting Engagement File.

```
Blue Attack
other          *quazrod dasht terrain stats
Frontal
10 10 10         * 10 BLUE vehicles
4 4 4            *  4 RED  vehicles
0 1 1 0 0 0 1    * output misc data, acqu., by range, shots
0 0 0 0 0 0 0
4000 4000 4000   * 4000 meter battle only
500.             *
100.  500.       * end game at 100m , output at 500m
0.0  0.0         *
300  11111111    * 300 replications
1                * restrict pinpoint capability
3500.   1  0     * IUA lethality file, dependent on range
3250.   0  1     * PKS file, independent of range
3.0
3500. 2000.    * smoke level changes at 3500 and 2000 m
9                * group dist. has 9 points
.2 .36 .64 .75 .83 .87 .92 .94 1.     *group distribution
19 11  * 19 points in in-out dist. 11 in opening distr.
      0      0.000      0.000
    100      0.133      0.198       ** Quazrod Dasht
    200      0.262      0.343       ** Range, In, Out
    300      0.382      0.446
    400      0.470      0.502
    500      0.539      0.548
    600      0.589      0.592
    700      0.632      0.629
    800      0.668      0.658
    900      0.713      0.686
   1000      0.737      0.704
   1500      0.803      0.775
   2000      0.860      0.822
   2500      0.890      0.855
   3000      0.919      0.885
   3500      0.974      0.918
   4000      0.988      0.942
   4500      0.995      0.954
   5000      1.000      1.000
      0         0.000       ** Opening Range Distribution
   1000         0.029       ** Range, P(open)
   2000         0.132
   3000         0.263
   4000         0.406
   5000         0.644
   6000         0.817
   7000         0.864
   8000         0.992
   9000         1.000
  10000         1.000
```

Figure II.F.3 Sample BLUE Attack File - with "other" terrain.

```
** Command Line of Sight Missile
Turret dimensions:        dl      d2      d3      d4
                          .8     1.7     2.3     2.3
Hull dimensions:          dl      d2      d3      d4
                         1.6     1.8     3.6     3.6
Inputs by Range:  Psense, ToF, Tfirst, Tfixed, Reliab
   8*0.0
   .3 .7  1.0  1.3 1.7  2.0  2.5  3.5 2*99.
   9.0 11.0 12.0 14.0 15.0 17.0 20.1  23.5 2*99.
   8*0.
   8*0.99
Movement:                 speed   accel   decel
                           5.6     1.0     2.0
Weapon Character's:       kindrd  nrds    ihalt   ndets
                            4      10       0       1
Times to Hide:            tblosj  tlempt  tlfkil
                           30.0    30.0    130.0
Jockeying:                ifpop   ntfjoc  timjoc
                            1       0      30.0
Subsequent Firing:        timsub  tmin
                           6.      1.0
 Tactics:                  itact   nrpt    nbump   tbump    pause
                            1       1       2      30.0       0
Firing Priorities:        recrng  tlook   nprior
                          2000.0   60.0     2
Burst Fire Inputs:        rof     nrpb
                          1.0       1
Missile System Inputs:    nipods  ntgts   trelod   pabtsm  pfterr
                            3       1      30.      0.7      1.
Decoy Inputs:             ndecoy  nfldec  tflash  rngfla
                            0       0      30.0    100.0
Potpourri:                pinpnt  pfalhd  pfalfe  if_art
                           0.1     0.00    0.00      0
Multiple Engagement:      ifmult   tmult   nmult   irldpt
                            0       00.     0       0
Artillery Prep:           mkill   fkill   mfkill  kkill
                           0.0     0.0     0.0     0.0
Artillery Oncall:         mkill   fkill   mfkill  kkill
                           0.17    0.25    0.18    0.10
Active Protection: arcdeg  probd   p(f/h)  p(f/m)  p(int) nrd
                     0.     1.0     1.0     1.0      .5   5
Active Protection: Deg. Factors  0,30,60,90,120
                          5*.5
Smoke Grenades:     ngrenades  p-pop  alphacl 1 & 2  duration
                        0        .8      2.0   5.0     60.
Communications:    ifcomm     pcomm   tcomm  tsearch
                     0         1.0     6.     34.
```

Figure II.F.4 Sample System Description File.

STATIONARYvsSTATIONARY ERRORS

| 6 ranges | 1st Round | | | | | | h/h ran | | h/lm ran | | h/sm ran | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * | fixed | | variable | | ran err | | | | | | | |
| *rg(m) | H | V | H | V | H | V | H | V | H | V | H | V |
| 500 | .00 | .00 | .382 | .381 | .707 | .707 | .798 | .797 | .878 | .877 | .00 | .00 |
| 1000 | .00 | .00 | .376 | .380 | .435 | .435 | .559 | .562 | .685 | .689 | .00 | .00 |
| 1500 | .00 | .00 | .374 | .382 | .356 | .356 | .480 | .485 | .619 | .625 | .00 | .00 |
| 2000 | .00 | .00 | .377 | .384 | .322 | .322 | .439 | .443 | .581 | .588 | .00 | .00 |
| 2500 | .00 | .00 | .385 | .387 | .304 | .304 | .414 | .416 | .561 | .563 | .00 | .00 |
| 3000 | .00 | .00 | .395 | .390 | .293 | .293 | .400 | .396 | .550 | .546 | .00 | .00 |

STATIONARYvsMOVING ERRORS

| 6 ranges | | fixed bias | | total error | |
|---|---|---|---|---|---|
| * 0 deg | | | | | |
| * | rg (m) | H | V | H | V |
| | 500 | -.171 | .000 | .520 | .522 |
| | 1000 | -.348 | .000 | .516 | .520 |
| | 1500 | -.529 | .000 | .515 | .522 |
| | 2000 | -.715 | .000 | .517 | .523 |
| | 2500 | -.904 | .000 | .523 | .525 |
| | 3000 | -1.096 | .000 | .530 | .528 |
| *30 deg | | | | | |
| | 500 | -.151 | .000 | .528 | .522 |
| | 1000 | -.312 | .000 | .524 | .521 |
| | 1500 | -.484 | .000 | .523 | .522 |
| | 2000 | -.665 | .000 | .525 | .523 |
| | 2500 | -.857 | .000 | .531 | .525 |
| | 3000 | -1.058 | .000 | .539 | .522 |
| *60 deg | | | | | |
| | 500 | -.901 | .000 | .545 | .522 |
| | 1000 | -.193 | .000 | .540 | .521 |
| | 1500 | -.309 | .000 | .539 | .522 |
| | 2000 | -.437 | .000 | .541 | .523 |
| | 2500 | -.580 | .000 | .547 | .525 |
| | 3000 | -.737 | .000 | .555 | .528 |
| *90 deg | | | | | |
| | 500 | -.005 | .000 | .554 | .404 |
| | 1000 | -.022 | .000 | .549 | .521 |
| | 1500 | -.051 | .000 | .547 | .522 |
| | 2000 | -.093 | .000 | .549 | .523 |
| | 2500 | -.148 | .000 | .555 | .525 |
| | 3000 | -.218 | .000 | .563 | .528 |

MOVINGvsSTATIONARY ERRORS

| 6 ranges | | fixed bias | | total error | |
|---|---|---|---|---|---|
| * | rg (m) | H | V | H | V |
| | 500 | .000 | .000 | .926 | .951 |
| | 1000 | .000 | .000 | .736 | .771 |
| | 1500 | .000 | .000 | .692 | .730 |
| | 2000 | .000 | .000 | .676 | .715 |
| | 2500 | .000 | .000 | .672 | .708 |
| | 3000 | .000 | .000 | .674 | .706 |

Figure II.F.5 Sample Accuracy File.

```
0.90 0.30 0.20 0.15 0.15 0.10 0.08 0.05 0.00     *HD mkill
0.70 0.20 0.15 0.12 0.10 0.08 0.05 0.01 0.00     *HD fkill
0.30 0.25 0.20 0.15 0.10 0.08 0.05 0.01 0.00     *HD mfkill
0.20 0.18 0.12 0.09 0.06 0.00 0.00 0.00 0.00     *HD kkill
0.82 0.25 0.19 0.14 0.14 0.09 0.05 0.01 0.00     *FE mkill
0.68 0.19 0.15 0.12 0.10 0.08 0.05 0.00 0.00     *FE fkill
0.28 0.22 0.18 0.13 0.07 0.05 0.01 0.00 0.00     *FE mfkill
0.15 0.14 0.11 0.07 0.04 0.02 0.01 0.01 0.00     *FE kkill
```

Figure II.F.6 Sample PKS File (Lethality Flag = 0).

```
0.90 0.70 0.30 0.20    *HD    0 meters
0.30 0.20 0.25 0.18    *HD  500 meters
0.20 0.15 0.20 0.12    *HD 1000 meters
0.15 0.12 0.15 0.09    *HD 1500 meters
0.15 0.10 0.10 0.06    *HD 2000 meters
0.10 0.08 0.08 0.00    *HD 2500 meters
0.08 0.05 0.05 0.00    *HD 3000 meters
0.05 0.01 0.01 0.00    *HD 3500 meters
0.00 0.00 0.00 0.00    *HD 4000 meters
0.82 0.68 0.28 0.15    *FE    0 meters
0.25 0.19 0.22 0.14    *FE  500 meters
0.19 0.15 0.18 0.11    *FE 1000 meters
0.14 0.12 0.13 0.07    *FE 1500 meters
0.14 0.10 0.07 0.04    *FE 2000 meters
0.09 0.08 0.05 0.02    *FE 2500 meters
0.05 0.05 0.01 0.01    *FE 3000 meters
0.01 0.00 0.00 0.01    *FE 3500 meters
0.00 0.00 0.00 0.00    *FE 4000 meters
```

Figure II.F.7 Sample PKS File (Lethality Flag = 2).

```
* Optical Sensor
* Wide Field of View
VISUAL
TWENTY
0.010 0.016 0.020 0.024 0.027 0.034 0.039 0.046 0.061
      0.075 0.109 0.129 0.174 0.221 0.270 0.300 0.400
      0.500 0.600 1.000
0.000 0.175 0.275 0.375 0.475 0.575 0.675 0.775 0.875
      0.975 1.075 1.175 1.275 1.375 1.475 1.575 1.675
      1.775 1.875 2.147
6.5   *HFOV
6.5   *VFOV
30.0  *HFOS
10.0  *VFOS
10.0  *MAG
1.0   *DETECT
7.0  0.59  *VISIBILITY RANGE   ATMOSPHERIC ATTENUATION
3*0.0 *ALPHA CL FOR INTERMEDIATE SMOKE BANDS
* Platform Description      HD        FE
                            0.2       0.4    *Optical Con.
                            1.5       2.0    *Thermal Con.
                            0.8       2.3    *Target Height
                            1.0       1.0    *Radar Section
```

Figure II.F.8 Sample of an Optical Acquisition File.

```
* Generic Radar file
* Wide Search Characteristics
RADAR
1      ** Rain
4      ** High Clutter
3*0.0     ** no smoke in this battle
**  BLUE PLATFORM DESCRIPTION      HD        FE
                                   0.2       0.4
                                   1.5       2.0
                                   0.8       2.3
                                   2.3       0.9
```

Figure II.F.9 Sample of a Radar Acquisition File.

# III. MODEL OUTPUT

## III.A Standard Output

Following is the standard output of the Groundwars Model. It includes all of the primary measures of effectiveness, and the initial conditions. The initial conditions include the scenario played, the terrain statistics which were used and the attack angle distribution. It also shows the atmospheric conditions on the battlefield including the visibility range and if any smoke was deployed. It then shows the number of replications that were simulated, the initial battle range, and the final range for battle. It then shows a limited breakdown of the capabilities of the two armies. It shows the numbers of combatants, the sensor type, and the round type for each side. If decoys were played in the simulation, they are also shown at this point.

After the initial conditions are stated, the results of the battle are output. The first section of the results shows general averages and gives a concise overview of the battle. The second section gives a detailed breakdown of the battle. It gives an analysis of first and all shots for each side. It then gives a table of shots broken into wasted shots, hits, misses,shots which resulted in each type of kill, etc. This can be used to look at probabilities of hit and kill, the effects of terrain, the effects of false targets, and more. After this table there is an ammunition report which shows the number of vehicles which are either low or out of ammunition; it gives a report of the average status of the combatants for each side (i.e., after a battle 20 percent were alive, 10 percent were mobility killed, etc. ). A section on terrain analysis is given which shows the average length of time a system has to detect,and engage a target. The next section shows the reasons for battles ending. A battle ends for one of three reasons, all vehicles are dead on one side, all vehicles are out of ammunition on one side, or the end game criteria was met. The final section of this standard output is the statistical analysis which shows the bounds of the results. The results have a 95 percent confidence level.

```
================================================================
                    GROUNDWARS  4.20
================================================================

    INITIAL CONDITIONS:

                    Scenario:  Red Attack
                    Terrain:  Hunfeld (2 meter elevation)
                    Attack Distribution:  Cardioid

                    Atmospheric Conditions:
                       7.  km. visibility
                       homogeneous alpha*cl
                       no bi-spectral smoke played

                    Pinpoint Restrictions:  None

                    Replications:  300
                    Starting range:  4000 meters
                    End range:        100 meters

                        Blue Army              Red Army
                        ---------              ---------
    Number of Systems:     5                      15
    Weapon Type:        Command LOS Missile    Kinetic Energy Round
    Sensor Type:        Optical                Optical


================================================================
    RESULTS:

          1.90  exchange ratio
          5.56  surviving force ratio

       6.66  direct fire kills of red      6.93  mean mfk red dead
       3.50  direct fire kills of blue     3.50  mean mfk blue dead
       1.90  direct fire exchange ratio    1.98  mfk exchange ratio

       6.66  mean red dead            44.40 percent red dead
       3.50  mean blue dead           70.00 percent blue dead


      15.67  percent red standard wins
       0.    percent blue standard wins

       2.86  mean red rounds per firer
       6.90  mean blue rounds per firer

      12.28  mean red rounds fired per kill
       5.18  mean  blue rounds  fired per kill
```

```
      0.    percent red rounds aborted
      1.56  percent blue rounds aborted

          red    237  regular  detections   7.02 percent
          red   3140  pinpoint detections  92.98 percent
          blue  5194  regular  detections  97.34 percent
          blue   142  pinpoint detections   2.66 percent
```

**********

```
INITIAL FIRING SHOT ANALYSIS:
     army      average range       shots    minimum   maximum
     red            2898.86         300     2002.20   3100.64
     blue           3098.90         300     2168.35   3171.31

TOTAL SHOT ANALYSIS:
     army      average range       minimum   maximum
     red            2301.52         100.38   3100.64
     blue           2473.24         104.02   3171.31

SHOTS BY:             blue   red
fired                10353 12892
  wasted               161   212
    total aborted      161     0
      ter/smk abrts   1039     0
    false tgts           0     0
    hidden tgts          0   212
  in flight at endg      0     3
  impacting          10192 12677
    misses            5311  9939
    duds               385    72
    live hits         4496  2666
       no damage      1769   730
       m-kill only     255    26
       f-kill only     207   401
      mf-kill only     687   971
       k-kill         1578   538

          AMMO REPORT:                    Detections Beyond
     low   <5        depleted              Max Firing Range
   blue     red    blue     red            blue        red
    310      52     528      27            1491          0

             Average Status of Combatants (pct of total)
             -------------------------------------------
            Alive   M-dead   F-dead   M&F-dead   K-dead
 Blue Army   29.9      0.1      5.9      28.5       35.6
 Red Army    53.8      1.8      1.6       7.8       35.0
```

Terrain In-Vu Data (calculated per replication)

Average amount of in-vu time: 139.1
Average length of all in-vu segments: 109.8
Average number of in-vu segs for each def-att pair: 1.3

Number of times game ended due to:

| | BLUE | RED |
|---|---|---|
| No ammo: | 4 | 0 |
| All dead: | 47 | 0 |
| Max time: | | 249 |

The average time for a replication was 662.4 sec.

relative width statistics (95% conf)

| | mean | half length | lower bound | upper bound | reltv width | |
|---|---|---|---|---|---|---|
| blue dead | 3.50 | 0.12 | 3.38 | 3.62 | 0.03 | good |
| red dead | 6.66 | 0.31 | 6.35 | 6.97 | 0.05 | good |
| exch ratio | 1.90 | 0.24 | 1.66 | 2.14 | 0.13 | good |
| blue rnds | 6.90 | 0.18 | 6.72 | 7.08 | 0.03 | good |
| red rnds | 2.86 | 0.13 | 2.74 | 2.99 | 0.04 | good |

III.B ECHO OF MISCELLANEOUS SYSTEM INPUTS

This output should be generated at the beginning of every study so that the user can double check the inputs. This output is controlled by the second output control flag in the scenario file. If this flag is set to a 2, this entire output is generated. If the flag is set to a 1, everything except for the probabilities of kill is printed.

```
**********blue system description**********

system dimensions                    motion characteristics
distance (m) from center of          acceleration  1.00 m/s**2
turret ring to:                      deceleration  2.00 m/s**2
turret top    0.80  ground     1.60
turret side   1.70  hull side  1.80
turret front  2.30  hull front 3.60
turret back   2.30  hull back  3.60


Average Time (seconds) for system to:
-------------------------------------
    break LOS before jockeying or reloading    :  90.0
    leave the battlefield when out of ammo     :  30.0
    leave the battlefield when firepower killed: 130.0

                                  ------firing cycle----
   rng    psense   reliability    tfirst    tfixed    tfly
   (m)                            (sec)     (sec)     (sec)
   500     0.         0.99         9.00      0.        0.30
  1000     0.         0.99        11.00      0.        0.70
  1500     0.         0.99        12.00      0.        1.00
  2000     0.         0.99        14.00      0.        1.30
  2500     0.         0.99        15.00      0.        1.70
  3000     0.         0.99        17.00      0.        2.00

switch targets after:
1. a k-kill (& don't re-engage)
2. an m&f-kill and 2 hits or 30.0 sec. (& don't re-engage)
systems can handle 1 targets simultaneously.
selects new targets before old, hit targets.
system pauses in defilade when engaging and attacking rather than breaking LOS
system ammo load is 10 wait-til-impact missiles
system holds  5 rounds in pod; reloads entire pod in 10.0 secs.
system fires on the move.
system maximum firing range = 3200. meters
median time between rounds is  6.00 sec.
minimum time to fire next round is  1.00 sec.
probability of firing signature detection is  0.10
recognizes targets inside   2000. meters.
probability of picking false hd, fe tgts are 0.    0.


**********red system description**********
```

system dimensions
distance (m) from center of
turret ring to:

| | | | |
|---|---|---|---|
| turret top | 0.80 | ground | 1.60 |
| turret side | 1.70 | hull side | 1.80 |
| turret front | 2.30 | hull front | 3.60 |
| turret back | 2.30 | hull back | 3.60 |

motion characteristics
acceleration 1.00 m/s**2
deceleration 2.00 m/s**2

Average Time (seconds) for system to:

break LOS before jockeying or reloading : 30.0
leave the battlefield when out of ammo : 30.0
leave the battlefield when firepower killed: 130.0

| rng (m) | psense | reliability | ------firing cycle---- tfirst (sec) | tfixed (sec) | tfly (sec) |
|---|---|---|---|---|---|
| 500 | 0. | 0.99 | 9.00 | 0. | 0.30 |
| 1000 | 0. | 0.99 | 11.00 | 0. | 0.70 |
| 1500 | 0. | 0.99 | 12.00 | 0. | 1.00 |
| 2000 | 0. | 0.99 | 14.00 | 0. | 1.30 |
| 2500 | 0. | 0.99 | 15.00 | 0. | 1.70 |
| 3000 | 0. | 0.99 | 17.00 | 0. | 2.00 |

switch targets after:
1. a k-kill (& don't re-engage)
2. an m&f-kill and 2 hits or 30.0 sec. (& don't re-engage)
systems can handle 0 targets simultaneously.
selects new targets before old, hit targets.
system does not jockey during the engagement process
system pauses in defilade when engaging and attacking rather than breaking LOS
system ammo load is 20 ke rounds
system fires on the move.
system maximum firing range = 3200. meters
median time between rounds is 6.00 sec.
minimum time to fire next round is 1.00 sec.
probability of firing signature detection is 0.10
recognizes targets inside 2000. meters.
probability of picking false hd, fe tgts are 0. 0.

Blue Probability of Kill against Red
proj code= 0 tgt code= 0

hull defilade

| rg (m) | sample m | sample f | head-on m\|f | kill k | probabilities monly | probabilities fonly | probabilities m&f | disp (ft) |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.588 | 0.716 | 0.716 | 0.312 | 0. | 0.128 | 0.276 | 1 |
| 500 | 0.586 | 0.715 | 0.715 | 0.311 | 0. | 0.129 | 0.275 | 1 |
| 1000 | 0.469 | 0.542 | 0.542 | 0.255 | 0. | 0.073 | 0.214 | 2 |
| 1500 | 0.371 | 0.426 | 0.426 | 0.199 | 0. | 0.055 | 0.172 | 3 |
| 2000 | 0.315 | 0.363 | 0.363 | 0.167 | 0. | 0.048 | 0.148 | 4 |
| 2500 | 0.263 | 0.300 | 0.300 | 0.140 | 0. | 0.037 | 0.123 | 5 |
| 3000 | 0.247 | 0.277 | 0.277 | 0.129 | 0. | 0.030 | 0.118 | 6 |

fully exposed

| rg (m) | sample m | sample f | head-on m\|f | kill k | probabilities monly | probabilities fonly | probabilities m&f | disp (ft) |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.754 | 0.797 | 0.806 | 0.508 | 0.009 | 0.052 | 0.237 | 1 |
| 500 | 0.736 | 0.779 | 0.787 | 0.498 | 0.008 | 0.051 | 0.230 | 1 |
| 1000 | 0.605 | 0.624 | 0.643 | 0.412 | 0.019 | 0.038 | 0.174 | 2 |
| 1500 | 0.487 | 0.481 | 0.516 | 0.318 | 0.035 | 0.029 | 0.134 | 3 |
| 2000 | 0.416 | 0.397 | 0.440 | 0.261 | 0.043 | 0.024 | 0.112 | 4 |
| 2500 | 0.375 | 0.347 | 0.394 | 0.232 | 0.047 | 0.019 | 0.096 | 5 |
| 3000 | 0.352 | 0.317 | 0.368 | 0.213 | 0.051 | 0.016 | 0.088 | 6 |

Red's Pk against Blue
proj code= 0 tgt code= 0

hull defilade

| rg (m) | sample m | sample f | head-on m\|f | kill k | probabilities monly | probabilities fonly | probabilities m&f | disp (ft) |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.639 | 0.898 | 0.898 | 0.336 | 0. | 0.259 | 0.303 | 1 |
| 500 | 0.636 | 0.898 | 0.898 | 0.323 | 0. | 0.262 | 0.313 | 1 |
| 1000 | 0.599 | 0.739 | 0.739 | 0.310 | 0. | 0.140 | 0.289 | 2 |
| 1500 | 0.530 | 0.649 | 0.649 | 0.244 | 0. | 0.119 | 0.286 | 3 |
| 2000 | 0.496 | 0.608 | 0.608 | 0.200 | 0. | 0.112 | 0.296 | 4 |
| 2500 | 0.468 | 0.580 | 0.580 | 0.159 | 0. | 0.112 | 0.309 | 5 |
| 3000 | 0.438 | 0.549 | 0.549 | 0.123 | 0. | 0.111 | 0.315 | 6 |

fully exposed

| rg (m) | sample m | sample f | head-on m\|f | kill k | probabilities monly | probabilities fonly | probabilities m&f | disp (ft) |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.837 | 0.855 | 0.904 | 0.051 | 0.049 | 0.067 | 0.737 | 1 |
| 500 | 0.832 | 0.855 | 0.901 | 0.047 | 0.046 | 0.069 | 0.739 | 1 |
| 1000 | 0.718 | 0.765 | 0.802 | 0.122 | 0.037 | 0.084 | 0.559 | 2 |
| 1500 | 0.604 | 0.637 | 0.679 | 0.115 | 0.042 | 0.075 | 0.447 | 3 |
| 2000 | 0.540 | 0.566 | 0.609 | 0.099 | 0.043 | 0.069 | 0.398 | 4 |
| 2500 | 0.499 | 0.523 | 0.566 | 0.081 | 0.043 | 0.067 | 0.375 | 5 |
| 3000 | 0.469 | 0.491 | 0.534 | 0.066 | 0.043 | 0.065 | 0.360 | 6 |

III.C ACQUISITION OUTPUT

The model will generate estimates of the acquisition capability of the sensors being played. When output control flag 3 is set to a 1, the model displays the type of sensor, the number of fields of view in the search area, the height of the target, and the associated contrast of the target.The output is the probability of detecting given infinite time(p-infinity) and the average time to detect (tbar). If smoke is to be played in the battle,the acquisition is estimated for all three levels of smoke.

========== Blue acquisition estimates ==========

Blue uses a visual acquisition device.
There are 9.2 fields of view in the search area.
The height of the target is 2.3 meters, and its visual contrast is 0.4

alphacl= 0.

| range | P-infinity | Tbar |
|---|---|---|
| 0. | 1.000 | 0.01 |
| 500. | 1.000 | 0.87 |
| 1000. | 1.000 | 1.98 |
| 1500. | 1.000 | 3.26 |
| 2000. | 1.000 | 4.77 |
| 2500. | 1.000 | 6.67 |
| 3000. | 1.000 | 8.84 |
| 3500. | 1.000 | 11.84 |
| 4000. | 0.999 | 16.79 |

========== Red acquisition estimates ==========

Red uses a visual acquisition device.
There are 6.7 fields of view in the search area.
The height of the target is 0.8 meters, and its visual contrast is 0.0

alphacl= 0.

| range | P-infinity | Tbar |
|---|---|---|
| 0. | 1.000 | 0.00 |
| 500. | 0.857 | 26.46 |
| 1000. | 0.008 | 3015.18 |
| 1500. | 0. | 9999.99 |
| 2000. | 0. | 9999.99 |
| 2500. | 0. | 9999.99 |
| 3000. | 0. | 9999.99 |
| 3500. | 0. | 9999.99 |
| 4000. | 0. | 9999.99 |

III.D MEASURES OF EFFECTIVENESS BY RANGE OR TIME

The default for this output is for it to be printed. Unless the user sets output control flag 6 to a 1, this section will be output. This section of output is helpful when a more detailed analysis is needed. It gives detections, shots, kills, and aborts as a function of range. Aside from the raw numbers, there are listings of the number of detections and shots per remaining vehicle per replication, and the average range for detections, kills, and aborts.

BLUE DETECTIONS BY RANGE

| range interval | Regular Dets dets | cumul dets | pct. | dets/ vehicle | Pinpoint Dets dets | cumul dets | pct. | dets/ vehicle |
|---|---|---|---|---|---|---|---|---|
| 4000 - 3500 | 1099 | 1100 | 21.2 | 0.73 | 0 | 0 | 0. | 0. |
| 3500 - 3000 | 749 | 1849 | 14.4 | 0.50 | 4 | 4 | 2.8 | 0.00 |
| 3000 - 2500 | 1260 | 3109 | 24.3 | 0.84 | 54 | 58 | 38.0 | 0.04 |
| 2500 - 2000 | 956 | 4065 | 18.4 | 0.84 | 49 | 107 | 34.5 | 0.04 |
| 2000 - 1500 | 547 | 4612 | 10.5 | 0.66 | 20 | 127 | 14.1 | 0.02 |
| 1500 - 1000 | 364 | 4976 | 7.0 | 0.54 | 11 | 138 | 7.7 | 0.02 |
| 1000 - 500 | 150 | 5126 | 2.9 | 0.26 | 3 | 141 | 2.1 | 0.01 |
| 500 - 0 | 68 | 5194 | 1.3 | 0.13 | 1 | 142 | 0.7 | 0.00 |

The average range of blue regular detections was 2659. meters.
The average range of blue pinpoint detections was 2277. meters.

RED DETECTIONS BY RANGE

| range interval | Regular Dets dets | cumul dets | pct. | dets/ vehicle | Pinpoint Dets dets | cumul dets | pct. | dets/ vehicle |
|---|---|---|---|---|---|---|---|---|
| 4000 - 3500 | 0 | 0 | 0. | 0. | 0 | 0 | 0. | 0. |
| 3500 - 3000 | 0 | 0 | 0. | 0. | 412 | 412 | 13.1 | 0.09 |
| 3000 - 2500 | 0 | 0 | 0. | 0. | 1344 | 1756 | 42.8 | 0.30 |
| 2500 - 2000 | 0 | 0 | 0. | 0. | 795 | 2551 | 25.3 | 0.21 |
| 2000 - 1500 | 0 | 0 | 0. | 0. | 330 | 2881 | 10.5 | 0.10 |
| 1500 - 1000 | 0 | 0 | 0. | 0. | 179 | 3060 | 5.7 | 0.06 |
| 1000 - 500 | 41 | 41 | 17.3 | 0.02 | 68 | 3128 | 2.2 | 0.03 |
| 500 - 0 | 196 | 237 | 82.7 | 0.08 | 12 | 3140 | 0.4 | 0.00 |

The average range of red regular detections was 341. meters.
The average range of red pinpoint detections was 2453. meters.

SHOTS FIRED BY RANGE

| range interval | Blue Shots on Red shots | pct. | cumul pct. | shots/ vehicle | Red Shots on Blue shots | pct. | cumul pct. | shots/ vehic |
|---|---|---|---|---|---|---|---|---|
| 3500 - 3000 | 1805 | 17.4 | 17.4 | 1.20 | 433 | 3.4 | 3.4 | 0.10 |
| 3000 - 2500 | 4208 | 40.6 | 58.1 | 2.81 | 5756 | 44.6 | 48.0 | 1.29 |
| 2500 - 2000 | 2399 | 23.2 | 81.3 | 2.10 | 3656 | 28.4 | 76.4 | 0.95 |
| 2000 - 1500 | 1076 | 10.4 | 91.6 | 1.30 | 1575 | 12.2 | 88.6 | 0.48 |
| 1500 - 1000 | 574 | 5.5 | 97.2 | 0.86 | 762 | 5.9 | 94.5 | 0.26 |
| 1000 - 500 | 212 | 2.0 | 99.2 | 0.37 | 375 | 2.9 | 97.4 | 0.14 |
| 500 - 0 | 79 | 0.8 | 100.0 | 0.15 | 335 | 2.6 | 100.0 | 0.13 |

KILLS (fire-power and above) BY RANGE

| range interval | BLUE kills of RED kills | pct. | cumul kills | cumul pct. | RED kills of BLUE kills | pct. | cumul kills | cumul pct. |
|---|---|---|---|---|---|---|---|---|
| 3500 - 3000 | 24 | 1.2 | 24 | 1.2 | 4 | 0.4 | 4 | 0.4 |
| 3000 - 2500 | 614 | 30.7 | 638 | 31.9 | 355 | 33.8 | 359 | 34.2 |
| 2500 - 2000 | 583 | 29.2 | 1221 | 61.1 | 316 | 30.1 | 675 | 64.3 |
| 2000 - 1500 | 360 | 18.0 | 1581 | 79.1 | 156 | 14.9 | 831 | 79. |
| 1500 - 1000 | 246 | 12.3 | 1827 | 91.4 | 93 | 8.9 | 924 | 88.0 |
| 1000 - 500 | 124 | 6.2 | 1951 | 97.6 | 63 | 6.0 | 987 | 94.0 |
| 500 - 0 | 47 | 2.4 | 1998 | 100.0 | 63 | 6.0 | 1050 | 100.0 |

The average of all blue's kills is 2072.75
The average of all red 's kills is 2070.63

SMOKE AND TERRAIN ABORTS BY RANGE

| range interval | Blue Aborts abts | pct. | cumul abts | cumul pct. | Red Aborts abts | pct. | cumul abts | cumul pct. |
|---|---|---|---|---|---|---|---|---|
| 3500 - 3000 | 233 | 22.4 | 233 | 22.4 | 0 | 0. | 0 | 0. |
| 3000 - 2500 | 363 | 34.9 | 596 | 57.4 | 0 | 0. | 0 | 0. |
| 2500 - 2000 | 237 | 22.8 | 833 | 80.2 | 0 | 0. | 0 | 0. |
| 2000 - 1500 | 128 | 12.3 | 961 | 92.5 | 0 | 0. | 0 | 0. |
| 1500 - 1000 | 61 | 5.9 | 1022 | 98.4 | 0 | 0. | 0 | 0. |
| 1000 - 500 | 16 | 1.5 | 1038 | 99.9 | 0 | 0. | 0 | 0. |
| 500 - 0 | 1 | 0.1 | 1039 | 100.0 | 0 | 0. | 0 | 0. |

## III.E DISTRIBUTION OF SHOTS

This last section is controlled by the last output control flag. This output will be generated if the user sets the flag to a 1. The output shows the distribution of the number of times a number of shots was fired. In the standard output the average number of shots was given. In the left most column is the number of shots fired; the next column gives the number of times a vehicle fired the corresponding number of shots. The next sections give the percent of the time that number of shots was fired, graphically and as a number. For the BLUE army shown, one can see the effect of having a missile pod of five missiles which resulted in a bimodal distribution. For RED, the results show that over half of the time vehicles didn't get a chance to fire.

Distribution of Shots -- Blue Army

| Num(N) Shots Fired | Number of Times | Percent of the Time N rnds were fired 0----------25-------50-------75-------100 | Percent |
|---|---|---|---|
| 0 | 19 | | 1.3 |
| 1 | 22 | | 1.5 |
| 2 | 59 | * | 3.9 |
| 3 | 80 | ** | 5.3 |
| 4 | 127 | **** | 8.5 |
| 5 | 355 | ********** | 23.7 |
| 6 | 47 | * | 3.1 |
| 7 | 68 | ** | 4.5 |
| 8 | 103 | *** | 6.9 |
| 9 | 92 | *** | 6.1 |
| 10 | 528 | ********** | |

Distribution of Shots -- Red Army

| Num(N) Shots Fired | Number of Times | Percent of the Time N rnds were fired 0----------25-------50-------75-------100 | Percent |
|---|---|---|---|
| 0 | 2294 | ********** | 51.0 |
| 1 | 254 | ** | 5.6 |
| 2 | 264 | ** | 5.9 |
| 3 | 234 | ** | 5.2 |
| 4 | 232 | ** | 5.2 |
| 5 | 209 | ** | 4.6 |
| 6 | 208 | ** | 4.6 |
| 7 | 194 | ** | 4.3 |
| 8 | 156 | * | 3.5 |
| 9 | 99 | * | 2.2 |
| 10 | 71 | | 1.6 |

## 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 or Place of Contact |
|---|---|
| GROUNDWARS Model | Mr. Tom Ruth (AV298-2924) or<br>Mr. Michael Schmidt (AV298-7288) or<br>Mr. Barry Burns (AV298-7283) or<br>Ms. Lilly Harrington (AV298-7289) or<br>Mr. Gary Comstock (AV298-2079),<br>Combined Arms Warfare<br>Analysis Branch (CABWAB),<br>Ground Warfare Division (GWD), AMSAA |
| Vulnerability Data | Vulnerability/Lethality Div (VLD), BRL |
| Terrain Data | Mr. Danny Champion (AV258-5891),<br>TRAC, White Sands Missile Range, NM |
| Firing Cycle Times/<br>Delivery Accuracy | Mr. Jesse Brewer (AV298-3374),<br>Armored Warfare Analysis Branch or<br>Mr. Edward Walker (AV298-5356),<br>Infantry Warfare Analysis Branch, GWD, AMSAA |
| Target Acquisition | Mr. Richard Mezan (AV298-2274) or<br>Mr. Jeff Matthews (AV298-7287) or<br>CABWAB, GWD, AMSAA |
| Tactics | Mr. Arthur Garrett (AV298-3175), GWD, AMSAA |

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| United States Army Materiel Systems Analysis Activity — AMSAA | *TYPE OF REPORT:* Technical<br>*REPORT NUMBER:* 514<br>*REPORT DATE:* December 1991 | U.S. ARMY MATERIEL COMMAND |

TITLE: GROUNDWARS 4.2 Reference Guide

REASON FOR PERFORMING THIS EFFORT: Document model requirements and abilities, and to aid the user in executing the model

MAIN OBJECTIVE OF THE EFFORT: Inform the user of the input requirements for the model. This also serves as general information in regards to the strong points and limitations of the model.

SCOPE OF THE EFFORT: GROUNDWARS combat simulation. Ground to ground combat simulation of a two sided battle between homogeneous forces.

IMPACT OF THE EFFORT: Allow users from numerous government agencies and authorized contractors to execute and understand the GROUNDWARS model.

CONTRACTED ADVISORY AND ASSISTANCE SERVICES: None.

SPONSOR: U.S. Army Materiel Systems Analysis Activity

PERFORMING ORGANIZATION/POINT OF CONTACT:
U.S. Army Materiel Systems Analysis Activity / Michael Schmidt

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