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CONTRACTOR REPORT BRL-CR-638

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AD-A227 284

TANKWARS FOR THE PARAMETRIC
CONSIDERATION OF SYSTEM CONCEPTS

HARRY L. REED, JR.
BATTELLE COLUMBUS
COLUMBUS, OHIO

AUGUST 1990

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AD-A227-284

REPORT DOCUMENTATION PAGEForm Approved
OMB No. 0704-0188

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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE August 1990	3. REPORT TYPE AND DATES COVERED Final 10/87 to 02/90	
4. TITLE AND SUBTITLE TANKWARS for the Parametric Consideration of System Concepts			5. FUNDING NUMBERS PE: AH80 CR: DAAL03-86-D-0001	
6. AUTHOR(S) Harry L. Reed, Jr.				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Battelle Columbus 505 King Avenue Columbus, OH 43201			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) US Army Ballistic Research Laboratory ATTN: SLCBR-DD-T Aberdeen Proving Ground, MD 21005-5066			10. SPONSORING / MONITORING AGENCY REPORT NUMBER BRL-CR-638	
11. SUPPLEMENTARY NOTES Task was performed under a Scientific Services Agreement issued by Battelle, Research Triangle Park Office, 200 Park Drive, P.O. Box 12297, Research Triangle Park, NC 27709				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; Distribution Unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This report discusses aspects of TANKWARS relevant to the future armament concepts for armored vehicles. TANKWARS was picked as a good tool for starting this effort. TANKWARS is a Monte Carlo computer simulation of engagements between two homogeneous mechanized forces. Recommendations are made of possible modifications to TANKWARS or the need for a new model. This report should be useful as an adjunct to documentation on TANKWARS or on GROUNDWARS.				
14. SUBJECT TERMS TANKWARS, GROUNDWAR, SYSTEM ANALYSIS, TANKS, TANK GUNS			15. NUMBER OF PAGES 120	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	

NSN 7540-01-280-5500

UNCLASSIFIEDStandard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

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TANKWARS for the Parametric Consideration of System Concepts

by

Harry L. Reed, Jr.

INTRODUCTION

The core of the effort was to develop and exercise a methodology for the analysis of future armament concepts for armored vehicles to allow the assessment of the application of new technology to those weapon systems. TANKWARS was picked as a good tool for starting this effort. Thus TANKWARS was adapted and used to carry out numerous parametric studies of tank armament concepts. The data from these studies were furnished as developed to Dr. Howe.

The data developed are of little use to anyone who is not aware of the classified issues involved, and in many instances the data represent stages in the thinking about what the methodology should do and what issues should be given attention for further analysis; thus Dr. Howe decided that no useful purpose would be served in including those data in this report. Of course, the data are being used by Dr. Howe to develop his recommendations for the Army's Technical Base Program in armaments.

OBJECTIVE

This report then will discuss aspects of TANKWARS relevant to the above work, changes that were made in the TANKWARS program, ideas for the future application of TANKWARS (or possibly its successor) in further parametric analyses, and some thoughts on the development of more advanced tools for modeling. This report should be specially useful as an adjunct to documentation on TANKWARS or on GROUNDWARS.

1. TANKWARS - A Computer Simulation

TANKWARS is a Monte Carlo computer simulation of engagements between two homogeneous mechanized forces. The model simulates individual weapon systems, and the engagements include search, detection, selection, firing, impact, functional destruction, disengagement, and reengagement. Nominally it can handle up to 20 armored vehicles on each side. The computer program was written by Mr. Fred Bunn of the Ballistic Research Laboratory (BRL), Aberdeen Proving Ground, Maryland (reference 1).

GROUNDWARS is an outgrowth of the TANKWARS model and was developed by the Army Material Systems Analysis Activity (AMSAA). Some of the features of GROUNDWARS are addressed in Section 3. At the time we first discussed GROUNDWARS with AMSAA, version 3.97 was running, version 4.0 was being worked on, and a new concept using the "C" language was in the early stages of development. We have had some very useful discussions with AMSAA people (specially Barry Burns) which we have found most useful and which we hope were of some use to AMSAA.

We felt that TANKWARS provides a reasonable model that includes a level of detail about the systems under consideration, that it could allow sensible engineering conclusions, and that it represents a tactically meaningful environment for giving military significance to any such conclusions.

An important consideration was running time since the parametric analyses require the running a large numbers of cases. TANKWARS appeared to offer a reasonable balance between system detail and tactical context with practical run times. The significance of running time became even more obvious when the computer originally picked for use (a Gould 9000) proved to be too slow, and the work was moved to a Cray X/MP-48. The latest version 4.0 of GROUNDWARS appears interesting in this regard as a considerably speeded up and improved successor to TANKWARS. Initially, GROUNDWARS 3.97 appeared to be more complicated than necessary, and it was too large to fit on the Gould computer (or so the compiler kept saying). Of course, the use of the larger Cray and the recent availability of the faster version of GROUNDWARS are reason for reopening that decision.

Other advantages of TANKWARS were felt to be:

- * It is well enough written to allow change - an important consideration since new weapon concepts often require changes in employment for full realization of their potential. This is specially the case in modern fire control concepts which offer concurrent advantages in target acquisition and in command and control.
- * TANKWARS is in use in the analysis community and is the basis for AMSAA's GROUNDWARS. Transition to GROUNDWARS 4.0 should be relatively easy if that proves to be desirable. In fact, many of the subroutines are the same.
- * Mr. Bunn, the developer of TANKWARS, was easily accessible for numerous discussions on nuances of the program and changes.

One feature of TANKWARS that was not utilized in the effort described in this report was that of modeling sequential engagements and looking at resupply on one side. AMSAA also did not include this feature when they created GROUNDWARS.

As was mentioned before, the general acceptance of TANKWARS is testimony to its usefulness. But there are always needs for more. For the purposes at hand the shortcomings of TANKWARS include:

Only one type of armored vehicle (including one type of weapon and one type of ammunition) is allowed on each side. Thus a mix of weapons that might have application at different ranges in the engagement cannot be played. Neither can different systems in a cooperative arrangement such as tanks advancing with other vehicles in protective overwatch with guided missile systems.

The available scenarios only include an advance by one side or a meeting engagement in which both sides are stationary throughout the engagement. We see the need for the ability to conduct engagements between two moving (and occasionally stopping) forces.

Likewise there is a need for simulating more complicated overwatch tactics such as leapfrogging. As will be noted further on, a simple overwatch tactic has been added in which the overwatching force never moves and has the same weapon as the advancing force.

The decision process for engaging, disengaging, and reengaging also needs to be reworked. For example, the ability might be added to disengage from a low priority target if a higher priority target were to become available. At present the disengagement criteria are uniformly applied based on time, or based on rounds fired, or based on damage to the target, but are not related to the relative importance of the target. The importance of the target comes into play only in the initial selection. Faking disengagement by firing only a small/fixed number of rounds and using the subsequent target selection process to represent the search for a more important target is not an adequate surrogate. The decision to reengage the old target would not be the same as the simple decision to continue the firing sequence since the time to fire the "next" round would be the time to fire a "first" round rather than the shorter time to fire a subsequent round. When runs were made in which target information was shared among the tanks in a force, the result was often negative. This indicates that the additional information was not being used properly by the decision process associated with engagement and disengagement.

Even when done on the X/MP-48, the calculations for vast parametric arrays are somewhat slow. Most of the computing time is spent in the search and related target acquisition process which is repeated every second. The version 4.0 of GROUNDWARS treats this differently and achieves a significant speed increase.

2. Changes to TANKWARS

In talking about the changes made to TANKWARS during this effort, we often refer to the FORTRAN source program listed in Appendix A. That listing is only given to allow one to get an idea of what the program does and more importantly to show the changes that were made. Anyone who is interested in acquiring the code for use should contact Mr. Bunn at BRL for documentation.

The program as shown includes a variety of changes by the author that are often rather crude patches. No uniform attempt has been made to clean up the modified code, clear out any parts that have been rendered useless by the changes, rework the code to make the additions more efficient, and blend the changes into the fabric of the code more smoothly. Since there appears to be good reasons to move to a more advanced program, there would be no good purpose served by such an effort. Also, a very large portion of the run time is spent in the process of searching for

targets and updating the positions of the vehicles; so any small inefficiencies introduced into most of the code are not a matter of great significance.

The UNIX environment was used for the minicomputer operation and UNICOS for the operation on the Cray computer.

As cases were run, we found hiccups, bugs, and needs for changes in the program. We also developed a sense of what we should be looking at and looking for.

The parametrics considered include accuracy, lethality, acquisition (regular and pinpoint), rates of fire, time to lay the weapon, decoys, overwatch, decision algorithms, and fire control options. Questions have proliferated more rapidly than answers, and that trend will probably continue.

TANKWARS uses a number of input files. The game file and the miscellaneous file are discussed in considerable detail in reference 1:

- * the game file sets up the numbers of players, the ranges of engagement, the types of scenarios (e.g. who is defender and who is aatacker), and other data including the names of files that define the characteristics of the weapon systems being played. For the version of TANKWARS discussed in this report there are two files for each of the two armored vehicles, a misc file and a vul file.

- * the misc file for a side gives a variety of data about the vehicle on that side such as its dimensions, speed, ability to detect targets, rate of fire, etc.

- * the vul file for a side gives the probabilities of hit and of various types of kill given a shot for the weapon used by that side against the vehicle on the other side. As noted below, the original version of TANKWARS used two files here, one for accuracy and one for conditional probability of kill given a hit.

2.1 Changes for Running

For the convenience of running numerous parametric cases, a shell file approach was created for overall management of the calculation. A few game files were created each of which used the same names for the other input files - namely blue.misc, blue.vul, red.misc, and red.vul.

Then a UNIX shell file (called runtw for example) was created such as

```
cp $2 blue.misc
cp $3 blue.vul
cp $4 red.misc
cp $5 red.vul
```

```

echo Defender: $2";" $3 > $6
echo Attacker: $4";" $5 >> $6
../source/twx1 < $1 >> $6

```

This shell program was called by a command line such as:

```

runtw file1 file2 file3 file4 file5 file6

```

This command line produces what we will call a case in this report. A case is a series of runs each with the number of Monte Carlo replications specified in file1 (the game file) and each with one of the opening ranges specified in file1. The misc file, file2, describes the blue force vehicles. The blue vul file, file3, contains data on the ability of the blue vehicles to kill the red vehicles. The misc file, file4, is for red. The vul file, file5 is for red kills of blue. The file, file6, is that into which the output data are to be stored.

Finally a number of cases can be run by setting up a shell file containing a number of these command lines.

As a matter of convenience we used the blue force as the defending force and the red force as the attacking force rather than using these terms as indicators of political affiliation.

TANKWARS prints a considerable amount of detailed data about each run made at each opening range. Except for occasional diagnostics, these data were more than were needed, and vast outputs were being produced for the large number of runs. Therefore the indicated change in the subroutine NXWAVE was introduced and used to produce one line of data for each opening range in a case. As that change is shown, that output line contains:

R	Ndef	Ndefdec	Natt	Noverw	Exch	Defrds	Attrds
where							
R	= the opening range						
Ndef	= the average number of defenders (not decoys) killed						
Ndefdec	= the average number of defender decoys killed						
Natt	= the average number of advancing attackers killed						
Noverw	= the average number of overwatching attackers killed						
Exch	= the exchange ratio = $Ndef / (Natt \text{ Noverw})$						
Defrds	= the average number of rounds fired by a defender vehicle						
Attrds	= the average number of rounds fired by a defender vehicle						

Other formats could be easily tailored as needed.

2.2 Modifications for Decoys and Overwatch

We were concerned with decoys that were stationary and flashing (simulating firing). We also included the ability to have tanks on the side of the attacking force that remained at the opening range in hull defilade; these were called overwatching tanks.

The changes needed for decoys and overwatching tanks are intertwined in the code and are contained in the subroutines CANGO, DEATHS, DEPLO2, FINISH, INIT2, INPUT, and SEARCH. Decoys were already in TANKWARS, but the changes were needed to remove them from win statistics (changed to say that if all the real tanks are killed on a side, that side loses even if the decoys are alive) and to count only real tanks in the exchange ratios.

The changes in INIT2 include ordering the real and decoy tanks so that if the attacking force (called red in the program) has any decoys, the decoys will be in the overwatching role as long as there are no more decoys than there are overwatching tanks. Since we didn't have a good idea on how to treat moving decoys, we only considered stationary ones. The stationary decoys are handled much the way that tanks are handled. They acquire and "shoot" at tanks but no rounds fly to the target, and they are acquired and killed as are tanks.

The change in SEARCH allows the defender's acquisition ability to account for both hull defilade stationary overwatchers and fully exposed moving attackers. We further decided that an attack would be stopped (and thus the attacking side would lose that case if all the advancing tanks were killed regardless of whether the overwatching tanks were killed or not. A more realistic model would include the possibility for the advancing tanks and the overwatching tanks to trade places (leapfrogging).

2.3 Change to Ensure Loading of "First" Rounds

This became a problem when some of the time constants associated with laying the gun became less than the time needed to load a round. As it was written, TANKWARS accounted for the time needed to reload the gun as subsequent rounds were fired at a target. However, no such loading time was "required" from the time the last round was fired at one target until the next round was fired at another target. This was not a problem for the very first round since it was assumed that the tank would go into battle with a round in the tube. Changes were made in the subroutines ENGAGE, HALT, and INIT2. The change in INIT2 was to put in a bogus value for `tfire2` which was `tmin` seconds before the battle would begin. The variable `tfire2` is the time that the tank last fired and `tmin` is the time to reload. Thus the tank could fire if needed as early as $t = 0$.

2.4 Stop to Fire Changes

Most of the runs that have been made under this project were made with an attacker who could shoot on the move, and the attacker rarely fired from a stationary position (only when he was mobility but not fire power killed). Some excursions were made into the question of the advantages (if any) of stopping to shoot. Some changes were required in the subroutine HALT which accommodates firing when stopped. The change adds the need to load for the "first" round as mentioned above, and the change also deletes the feature that removes 3 seconds from the laying sequence (which presumably was included since the laying process might have been started

before the tank had come to a halt). However it is possible for a tank which is stopped and has just finished firing at a target to start to move and immediately find another target and halt in less than 3 seconds. This is exacerbated by the often short times we have been using for the time to lay the first rounds, and it is further complicated by the fact that we have been using times to lay the gun that are different for stationary firing and for moving firing for our baseline fire control system. It is unclear how to pro rate these two laying times during the stopping process. While not thoroughly satisfying, we decided to let the vehicle come to a halt and then use the shorter lay time associated with a stationary firer.

Note that the piece of programming

$$t_{\text{last}} = t - 3.$$

remains as a relic in the modified subroutine.

2.5 Changes for Cardioid Distribution

The original TANKWARS handled the consideration of the azimuthal orientation of hits on the vehicles by creating a distribution of attack geometries. The advancing force proceeded on a course that for each Monte Carlo replication had an orientation that was randomly chosen (usually cardioid) about the axis that joined the center of the target array and the center of the attacking force. Thus the tanks often marched in a direction that resulted in the forces never coming very close. This led to a number of indecisive replications within a sequence of Monte Carlo runs.

AMSAA does not have this feature in GROUNDWARS. The attackers advance toward the target, and they apply a random angle at the time of each impact.

TANKWARS and GROUNDWARS use two tables - a table of dispersions for different cases and ranges and a table of conditional kill probabilities for different kill criteria, dispersions, ranges, exposures, and angles of attack. The probability of hit is calculated using normal distributions for hits on the turret and chassis and then the conditional kill probabilities are multiplied by the hit probability to obtain the probabilities of kill for that instance. These kill probabilities are compared against a random number and one (or none) is selected.

We have adopted a scheme that has the attackers advancing directly toward the defenders as does GROUNDWARS; but we also do a lot of preprocessing of the data to account for the angular distribution of hits. The rationale follows:

The conditional kill tables are large, having some 6000 entries.

The hit probability calculations involve Gaussian function calculations.

We had hopes that we eventually could add more than one type of ammo for each side; so that the memory requirements would get large.

Almost all the shooting was either by stationary vehicles shooting at moving vehicles or vice versa. The issue of the difference between the probability of hit for first and for subsequent rounds in stationary fire against stationary targets was moot (this involves random bias and random dispersion).

The approach was to create a table of hit and kill probabilities (given a shot) as functions of range for:

- * the three cases of:
 - stationary shooting at stationary targets
 - stationary shooting at moving targets
 - moving shooting at stationary targets
- * two target conditions of:
 - hull defilade
 - fully exposed
- * five levels of kill
 - hit
 - mobility kill
 - fire power kill
 - mobility and firepower kill
 - catastrophic kill

This along with nine range values (0 to 4000 meters by 500 meters) gives a table with 270 entries and puts a lot of mathematical calculation outside the Monte Carlo replications. The only drawback seems to be the need to do something about the correlation of impacts for the stationary / stationary case should that become important.

The changes to accommodate this kill model are in the subroutines DAMAGE, INPUT, KILL, MAYHIT, and RDPKH. Note that the subroutines ACCERR, ACCMS, ACCSM, ACCSS, IZHIT, and RDEROR are not needed.

Most of the changes are straightforward and relate to shortening the calculation by avoiding specific efforts to calculate hit probability.

One piece of the code is worth discussing. While it is very similar to the original code, it must be understood to understand the BASIC program given below for the calculation of the vulnerability table.

It is in the subroutine KILL:

```

temp = ranu(0.0)    ranu returns a random number
IF      (temp .gt. p(1)) THEN
c no hit and no kill
    hit      = .false.
```

```

        injury = ALIVE
    ELSEIF (temp .gt. p(2)) THEN
c a hit and a "k" kill
        hit = .true.
        injury = KILL
    ELSEIF (temp .gt. p(3)) THEN
c a hit and an "m&f" kill but no "k"
        hit = .true.
        injury = MFKILL
    ELSEIF (temp .gt. p(4)) THEN
c a hit and an "f" kill but no "m" kill
        hit = .true.
        injury = FKILL
    ELSEIF (temp .gt. p(5)) THEN
c a hit and an "m" kill but no "f" kill
        hit = .true.
        injury = MKILL
    ELSE
c a hit but no kill
        hit = .true.
        injury = ALIVE
    ENDIF.

```

In this section of code the random number (temp) is located within a collection of segments in the unit interval which represent various mutually independent outcomes of the hit or miss:

p(1) is the probability of a hit; so if $1.0 > \text{temp} > p(1)$ the round missed,

p(2) is the probability of any kill less than a K (catastrophic) kill; so if $p(1) > \text{temp} > p(2)$ the round hit and achieved a K kill,

p(3) is the probability of any kill that is not both a mobility and a firepower kill; so if $p(2) > \text{temp} > p(3)$ the round hit and achieved both a mobility and a firepower kill,

p(4) is the probability of a mobility kill but not a firepower kill; so if $p(3) > \text{temp} > p(4)$ the round hit and achieved a firepower kill but not a mobility kill,

p(5) is the probability that the hit produced no kill; so if $p(4) > \text{temp} > p(5)$ the round hit but did not kill.

With some thought the reader should be able to convince himself that:

$$1.0 \geq p(1) \geq p(2) \geq p(3) \geq p(4) \geq p(5) \geq 0.0.$$

A BASIC program has been written to produce the vulnerability table from accuracy data and from the BRL vulnerability data format. This program considers the turret and the hull to be two shoeboxes. The particular code shown in Appendix B treats both boxes with the same

cardioid distribution for all cases (fully exposed, hull defilade, moving, stationary). This can be easily expanded to consider different distributions for different cases, and could be extended to different distributions for the hull and the turret for the same case. The latter would require some rework of the original vulnerability data which only treat the hull and the turret together for one aim point and the turret separately for another aim point. We would need the data for the hull and the turret separately for the one aim point associated with the fully exposed target. Such data are basically available, but probably not in the right form.

The BASIC program was written for and run on a PC. It could of course be easily written in FORTRAN or left in BASIC and run on a more capable computer if desired. The program takes about 10 minutes to run under interpreted BASIC on a Tandy 1000SX. This is no problem since it need run very infrequently.

2.6 Detection and Pinpoint Changes

Changes were made in the two types of detection addressed by TANKWARS - pinpoint detection and the detection of targets without using their firing signatures.

Here, pinpoint detection is defined as the detection of the firing of an opponents gun and the subsequent location of the firing vehicle well enough for the person detecting to be able to aim his gun effectively at the firer. Two probabilistic concepts are involved - the probability that the observer can achieve a pinpoint detection as defined above and the median time it takes him to accomplishment that pinpoint detection.

Pinpoint is handled in the subroutine PINPNT. One change was to allow the median time for the pinpoint process to be input from the appropriate misc input file. TANKWARS has this value as a fixed number and a recompilation of the program was required each time the value was changed. There is a related change in the subroutine RDMISC that gets this median time from the misc file.

We found (as have others) that pinpoint was an important capability for the attacker who is looking for otherwise often hard to find targets that are in hull defilade. One thought for improved systems was to add the capability for a tank to tell other tanks on his side that he saw a firing and give them the location of that targets. To test this idea, we added a change to the subroutine PINPNT that allowed the other tanks to locate the target at the same time that the observer saw it. So far we have been working with this optimistic version of the idea. This could be easily changed in the PINPNT subroutine by adding additional time to the time used to schedule the XFER event; the others would then locate the target later than the original observer.

XFER is the subroutine that has been added to accomplish this transfer.

The misc file contains an additional logical value that is read in the subroutine RDMISC and used to set the value of the variable xxfer which is used as a flag to call or not call transfer in PINPNT.

The other type of detection is what one gets with looking for the targets with binoculars, IR devices, etc. without the aid of a firing signature.

Since the transfer of pinpoint seemed to be a help in some instances and since VHSIC seem to offer considerable possibilities for fire control improvement, we considered the possibility that any target that is detected could be made available to everyone on the side of the observer.

This was accomplished simply enough by adding a change to the subroutine DETECT that is similar to that added to PINPNT. In the version of the program in Appendix A, the variable xxfer either initiates the transfer of both types of detection or inhibits the transfer of any detections.

As alluded to above in Section 1, the availability of all these targets did not produce the Nirvana anticipated. Transfer of pinpoint detections in situations with low pinpoint ability seems desirable, but the gross exchange sometimes seems to produce problems and sometimes seems to help. Also as mentioned above, the prioritization of targets and the ability to keep one target from saturating the attention of the force need much further consideration.

Issues such as, the prioritization of targets, the disengagement algorithms, the ability to transfer targets to vehicles that can't see the targets at that time, and the ability of a moving vehicle to remember stationary targets when the moving vehicle loses line of sight contact all need further consideration. The few limited results we've gotten in this regard have not been satisfactory in the sense of providing understanding. A good bit more work is still needed.

2.7 Changed Handling of Shared Targets

TANKWARS has an option that keeps a tank from firing at a target if another tank is already firing at that target. To accomplish this option, one sets a variable called share() to true to prohibit firing at the same target. We felt that it was extreme to prohibit such firing, but that is was still desirable to be able to limit it. A change was added to the subroutine PRIORN so that if share() = true, the priorities are adjusted so that a target being attacked has a lower priority than anyone not being attacked. The targets being attacked are ordered in the same way among themselves as are the targets not being attacked. Again the results of using this option have been mixed, and more thought about the prioritization scheme is indicated.

2.8 Busy Bug

There is a bug in TANKWARS in the subroutine VANTER that

handles the vanishing of vehicles in terrain. If the tank has made the decision to engage a target and then schedules a firing, it has set a flag `busy() = true`. When the scheduled firing routine is reached, the busy flag is set to false, and a firing-on-target flag is set. If the firing tank loses line of sight by vanishing in terrain before the scheduled firing, VANTER cancels the firing but does not reset the busy flag to false. Since the firing that would have reset the flag has been canceled, the busy flag is never reset during the engagement, and the tank can no longer select any targets after it reappears. We added a fix that sets busy to false in VANTER. This resulted in a sizable improvement in the general performance of the attacking force. The defender has little occasion to use VANTER.

2.9 Know Bug

There is another bug in version 2 of TANKWARS which seems to be caught in version 2a. The variable `know()` is used in the subroutine PRIORT to distinguish between a target that has been hit and one that has been missed. However, the value `know() = 1` was not set in the subroutine MAYHIT if the target was missed (`know() = 2` was set if the target was hit). We added a correction for this in MAYHIT.

3. Possible Advantages of GROUNDWARS

GROUNDWARS is more actively maintained and is among other things a newer version of TANKWARS. It also has some additional features including the availability of a very large output option for detailed data on the combat that might be useful for some diagnostics, the ability to handle subgroups of attacking vehicles, the inclusion of the effects of artillery fire, an improved smoke model, and most of all an improved acquisition model which is claimed to produce a factor of six or seven improvement in runtime. This acquisition model replaces the step-by-step model in TANKWARS with a model that predicts when the detections will occur if at all. Note that this is not a different physical model but rather a different mathematical formulation of the solution.

On the other hand, as with TANKWARS, GROUNDWARS also needs an ability to handle leapfrogging, an ability to handle moving meeting engagements, the ability to handle multiple weapon types, and some rework of the assignment of priorities for engagement and disengagement. Also Dr. Howe wishes to look at the synergistic effects among multiple hits on a target which will require a new vulnerability model for either TANKWARS or GROUNDWARS.

4. What Next

The next major step that is planned is to develop a more complete model which can handle combined arms in essentially the same detail as TANKWARS or GROUNDWARS and address the additional issues mentioned above. This could be a natural (but very large) step forward from developing the ability to have more than one armored weapon system on each side, the ability to do leapfrogging, and the ability for handling more dynamic meeting engagements.

While there is that longer term goal, there is also a shorter term set of questions to which Dr. Howe needs answers which include:

- * The ability to model advanced C3 concepts including the ability to remember targets, the ability to transfer targets, and a rework of the assignment of priorities for engagement and disengagement.
- * A new vulnerability model that can account for possible synergistic effects among impacts on the target.
- * The ability to handle a meeting engagement between two forces that are moving.
- * The ability to have more than one weapon systems on each side. In particular, the ability to have both missiles and guns on each side.

There are two interesting approaches to the longer term goal:

- (1). to start from scratch and build a model using the "C" programming language and particularly using "structures" to represent the fundamental elements (weapon systems, vehicles, etc.)
- (2). to build on existing code (here it would seem desirable to use GROUNDWARS, specially in view of the new version 4.0, it's state of maintenance, and it's acceptance by AMSAA.). Note here that this would most certainly require major surgery.

CONCLUSIONS

It's interesting that both AMSAA people and the author arrived at the conclusion that structures were particularly appropriate in this application. AMSAA is presently developing yet a newer combat model using "C". In terms of the final (if one could say that there ever is a final version of such a code) code, the use of structures would be the more powerful approach and would be more amenable to the modifications that are always required to consider new weapon and tactical concepts. The difficulty, of course, with such an approach is that there will be little short term benefit of such an effort. And the questions to which the above changes could produce answers would have to wait.

The second approach has the advantage that the things to be added to the code could produce useful results as they are added. However, where major surgery is necessary this will not be so likely. On the other hand, the use of FORTRAN and the basic architecture of GROUNDWARS which relies on numerous globally declared arrays could make generalization of the code very difficult and could make the resulting code very opaque and very awkward to adapt to changing concepts.

It is the author's opinion that the first approach is the proper one. At the same time it may be possible to provide some short term ability without too much difficulty by adding a new prioritization scheme and a more

complete vulnerability model to existing code. The exercise of particularly the prioritization scheme might be valuable in the development of a new code by providing a mechanism for discussing tactics with the User with a view toward a better representation of tactics in the new code.

Certainly even if the first approach is taken, TANKWARS and GROUNDWARS will be valuable sources of ideas.

REFERENCES

1. Fred Bunn, Unpublished paper on TANKWARS, if anyone is interested in TANKWARS, he should contact Mr. Bunn at the Ballistic Research Laboratory (301-278-6676).
2. Michael C. Schmidt, Gary R. Comstock, Lilly D. Harrington, Barry J. Burns, "GROUNDWARS 4.0 User's Guide", AMSAA Technical Report, October 1989

APPENDIX A
TANKWARS PROGRAM

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Appendix A
TANKWARS Program

```

c VXi%
c      common.h file
c      -----
c      common block declarations for Extended Combat Simulation (TankWars II)

      implicit integer(i-n), real(a-h,o-z)

      parameter (NN=20)
      character*4 color
      character*1 kview
      integer ALL, NULL, FLS TGT
      integer FD, HD, FE
      integer TURRET, HULL
      integer BLU, RED
      integer MEETING, RATTAK, BATTAK
      integer ALIVE, MKILL, FKILL, MFKILL, IKILL, KILL
      integer SLOWNG, STATNY, ACCELG, MAXVL
      integer scene, tactic, prevrd, army
      logical cansee, fot, mot, kncels
      logical busy, empty, foes, los, seen, serchg, repeat
c      Change by HLReed
      logical istest, share, xxfer, memory
      real INFINT
c      Change introduced by H.L.Reed on 8 Mar 89 to allow overwatch
c      tanks to be added to the attacking force. See also changes in
c      subroutines cango, deplo2, init2, and input.
      logical inwatch
c
      common /aspekt/ angles(15), pangle(15), iangd
      common /charc / color(2), kview(2)
      common /consts/ PI, TWOPI, DEG, VNORTH(3)
      common /const2/ ALL, NULL, FLS TGT,
1      FD, HD, FE, TURRET, HULL, BLU, RED, MEETING, RATTAK,
2      BATTAK, ALIVE, MKILL, FKILL, MFKILL, IKILL, KILL,
3      SLOWNG, STATNY, ACCELG, MAXVL, INFINT
      common /contrl/ nreps, keyd(20), keym(20), scene, tmax, meth sm
      common /cpath / nmaxt(2), accel(2), decel(2), ishtfs(2),
1      speed(2), angle(2), accmax(2), wvith(2), ampl(2)
      common /cranda/ iranda, jranda
      common /cshot/ kshot(2,20)
      common /ctrace/ trace
      logical trace
      common /endgam/ sysdim(2,8), nang, ndisp
c      common /errors/ sargs(2,10), smargs(2,10), velms(2,20),
c      1      sserrs(2,10), smerrs(2,10), addons(2,2,20), nadds(2)
      common /error2/ rex, rey, reliab(2)
c      Change by HL Reed to allow transfer added xxfer. Also added the
c      variables which follow xxfer but are not being used at this time.
      common /fcycle/ nrds(2), nrpt(2), nipods(2), nrpb(2), tactic(2),
1      tof(2,8), trelod(2), tfirst(2,8), tmedin(2), tfixed(2,8),
2      rof(2), kind rd(2), tbump(2), nbump(2), thide(2), tain(2),
3      nprior(2), nchans(2), share(2), xxfer(2), memory(2),
4      tpop1(2), tpop2(2), tpop3(2), nstatn, nmove, rstatn,
5      rmove, ttotat, nstatf, nmovef, rstatf, rmovef
      common /n sys/ ntanks(4,8), nblu, nred
c      Change by HLReed added pntime for median pinpoint time
      common /sensor/ psense(2,8), pinfin(2,3,10), tbar(2,3,10),
1      ndets(2), tlook(2), pinp(2), repeat, recknz(2), pfalse(2,2),
2      pntime(2)
      common /states/ army(NN), aspect(NN,2), cansee(NN),
1      busy(NN), empty(NN), fot(NN,NN), foes(NN,NN), ichg(NN),
2      kncel(NN), kncels(NN,NN), know(NN,NN),
2      life(NN), los(NN,NN), mot(NN,NN), motion(NN), msfly(2,NN,5),
3      nhot(NN), nbrst(NN), ndet(NN), nrd(NN), nrrib(NN), nipod(NN),
4      nrot(NN), nrtgt(NN), nchan(NN), prevrd(NN), rgvis(3,NN),
5      seen(NN,NN), serchg(NN), tfire(NN,NN), tfire2(NN), vbx(NN),
6      vby(NN), t0(NN), x0(NN), y0(NN), vx0(NN), vy0(NN),
7      xp(NN), tlast(NN)
      common /state2/ idecoy(NN), iflash(NN), ndecoy(2), nflash(2)

```

```

c      Change for output HLReed
common /stats/ statb(8), mystat(4)
common /tstore/ a(1000), iholy
common /vars8/ irginc, rgincr, rginc2
common /csmoke/ tsmoke(20),psmoke(20,3), invisb
common /smoke1/ toutil(21,5),toutv1(21,5),touti(21,5),
1      toutv(21,5),tini(21,5),tinv(21,5),ptbi(21),rtbi(5)
common /v16a/ krep
common /v17a/ istest
common /v23/ nwave, nwaves, nsurv, neval, nused(3000), nreps3,
1      statc(8), noammo, loammo, noammo2, loammo2
common /v24/ nstats(5,2)
common /where/ min rg, max rg, inc rg
common /where2/ nrg, rg0, rg, s(3), vt(3), vf(3)
common /fitnes/ quit(2,2), alloc(2,6), fit(NN,6)
c      Change introduced by H.L.Reed on 8 Mar 89 for overwatch
common /ovrwtch/ nwatch(3),inwatch(NN)

c V7.2
c      MAIN ROUTINE
c 9      Main: read input and simulate scenarios.
include 'common.h'
1      format (' The Sustained Combat Model: Tank Wars II.',/,
1      ' Written by Fred Bunn (ph (301) 278-6648, autovon 298-6648)',/,
2      ' Ballistic Research Laboratory, Aberdeen Proving Ground, MD',/,
3      ' Version 7.2 Created 10/24/88.',/)

c
      call input
      DO 20 scene=1,3
      call forces
20      CONTINUE
      END

c V7.1

```

```

SUBROUTINE ABORT (t,firer,tgt)
c 6  Abort: abort msl from firer to tgt (to all tgts if tgt=0)
      include 'common.h'
      logical defndr
      integer arrayf, arrayt, firer, tgt
1      format(f8.2,1x,a4,i3,' msl for ',a4,i3,' aborted.')
2      format ('ABORT: firer,tgt,i,mslfly=',4i3)
3      format ('ABORT: msl approaching tgt',i3)
c
      if (trace) print *, '>abort'
      arrayf = array(firer)
      arrayt = 3-arrayf
      DO 20 i=1,5
c      Check all 5 missile pointers for this firer
        msl = msl fly(arrayf,firer,i)
        if (keym(19).gt.0) print 2, firer, tgt, i, msl
        IF (msl.gt.0) THEN
c      Missile found (pointer is non-zero)
          msl tgt = a(msl+1)
          if (keym(19).gt.0) print 3, msl tgt
          IF (tgt.eq.0 .or. tgt.eq.msl tgt) THEN
c      Abort this missile
            kshot(arrayf,3) = kshot(arrayf,3)+1
            call cancel (msl, eIMPCT, NULL)
            msl fly(arrayf,firer,i) = 0
            if (msl tgt.ne.FLS TGT) not(firer,msl tgt) = .false.
c      Release area for storage of missile data
            a(msl) = -a(msl)
            if (keyd(1).ge.2) print 1,t,color(arrayf),firer,
1              color(arrayt),msl tgt
c      Pop-down to reload if defender, pod empty, & fully alive
            defndr = (scene.eq.BATTAK .and. arrayf.eq.RED) .or.
1              (scene.eq.RATTAK .and. arrayf.eq.BLU)
            if (defndr.and.empty(firer).and.(life(firer).le.ALIVE))
2              call skedul(t,firer,ePOPDN,NULL)
            ENDIF
          ENDIF
20     CONTINUE
      if (trace) print *, '<abort'
      END
c V7.1

```

```

SUBROUTINE ACCELF (t, firer)
c 9  Accefl: simulate tank starting to accelerate.
      include 'common.h'
      integer firer
1     format (f8.2,1x,a4,i3,' speed up',9x,'(was slowing)')
2     format (f8.2,1x,a4,i3,' speed up',9x,'(was halted)')
3     format (f8.2,1x,a4,i3,' speed up',9x,'(was speeding up)')
4     format (f8.2,1x,a4,i3,' speed on',9x,'(is cruising)')
c
      if (keyd(4).gt.0) print *, '>accel'
      if (life(firer).ne.FKILL.and.invisb.eq.1.and.knceal(firer).ne.FD)
1      call skedul (t,firer,'vanish',NULL)
      narmy = army(firer)
      IF (motion(firer).eq.SLOWNG) THEN
c      Previous motion was slowing
        if (keyd(1).ge.2) print 1, t, color(narmy), firer
        call path(firer,t,motion(firer),0.0,x,y,vx,vy)
        dt = (speed(narmy)-vy)/accel(narmy)
        call skedul (t+dt,firer,'maxvel',NULL)
        motion(firer) = ACCELG
      ELSE IF (motion(firer).eq.STATNY) THEN
c      Previous motion was stationary
        if (keyd(1).ge.2) print 2, t, color(narmy), firer
        call path(firer,t,motion(firer),0.0,x,y,vx,vy)
c      schedule time full velocity reached (max vel)
        dt = speed(narmy)/accel(army(firer))
        call skedul(t+dt,firer,'maxvel',NULL)
        motion(firer) = ACCELG
      ELSE IF (motion(firer).eq.ACCELG) THEN
c      Previous motion was accelerating
        if (keyd(1).ge.2) print 3, t, color(narmy), firer
      ELSE IF (motion(firer).eq.MAXVL) THEN
c      Previous motion was cruising at max velocity
        if (keyd(1).ge.2) print 4, t, color(narmy), firer
      ENDIF
      if (keyd(4).gt.0) print *, '<accel'
      END
c V7.1

```

```

FUNCTION ANGLEF (a, b)
c 9  Anglef: find angle between two vectors.
      dimension a(3), b(3)
c
      vabsa = sqrt( dot( a,a ) )
      vabsb = sqrt( dot( b,b ) )
      dotab =      dot( a,b )
CHANGED 1 Apr 86. Next line replaced by 3.
c      dm = acos(dotab/(vabsa*vabsb))
      dm = dotab/(vabsa*vabsb)
      dm = amin1(1.,amax1(-1.,dm))
      dm = acos(dm)
      r3 = a(1)*b(2) - a(2)*b(1)
      anglef = -sign(dm,r3)
      END
c V7.1

```

A - 6

```

c 3  FUNCTION ANGSUM (a, b)
      Angsum: add 2 angles and adjust answer to lie between +-PI.
      c = a+b
10   IF (c.lt.-180.) THEN
      c = c+360.
      GOTO 10
      ELSE IF (c.gt.180.) THEN
      c = c-360.
      GOTO 10
      ENDIF
c    angle is adjusted.
      angsum = c
      END
c V7.3
```

```

SUBROUTINE APPEAR(t,tgt,firer)
c 0  Appear: if tgt appears treat, otherwise reschedule appearance
      include 'common.h'
      integer tgt,firer, arrayf, arrayt
      common /terane/ d(40), xold(20), yold(20), dist(20), iseg(20)
      rss(x,y) = sqrt(x*x+y*y)
1     format(f8.2,1x,a4,i3,' appears ',9x,'(x=',f8.1,' y=',f8.1,')')
2     format(f8.2,1x,a4,i3,' LOS to ',a4,i3,' starts.')
```

c

```

      if (trace) print *,>appear'
      arrayt = array(tgt)
      arrayf = 3-arrayt
      IF (invisb.eq.1) THEN
1         if(speed(arrayt).le.0.)print *,>APPEAR: arrayt,speed=',arrayt,
           speed(arrayt)
           if(speed(arrayt).le.0.) stop
           call path(tgt,t,motion(tgt),0.2,x,y,vx,vy)
c        Terrain causes intermittent LOS.
           travel = rss(x-xold(tgt), y-yold(tgt))
           IF (travel.gt.dist(tgt)) THEN
c            Tgt is no longer masked by terrain
               if (keyd(1).gt.1) print 1,t,color(arrayt),tgt,x,y
               xold(tgt) = x
               yold(tgt) = y
               iseg(tgt) = iseg(tgt)-1
               if (iseg(tgt).gt.40) iseg(tgt)=iseg(tgt)-40
               dist(tgt) = d(iseg(tgt))
               call aprter(t,tgt,firer,FE)
c            Schedule next disappearance
               dt = dist(tgt)/speed(arrayt) + 0.01
               call skedul(t+dt,tgt,'vanish',NULL)
           ELSE
c            Still masked by terrain, so reschedule mask end
               IF (life(tgt).eq.ALIVE) THEN
                   dt = (dist(tgt) - travel) / speed(arrayt) + 0.01
                   call skedul (t+dt,tgt,'appear',NULL)
               ENDF
           ENDF
           ELSE
c            Tgt is no longer masked by smoke
               if (keyd(1).gt.1) print 2,t,color(3-arrayt),firer,
1              color(arrayt),tgt
               call aprsmk(t,tgt,firer)
c            Schedule next disappearance
               r = rgf(t,firer,tgt)
               p = ranu(0)
               pout = ranu(0)
               IF (kview(RED).eq.kview(BLU)) THEN
                   IF (arrayf.eq.BLU) THEN
                       IF (kview(arrayf).eq.'I') THEN
                           dtin=tdintp(ptbl,rtbl,tini,p,r,21,5)
                           dtout=tdintp(ptbl,rtbl,touti,pout,r,21,5)
                       ELSE
                           dtin=tdintp(ptbl,rtbl,tinv,p,r,21,5)
                           dtout=tdintp(ptbl,rtbl,toutv,pout,r,21,5)
                       ENDF
                       call skedul(t+dtin,tgt,'vanish',firer)
                       call skedul(t+dtin,firer,'vanish',tgt)
                       call skedul(t+dtin+dtout,tgt,'appear',firer)
                       call skedul(t+dtin+dtout,firer,'appear',tgt)
                   ENDF
               ELSE
                   IF (kview(arrayf).eq.'V') THEN
                       dtinv=tdintp(ptbl,rtbl,tinv,p,r,21,5)
                       dtoutv=tdintp(ptbl,rtbl,toutv,pout,r,21,5)
                       dtouti=tdintp(ptbl,rtbl,touti,pout,r,21,5)
                       dtini=d*inv-(dtoutv-dtouti)*0.5
                       call skedul(t+dtinv,tgt,'vanish',firer)
                       call skedul(t+dtinv+dtoutv,tgt,'appear',firer)
                   ENDF
               ENDF
           ENDF
       ENDF

```

A - 8

```
      call skedul(t-dtini,firer,'vanish',tgt)
      call skedul(t-dtouti-dtini,firer,'appear',tgt)
    ENDIF
  ENDIF
  if (trace) print *, '<appear'
END
```

c V7.1

```

SUBROUTINE APRSMK(t,tgt,firer)
c 0  Aprsak: Tgt appears out of smoke, reset.
      include 'common.h'
      integer tgt,firer
      common /terane/ d(40), xold(20), yold(20), dist(20), iseg(20)
c
      if (trace) print *, '>aprsak'
      narmy = army(tgt)
c  Restore all lines-of-sight involving tgt
      los(firer,tgt) = army(firer).ne.narmy
c  Turn search on if it is off
      IF (.not.repeat) THEN
        repeat = .true.
        call skedul(t+.01,0,'search',NULL)
      ENDIF
      if (trace) print *, '<aprsak'
      END
c V7.1

```

```

SUBROUTINE APRTER(t,tgt,firer,jexpos)
c 0  Aprter: Tgt has appeared from behind terrain, reset.
      include 'common.h'
      integer tgt,firer
      common /terane/ d(40), xold(20), yold(20), dist(20), iseg(20)
1    format(f8.2,1x,a4,i3,' aprters ',9x,'(x=',f8.1,' y=',f8.1,')')
c
      if (trace) print *,>aprter'
      narmy = army(tgt)
      knceal(tgt) = jexpos
c    Restore all lines-of-sight involving tgt
      DO 20 i=1,nblu-nred
        IF (knceal(i).ne.FD) THEN
          los(tgt,i) = army(i).ne.narmy
          los(i,tgt) = army(i).ne.narmy
        ENDIF
20    CONTINUE
c    Turn search on if it is off
      IF (.not.repeat) THEN
        repeat = .true.
        call skedul(t-.01,0,'search',NULL)
      ENDIF
      if (trace) print *,<aprter'
END
c V7.1

```

```

BLOCK DATA BLKDAT
include 'common.h'
data color, pi, twopi, deg
1 /'Blue', 'Red ', 3.141592654, 6.283185308, 57.29577951/
data VNORTH /0., 1., 0./
data ALL, NULL, FLS TGT /0, 0, -1/
data FD, HD, FE /1, 2, 3/
data TURRET, HULL /1, 2/
data BLU, RED /1, 2/
data MEETING, RATTAK, BATTAK /1, 2, 3/
data ALIVE, WKILL, FKILL, WFKILL, IKILL, KKILL /1,2,3,4,5,6/
data SLOWNG, STATNY, ACCELG, MAXVL, INFINT
1 / 1, 2, 3, 4, 1.e35/
data keyd, keys /48*0/
END

```

c V7.1

```

SUBROUTINE BOUNDS (nary, box, angl, r1, r2)
c 8 Bounds: find the horizontal bounds of hull or turret.
c Definitions:
c   angl - angle off the nose of the box (rad).
c   box - 1 means turret box, 2 means hull box.
c   nary - 1 means blue firers, 2 means red firers.
c   c, s2, s3 - temporary variables.
c   r1, r2 - left and right boundaries of boxes (m).
c   include 'common.h'
c   integer box

c   if (trace) print *, 'bounds'
c   initialize
c     temp = (angl+twopi)/twopi
c     theta = (temp-aint(temp))*twopi
c     theta = amod (angl+twopi,twopi)
c     c = sysdim(nary,4*(box-1)+2) * cos(theta)
c     s2= sysdim(nary,4*(box-1)+3) * sin(theta)
c     s3= sysdim(nary,4*(box-1)+4) * sin(theta)

c   IF (theta.le.0.25*twopi) THEN
c     case 0 < theta <= 90
c       r1 = -s2 - c
c       r2 = s3 + c
c     ELSEIF (theta.le.0.5*twopi) THEN
c     case 90 < theta <= 180
c       r1 = -s2 + c
c       r2 = s3 - c
c     ELSEIF (theta.le.0.75*twopi) THEN
c     case 180 < theta <= 270
c       r1 = s3 + c
c       r2 = -s2 - c
c     ELSE
c     case 270 < theta <= 360
c       r1 = s3 - c
c       r2 = -s2 + c
c     ENDIF
c     if (trace) print *, 'bounds'
c     END
c V7.1

```

```

SUBROUTINE CANCEL (I, act, it)
c 0  Cancel: cancel 'act' events for 'I' entity.
c      (all events if act='')
c      Definitions of local variables:
c          m - pointer to previous event
c          n - pointer to current event being considered
c      include 'clock.h'
c      logical is what, is who, is whom
c      character*8 act
1      format(9x,'cancel ',i3,' ',a6,i3,' at time',f8.2)
c
c      m = 0
c      n = nxevnt
10     IF (n.ne.0) THEN
c         Continue until n=0
c         is who = I .eq. who(n)
c         is what = act.eq.what(n) .or. act.eq.'all '
c         is whom = it.eq.whom(n) .or. it.eq.0
c         IF (is who .and. is what .and. is whom) THEN
c             Then remove event
c             if (prflag) print 1, I, act, it, when(n)
c             if (m.eq.0) nxevnt = next(n)
c             if (m.ne.0) next(m) = next(n)
c             next(n) = nxidle
c             nxidle = n
c             if (m.eq.0) n = nxevnt
c             if (m.ne.0) n = next(m)
c         ELSE
c             Don't remove event. Shift to next event.
c             m = n
c             n = next(n)
c         ENDIF
c         GOTO 10
c     ENDIF
c     END
c V7.1

```

```

LOGICAL FUNCTION CAN GO (firer, t)
c 6 Can go: True iff is stationary and can move.
    include 'common.h'
    integer firer
    logical is atkr, a alive, faster

c
    narmy = army(firer)
    is atkr = (narmy.eq.BLU .and. scene.eq.BATTAK) .or.
1      (narmy.eq.RED .and. scene.eq.RATTAK)
    a alive = life(firer).eq.ALIVE .or.
1      life(firer).eq.FKILL
    faster = (motion(firer).eq.STATNY .or.
1      motion(firer).eq.SLOWNG)
c Change introduced by H.L.Reed on 8 Mar 89 to allow overwatch tanks
c to be added to the attacking force. See also changes in subroutines
c deplo2, init2, and input and in common.h.
    can go = is atkr .and. a alive .and. faster .and.
1      (.not. inwatch(firer))
    END
c V7.1

```

```

SUBROUTINE CREATE (n, ient)
c 8 Create: create a temporary entity. (a bullet or msl)
c purpose - this routine 'creates' a temporary entity. what it
c actually does is find space to store the attributes of that
c entity and reports back the index of the first storage word
c as the entity number.
c definitions -
c a is the vector used to store attributes in.
c i this is the index of the storage space we are currently
c looking at.
c ient is the index of the storage space where the attributes
c will be stored. it is also the number that will be used
c to identify the temporary entity created.
c isdone the routine is done if isdone = 1 and it is not done
c if isdone = 0. the only reason for the routine to be done
c is if it finds space to store the attributes in.
c istart this is the starting point for the search. if we get
c back to istart without a find, we have a storage overload
c and we error off.
c j this is the index of the next storage space. we want
c to look at it with the possibility of catenating it to the
c storage space beginning at i. c n the number of
c attributes to be stored.
c nreq this is the number of spaces required. it equals the
c number of attributes plus one word. this one word is used
c for searching purposes. if it is negative (-abs(m)), that
c indicates that the next m words are being used to store
c the m attributes of an entity. if it is positive, then the
c next m words are available for use.
c note - the amount of storage space is 1000 words. if you want to
c increase this you'll have to change all occurrences of 1000.
c also note that in initx these must be set - a=0, a(1)=1000.,
c i=1.
c
c logical trace
common /ctrl/ nreps, keyd(20), keys(20), scene, tmax, meth sa
common /ctrace/ trace
common /tstore/ a(1000), i
1 format (10x, 'CREATE: Not enuf space to store',
1 i5, ' attributes. ')
2 format (10x, 'CREATE: i, j, a(i), a(j) = ',
1 /10x, 2i5, 2f10.3)
c
c if (trace) print *, '>create'
c Initialize
c isdone = 0
c istart = i
c nreq = n-1
c Find empty space in the a-array
10 IF (isdone.ne.1) THEN
c Try next empty space
c Catenate empty spaces if possible
20 CONTINUE
c Find next space (and error off if we're back at start)
j = i+1abs(int(a(i)))
if (j.gt.1000) j=1
IF ((j.eq.1) .or. (a(i).lt.0) .or. (a(j).lt.0)) THEN
c test this space for size.
IF (a(i).lt.float(nreq)) THEN
c move to next space
i = j
if (i.eq.istart) print 1, n
IF (i.eq.istart) STOP
ELSE
c reserve space
isdone = 1
itemp = i-nreq
if(a(i).ne.float(nreq))a(itemp) = a(i)-float(nreq)
a(i) = -nreq

```

```

        ient = i
        i = j
    ENDIF
ELSE
c      do catenation
        a(i) = a(i)+a(j)
        IF (a(i).gt.0.0 .and. a(j).gt.0.0) GOTO 20
        print 2, i, j, a(i), a(j)
        STOP
    ENDIF
    GOTO 10
ENDIF
if (trace) print *, '<create'
END
c V7.1

```

```

SUBROUTINE CRESET
c 0  Creset - Reset variables used by create.
      common /tstore/ a(1000), iholy
      parameter (NN=20)
      DO 20 i=2,1000
        a(i)=0.0
20  CONTINUE
      a(1)=-NN
      a(NN+1) = 1000-NN
      iholy=NN+1
      END
c V7.1
```

```

SUBROUTINE DAMAGE (t, I, it, injury)
C 0  Damage: schedule effects.
c    Changed May 18, 1989 for simplified hit and kill model, HL Reed
      include 'common.h'
      character*2 kt(6)
      data kt /'no','M-','F-','MF','I-','K-'/
1     format(f8.2,1x,a4,i3,1x,'Hits      ',a4,i3,' (no damage).')
2     format(f8.2,1x,a4,i3,1x,a2,'-kills ',a4,i3)
c
      if (trace) print *, '>damage'
      n=array(I)
      m = 3-n
      IF(keyd(1).ge.2) THEN
        if (injury.eq.1) print 1,t,color(n),I,color(m),it
        if (injury.gt.1) print 2,t,color(n),I,kt(injury),color(m),it
      ENDIF

      injold = life(it)
      IF (injury.eq.KKILL .and. injury.ne.injold) THEN
c    Treat first catastrophic kill.
        life(it) = KKILL
        call damagf(t,it,m)
        call damaga(t,it)
        call cancel(it,'ikill ',NULL)
        call newtgt (t,I,it)
        call deaths(t)
      ELSEIF (injury.ne.injold .and. injold.lt.MFKILL) THEN
c    Treat new damage (less than catastrophic).
      IF (injury.eq.MKILL) THEN
        if (injold.eq.FKILL) life(it) = MFKILL
        if (injold.eq.ALIVE) life(it) = MKILL
        if (injold.eq.ALIVE .or. injold.eq.FKILL) call damaga (t,it)
      ELSE IF (injury.eq.FKILL) THEN
        if (injold.eq.ALIVE) life(it)=FKILL
        if (injold.eq.MKILL) life(it)=MFKILL
        call damagf(t,it,m)
      ELSE IF (injury.eq.MFKILL) THEN
        if (injold.lt.MFKILL) life(it) = MFKILL
        if (injold.ne.MKILL) call damaga (t, it)
        if (injold.ne.FKILL) call damagf (t,it,m)
      ENDIF
      if (life(it).eq.MFKILL.and.injold.lt.MFKILL)
1      call skedul(t+tbump(n),it,'ikill ',NULL)
      ENDIF
      if (trace) print *, '<damage'
      END
c V7.1

```

```

SUBROUTINE DAMAGF (t,it,m)
c  Damagf - Discard activities due to firepower kill.
  include 'common.h'

  nrtgt(it) = 0
  nchan(it) = 0
c  Clear any guidance channels in use by target.
  if (kindrd(m).eq.4) call abort(t,it,0)
  DO 40 j=1,nblu+nred
    fot(it,j) = .false.
40  CONTINUE
  call cancel(it,'fire ',NULL)
  call cancel(it,'reload',NULL)
  call cancel(it,'select',NULL)
  IF (life(it).eq.FKILL .and. speed(m).gt.0.0) THEN
    call cancel(it,'slowup',NULL)
    call cancel(it,'halt ',NULL)
    call cancel(it,'accel ',NULL)
    call skedul (t, it, 'accel ',NULL)
    dt = thide(m)
    if (m.eq.BLU .and. scene.eq.RATTAK) dt = 5.0
    if (m.eq.RED .and. scene.eq.BATTAK) dt = 5.0
    call skedul (t+dt,it,'hide ',NULL)
  ENDIF
END
c V7.1

```

```

SUBROUTINE DAMAGN (t, it)
c 9  Damage - Simulate mobility kill on the tgt.
      include 'common.h'
      logical sos
c      sos - stopped or slowing
      if (trace) print *, '>damage'
      call cancel (it, 'maxvel', NULL)
      call cancel (it, 'accel ', NULL)
      call cancel (it, 'hide  ', NULL)
      sos = vabs(vt).le.0.0 .or. motion(it).eq.SLOWING
      if (.not.sos) call skedul (t, it, 'slowup', NULL)
      if (trace) print *, '<damage'
      END
c V7.1

```

```

SUBROUTINE DEATHS (t)
c 0 Deaths: Find death toll on each side. A tank is considered
c   dead if it is I-killed, K-killed, or F-killed & hidden.
      include 'common.h'
      logical dead1, dead2
      integer dead(2)
1    format (i3,' Blu dead,',i3,' Red dead.')
```

c

```

      if (trace) print *, '>deaths'
      dead(BLU) = 0
      dead(RED) = 0
c    Change made by H.L. Reed on March 31, 1989 to keep decoys out
c    of the win decision and to keep them out of the exchange ratio
c    (see also finish.f).
      DO 20 i=1,(nblu-ndecoy(BLU))
        dead1 = life(i).ge.IKILL
        dead2 = knceal(i).eq.FD .and. life(i).ge.FKILL
        if (dead1 .or. dead2) dead(BLU)=dead(BLU)+1
20    CONTINUE
      DO 30 i=nblu+1,(nblu+nred-ndecoy(RED)-nwatch(scene))
        dead1 = life(i).ge.IKILL
        dead2 = knceal(i).eq.FD .and. life(i).ge.FKILL
        if (dead1 .or. dead2) dead(RED)=dead(RED)+1
30    CONTINUE
      if (keyd(1).ge.2) print 1,dead
      if ((nblu-ndecoy(BLU)).eq.dead(BLU) .or.
1     (nred-ndecoy(RED)-nwatch(scene)).eq.dead(RED))
1     call skedul(t+5, NULL, 'finish', NULL)
      if (trace) print *, '<deaths'
      END
c V7.1
```

```

SUBROUTINE DEPLO2(isouth,jsouth,nsouth,inorth,jnorth,nnorth)
c 0  Deploy: position & orient all tanks at beginning of engagement.
    include 'common.h'
2    format('tank',i2,' x=',f6.0,' y=',f6.0,' heading=',f5.0,
1      ' speed=',f5.1,'m/s')

    if (trace) print *,')deplo2'
    spacng = 100.0

c    Position southern tanks on the x-axis
    vsouth = 0.0
    if (scene.eq.BATTAK) vsouth = speed(BLU)
    if (scene.eq.RATTAK) vsouth = speed(RED)
    x0(isouth) = -0.5*(nsouth-1)*spacng
    xp(isouth) = x0(isouth)
    y0(isouth) = 0.0
    vy0(isouth) = vsouth
    aspect(isouth,TURRET) = 0.0
    aspect(isouth,HULL) = 0.0
    n = isouth

c    Related to 8 Mar 89 change
    inwatch(n) = .false.
    if (keyd(1).ge.2) print 2, n, x0(n), y0(n), 0.0, vy0(n)
    DO 20 n=isouth+1,jsouth
        x0(n) = x0(n-1) + spacng
        xp(n) = x0(n)
        y0(n) = 0.0
        vy0(n) = vsouth

c    Change introduced by H. L. Reed on 8 Mar 89 to allow overwatch
c    tanks to be added to the attacking force. See also changes in
c    the subroutines cango, init2, and input and in common.h.
        inwatch(n) = .false.
        IF(n.gt.(jsouth - nwatch(scene))) THEN
            inwatch(n) = .true.
            vy0(n) = 0.0
            motion(n) = STATNY
            knceal(n) = HD
        ENDIF

c    End of 8 Mar 89 change
        aspect(n,TURRET) = 0.0
        aspect(n,HULL) = 0.0
        if (keyd(1).ge.2) print 2, n, x0(n), y0(n), 0.0, vy0(n)
20    CONTINUE

c    Position northern tanks
c    find center of northern line of tanks
c    Change by HLRReed thetal is no longer used to provide the cardioid
c    distribution. That is done in the new vulnerability model.
        thetal = 0.
        xcen = rg0*sin(thetal)
        ycen = rg0*cos(thetal)

c    place northern tanks on northern line
c    Change by HLRReed theta2 is no longer used to provide the cardioid
c    distribution. That is done in the new vulnerability model.
        theta2 = 0.
        headng = thetal+theta2*PI
        cosa = cos(headng)
        sina = sin(headng)
        dx = -cosa*spacng
        dy = sina*spacng
        x0(inorth) = xcen-0.5*(nnorth-1)*dx
        y0(inorth) = ycen-0.5*(nnorth-1)*dy
        vy0(inorth) = 0.0
        da = headng*deg
        n = inorth
        if (keyd(1).ge.2) print 2, n, x0(n), y0(n), da, vy0(n)
CHANGED 31 Mar 85 Following 2 lines added.
        aspect(inorth,TURRET) = headng
        aspect(inorth,HULL) = headng

```

```

      DO 30 n=inorth+1,jnorth
c      Related to 8 Mar 89 change
          inwatch(n) = .false.
          x0(n) = x0(n-1) + dx
          y0(n) = y0(n-1) + dy
          vy0(n) = 0.0
          aspect(n,TURRET) = headng
          aspect(n,HULL) = headng
          dm = headng*deg
          if (keyd(1).ge.2) print 2, n, x0(n), y0(n), dm, vy0(n)
30      CONTINUE
          last=nnorth+nsouth
          if (trace) print *, '<deplo2'
          END
c V7.1

```

```

SUBROUTINE DEPLOY
c 0  Deploy: position & orient all tanks at beginning of engagement.
    include 'common.h'

    if (trace) print *, '>deploy'
    DO 20 n=1,nblu+nred
        t0(n) = 0.0
20  CONTINUE
    IF (scene.eq.BATTAK) THEN
c      position blue tanks on the x-axis
        call deplo2(1,nblu,nblu,nblu+1,nblu+nred,nred)
    ELSE
c      position red tanks on the x-axis
        call deplo2(nblu+1,nblu+nred,nred,1,nblu,nblu)
    ENDIF
    if (trace) print *, '<deploy'
    END
c V7.1

```

```

SUBROUTINE DETECT (t, firer, tgt)
c 3 Detect: find if tgt detected and schedule subsequent events.
include 'common.h'
integer firer, tgt, arrayf, arrayt
1 format (f8.2,1x,a4,i3,' detects ',1x,a4,i3)
c
  if (trace) print *, '>detect'
  arrayf = array(firer)
  arrayt = 3-arrayf
  IF (los(firer,tgt) .and. .not.seen(firer,tgt) .and.
1   ndet(firer).lt.ndets(arrayf)) THEN
    if(keyd(1).ge.2)print 1,t,color(arrayf),firer,color(arrayt),tgt
    ndet(firer) = ndet(firer)+1
    seen(firer,tgt) = .true.
c Set thuman to zero as does GROUNDWARS - HLReed
    t human = 0.0*exp(rolln(0.5))
    call select(t,firer,thuman)
c Change by HLReed to allow transfer of targets
    IF(xxfer(arrayf)) THEN
      i = 1
      if(firer .GT. nblu) i = nblu+1
      call skedul(t+2,i,'xfer ',tgt)
    ENDIF
  ENDIF
  if (trace) print *, '<detect'
END
c V7.3

```

```

SUBROUTINE DET RG (narmy)
c Det rg: Find the max ranges at which each firer in 'narmy' detects.
include 'common.h'
integer narmy, first, last, tank, cond, krg
real p1, p2, r, r1, p
1 format (' Range to which tank can see',/,
1 ' Tank HD FE-S FE-W ranu')
2 format (i5,3f8.1,f8.4)
c
if (trace) print *, '>detrg'
if (keyd(1).ge.2) print 1
c Find first and last firers on this side (narmy).
IF (narmy.eq.BLU) THEN
first = 1
last = nbilu
ELSE
first = nbilu-1
last = nbilu-nred
ENDIF
c Loop thru all tanks on the side
DO 80 tank = first,last
p = ranu(0.0)
DO 70 cond=1,3
p1 = 1.0
c Search for P-infinity values bounding x
DO 60 krg=1,8
p2 = pinfin(narmy,cond,krg)
IF (p2 .lt. p) GOTO 65
p1 = p2
60 CONTINUE
p2 = 0.0
65 CONTINUE
c Interpolate on p-infinity to find range.
r1 = irginc*(krg-1)
r = r1 + irginc*(p1-p)/(p1-p2)
rgvis(cond,tank) = r
70 CONTINUE
if (keyd(1).ge.2) print 2,tank,(rgvis(cond,tank),cond=1,3),p
80 CONTINUE
if (trace) print *, '<detrg'
END
c V7.1

```

```

FUNCTION DEVIC2 (attn, range)
c  Devic2: find resolvable cycles for device 2.
  real cofs(6), s(7)
  save cofs, foviv, s, tempd
  data tempd, foviv /2.5, .54/
  data cofs /.41089327, -.0892577, .026000138,
1   -.004097143, .0003209958, -.00000982049/
  data s/4.798, .938, -.236, .011, .013, -.001, 0./

c
c  Calculate contrast
  y = -.45 + 1.19*log10(attn)
  extcof = 10.**(y)
  amls = cofs(6)
  DO 30 i=5,1,-1
    amls = amls*range + cofs(i)
30  CONTINUE
  attn2 = extcof*amls
  cntrst = abs(tempd*exp(-attn2*range))
  IF (cntrst.gt.0.0112) THEN
c    Target/background is sufficient to detect
    clog = alog(cntrst)
c    $rc = sum from i=1 to 7 {s sub i clog sup {i-1}}
    rc = s(7)
    DO 40 i=6,1,-1
      rc = rc*clog + s(i)
40  CONTINUE
    devic2 = amin1(rc/3.44, .9/foviv)
  ENDIF
END
c V7.1

```

```

SUBROUTINE DIS ENG (t, firer, tgt, drop, take)
c 7 Diseng: attempt to disengage 1 firer from 1 target.
c Diseng is called by impact if firer condition warrants.
c When I include guns, other routines may call it.
  include 'common.h'
  integer arrayf, armyt, tgt, firer
  logical in brst, hav amo, on tgt, drop, take, cango
3  format (f8.2,1x,a4,i3,' dis-engs ',a4,i3,20x,'#tgts=',i2)
c
  if (trace) print *, '>diseng'
c Set useful local variables
  my tgt = nrtgt(firer)
  armyf = army(firer)
  armyt = 3-armyf
  hav amo = nrd(firer).lt.nrds(arrayf)
  inbrst = nrpb(arrayf).gt.1 .and. (0.ne.mod(nrpb(firer),
1  nrpb(arrayf)))
  if (tgt.eq.FLS TGT) on tgt = .true.
  if (tgt.ne.FLS TGT) on tgt = fot(firer,tgt) .or.
1  (kindrd(arrayf).eq.4 .and. not(firer,tgt))
  IF (on tgt) THEN
c Firer on this target
    kind = kindrd(arrayf)
    IF (kind.le.2 .or. kind.eq.5) THEN
      IF (nrpb(arrayf).le.1) THEN
c Single shot gun system or STAFF fire & forget system.
        IF (tgt.ne.FLS TGT) THEN
          if (fot(firer,tgt)) call cancel (firer,'fire ',tgt)
          fot(firer,tgt) = .false.
        ENDIF
        hav amo = nrd(firer).lt.nrds(arrayf)
        IF (hav amo) THEN
          thuman = 0.*exp(rolln(0.5))
          call select(t,firer,thuman)
        ELSEIF (can go(firer,t).and.ishtfs(arrayf).gt.0) THEN
c Firer moves on.
          if(keyd(1).ge.2)print 3, t,color(arrayf),firer,
1          color(arrayt),tgt,nchan(firer)
          call skedul(t,firer,'accel ',NULL)
        ENDIF
        nrot(firer) = 0
        nrtgt(firer) = 0
      ELSE
c Burst fire gun system.
        print *, 'DISENG: Not implemented for burst fire guns.'
        STOP
      ENDIF
    ELSEIF(kind.eq.4) THEN
c Guided missile system.
      if (drop) nchan(firer) = nchan(firer)-1
      IF (tgt.ne.FLS TGT) THEN
        IF (fot(firer,tgt)) THEN
          call cancel(firer,'fire ',tgt)
          fot(firer,tgt) = .false.
        ENDIF
      ENDIF
      if(keyd(1).ge.2)print 3, t,color(arrayf),firer,
1      color(arrayt),tgt,nchan(firer)
c Firer attempts to select a new target
      IF (take) THEN
        call frdasl(t,firer,tgt,arrayf)
c The firer begins to select a new target right now and
c finishes the selection in a few seconds.
      ENDIF
    ENDIF
  ENDIF
ENDIF

```

```
IF (.not.repeat) THEN
  repeat = .true.
  call skedul (t+.01,0,'search',NULL)
ENDIF
if (trace) print *, '<diseng'
END
```

c V7.1

```
FUNCTION DOT (a, b)
c 9  Dot: find dot product  a dot b.
    dimension a(3), b(3)
c
    dot = a(1)*b(1)+a(2)*b(2)+a(3)*b(3)
    END
c V7.3
```

```

SUBROUTINE ENGAGE (t1, t2, firer, tgt)
c ? Engage: begin engagement of a new tgt by this firer.
    include 'common.h'
    integer arrayf, arrayt, firer, tgt
    format(' ENGAGE: arrayf,ishtfs,firer,motion,STATNY',8i3)
c
    if (trace) print *, '>engage'
    arrayf = array(firer)
    arrayt = 3-arrayf
    IF (life(firer).lt.FKILL.AND.nrd(firer).lt.nrds(arrayf) )THEN
        if(keya(18).gt.1)print 1,
1      arrayf,ishtfs(arrayf),firer,motion(firer),STATNY
        nbrst(firer) = 1
        IF (ishtfs(arrayf).gt.0 .AND. motion(firer).ne.STATNY
1      .AND. speed(arrayf).gt.0.0) THEN
c      halt to fire
        call cancel (firer,'maxvel',NULL)
        call cancel (firer,'accel ',NULL)
        call skedul(t1,firer,'slowup',NULL)
        ELSE
c      Schedule a fire event otherwise
c      find range to target
        IF (tgt.eq.-1) THEN
            rg = rg0
CHANGED 1 Apr 86. Next line changed.
c      nrg = int((250.-rg)*.002)
            nrg = int(1.5*rg/irginc)
CHANGED 11 Jun 86 Preceding line changed to next line.
            nrg = int(0.5*rg/irginc)
            ELSE
                da = rgf(t1,tgt,firer)
            ENDIF
            nrg = min(8,nrg)
            dt = tfirst(array(firer),nrg) * exp(rolln(0.5))
            prev rd(firer) = 1
            nrif(firer) = 0
            nrot(firer) = 0
CHANGED 16 Jul 86 Next line added.
c      if(kindrd(arrayf).eq.4) dt=0.1
change 23 Nov 89 by HLReed to make sure a round has been loaded
            t3 = amax1(tfire2(firer)+tmin(arrayf),t2-dt)
            call skedul(t3,firer,'fire ',tgt)
            ENDIF
        ENDIF
        IF (trace) print *, '<engage'
    END
c V7.1

```

```

SUBROUTINE EVENTS
c 9  Events: call each event in sequence.
    include 'common.h'
    character*6 iwhat
1    format (' EVENTS: No such event type. Event=',a6,',',
1      ' Who=',i2,', Whom=',i2,', Time=',f7.2)
c
    if (trace) print *, '>events'
c    Initialize for battle
        call reset(keyd(5).gt.0)
        call creset
        call init
        tm lst = 0.0
c    Perform all events in the battle
10   CONTINUE
        call nextev (iwho, iwhat, iwhom, t)
        IF (iwhat.eq.'search') THEN
            call search (t)
        ELSEIF (iwhat.eq.'vanish') THEN
            call vanish (t,iwho,iwhom)
        ELSEIF (iwhat.eq.'appear') THEN
            call appear (t,iwho,iwhom)
        ELSEIF (iwhat.eq.'detect') THEN
            call detect (t,iwho,iwhom)
        ELSEIF (iwhat.eq.'select') THEN
            call select (t,iwho)
c    Change by HLReed to allow transfer of targets
        ELSEIF (iwhat.eq.'xfer ') THEN
            call xfer(t,iwho,iwhom)
        ELSEIF (iwhat.eq.'fire ') THEN
            call fire (t,iwho,iwhom)
        ELSEIF (iwhat.eq.'impact') THEN
            call impact (t,iwho)
        ELSEIF (iwhat.eq.'slowup') THEN
            call slowup (t,iwho)
        ELSEIF (iwhat.eq.'halt ') THEN
            call halt (t,iwho)
        ELSEIF (iwhat.eq.'accel ') THEN
            call accel (t,iwho)
        ELSEIF (iwhat.eq.'maxvel') THEN
            call maxvel (t,iwho)
        ELSEIF (iwhat.eq.'ikill ') THEN
            call latekl (t,iwho,iwhom)
        ELSEIF (iwhat.eq.'hide ') THEN
            call hide (t,iwho)
        ELSEIF (iwhat.eq.'reload') THEN
            call reload (t,iwho)
        ELSEIF (iwhat.eq.'popdn ') THEN
            call pop dn (t,iwho)
        ELSEIF (iwhat.eq.'finish') THEN
            call finish (tm lst)
            GOTO 99
        ELSE
            print 1,iwhat, iwho, iwhom, t
            STOP
        ENDIF
        tm lst=t
        GOTO 10
99   if (trace) print *, '<events'
      END
c V7.1

```

```

FUNCTION EYE (alumnc, attn, range, visrg)
c   Eye: find resolvable cycles for the human eye. (Device 1)
      real a(4,7)
      save a, acon
c   sunset o'cast heavy o'cast overcast day clear day
      data a/
1  1.2378091942, 1.7176916034, 1.9909928015, 2.0892716525,
2  0.4694720809, .4739084812, .4484981232, .2813866389,
3  .0493317078, -.2102695514, -.4084256747, -1.0084578626,
4  -.0601756751, -.4161055149, -.6856409935, -1.4323484287,
5  -.0558327470, -.2696921300, -.4318233767, -.8450225947,
6  -.0174190671, -.0756229822, -.1197712507, -.2235482536,
7  -.0018530403, -.0077222394, -.0121729428, -.0218136690/
      data acon /.4/
c
c   Find sky-to-ground ratio
      sog = (visrg+1.0)/3.
      sog = amin1(3.,amax1(1.,sog))
      cntrst = acon/(1.0-sog*(exp(attn*range)-1.0))
      IF (cntrst.ge.0.02) THEN
c   Target/Background contrast is sufficient to detect
        i = min0(4,1+int(alog10(alumnc)))
        ack = 10.**i
        j = min0(4,i+1)
        clog = alog(cntrst)
        rlo = a(i,7)
        rhi = a(j,7)
        DO 20 k=6,1,-1
          rlo = rlo * clog + a(i,k)
          rhi = rhi * clog + a(j,k)
20      CONTINUE
c   Interpolate & compute cycles across target
        eye = rlo+(rhi-rlo)*(alumnc-ack/10.)/(ack*.9)
      ENDIF
      END
c V7.2

```

```

SUBROUTINE FINISH (t)
c 3  Finish: update statistics at end of a single engagement.
      include 'common.h'
      integer balive, dalive, ralive, brds, rlds
      dimension stata(8)
1      format(i6,2(5i3),4i3,1x,2f5.1,i9)
2      format('  Rep      Status of Combatants      ',
1      ' Rds Used    Used/Tank',/
1      ' |----Blue----| |----Red----| ',
1      'by System  Blue Red   seed',/
1      6x,2(1x,'AL MO FO MF K'),2x,'1 2 3 4')

c      if (trace) print *, '>finish'
c      Count surviving blues and rounds fired
      balive = 0
      brds = 0
      dalive = 0
c      Change made by H.L. Reed on March 31, 1989 to keep decoys out of
c      win ratios and exchange ratio. See also deaths.f
      DO 10 i=1,(nblu-ndecoy(BLU))
        k = life(i)
        if (k.ge.5) k=k-1
        nstats(k,BLU) = nstats(k,BLU)+1
        if (life(i).lt.FKILL) balive = balive+1
        brds = brds+nrd(i)
10      CONTINUE
      DO 11 i = nblu - ndecoy(BLU) +1, nblu
        if (life(i).lt.FKILL) dalive = dalive+1
11      CONTINUE
      call finsh2
c      Count surviving reds and red rounds fired.
      ralive = 0
      rlds = 0
      DO 20 i=1,(nred-ndecoy(RED))
        j = i+nblu
        k = life(i+nblu)
        if (k.ge.5) k=k-1
        nstats(k,RED) = nstats(k,RED)+1
        if (life(j).lt.FKILL) ralive = ralive+1
        rlds = rlds+nrd(j)
20      CONTINUE
      mystat(1) = mystat(1) + nblu-balive - ndecoy(BLU)
      mystat(2) = mystat(2) + ndecoy(BLU) - dalive
      nmov = 0
      ndow = 0
      DO 23, i = nblu+1, nblu+nred - ndecoy(RED)
        if(life(i).ge.FKILL.and.inwatch(i)) ndow = ndow + 1
        if(life(i).ge.FKILL.and..not.inwatch(i)) nmov = nmov +1
23      CONTINUE
      mystat(3) = mystat(3) + nmov
      mystat(4) = mystat(4) + ndow

c
      DO 30 i=1,4
30      stata(i) = 0.0
      j = nred-nwatch(scene)-ndecoy(RED)-nmov
      if (balive.gt.0 .and. j.eq.0) stata(1)=1.
      if (balive.eq.0 .and. j.gt.0) stata(2)=1.
      if (balive.gt.0 .and. j.gt.0) stata(3)=1.
      if (balive.eq.0 .and. j.eq.0) stata(4)=1.
      stata(5) = (nblu-ndecoy(BLU))-balive
      stata(6) = (nred-ndecoy(RED))-ralive
      stata(7) = float(brds)/float(nblu)
      stata(8) = float(rlds)/float(nred)
      excha = 0.0
      if (stata(5).gt.0.0) excha = stata(6)/stata(5)

```

```

      DO 40 i=1,8
        statb(i) = statb(i)+stata(i)
40    CONTINUE
c    Update ammo consumption for F-alive Blue tanks if combat occurred.
      IF (brds+rrds .gt.0) THEN
        DO 50 i=1,nblu
          j=nrd(i)+1
50    CONTINUE
      ENDIF
c
      if (keyd(1).ge.2 .or.
1      (krep.eq.1 .and. keyd(1).eq.1)) print 2
      if (keyd(1).gt.0) print 1, krep, nstats, (nrd(i),i=1,4),
1      stata(7), stata(8), irands
      if (trace) print *, '<finish'
      END
c V7.1

```

```

SUBROUTINE FINSH2
c 9  Finsh2: update statistics at end of a single engagement.
      include 'common.h'
c
      if (trace) print *, '>finsh2'
      DO 90 i=1,nblu
c        select blues for further combat
          IF (life(i).eq.ALIVE .and. nwaves.gt.1) THEN
            nsurv = nsurv+1
            nused(nsurv) = nrd(i)
          ENDIF
          IF (nrd(i).gt.nrd(BLU)-5) THEN
c            count systems with no & low ammo
              if (nrd(i).lt.nrd(BLU)) loammo = loammo+1
              if (nrd(i).ge.nrd(BLU)) noammo = noammo+1
          ENDIF
90    CONTINUE
      if (trace) print *, '<finsh2'
      END
c V7.1

```

```

SUBROUTINE FIRE (t,firer,tgt)
c 7  Fire: Simulate firing of a round & schedule effects.
    include 'common.h'
    integer bullet, armyf, armyt, firer, tgt
1    format(f8.2, 1x, a4, i3, ' fires at ', a4, i3)
2    format(f8.2, 1x, a4, i3, ' ran out of ammo.')
c
    if (trace) print *, '>fire'
    busy(firer)=.false.
    IF (life(firer).ge.FKILL) THEN
        print *, 'FIRE: firer', firer, ' is F-killed or worse.'
        STOP
    ELSEIF (tgt.eq.0) THEN
        print *, 'FIRE: firer', firer, ' has no target.'
        STOP
    ELSE
c      Find nrs for tgt, army of firer, army of tgt
        armyf = army(firer)
        armyt = 3-armyf
        if (keyd(1).ge.?) print 1,t,color(armyf),firer,
1      color(armyt),tgt
c      Update last firing time for firer & for firer at this tgt
        if (tgt.gt.0) tfire(firer,tgt) = t
        tfire2(firer) = t
c      Update positions, velocities and turret orientation
        IF (tgt.eq.-1) THEN
            rg = rg0
            nrg = max0(1,int(0.5-rg/irginc))
            s(1) = 0.0
            s(2) = rg0
            s(3) = 0.0
            if ((armyf.eq.BLU .and. scene.eq.BATTAK) .or.
1          (armyf.eq.RED .and. scene.ne.BATTAK)) s(2) = -rg0
        ELSE
            da = rgf(t,tgt,firer)
            ENDF
            aspect(firer,TURRET) = anglef(VNORTH,s)
c      Schedule any pinpoint detections
            call pinpnt (t,firer)
            IF (iflash(firer).eq.0) THEN
c      Branch for real firer (do nothing if firer is flashing decoy)
c      Create round with various attributes
            call create (10,bullet)
            a(bullet-1) = tgt
            a(bullet-2) = firer
            tfly = tof(armyf,nrg)
            t2 = t+tfly
            a(bullet-3) = s(1)+tfly*vt(1)
            a(bullet-4) = s(2)+tfly*vt(2)
            a(bullet-7) = psense(armyf,nrg)
            a(bullet-9) = vabs(vf)
            if (tgt.eq.-1) a(bullet-10) = 0.0
            if (tgt.gt.0) a(bullet-10) = vabs(vt)
            a(bullet-10)= vabs(vt)
            kshot(armyf,1) = kshot(armyf,1) + 1
c      Schedule impact for bullet
            call schedul (t+tfly,bullet,'impact',tgt)
            IF (kind rd(armyf).eq.4) THEN
                if (tgt.gt.0) mot(firer,tgt) = .true.
                DO 20 i=1,5
                    IF (asl fly(armyf,firer,i) .eq. 0) GOTO 25
20      CONTINUE
                print *, 'FIRE: Too many missiles'
                STOP
25      asl fly(armyf,firer,i) = bullet
            ENDF

```

```

c      Update stowed rounds and expenditure
      nrd(firer) = nrd(firer)+1
      nrrib(firer) = nrrib(firer)+1
      if(nrrib(firer).gt.nrpib(arrayf)) nrrib(firer)=1
      nrot(firer) = nrot(firer)+1
c      Move, fire, or switch targets as required
      IF (kind rd(arrayf).le.2 .or. kind rd(arrayf).eq.5) THEN
        IF (nrpb(arrayf) .le.1) call frd ssg(t,firer,tgt,arrayf)
      ELSEIF (kind rd(arrayf) .eq. 4) THEN
c      Simultaneous missiles branch
        IF (nchan(firer).lt.nchans(arrayf)) THEN
          call frd msl(t,firer,tgt,arrayf)
c      ELSE
c      All guidance channels busy. Wait until impact.
        ENDIF
      ELSE
        print *, 'FIRE: kind rd', kind rd(firer), ' unknown.'
      ENDIF
    ENDIF
  ENDIF
  if (keyd(1).ge.2 .and. nrd(firer).ge.nrds(arrayf)) print 2,
1    t,color(arrayf),firer
  if (trace) print *, '<fire'
END
c V7.1

```

```

SUBROUTINE FORCES
c 7  Forces: loop through desired blue/red force ratios.
      include 'common.h'
      integer range0
1     format(' SCENE:',i3)
2     format(' Meeting engagement. #Blues =',i3,' #Reds =',i3)
3     format(' Red attack.          #Blues =',i3,' #Reds =',i3)
4     format(' Blue attack.         #Blues =',i3,' #Reds =',i3)
c
      if (trace) print *, '>forces'
      min blu = ntanks(scene,1)
      min red = ntanks(scene,4)
      IF (min blu .gt. 0 .and. min red .gt. 0) THEN
        max blu = ntanks(scene,2)
        max red = ntanks(scene,5)
        inc blu = max0(1,ntanks(scene,3))
        inc red = max0(1,ntanks(scene,6))
        DO 50 nblu = min blu,max blu,inc blu
          DO 40 nred = min red,max red,inc red
            if (scene .eq. MEETING) print 2, nblu, nred
            if (scene .eq. RATTAK) print 3, nblu, nred
            if (scene .eq. BATTAK) print 4, nblu, nred
          DO 30 range0 = min rg, max rg, inc rg
            rg0 = range0
            call waves (scene)
30         CONTINUE
40         CONTINUE
50         CONTINUE
      ENDIF
      if (trace) print *, '<forces'
      END
c V7.1

```

```

SUBROUTINE FRD MSL (t, firer, tgt, arrayf)
c 0  Frd msl: Fired a missile. now schedule effects.
      include 'common.h'
      logical done, tactc3, prflag
      integer arrayf, firer, tgt
1      format('FRD MSL: t,firer,tgt,arrayf=',f7.2,3i3)
2      format(f8.2, 1x, a4, i3, ' begins to reload.')
3      format('FRD MSL: firer=',i3,' tactic=',i2,' #rds fired=',i2,
1      ' #rds to fire=',i2)
c
      if (trace) print *, '>frd msl'
      prflag=.false.
      if (prflag) print 1,t,firer,tgt,arrayf
      IF (nrd(firer).lt.nrds(arrayf)) THEN
c      System has more rounds on board.
        if (prflag) print *, 'FRD MSL: nrd(firer)=',nrd(firer)
        IF (mod(nrd(firer),nipods(arrayf)).gt.0 .or.
1        nrd(firer).eq.0) THEN
c      System has more rounds in pod.
        if (prflag) print *, 'FRD MSL: No reload. nrd, nipods=',
1        nrd(firer),nipods(arrayf)
        tactc3 = tactic(arrayf).eq.3
        done = nrot(firer).eq.nrpt(arrayf)
        if (prflag) print 3, firer, tactic(arrayf),
1        nrot(firer), nrpt(arrayf)
        IF (tactc3 .and. done) THEN
c      Switch targets after firing a fixed nr of rds at it
          if (tgt.ne.FLS TGT) fot(firer,tgt) = .false.
          call selecs (t,firer,0.0)
        ELSE
c      Schedule next round fired
          timea = tain(arrayf)
          if (prflag) print *, 'FRD SSQ: shoot again.'
          timeb = tfixed(arrayf,nrg)
          timec = taedin(arrayf) * exp(rolln(0.5))
          dt = amax1(timea,timeb-timec)
          call skedul (t+dt,firer,'fire ',tgt)
        ENDIF
      ELSE
c      Treat empty missile pod
        if (prflag) print *, 'FRD MSL: Reloading'
        empty(firer) = .true.
        call cancel(firer,'fire ',tgt)
        call cancel(firer,'select',NULL)
        nrot(firer) = 0
c      shud htf that is slowing to engage speed up now?
        call skedul (t+treload(arrayf),firer,'reload',NULL)
        if (keyd(1).ge.2) print 2,t,color(arrayf),firer
      ENDIF
    ENDIF
    if (tgt.gt.0) fot(firer,tgt) = .false.
c  ABOVE LINE GOOD FOR MMSL THAT IS NOT LOADED W/ TARGETS
    if (trace) print *, '<frd msl'
  END

```

c V7 1

```

SUBROUTINE FRD SSG (t, firer, tgt, arrayf)
c 6  Frd ssg: Schedule effects after firing single shot gun.
      include 'common.h'
      logical can go, done, tactc3
      integer arrayf, firer, tgt
1      format('FRD SSG:  t,firer,tgt,arrayf=',f7.2,3i3)
2      format(f8.2, 1x, a4, i3, 'is out of ammo. Will attempt',
1      ' to hide if mobile.')
c
      if (trace) print *, '>frd ssg'
      IF (nrd(firer).lt.nrds(arrayf)) THEN
c      Have ammo branch
        tactc3 = tactic(arrayf).eq.3
        done = nrot(firer).eq.nrpt(arrayf)
        IF ((tactc3 .and. done)) THEN
c      Switch targets after firing a fixed nr of rds at it
          busy(firer) = .false.
          call dis eng (t, firer, tgt,.true.,.true.)
c          If no other tgt and can move, skedul acceleration
            if (can go(firer,t) .and. ishtfs(arrayf).eq.1)
1              call skedul(t,firer,'accel ',NULL)
              nrot(firer) = 0
        ELSEIF (tgt.gt.0) THEN
c      Schedule next round fired
          timea = twin(arrayf)
          timeb = tfixed(arrayf,nrg)
          timec = tmedin(arrayf) * exp(rolln(0.5))
          dt = amax1(timea,timeb-timec)
          call skedul (t-dt,firer,'fire ',tgt)
        ENDIF
      ELSE
c      Out-of-ammo branch
        empty(firer) = .true.
        IF (cango(firer,t)) THEN
          call skedul (t,firer,'accel ',NULL)
          call skedul (t-thide(arrayf),firer,'hide ',NULL)
        ENDIF
      ENDIF
      if (trace) print *, '<frd ssg'
      END
c V7.2

```

```

SUBROUTINE HALT (t, firer)
c 7 Halt: simulate tank halting.
    include 'common.h'
    logical cango, threat
    integer armyf, firer, tgt
1    format (f8.2,1x,a4,i3,' halts',12x,'(x=',f8.1,' y=',f8.1',)')
2    format(' HALT:  firer, 0turrer, 0hull =', i3, 2f8.1)
3    format(' HALT:  firer, tgt, armyf, nrg =', 4i3)
4    format(' HALT:  rx1,rx2,tfirst,dt =',5f10.3)
5    format(' HALT:  t, tlastx, dt =',5f10.3)
c
    if (trace) print *, '>halt'
    if (invisb.eq.1) call cancel (firer, 'vanish', NULL)
    narmy = army(firer)
    call path (firer, t, motion(firer), 0.0, x, y, vx, vy)
    if (keyd(1).ge.2) print 1, t, color(narmy), firer, x, y
    motion(firer) = STATNY
    tlastx = t-3.
    armyf = narmy
c    see if fire is a halt-to-fire-system and can still shoot
    IF (ishtfs(armyf).eq.1 .and.
1      life(firer).lt.FKILL .AND. nrd(firer).lt.nrds(armyf)) THEN
c      This is a halt-to-fire system. schedule firing if tgt
c      still available.
        threat = .false.
        IF (nrtgt(firer).eq.FLS TGT) THEN
            threat = knceal(firer).ne.FD
        ELSEIF (nrtgt(firer).gt.0) THEN
            threat = fot(firer,nrtgt(firer))
        ENDIF
        IF (.not.threat) THEN
c          firer's tgt has vanished. firer may move
            if (cango(firer,t)) call skedul (t, firer, 'accel ', NULL)
        ELSE
            if (keyd(1).ge.2) print *, 'HALT: tlastx, aspect needs wk!'
            rx1=rolln(0.5)
            rx2=exp(rx1)
            tgt=nrtgt(firer)
            dummy = rgf(t,firer,tgt)
            dt = tfirst(armyf,nrg)*rx2
c change Dec 89 by HLR
            dt = amax1(dt,tfire2(firer)-tmin(armyf) -t)
            prev rd(firer) = 1
            nrub(firer) = 0
            nrot(firer) = 0
            call skedul (t-dt, firer, 'fire ', tgt)
        ENDIF
    ENDIF
    if (trace) print *, '<halt'
END
c V7.1

```

```

SUBROUTINE HIDE (t, tgt)
c 5  Hide: Simulate tank hiding.
      include 'common.h'
      integer firer, tgt
      format (f8.2,x,a4,i3,' goes into full defilade.')
c
      if (trace) print *, '>hide '
      if (keyd(1).gt.1) print 1, t, color(army(tgt)), tgt
      knceal(tgt) = FD
c  Cancel all activities involving this tgt
c  except discard rounds-in-flight in the impact routine
      firer = 1
      if (tgt.le.nblu) firer=nblu+1
      last = nblu
      if (tgt.le.nblu) last=nblu+nred
      DO 20 i=firer,last
         los(i,tgt) = .false.
         los(tgt,i) = .false.
20  CONTINUE
      call newtgt (t, firer, tgt)
      call cancel (tgt,'all ',NULL)
      call skedul(t,tgt,'slowup',NULL)
      call deaths(t)
      if (trace) print *, '<hide '
      END
c V7.3

```

```

SUBROUTINE IMPACT (t, bullet)
c 0  Impact: find what bullet does & what firer does.
    include 'common.h'
    logical loaded, hit
    integer bullet, expose
    atr(i) = a(bullet+i)

    if (trace) print *, '>impact'
c  Find useful variables.
    it = atr(1)
    I = atr(2)
    n = arny(I)
    k = kindrd(n)
    expose = knceal(it)
    rgx = 0.0
c  Find what bullet does.
    IF (it.eq.FLS TGT) THEN
c  Round does nothing.
        kshot(n,4) = kshot(n,4)+1
    ELSEIF (expose.eq.FD .and. k.le.2) THEN
c  Count round hitting berm.
        kshot(n,5) = kshot(n,5)+1
        if (keyd(1).ge.2) print *, 'Tgt in full defilade.'
    ELSE
c  See if round hits.
        call mayhit(t,I,it,n,k,atr(9),atr(10),expose,hit)
    ENDIF
    a(bullet) = -a(bullet)
c  Find what firer does.
    IF (k.eq.4) THEN
c  Missile
c  Clear guidance channel.
        DO 20 j=1,5
            IF (mslfly(n,I,j).eq.bullet) GOTO 30
20      CONTINUE
        print *, 'IMPACT: Msl not assigned a channel.'
        print *, 'Channels assigned to',(mslfly(n,I,j),j=1,5)
        print *, 'Msl #=',bullet,' Contact Fred Bunn'
        STOP
30      CONTINUE
        mslfly(n,I,j) = NULL
        loaded = nchan(I).ge.nchans(n)
        call diseng (t,I,it,.true.,loaded)
        mot(I,it)=.false.
        fot(I,it)=.false.
        if (knceal(I).eq.HD .and. nchan(I).eq.0 .and. empty(I))
1          call skedul(t,I,'popdn ',NULL)
        ELSE
c  KE, HEAT, or STAFF [rethink this for STAFF]
        IF (it.eq.FLS TGT .or. hit.and.tactic(n).eq.2 .or.
1          rgx.gt.4000.0) THEN
c  Switch targets if false target or rd hit & I switch on a hit.
c  Won't go here if I hit the berm; fls tgts don't go behind the
c  berm, and if true tgts do, the rd won't hit.
            ndet(I) = ndet(I)-1
            nrtgt(I)=0
            call diseng(t,I,it,.true.,.true.)
        ENDIF
    ENDIF
    if (trace) print *, '<impact'
END
c V7.2

```

```

c      INTEGER FUNCTION INDEXX(a, n, x)
c      -----
c      Find the index j, where  $a(j) \leq x < a(j+1)$ 
c      Adapted from Numerical Recipes, p98. The array ii must be increasing.
c      integer n, j1, ju, jm
c      logical incre, above
c      real a(n), x
c
c      incre = a(n).gt.a(1)
c      j1=0
c      ju=n+1
10      IF (ju-j1.gt.1) THEN
c          jm=(ju+j1)/2
c          above=x.gt.a(jm)
c          IF ((incre.and.above) .or. .not.(incre.or.above)) THEN
c              j1=jm
c          ELSE
c              ju=jm
c          ENDIF
c      GOTO 10
c      ENDIF
c      indexx=j1
c      END
c V7.1

```

```

SUBROUTINE INIT
c 4  Init: Initialize scenario & schedule search at time zero.
      include 'common.h'
      integer firer, tgt
      logical regard
      common /cdetrg/ tdet(2)
      common /cregrd/ regard(NN)

c
      if (trace) print *, '>Init'
      call skedul(tmax,0,'finish',NULL)
      call deploy
      last = nred+nblu
      call init2 (1, nblu)
      call init2 (nblu+1, last)
      dm = rgf (0.0,1,1+nblu)
c  Set state variables for both red and blue systems.
      DO 30 firer=1,last
         busy(firer) = .false.
         empty(firer) = .false.
         serchg(firer) = .true.
         ndet(firer) = 0
         narmy = army(firer)
         ncol = knceal(firer)-1
         if(narmy.eq.BLU .and. scene.eq.BATTAK) ncol = 3
         if(narmy.eq.RED .and. scene.eq.RATTAK) ncol = 3
         cansee(firer) = rg.lt.rgvis(ncol,firer)
         regard(firer) = .true.
      DO 20 tgt=1,last
         foes(firer,tgt)= army(firer).ne.army(tgt)
         know(firer,tgt) = 0
         los(firer,tgt) = foes(firer,tgt) .and. invisb.ne.2
         mot(firer,tgt) = .false.
         fot(firer,tgt) = .false.
         seen(firer,tgt) = .false.
20      CONTINUE
30      CONTINUE
c  Hardwired values
      accmax(BLU) = 2.5
      accmax(RED) = 2.5
      wvlth(BLU) = 50.
      wvlth(RED) = 50.
      ampl(BLU) = accmax(BLU)/(TWOPI*speed(BLU)/wvlth(BLU))**2
      ampl(RED) = accmax(RED)/(TWOPI*speed(RED)/wvlth(RED))**2
      call serchl
      if (trace) print *, '<Init'
      END
c V7.1

```

```

SUBROUTINE INIT2 (ifirst, last)
c 0 Init2: initialize each tank on one side.
include 'common.h'
dimension iexpos(2,3)
data iexpos /3, 3, 2, 3, 3, 2/
1 format(' INIT2: neval, nrd(1-3)=',4i5)
c
  if (trace) print *, '>init2'
  narmy = BLU
  if (ifirst.gt.1) narmy=RED
  last2 = nblu-nred
  jscene = iexpos(narmy, scene)
  DO 10 i=ifirst, last
    army(i) = narmy
    life(i) = ALIVE
    nrd(i) = 0
    nrtgt(i) = 0
    nchan(i) = 0
    nrot(i) = 0
    knceal(i) = jscene
c Change introduced by HL Reed 8 Mar 89 to allow overwatch tanks to
c be added to the attacking force. See also subroutines dr, lo2,
c input, and cango and common.h.
    if(inwatch(i)) knceal(i) = HD
    ichg(i) = 0
    motion(i) = MAXVL
    if(knceal(i).eq.HD .or. scene.eq.MEETING) motion(i) = STATNY
c End of 8 Mar 89 changes.
    nhot(i) = 0
    DO 8 j=1,5
      nsi fly(narmy,i,j) = 0
      nstats(j,narmy) = 0
8 CONTINUE
    DO 10 j=1,last2
      tfire(i,j) = 0.0
c Change by HLReed to make sure first round is loaded see ENGAGE also
      tfire2(i) = - tain(narmy)
      knceals(i,j) = .false.
10 CONTINUE
    IF (ndecoy(narmy).gt.0) THEN
c Change by H.L. Reed on 16 March 89 to correct decoys for Red Force
c and to make flashing decoys usually be overwatching tanks.
      ldecoy = last - ndecoy(narmy) - 1
      DO 20 i = ldecoy, last
        iflash(i) = 0
        if (i.gt.last - nflash(narmy)) iflash(i)=1
        if(iflash(i).eq.0)nrd(i)=999
c End of 16 March 89 change.
20 CONTINUE
      ENDIF
      call detrg(narmy)
      IF (invisb.eq.1) THEN
        if (narmy.eq.RED .and. scene.eq.RATTAK)
1 call terrain (ifirst,last)
        if (narmy.eq.BLU .and. scene.eq.BATTAK)
1 call terrain (ifirst,last)
      ELSE
        if (narmy.eq.BLU) call smoke
      ENDIF
c Correct the nr of rounds used by blue systems
      IF (narmy.eq.BLU .and. nwaves.gt.1) THEN
        DO 40 i=1,nblu
          nrd(i) = nused(neval+i)
40 CONTINUE
        print 1, neval, (nrd(i),i=1,3)
c
        neval = neval-nblu
      ENDIF
      if (trace) print *, '<init2'
      END
c V7.2

```

```

SUBROUTINE INPUT
c 9  Input: read misc inputs.
      include 'common.h'
      character*32 fname
      integer indx(5)
1     format(i1,a32)
4     format(a32)
c
c     Change introduced by H.L.Reed on 8 Mar 89 to allow overwatch
c     tanks to be added to the attacking force. See also changes in
c     subroutines deplo2, init2, and cango and in common.h.
      read(5,*)(ntanks(1,j),j=1,6), nwatch(1)
      read(5,*)(ntanks(2,j),j=1,6), nwatch(2)
      read(5,*)(ntanks(3,j),j=1,6), nwatch(3)
c     End of 8 Mar 89 change
      read(5,*)(keyd(i),i=1,5)
      trace=keyd(4).gt.0
      read(5,*)indx
      DO 20 i=1,5
        if (indx(i).gt.1 .and. indx(i).le.20) keym(indx(i))=1
20    CONTINUE
      read(5,*)min rg, max rg, inc rg, irginc
      rgincr = irginc
      rginc2 = 0.5*irginc
      read(5,*) nreps, nwaves, iangd, meth sm, iranda
      read(5,*) tmax
      read(5,4) fname
      call rdmisc(fname,BLU)
c     Read pkh data for Blue. Change by HLReed for new vulnerability model
      read 1, ipkh, fname
      call rdpkh(fname,BLU)
      read(5,4) fname
      call rdmisc(fname,RED)
c     Read pkh data for Red. Change by HLReed for new vulnerability model
      read 1, ipkh, fname
      call rdpkh(fname,RED)
      read(5,*) invisb,r
      IF (invisb.ne.1) THEN
        print *, 'Smoke causes intervisibility.'
        read *
        read *, ((touti1(i,j),j=1,5),i=1,21)
        read *
        read *, ((toutv1(i,j),j=1,5),i=1,21)
        read *
        read *, ((touti(i,j),j=1,5),i=1,21)
        read *
        read *, ((toutv(i,j),j=1,5),i=1,21)
        read *
        read *, ((tini(i,j),j=1,5),i=1,21)
        read *
        read *, ((tinvi(i,j),j=1,5),i=1,21)
      ENDIF
      if (trace) print *, '(input'
      END
c V7.1

```

```

FUNCTION IZHIT (nbox, ndim, narmy, x, y, tgt, theta)
c 6  Iz hit: find if the target is hit.
      include 'common.h'
      integer tgt
1     format (' IZHIT: the round is high. y, ylimit, x =', 3f7.3)
2     format (' IZHIT: the round is low. y, ylimit, x =', 3f7.3)
3     format (' IZHIT: the round is wide. y, ylimit =', 2f7.3, /
1     ' x, xleft, xright = ', 3f7.3)
4     format (' IZHIT: the round hits. y, ylimit =', 2f7.3, /
1     ' x, xleft, xright = ', 3f7.3)
c
      if (trace) print *, 'izhit'
      izhit = 0
      ylimit = sysdim(narmy, ndim)
      IF (ylimit.le.abs(y)) THEN
c        Too high or too low
          IF (keys(6).gt.0) THEN
            if (y.gt.0.0) print 1, y, ylimit, x
            if (y.le.0.0) print 2, y, ylimit, x
          ENDIF
        ELSE
c        Height ok
c        Find theta
          vtgt = vabs(vt)
          theta = aspect(tgt, nbox)*deg
c        Select tgt orientation between 0 & 360 deg.
          if (vtgt.gt.0 .and. nbox.eq.HULL) theta=anglef(VNORTH, vt)*deg
          phi = anglef(VNORTH, s)*deg
          thetal = angsum(phi, -theta)
          theta = thetal/deg
          call bounds (narmy, nbox, theta, xleft, xright)
          if (x.gt.xleft .and. x.lt.xright) izhit = 1
          IF (keys(8).gt.0) THEN
            if (izhit.eq.0) print 3, y, ylimit, x, xleft, xright
            if (izhit.eq.1) print 4, y, ylimit, x, xleft, xright
          ENDIF
        ENDIF
      if (trace) print *, '<izhit'
      END
c V7.2

```

```

SUBROUTINE KILL (firer, tgt, hit, injury, r)
c 9 Kill: find kill type for a hit on a tgt.
c The routine is called by mayhit.
c changed May 18, 1989 for simplified hit and kill model, HL Reed
include 'common.h'
logical hit
integer firer, tgt
common /cpkh2/ pkill(2,3,2,5,9)
save /cpkh2/
c Change for interpolation on range for pkill
p(i) = (1.0 - r) * pkill(narmy,ncase,nhdfe,i,jrg)
1 p(i) = r * pkill(narmy,ncase,nhdfe,i,jrg+1)
if (trace) print *, 'kill'
nhdfe = knceal(tgt)-1
narmy = army(firer)
IF (motion(tgt) .ne. STATNY) THEN
ncase = 3
ELSE IF (motion(firer) .ne. STATNY) THEN
ncase = 2
ELSE
ncase = 1
END IF
c Find kill level
c Change 12-9-89 by HLReed for interpolation on range for pkill
c Get ratio based on 500 meter intervals
r = r/500.
c Is range > 4000 meters if so then use 3999.5
if (r .GE. 8.) r = 7.999
c Get integer part
jrg = int(r)
c and fractional part
r = r - float(jrg)
c Correct for the fact that indices start at 1 rather than 0
jrg = jrg + 1
temp = ranu(0.0)
IF (temp .gt. p(1)) THEN
c no hit and no kill
hit = .false.
injury = ALIVE
ELSEIF (temp .gt. p(2)) THEN
c a hit and a 'k' kill
hit = .true.
injury = KKILL
ELSEIF (temp .gt. p(3)) THEN
c a hit and an 'mf' kill but no 'k'
hit = .true.
injury = MFKILL
ELSEIF (temp .gt. p(4)) THEN
c a hit and an 'f' kill but no 'm' kill
hit = .true.
injury = FKILL
ELSEIF (temp .gt. p(5)) THEN
c a hit and an 'm' kill but no 'f' kill
hit = .true.
injury = MKILL
ELSE
c a hit but no kill
hit = .true.
injury = ALIVE
ENDIF
if (injury.eq.ALIVE) kshot(narmy,10) = kshot(narmy,10)+1
if (injury.eq.MKILL) kshot(narmy,11) = kshot(narmy,11)+1
if (injury.eq.FKILL) kshot(narmy,12) = kshot(narmy,12)+1
if (injury.eq.MFKILL) kshot(narmy,13) = kshot(narmy,13)+1
if (injury.eq.KKILL) kshot(narmy,14) = kshot(narmy,14)+1
if (trace) print *, 'kill'
END
c V7 2

```

```

FUNCTION KILLS (firer, tgt, x, y)
c 9 Kill5: find kill type for a STAFF-like round.
c   sector = angle band
c   band = range band (distance above tgt).
   include 'common.h'
   integer firer, tgt
   integer fan, fans, band, sector
   common /cpkh5/ anglie(4), pkh5(2,7,4,4,12), y1, y2, y3, fans
   save /cpkh5/
   dimension pksave(4)
1   format (' KILL5: narray, ht,d,y1,y2,y3 =', i4,f8.1)
2   format (' kill level=', i1, ' ran=', f5.3, ' p(a,f,af,k)=', 4f5.2)
3   format (' KILL5: band, anglx, sector, fan=', i4,f8.1,2i4)
4   format (' KILL5: x,y=', 2f8.3)
c
   if (keyd(4).gt.0) print *, '>kill5'
   fan = nang
   if (nang.gt.fans) fan=14-nang
   pk = ranu(0,0)
   narray = array(firer)
   ht = y-y2-y3
   d = sqrt(x**2 + ht**2)
   IF (d.le.y1-y2) THEN
       kill = ALIVE
   ELSEIF (d.ge.y1-y2-70.0) THEN
       kill = ALIVE
   ELSE
       band = 7-int((d-y1-y2)/10.0)
       anglx = atan2(abs(x),ht)*DEG
       anglx = 90.-anglx
       sector = indexx(anglx,4,anglie)
       pksave(1) = pkh5(narray,band,sector,1,fan)
       pksave(2) = pksave(1)+pkh5(narray,band,sector,2,fan)
       pksave(3) = pksave(2)+pkh5(narray,band,sector,3,fan)
       pksave(4) = pksave(3)+pkh5(narray,band,sector,4,fan)
c   Find which kill type occurs.
       if (pk.lt.pksave(4)) kill = KKILL
       if (pk.lt.pksave(3)) kill = MFKILL
       if (pk.lt.pksave(2)) kill = FKILL
       if (pk.lt.pksave(1)) kill = MKILL
       if (pk.ge.pksave(4)) kill = ALIVE
       if (kill.eq.ALIVE) kshot(narray,10) = kshot(narray,10)+1
       if (kill.eq.MKILL) kshot(narray,11) = kshot(narray,11)+1
       if (kill.eq.FKILL) kshot(narray,12) = kshot(narray,12)+1
       if (kill.eq.MFKILL) kshot(narray,13) = kshot(narray,13)+1
       if (kill.eq.KKILL) kshot(narray,14) = kshot(narray,14)+1
   ENDIF
   kill5=kill
   if (keyd(4).gt.0) print *, '<kill5'
   END
c V7.1

```

```

SUBROUTINE LATE KL (t, tgt, jj)
c 3  Late kl: Simulate recognition of a&f kill after period of inactivity.
      include 'common.h'
      integer firer, tgt
1     format(f8.2,1x,a4,i3,' I-killed.')
c
      if (trace) print *, '>latekl'
      if (keyd(1).gt.1) print 1, t, color(army(tgt)), tgt
      firer = 1
      if (tgt.le.nblu) firer=nblu-1
      life(tgt) = IKILL
      call cancel (tgt, 'ikill ',NULL)
      call newtgt (t,firer,tgt)
      call deaths(t)
      if (trace) print *, '<latekl'
      END
c V7.1

```

```

SUBROUTINE MAX VEL(t, firer)
c 6 Max vel: simulate tank reaching cruise speed.
  include 'common.h'
  integer firer, tgt
1  format (f8.2,1x,a4,i3,' at full speed.')
c
  if (trace) print *, 'maxvel'
  if (keyd(1).ge.2) print 1, t, color(array(firer)), firer
  call path(firer,t,motion(firer),0.0,x,y,vx,vy)
  motion(firer) = MAXVL
  tgt = nrtgt(firer)
  IF (tgt.gt.0) THEN
    if (life(tgt).lt.IKILL) call engage(t,t,firer,nrtgt(firer))
  ENDIF
  if (trace) print *, '<maxvel'
END
c V7.4

```

```

SUBROUTINE MAYHIT (t,I,it,n,k,v1,v2,expose,hit)
c 0 Mayhit: Find what the round does.
c Changed May 18, 1989 for simplified hit and kill model, HL Reed
  include 'common.h'
  logical hit
  integer expose

  if (trace) print *, '>mayhit'
  kshot(n,6) = kshot(n,6)+1
c Find whether a hit occurs.
  hit = .false.
  rgx = rgf(t,I,it)
  r = rgx
  call kill(I,it,hit,injury,r)
  IF (hit) THEN
c Treat hit.
    kshot(n,8) = kshot(n,8)+1
    if (life(it).eq.MFKILL) nhot(it)=nhot(it)+1
    if (nhot(it).gt.nbump(n)) call skedul(t,it,'ikill',NULL)
    know(I,it)=2
    prevrd(I) = 2
    IF (reliab(n) .ge. ranu(0)) THEN
      call damage(t, I, it, injury)
    ELSE
c Round is a dud.
      kshot(n,9) = kshot(n,9)+1
    ENDIF
  ELSE
c Treat miss.
    kshot(n,7) = kshot(n,7)+1
    IF (psense(n,nrgf(rgx,rgincr)) .gt.ranu(0.0)) THEN
      prevrd(I) = 4
c Changed by HLReed. seems to be needed
      know(I,it)=1
      if (keyd(1).ge.2) print *, ' Miss is sensed.'
    ELSE
      prevrd(I) = 3
      if (keyd(1).ge.2) print *, ' Miss is not sensed.'
    ENDIF
  ENDIF
c Careful. If either moving, make sure nx rd is treated as 1st
c round if SS case occurs.
  if (vabs(vt).gt.0 .or. vabs(vf).gt.0) prevrd(I)=1
  if (v1.gt.0 .or. v2.gt.0) prevrd(I)=1
  if (trace) print *, '<mayhit'
END
c Needs data checking.
c V7.1

```

```

SUBROUTINE MK TBL (onlym,onlyf,fandm,mdisp,k,nrow)
c 3  Mk tbl: make head-on pkh table for echo.
      include 'common.h'
      common /cpkh/ table (4,12), echo(2,7,7), jrg(2,7), jdisp(2,7)
c
      if (trace) print *, '>aktbl'
      jrg(k,nrow) = (nrow-1)*irginc
      DO 11 j=1,4
        echo(k,nrow,j) = table(j,1)
11    CONTINUE
      echo(k,nrow,5) = onlym
      echo(k,nrow,6) = onlyf
      echo(k,nrow,7) = fandm
      jdisp(k,nrow) = mdisp
90    if (trace) print *, '<aktbl'
      END
c V7.2

```

```

SUBROUTINE NEWTGT (t, firer, tgt)
c 3 New tgt: redirect all 'attackers' of tgt to a new target.
c New tgt called for non-false tgts only and only if tgt condition
c warrants it. It should only be called if tgt is V-killed,
c vanishes, or hides.
c Maybe it should be called if the tgt is I-killed by a gun system.
c include 'common.h'
integer first, firer, tgt, arrayf, arrayt
logical loaded, hav amo, cango
1 format(f8.2,1x,a4,i3,' dis-engs ',a4,i3,20x,'#tgts=',i2)
2 format(f8.2,1x,a4,i3,' begins to reload.')
c
  if (trace) print *, 'newtgt'
c Find first and last 'attacker'
  first = 1
  if (firer.gt.nblu) first = nblu+1
  last = nblu
  if (firer.gt.nblu) last = nblu-nred
arrayf = array(first)
arrayt = 3-arrayf
kind = kindrd(arrayf)
nrpb2 = nrpb(arrayf)
DO 20 j=first, last
  IF ((not(j,tgt) .or. fot(j,tgt)) .and. life(j).lt.FKILL) THEN
    IF (kind.le.2 .or. kind.eq.5) THEN
c Single shot gun system or other fire & forget system.
      IF (nrpb(arrayf).le.1) THEN
c Single shot gun system.
        call cancel(j,'fire ',tgt)
        if (nrtgt(j).eq.tgt) busy(j) = .false.
        if (nrtgt(j).eq.tgt) nrtgt(j) = 0
        hav amo = nrd(j).lt.nrds(arrayf)
        IF (hav amo) THEN
          thuman = 0.*exp(rolln(0.5))
          call seles(t,j,thuman)
        ELSEIF (can go(j,t).and.ishtfs(arrayf).gt.0) THEN
c Move out
          call skedul(t,j,'accel ',NULL)
        ENDIF
        nrot(j) = 0
        fot(j,tgt) = .false.
        if (keyd(1).ge.2) print 1, t, color(arrayf), j,
1 color(arrayt), tgt, nchan(j)
      ELSE
c Burst fire gun.
        print *, 'NEWTGT: Not implemented for burst fire.'
        STOP
      ENDIF
    ELSEIF (kind.eq.4) THEN
c Guided missile branch.
      if (fot(j,tgt)) call cancel(j,'fire ',tgt)
      if (not(j,tgt)) call abort(t,j,tgt)
      loaded = nchan(j) .eq. nchans(arrayf)
      IF ((.not.empty(j) .and. not(j,tgt) .and. loaded) .or.
1 (.not.empty(j) .and. fot(j,tgt))) THEN
1 IF ((mod(nrd(j),nipods(arrayf)) .gt. 0) .or.
c fot(j,tgt)) THEN
      More rds in pod
      IF (fot(j,tgt)) THEN
        call cancel(j,'select',NULL)
        busy(j) = .false.
        fot(j,tgt) = .false.
      ENDIF
c if (tgt.ne.FLS TGT) fot(j,tgt) = .false.
      thuman = 0.*exp(rolln(0.5))
      call seles(t,j,thuman)

```

```

ELSE
c   Treat empty missile pod
      empty(j) = .true.
      call cancel(j,'fire ',tgt)
      call cancel(j,'select',NULL)
      busy(j) = .false.
      nrot(j) = 0
c   shud htf that is slowing to engage speed up now?
      call skedul (t+treiod(arrayf),j,'reload',NULL)
      if (keyd(1).ge.2) print 2,t,color(arrayf),j
ENDIF
ENDIF
nchan(j) = nchan(j) -1
nrtgt(j) = 0
fot(j,tgt) = .false.
ENDIF
ENDIF
if (seen(j,tgt)) ndet(j) = ndet(j) - 1
seen(j,tgt) = .false.
20  CONTINUE
IF (.not.repeat) THEN
      repeat = .true.
      call skedul (t+.01,0,'search',NULL)
ENDIF
c   Following removed cause duplicates code in deaths routine
c   and is incorrect.
c   ndead=0
c   IF (arrayt.eq.RED) THEN
c       DO 30 i=nblu+1,nblu+nred
c           if(life(i).gt.FKILL) ndead=ndead+1
c30  CONTINUE
c       if (ndead.eq.nred) call skedul(t+.5.,NULL,'finish',NULL)
c   ELSE
c       DO 40 i=1,nblu
c           if(life(i).gt.FKILL) ndead=ndead+1
c40  CONTINUE
c       if (ndead.eq.nblu) call skedul(t+.5.,NULL,'finish',NULL)
c   ENDIF
c   if (trace) print *, '<newtgt'
c   END
c V7.1

```

```

SUBROUTINE NEXTEV (I,act,it,t)
c 0  Nextev: Find the next scheduled event.
      include 'clock.h'
      character*8 act
c
c  Fill arguments
      I = who(nxevnt)
      act = what(nxevnt)
      it = whom(nxevnt)
      t = when(nxevnt)
c  Drop storage unit from active storage chain
      n = nxevnt
      nxevnt = next(nxevnt)
c  Add storage unit to inactive storage.
      next(n) = nxidle
      nxidle = n
      END
c V7.1

```

```

FUNCTION NRGF (rg,rgincr)
c 9   Nrgf: find which rgincr meter rg band range is in.
CHANGED 1 Apr 88. Next line changed.
c     nrgf = max0(1,int( (250.*rg)/500. ))
      nrgf = max0(1,int(0.5*rg/rgincr))
      END

c V7.2

```

```

SUBROUTINE NXWAVE
c 9  Nx wave: Simulate all reps for the nth engagement.
      include 'common.h'
      character*4 str(3)
      dimension istatb(8)
      data str /'Mtg ','Ratk','Batk'/

c
      if (trace) print *, '>Nxwave'
      nrg = rg0/irginc
      nreps2 = nsurv/nblu
      neval = mod(nsurv,nblu)
      noammo = 0
      loammo = 0
      nsurv = neval
      DO 20 i=1,8
        statb(i) = 0.0
20    CONTINUE
c      Changed by HLReed for printing
      DO 21 i=1,4
        mystat(i) = 0
21    CONTINUE
      DO 30 nrep = 1,nreps2
        krep=nrep
        call events
30    CONTINUE
c      Update statistics after all reps of nth engagement.
c      Changed by HLReed for printing
      temp1 = float(mystat(1))/float(nreps2)
      temp2 = float(mystat(2))/float(nreps2)
      temp3 = float(mystat(3))/float(nreps2)
      temp4 = float(mystat(4))/float(nreps2)
      DO 40 i=1,8
        statc(i) = statc(i) + statb(i)
40    CONTINUE
      noammo2 = noammo2-noammo
      loammo2 = loammo2-loammo
      DO 50 i=1,4
        istatb(i) = 0.5 + 100*statb(i) / nreps2
        statb(i+4) = statb(i+4) / nreps2
50    CONTINUE
c      Changed by HLReed for printing
2      format(f5.0,f6.3,f6.3,f6.3,f6.3,i4,i4,f6.2,f8.3,f8.3)
        exchc = 0
        if (statc(5).gt.0) exchc = statc(6)/statc(5)
        print 2,rg0,temp1,temp2,temp3,temp4,istatb(1),istatb(2),
1      exchc,statb(7), statb(8)
        nreps3 = nreps3+nreps2
        if (trace) print *, '<nxwave'
      END
c V7.2

```

```

SUBROUTINE PATH (firer,t, motio2, delt, x, y, vx, vy)
c 4 Path: search path table for position and vel at time t.
include 'common.h'
logical is atkr, kan go, old
integer firer

c
  if (trace) print *, '>path'
  narmy = army(firer)
  is atkr = (scene.eq.RATTAK .and. narmy.eq.RED) .or.
1 (scene.eq.BATTAK .and. narmy.eq.BLU)
  kan go := (motio2.ne.STATNY .or.
1 life(firer).eq.ALIVE .or. life(firer).eq.FKILL)
  dt = t-t0(firer)
  old = dt .gt. delt
  IF (is atkr .and. kan go .and. old) THEN
c Update positions and velocity.
    t0(firer) = t
    if (motio2.eq.SLOWNG) THEN
      dv = decel(narmy)*dt
      y0(firer) = y0(firer)-dt*(vy0(firer)-0.5*dv)
      v = vy0(firer)-dv
      if (abs(v).lt.0.001) v = 0.0
      vy0(firer) = v
    ELSEIF (motio2.eq.STATNY) THEN
      vy0(firer) = 0.0
    ELSEIF (motio2.eq.ACCELG) THEN
      dv = accel(narmy)*dt
      y0(firer) = y0(firer)-dt*(vy0(firer)+0.5*dv)
      vy0(firer) = vy0(firer)+dv
    ELSEIF (motio2.eq.MAXVL) THEN
      y0(firer) = y0(firer)+vy0(firer)*dt
      vy0(firer) = speed(narmy)
    ELSE
      print *, 'PATH: no such motion. motio2=,', motio2
      STOP
    ENDIF
    IF (accmax(narmy) .ne.0.) THEN
c Add sinusoidal motion
      omega = TWOPI/wvlth(narmy)
      x0(firer) = ampl(narmy)*sin(omega*y0(firer))+
1 xp(firer)
      vx0(firer) = ampl(narmy)*cos(omega*y0(firer))+
1 omega*vy0(firer)
    ENDIF
    ENDIF
    x=x0(firer)
    y=y0(firer)
    vy=vy0(firer)
    vx=vx0
    if (trace) print *, '<path'
  END

```

c V7.2

```

SUBROUTINE PINPNT (t,firer)
c 8  Pinpnt: Simulate firing signature (pinpoint) detection by some foes.
      include 'common.h'
      integer first, firer
      logical wilsee
1     format (f8.2,1x,a4,i3,' sees      ',a4,i3,' muzzle flash')
c
      if (trace) print *, '>pinpnt'
      first = 1
      if (firer.le.nblu) first = nblu+1
      last = nblu
      if (firer.le.nblu) last = nblu+nred
      pinpx = pinp(array(first))
      DO 20 i=first, last
         wilsee = pinpx.gt.ranu(0.0)
         IF (life(i).lt.FKILL .and. wilsee .and.
2          ndet(i).lt.ndets(array(i)) .and.
1          los(i,firer) .and. .not.seen(i,firer)) THEN
            if (keyd(1).ge.2) print 1,
1            t, color(array(i)), i, color(array(firer)), firer
            seen(i,firer) = .true.
            ndet(i) = ndet(i) + 1
c          Change by HLReed added new variable for pinpoint time and
c          transfer of pinpoint detection
            thuman = pntime(array(i)) *exp(rolln(0.5))
            call selects(t,i,thuman)
            if(xfer(array(i))) call skedul(t-thuman,first,'xfer ',firer)
            ENDIF
20      CONTINUE
      if (trace) print *, '<pinpnt'
      END
c V7.1

```

```
      SUBROUTINE POP DN (t,firer)
c 0      Pop dn: Have defender pop down to reload?
          include 'common.h'
          integer firer
c
          if (trace) print *, '>pop dn'
          call vanter(t,firer,NULL)
          if (trace) print *, '<pop dn'
          END
c V7.1
```

```

SUBROUTINE PR GAME
c 9  pr game: print game control constants.
      include 'common.h'
1    format(21x,'#Blues      #Reds',/,
2    ' Meeting engagement: ',3i2,4x,3i2,/,
3    ' Red attack:         ',3i2,4x,3i2,/,
4    ' Blue attack:        ',3i2,4x,3i2)
2    format (' DO rg=',3i5,' (opening ranges)')
3    format (20i2)
4    format (' nreps =',i5,' nwaves =',i3,' iangd =',i2)
5    format (/,20('='),'RUN DESCRIPTION',20('='))
6    format (55('='),/)
c
      if (trace) print *, '>prgame'
      print 5
      print 1, ((ntanks(i,j), j=1, 6), i=1, 3)
      print 2, minrg, maxrg, incrg
      print 3, keyd
      print 3, keya
      print 4, nreps, nwaves, iangd
      IF (meth sm.eq.1) THEN
        print *, 'AMSAA MS error treatment.'
      ELSEIF (meth sm.eq.2) THEN
        print *, 'BRL MS error treatment.'
      ELSE
        print *, 'Error treatment value 'meth sm' wrong.'
      ENDIF
      print 6
      if (trace) print *, '<prgame'
      END
c V7.2

```

```

c 6  INTEGER FUNCTION PRIORN (t, firer, lev old)
      Priorn: select tgt with highest priority.
      include 'common.h'
      logical better, ck tgt
      logical pick
      integer firer, armyf

c
      if (trace) print *, '>priorn'
      armyf = army(firer)
c      'make' dummy tgt for comparison
      rg old=1.e35
      t old=1.e35
      lev old=1000
      priorn = NULL
      last = nblu-nred
      DO 30 mtgt=1,last
c      Compare all possible targets
      pick=.true.
c      Don't select this target if I'm already servicing it.
      if(not(firer,mtgt).or fot(firer,mtgt))pick=.false.
      rg tgt = rgf (t,firer,mtgt)
      ck tgt = seen(firer,mtgt) .and. life(mtgt).lt.IKILL
1      .and. rgtgt.le.4000.0 .and. pick
      IF (ck tgt) THEN
c      Firer sees tgt, it's threatening, & he's not firing at it.
      call priort(firer, mtgt, rg tgt, t, level)
c      Change by HLReed for way share is handled
      if(share(armyf)) then
      lll = 0
      do 20 jjj = 1,last
      if(not(jjj,mtgt).or.fot(jjj,mtgt)) lll=30
20      continue
      level = level + lll
      endif
c      Now pick the tgt with highest priority
      rg tgt = rg tgt *(1+.05*rolln(1.0))
      t tgt = tfire(firer,mtgt)
      better = level .lt. lev old
      IF (lev old.eq.level) THEN
c      Same priority class; now break ties
c      if new tgts pick closer
      if (t tgt.le. 0) better = rg tgt .lt. rg old
c      if old tgts, pick older (least recently fired on)
      if (t tgt.gt. 0) better = t tgt .lt. t old
      ENDIF
      - IF (better) THEN
      lev old = level
      t old = t tgt
      rg old = rg tgt
      priorn = mtgt
      ENDIF
      ENDIF
30      CONTINUE
      if (trace) print *, '<priorn'
      END
c V7.2

```

```

SUBROUTINE PRIORT(firer, tgt, rg tgt, t, L)
c 0  PRIORT: find priority of tgt (w/ preference to old tgts)
      include 'common.h'
      integer firer, tgt
      dimension lev(21,2)
      save lev
      data lev/1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,
*       1,2,3,4,5,6,7,8,9,15,16,17,18,19,20,21,10,11,12,13,14/
1  format(' PRIORT: ',a4,i3,' consids ',a4,i3,' with priority',
1  i4,' ('i2,')')
c
      if (trace) print *, '>priorit'
      j = nprior(array(firer))
      m = motion(tgt)
      t activ = 1.e35
      if (tfire2(tgt).gt.0.) t activ = t-tfire2(tgt)
      IF (tfire(firer,tgt).gt.0) THEN
c  firer has already shot at this target previously
      IF (know(firer,tgt).eq.1) THEN
c  Missed target with last round fired at it
      IF (rg tgt.lt.recknz(array(firer))) THEN
c  Target is within recognition range
          L = 5
          if (m.eq.STATNY .or. m.eq.SLOWNG) L = 3
          if (nrtgt(tgt).ne.0) L = 2
          if (t activ .lt. 30.) L = 1
      ELSE
c  Target is beyond recognition range
          L = 7
          if (m.eq.STATNY) L = 6
          if (t activ .lt. 30.) L = 4
      ENDIF
      ELSE
c  Hit target with last round fired at it
      IF (rg tgt.lt.recknz(array(firer))) THEN
c  Target is within recognition range
          L = 14
          if (m.eq.STATNY .or. m.eq.SLOWNG) L = 12
          if (nrtgt(tgt).ne.0) L = 11
          if (t activ .lt. 30.) L = 10
      ELSE
c  Target is beyond recognition range
          L = 16
          if (m.eq.STATNY) L = 15
          if (t activ .lt. 30.) L = 13
      ENDIF
      ENDIF
      ELSE
c  Target is a new target
      IF (rg tgt.lt.recknz(array(firer))) THEN
c  Target is within recognition range
          L = 19
          if (m.eq.STATNY .or. m.eq.SLOWNG) L = 18
          if (nrtgt(tgt).ne.0) L = 17
          if (t activ .lt. 30.) L = 8
      ELSE
c  Target is beyond recognition range
          L = 21
          if (m.eq.STATNY) L = 20
          if (t activ .lt. 30.) L = 9
      ENDIF
      ENDIF
      L = lev(L,j)
      if (trace) print *, '<priorit'
      END

```

c V7.2

```

SUBROUTINE PR MISC(narmy)
c 3  Pr misc: print misc tank characteristics.
      include 'common.h'
      integer irg(8)
10   format(/, '=====BLUE SYSTEM DESCRIPTION',
1     '=====')
11   format(/, '=====RED SYSTEM DESCRIPTION',
1     '=====')
12   format(/,
1     ' SYSTEM DIMENSIONS', 21x, 'MOTION CHARACTERISTICS', /,
1     ' Distance (m) from center of',
1     11x, 'Acceleration', f8.2, ' m/s**2', /,
1     ' turret ring to:', 23x, 'Deceleration', f8.2, ' m/s**2', /,
1     ' Turret top ', f8.2, ' Ground ', f8.2,
1     ' Time to hide', f8.2, ' sec', /,
1     ' Turret Side ', f8.2, ' Hull side ', f8.2, /,
1     ' Turret front', f8.2, ' Hull front', f8.2, /,
1     ' Turret back ', f8.2, ' Hull back ', f8.2, /)
13   format(/,
1     9x, '-----DETECTION CAPABILITY-----',
2     ' -----FIRING CYCLE-----'
1     , /, ' Rg Psense P-detect T-median ',
1     ' Tfirst Tfixed Tfly', /,
1     ' (m) HD FE FE-M HD FE FE-M',
1     ' (sec) (sec) (sec)', /,
1     8(i7,2f7.2,2f8.2,f8.2,2f7.2,f7.1,f8.1,f8.2, /))
15   format(' System ammo load is', i3, ' KE rounds')
16   format(' System ammo load is', i3, ' HEAT rounds')
17   format(' System ammo load is', i3, ' wait-til-impact missiles')
18   format(' System ammo load is', i3,
1     ' simultaneous-flight missiles with', i2, 'pod &', /,
2     ' reload time', f7.1)
19   format(' System ammo load is', i3, ' STAFF-like rounds')
20   format(' Systems can engage', i2, ' targets simultaneously.')
21   format(
1     ' Switch targets after:', /, ' 1. A K-kill',
2     ' (& don''t re-engage)', /,
1     ' 2. An M&F-kill and', i2, ' hits or', f5.1, ' sec.',
2     ' (& don''t re-engage)')
22   format(' 3. After scoring a hit.')
23   format(' 3. After', i3, ' shots.')
24   format(' Return to partially serviced target after vainly', /,
1     ' searching', f7.2, ' sec for a new target.')
25   format(' System halts to fire.')
26   format(' System fires on the move.')

27   format(' Median time between rounds is', f8.2, ' sec.')
28   format(' System fires', i2, ' round bursts with rounds',
1     ' spaced', f8.2, ' sec apart.')
29   format(' There are', i3, ' decoys', i3,
1     ' of which are flashing.')
30   format(' Minimum time to fire next round is', f8.2, ' sec.')
31   format(' Probability of firing signature detection is', f8.2)
32   format(' Reliability is', f8.2)
33   format(' Recognizes targets inside', f8.8, ' meters.')
34   format(' Probability of picking false HD, FE tgts are', 2f8.3)
35   format(' Selects old, hit targets before new targets.')
36   format(' Selects new targets before old, hit targets.')
37   format(' Tgt sharing is set. Won''t pick a tgt being serviced.')
38   format(' Tgt sharing is off. Will pick a tgt being serviced.')
39   format(' Systems can detect', i2, ' targets simultaneously.')
c

```

```

        if (trace) print *, '>prmisc'
        DO 50 i=1,8
            irg(i) = iairginc
50      CONTINUE
c      Write header
        if (narmy.eq.1) print 10
        if (narmy.eq.2) print 11
c      Write system dimensions and motion characteristics
        print 12, accel(narmy), decel(narmy),
1      sysdia(narmy,1), sysdia(narmy,5), thide(narmy),
1      (sysdia(narmy,i), sysdia(narmy,i+4), i=2,4)
c      Write range dependent values
        print 13,
1      (irg(i), psense(narmy,i), (pinfin(narmy,j,i), j=1,3),
2      (tbar(narmy,j,i), j=1,3),
1      tfirst(narmy,i), tfixed(narmy,i),
1      tof(narmy,i), i=1,8)
c      Target switching policy
        i = tactic(narmy)
        print 21, nbump(narmy), tbump(narmy)
        if (i.eq.2) print 22
        if (i.eq.3) print 23, nrpt(narmy)
        if (i.gt.1) print 24, tlook(narmy)
        print 29, ndets(narmy)
        print 20, nchans(narmy)
        if (nprior(narmy).eq.1) print 35
        if (nprior(narmy).eq.2) print 36
        print *
c      Write projectile information
        if (kind rd(narmy).eq.1) print 15, nrds(narmy)
        if (kind rd(narmy).eq.2) print 16, nrds(narmy)
        if (kind rd(narmy).eq.3) print 17, nrds(narmy)
        if (kind rd(narmy).eq.4) print 18, nrds(narmy),
1      nipods(narmy), trelod(narmy)
        if (kind rd(narmy).eq.5) print 19, nrds(narmy)
        if (ishtfs(narmy).gt.0) print 25
        if (ishtfs(narmy).eq.0) print 26
        print 27, taedin(narmy)
        print 30, tain(narmy)
        print 32, reliab(narmy)
        print 31, pinp(narmy)
        print 33, recknz(narmy)
        print 34, (pfalse(narmy,i), i=1,2)
        if (nrpb(narmy).gt.1) print 28, nrpb(narmy), rof(narmy)
        if (ndecoy(narmy).gt.0) print 29, ndecoy(narmy),
1      nflash(narmy)
        if (share(narmy)) print 37
        if (.not.share(narmy)) print 38
        if (trace) print *, '<prmisc'
        END
c V7.2

```

```
FUNCTION RANU (dm)
c  Ranu: A version of uran31 random uniform nr generator.
common /crandm/ i, j
real a1
j=i
j=j*25
j=j-(j/67108864)*67108864
j=j*25
j=j-(j/67108864)*67108864
j=j*5
j=j-(j/67108864)*67108864
a1=j
i=j
ranu= a1/67108864
END
c V7.2
```

```

SUBROUTINE RD MISC (dbname,narmy)
c 9  Rd misc: read miscellaneous tank characteristics.
    include 'common.h'
    character dbname*32, line*72
    real high(2)
2    format(1a1)
3    format(a)
c
    if (trace) print *, '>Rdmisc'
    open(4, file=dbname, status='old')
    rewind 4
    read(4,*) (sysdim(narmy,i),i=1,8)
    read(4,*) (psense(narmy,i),i=1,8)
c    Read nvl outputs.
        read(4,*) (pinfin(narmy,1,j),j=1,8)
        read(4,*) (pinfin(narmy,2,j),j=1,8)
        read(4,*) (pinfin(narmy,3,j),j=1,8)
        read(4,*) (tbar(narmy,1,j),j=1,8)
        read(4,*) (tbar(narmy,2,j),j=1,8)
        read(4,*) (tbar(narmy,3,j),j=1,8)
c    Change by HLReed added pinpoint time input
        read(4,*) recknz(narmy), (pfalse(narmy,i),i=1,2),
1        tlook(narmy), pinp(narmy), reliab(narmy), trelod(narmy),
2        pntime(narmy)
        read(4,*) nrds(narmy), nrpt(narmy), nrpb(narmy),
1        tactic(narmy), kind rd(narmy), nprior(narmy),
2        nipods(narmy), nchans(narmy)
        read(4,*) (tof(narmy,i),i=1,8)
        read(4,*) (tfirst(narmy,i),i=1,8)
        read(4,*) tamedin(narmy), tmin(narmy), rof(narmy)
        read(4,*) (tfixed(narmy,i),i=1,8)
        read(4,*) accel(narmy), decel(narmy), speed(narmy),
1        angle(narmy), thide(narmy)
        read(4,*) ishtfs(narmy), nbump(narmy), ibump
        tbump(narmy) = ibump
        read(4,*) ndecoy(narmy), nflash(narmy)
c    Change by HLReed added xfer for control of target transfer
        read(4,*) share(narmy), xfer(narmy)
        read(4,2) kview(narmy)
        read(4,*) ndets(narmy)
        close (4)
        if (keyd(2).gt.8) call pr misc (narmy)
c    Convert tbar to detection probability / second.
        DO 30 i=1,8
            DO 20 j=1,3
                tbar(narmy,j,i) = 1.8-exp(-1.8/tbar(narmy,j,i))
20            CONTINUE
30        CONTINUE
        if (trace) print *, '<rdmisc'
        END
c V7.2

```

```

SUBROUTINE RDPKH (dbname, narmy)
c 3  Rd pkh: read probability-of-kill data.
c    Changed for simplified hit and kill model May 19, 1989, HL Reed
      include 'common.h'
      character*32 dbname
      common /cpkh2/ pkill(2,3,2,5,9)
      save /cpkh2/
      if (trace) write(*,*) '>rdpkh'
      open (4, file=dbname, status='old')
      rewind 4
      DO 100 ncase = 1,3
      DO 70 nhdf=1,2
      DO 30 i=1,5
        read (4,*) n1,n2,n3, (pkill(narmy,ncase,nhdf,i,j),j=1,9)
30    CONTINUE
70    CONTINUE
100   CONTINUE
      close(4)
90    if (trace) write(*,*) '<rdpkh'
      END
c V7.1

```

```

SUBROUTINE RELOAD (t,firer)
c 6 Reload: simulates completion of reloading
c 30 Oct 85 Fixed statement printing error message
include 'common.h'
integer firer
logical defndr
1 format(f8.2,1x,a4,i3,' finishes reloading')
2 format(f8.2,1x,a4,i3,' pops-up')
c
  if (trace) print *,')reload'
  narmy = army(firer)
  if (keyd(1).ge.2) print 1,t,color(narmy),firer
  nrtgt(firer) = 0
  empty(firer) = .false.
  defndr = (scene.eq.BATTAK .and. narmy.eq.RED) .or.
1 (scene.eq.RATTAK .and. narmy.eq.BLU)
  IF (defndr) THEN
c Defender pops back up and will start searching.
  if (keyd(1).ge.2) print 2,t,color(narmy),firer
  call aprter(t,firer,tgt,HD)
  ELSE
c Attacker or 'meeter' never popped down.
  thuman = 0.0*exp(rolln(0.5))
  call selecs(t,firer,thuman)
  ENDIF
  if (trace) print *,'<reload'
  END
c V7.1

```

```
      SUBROUTINE RESET (prflg)
c 0      Reset: Initialize the clock to time zero.
          include 'clock.h'
          logical prflg
c
          prflag = prflg
          nxevnt = 0
          nxidle = 1
          DO 10 j=1,NE
              next(j) = j+1
10      CONTINUE
          next(NE) = 0
          END
c V7.2
```

```

FUNCTION RGF (t, firer, tgt)
c 3  Rgf: find the position of the firer w.r.t. the tgt.
      include 'common.h'
      integer firer, tgt
      common /pathc / xf, yf, xt, yt
      save /pathc /
1      format (9x, 'Firer  x, y, vx, vy =', 4f10.1, /
*         9x, 'Target x, y, vx, vy =', 4f10.1)
c
      if (trace) print *, '>rgf'
      call path (firer, t, motion(firer), 0.0, xf, yf, vf(1), vf(2))
      call path (tgt, t, motion(tgt), 0.0, xt, yt, vt(1), vt(2))
      s(1) = xf - xt
      s(2) = yf - yt
      s(3) = 0.0
      vt(3) = 0.0
      vf(3) = 0.0
      temp = vabs(s)
      if (temp.GT.4000) temp = 4000
      nrg = nrgf(temp, rgincr)
      rgf = temp
      rg = irgincenrg
      if (keyn(20).gt.0) print 1,
*         xf, yf, vf(1), vf(2), xt, yt, vt(1), vt(2)
      if (trace) print *, '<rgf'
      END
c V7.2

```

```

FUNCTION RNDANG(iangd)
c  RNDANG: Draw a random angle from a cardioid/other distribution.
c
  PI=3.1415926536
  denom = 0.5/PI
  p=ranu(dummy)
c  Do binary search to find theta associated with random draw
  tlo = -PI
  if (iangd.gt.1) tlo = -PI/3.
  thi = PI
  if (iangd.gt.1) thi = PI/3.
  DO 20 i=1,10
    theta = 0.5*(tlo+thi)
    if (iangd.eq.1) px = (theta+sin(theta)*PI)*denom
    if (iangd.gt.1) px = (3.*theta+sin(3.*theta)*PI)*denom
    IF (px.lt.p) THEN
      tlo = theta
    ELSE
      thi = theta
    ENDIF
  20  CONTINUE
  rndang=theta
  theta=theta*180./PI
  END
c V7.2

```

```

FUNCTION ROLLN(sigma)
c 6  Rolln: find a random number from a normal distribution.
c    Box-Muller method
      save j, z
      data j/0/
c
      IF (j.eq.0) THEN
        x = sqrt(-2.*alog(ranu(dm)))
        y = 2.*3.1415926535*ranu(dm)
        rolln = x*cos(y)*sigma
        z = x*sin(y)
      ELSE
        j = 1-j
        rolln = z*sigma
      ENDIF
      END
c V7.3

```

```

SUBROUTINE SEARC2 (t,firer,tgt,narmy,cond,dt)
c ?  Searc2: see if a tank detects a target during this second.
      include 'common.h'
      integer firer, tgt, cond
c
      if (trace) print *, '>searc2'
      temp = rg/rgincr
      indx = int(temp)
      IF (indx .lt. 1) THEN
         tlo = 1.0
         thi = tbar(narmy,cond,1)
      ELSEIF (indx .lt. 8) THEN
         tlo = tbar(narmy,cond,indx)
         thi = tbar(narmy,cond,indx+1)
      ELSE
         tlo = tbar(narmy,cond,8)
         thi = 0.0
      ENDIF
      frac = temp-int(temp)
      pdetct = tlo + frac*(thi-tlo)
      IF (ranu(0.0).gt.pdetct) THEN
c      The firer doesn't detect the target in the next second.
         repeat = .true.
         dt = 1.0
      ELSE
c      This firer detects the target in this second.
         call skedul(t-ranu(0.0),firer,'detect', tgt)
      ENDIF
      if (trace) print *, '<searc2'
      END
c V7.3

```

```

SUBROUTINE SEARCH (t)
c 3 Search: see if any targets are detected in1 the next second.
include 'common.h'
logical ignore
common /cserch/ i1,in,j1,jn,v,rgtbl(NN,NN),ignore(NN),rgvs(NN),
1 ymax(NN),iarmy,jarmy,ndeti,ndetj,ni,nj
save /cserch/
rss(x,y) = sqrt(x*x+y*y)

c
if (trace) print *, '>search'
repeat = .false.
c Update status of tanks.
c (Next line shud eventually be updated in damage.f, ltkill.)
DO 20 i=1,nblu-nred
ignore(i) = ignore(i).or.life(i).ge.IKILL
IF (.not.ignore(i) .and. motion(i).ne.STATNY) THEN
call path(i,t,motion(i),0.0,dm,dm,dm,dm)
DO 10 j=j1,jn
rgtbl(i,j) = rss(x0(i)-x0(j),y0(i)-y0(j))
rgtbl(j,i) = rgtbl(i,j)
10 CONTINUE
ENDIF
20 CONTINUE
c
DO 40 i=i1,in
c Loop thru Southern tanks.
IF (.not.ignore(i)) THEN
c Consider tank i (It is alive and can detect or be detected.)
c Change made March 20, 1989 by H.L.Reed to allow the individual condition
c of each target tank to be used to define the probability of acquisition
icond = 2
if(motion(i).ne.STATNY) icond = 3
if(knceal(i).eq.HD) icond = 1
DO 30 j=j1,jn
IF (.not.ignore(j)) THEN
c Consider tank j (Also alive and can detect or be detected.)
jcond = 2
if(motion(j).ne.STATNY) jcond = 3
if(knceal(j).eq.HD) jcond = 1
rgi = rgvis(jcond,i)
rgj = rgvis(icond,j)
rgmax = amax1(rgi,rgj)
rg = rgtbl(i,j)
IF (rg.lt.rgmax) THEN
c At least one is in detection rg of the other.
IF (los(i,j)) THEN
c Line-of-sight exists between them.
c Treat Southern tank as searcher
IF (rg.lt.rgi .and. .not.seen(i,j) .and.
1 ndet(i).lt.ndetj) THEN
call searc2(t,i,j,iarmy,jcond,dt)
ELSE
repeat = .true.
ENDIF
ENDIF

```

```

c      Treat Northern as searcher
      IF (rg.lt.rgj .and. .not.seen(j,i) .and.
1      ndet(j).lt.ndetj) THEN
        call searc2(t,j,i,jarmy,icond,dt)
      ELSE
        repeat = .true.
      ENDIF
      ELSE
        repeat = .true.
      ENDIF
      ELSEIF (y0(i).gt.ymax(i)) THEN
c      Neither are in detection rg of the other.
        call cancel(i,'all ',ALL)
        ignore(i) = .true.
        if (keyd(1).ge.2) print *, ' Cancel all events for',i
        GOTO 40
      ENDIF
    ENDIF
30    CONTINUE
    ENDIF
40    CONTINUE
    if (repeat) call skedul(t+1.0,0,'search', NULL)
    if (trace) print *, '<search'
  END
c V7.1

```

```

SUBROUTINE SELECS (t,firer,dt)
include 'common.h'
logical loaded
integer firer, arrayf
1  format (f8.2,1x,a4,i3,' does not select; selecting already.')
2  format (f8.2,1x,a4,i3,' does not select; channels full.')
3  format (f8.2,1x,a4,i3,' does not select; pod empty.')
4  format (f8.2,1x,a4,i3,' begins selection.')
c
  if (trace) print *, '>selecs'
  arrayf = array(firer)
  if (kind.eq.4) loaded = nchan(firer).ge.nchans(arrayf)
  if (kind.ne.4) loaded = nrtgt(firer).ne.0
  IF (busy(firer) .or. empty(firer) .or. loaded) THEN
c    Wait cause busy selecting, pod empty, or channels full.
    IF (keyd(1).ge.2) THEN
      IF (busy(firer)) THEN
        print 1, t, color(arrayf), firer
      ELSEIF (loaded) THEN
        print 2, t, color(arrayf), firer
      ELSEIF (empty(firer)) THEN
        print 3, t, color(arrayf), firer
      ENDIF
    ENDIF
  ELSE
c    Start selection: none in progress and a channel is free.
    busy(firer) = .true.
    if (kind.eq.4) nchan(firer) = nchan(firer)+1
    call skedul(t-dt,firer,'select', NULL)
    if (keyd(1).ge.2) print 4, t, color(arrayf), firer
  ENDIF
  if (trace) print *, '<selecs'
  END
c V7.2

```

```

SUBROUTINE SELECT (t, firer)
c 6  Select: gunner chooses most dangerous target he sees.
      include 'comcon.h'
      character*4 colort
      logical tgt fls, f alive, can go
      integer firer, tgt, priorn, arrayf
1      format(f8.2,1x,a4,i3,' selects ',a4,i3,' with priority',i4,
2      ' ',#tgts=i2)
2      format(f8.2,1x,a4,i3,' selects ',a4,' -1',
1      ' & discards ',a4,i3,' ',#tgts=i2)
3      format(f8.2,1x,a4,i3,' selects',8x,'- (empty target set)')
4      format(' SELECT: ',a4,i3,' selects ',a4,i3,' with priority',i4)
c
      if (trace) print *, 'select'
      arrayf = array(firer)
      kind = kindrd(arrayf)
      f alive = life(firer).lt.FKILL
      IF (f alive) THEN
c      Firer can shoot, so have him select.
        tgt = priorn(t,firer,level)
        IF (tgt.eq.NULL) THEN
c      Firer has no targets to select so he moves if possible
          if (keyd(1).ge.2) print 3, t,color(arrayf), firer
          busy(firer) = .false.
          if (kind.eq.4) nchan(firer) = nchan(firer)-1
          IF (can go(firer,t) .and. (kind.le.2 .or.
1          kind.eq.5 .or. nchan(firer).eq.8)) THEN
            call cancel(firer,'halt ', NULL)
            call cancel(firer,'accel ', NULL)
            call skedul(t,firer,'accel ',NULL)
          ENDIF
        ELSE
c      Tgt has been selected
          colort = color(array(tgt))
          IF (tfire(firer,tgt).le.8.) THEN
c      Tgt is new; replace with false tgt randomly.
            i = knceal(tgt)-1
            pf = ranu(8)
            tgt fls = pf .lt. pfalse(arrayf,i)
            IF (tgt fls) THEN
              seen(firer,tgt) = .false.
              if (keyd(1).ge.2) print 2, t, color(arrayf),
1              firer, colort, colort, tgt, nchan(firer)
              tgt = FLS TGT
            c      Restart search if it is turned off
              IF (.not.repeat) THEN
                repeat = .true.
                call skedul(t,8,'search',NULL)
              ENDIF
            ELSE
              fot(firer,tgt) = .true.
              if (keyd(1).ge.2) print 1, t, color(arrayf),
1              firer,colort,tgt,level,nchan(firer)
            ENDIF
          ELSE
c      Firer has previously serviced this target.
            fot(firer,tgt) = .true.
            if (keyd(1).ge.2) print 1, t, color(arrayf),
1            firer,colort,tgt,level,nchan(firer)
          ENDIF
          call engage (t, t, firer, tgt)
        ENDIF
        nrtgt(firer) = tgt
      ENDIF
      if (trace) print *, '<select'
      END

```

```

SUBROUTINE SERCH0
c Serch0: Find useful constants for search.
  include 'common.h'
  logical ignore
  common /cserch/ i1,in,j1,jn,v,rgtbl(NN,NN),ignore(NN),rgvs(NN),
1 ymxx(NN),iarmy,jarmy,ndeti,ndetj,ni,nj
  save /cserch/
  integer ncols(3)
  data ncols /2,3,1/

  if (trace) print *, 'serch0'
c Find 1st and last in Southern & Northern forces.
  IF (scene.eq.BATTAK) THEN
    i1 = 1
    in = nblu
    j1 = nblu+1
    jn = nblu+nred
    v = speed(BLU)
  ELSE
    i1 = nblu+1
    in = nblu+nred
    j1 = 1
    jn = nblu
    v = 0.0
    if (scene.eq.RATTAK) v = speed(RED)
  ENDIF
c Find actual detection ranges for targets.
  nb = ncols(scene)
  DO 20 i=1,nblu
    rgvs(i) = rgvis(nb,i)
    ignore(i) = .false.
20  CONTINUE
  nr = 4-nb
  DO 25 i=nblu+1,nblu+nred
    rgvs(i) = rgvis(nr,i)
    ignore(i) = .false.
25  CONTINUE
  iarmy = army(i1)
  jarmy = army(j1)
  ndeti = ndets(iarmy)
  ndetj = ndets(jarmy)
  ni = 2
  nj = 2
  if (scene.ne.MEETNG) ni = 3
  if (scene.ne.MEETNG) nj = 1
  if (trace) print *, 'serch0'
END
c V7.2

```

```

SUBROUTINE SERCH1
c Find whether & when search should be started.
include 'common.h'
logical ignore
common /cserch/ i1,in,j1,jn,v,rgtbl(NN,NN),ignore(NN),rgvs(NN),
1 ymx(NN),iarmy,jarmy,ndeti,ndetj,ni,nj
save /cserch/

if (trace) print *, '>serch1'
call serch0
dtain=1.0e10
c Loop thru Southern force and Northern force.
DO 40 i=i1,in
  ymin = 1.0e10
  ymax(i) = -1.0e10
  DO 30 j=j1,jn
    x = x0(j)-x0(i)
    y = y0(j)
    d = sqrt(x**2 + y**2)
    rgtbl(i,j) = d
    rgtbl(j,i) = d
    r = amax1(rgvs(i), rgvs(j))
    IF (r .gt. d) THEN
c At least one is in detection range at time zero.
      ymin = amin1(ymin,0.0)
      ymax(i) = amax1(ymax(i),y+sqrt(r**2-x**2))
    ELSE
c Neither is in detection range at time zero.
      IF (v .gt. 0.0 .and. abs(x) .lt. r) THEN
c At least one will enter.
        q = sqrt(r**2 - x**2)
        ymin = amax1(0.0,amin1(ymin, y - q))
        ymax(i) = amax1(ymax(i), y + q)
      ENDIF
    ENDIF
  30 CONTINUE
c See if tank i should be ignored and update start time (dtain).
  dt = 1.0e10
  if (ymin.eq.0.0) dt = 0.0
  if (v.ne.0.0) dt = ymin / v
  ignore(i) = dt.gt.tmax .or. ymax(i).le.0.0
  if (ignore(i)) call cancel(i,'all ',ALL)
  IF (keyd(1).ge.2) THEN
    if (ignore(i)) print *,i,' Never enters detect rg of foe.'
    if (.not.ignore(i)) print *, i,
1    ' Enters detect rg after traveling',ymin,' metres.'
  ENDIF
  dtain = amin1(dtain,dt)
40 CONTINUE
if (dtain.lt.tmax) call skedul(dtain,ALL,'search',ALL)
repeat = dtain.lt.tmax
if (trace) print *, '<serch1'
END
c V7.1

```

```

SUBROUTINE SKEDUL (t,I,act,it)
c 9  Schedule: Schedule an event for later execution.
      include 'clock.h'
      character*8 act
1     format(9x,'skedul ',i3,' ',a8,i3,' at time',f8.2)
c
      if (prflag) print 1, I, act, it, t
      IF (nxidle.eq.0) THEN
c      If storage all used stop
        print *, 'Storage overloaded with too many events.'
        STOP
      ELSE
c      Store the event
c      Cut storage unit from empties
        n = nxidle
        nxidle = next(nxidle)
c      Then find where to insert this event in the event list.
        IF (nxevnt.le.0) THEN
c      New event is only event
          next(n) = 0
          nxevnt = n
        ELSE
c      Then find where to insert it.
c      Point to first 2 events
          l = nxevnt
          a = next(l)
c      Find where to insert them
          IF (t.ge.when(l)) THEN
c      See if between 2 scheduled events.
c      Loop till found.
c      IF (a.ne.0 .and. t.ge.when(a)) THEN
20          l = a
              a = next(a)
              GOTO 20
            ELSE
c      Splice new event into list
              next(n) = a
              next(l) = n
            ENDIF
          ELSE
c      Place new event as most imminent
              next(n) = nxevnt
              nxevnt = n
            ENDIF
          ENDIF
c      Finally store event info
          when(n) = t
          what(n) = act
          who(n) = I
          whom(n) = it
        ENDIF
      END
c V7.1

```

```

SUBROUTINE SLOW UP (t, firer)
c 8  Slow up: simulate tank starting to slow down.
      include 'common.h'
      integer firer
1      format (f8.2,1x,a4,i3,' continues to slow up.')
2      format (f8.2,1x,a4,i3,' would slow up if it weren't',
1      ' already stopped.')
3      format (f8.2,1x,a4,i3,' brakes',11x,'(was accelerating)')
4      format (f8.2,1x,a4,i3,' brakes',11x,'(was cruising)')
c
      if (trace) print *, '>slowup'
      kind mv = motion(firer)
      narray = array(firer)
      IF (kind mv.eq.SLOWNG) THEN
c          Previous motion was slowing
            if(keyd(1).ge.2)print 1, t, color(narray), firer
      ELSE IF (kind mv.eq.STATNY) THEN
c          Previous motion was stationary
            if(keyd(1).ge.2)print 2, t, color(narray), firer
      ELSE IF (kind mv.eq.ACCELG) THEN
c          Previous motion was accelerating
            if(keyd(1).ge.2)print 3, t, color(narray), firer
            call path (firer,t,motion(firer),0.0,x,y,vx,vy)
            dt = vy/decel(narray)
            motion(firer) = SLOWNG
            call skedul(t+dt,firer,'halt ', NULL)
      ELSE IF (kind mv.eq.MAXVL) THEN
c          Previous motion was cruising at max vel
            if(keyd(1).ge.2)print 4, t, color(narray), firer
            call path (firer,t,motion(firer),0.0,x,y,vx,vy)
c          schedule halt time
            dt = vy/decel(narray)
            call skedul(t+dt,firer,'halt ', NULL)
            motion(firer) = SLOWNG
      ENDIF
      if (trace) print *, '<slowup'
      END
c V7.2

```

```

SUBROUTINE SMOKE
c 0  Smoke: Find path lengths where attacker is hidden by smoke.
    include 'common.h'
    data ptbl /0.,.05,.1,.15,.2,.25,.3,.35,.4,.45,.5,.55,.6,.65,.7,
1    .75,.8,.85,.9,.95,1.0/
    data rtbl /0.,1000.,2000.,3000.,4000./
c
    if (trace)print *, '>smoke'
    DO 80 nb=1,nblu
    DO 70 nr=nblu+1,nblu+nrnd
c      Find first time window for LOS between tanks nb, nr.
        p=ranu(da)
        r=rg0
        if (kview(RED).eq.'V') dt=tdintp(ptbl,rtbl,toutv1,p,r,21,5)
        if (kview(RED).eq.'I') dt=tdintp(ptbl,rtbl,toutil,p,r,21,5)
        call skedul(dt,nb,'appear',nr)
        if (kview(BLU).eq.'V') dt=tdintp(ptbl,rtbl,toutv1,p,r,21,5)
        if (kview(BLU).eq.'I') dt=tdintp(ptbl,rtbl,toutil,p,r,21,5)
        call skedul(dt,nr,'appear',nb)
70      CONTINUE
80      CONTINUE
        if(trace)print *, '<smoke'
    END
c V7.1

```

```

FUNCTION TDINTP(x1a, x2a, y, x1, x2, ix1a, ix2a)
c  TDINTP: Interpolates in a two dimensional matrix.
integer ix1a, ix2a
real y(ix1a, ix2a), x1a(ix1a), x2a(ix2a)
integer j, k
real y1, y2, y3, y4, t, u
c
j = INDEX( x1a, ix1a, x1 )
k = INDEX( x2a, ix2a, x2 )
IF(k.eq.0) THEN
PRINT*, 'TDINTP: p,r,j,k=', x1, x2, j, k
print *, x1a, x2a, ix1a, ix2a
ENDIF
c
y1 = y(j, k)
y2 = y(j+1, k)
y3 = y(j+1, k+1)
y4 = y(j, k+1)
c
t = (x1-x1a(j))/(x1a(j+1)-x1a(j))
u = (x2-x2a(k))/(x2a(k+1)-x2a(k))
c
TDINTP = (1-t)*(1-u)*y1 + t*(1-u)*y2 + t*u*y3 + (1-t)*u*y4
END
c V7.2

```

```

SUBROUTINE TERAIR (ifirst,last)
c 0  Mask at: find path lengths where attacker is masked by terrain
      include 'common.h'
      common /terane/ d(40), xold(20), yold(20), dist(20), iseg(20)
1    format (' visible for',f5.0,'m, then hidden for',f5.0,'m.')
c
      if (trace) print *, '>terain'
c    Find segment length at start of each engagement.
      DO 20 i=1,39,2
c      Hunfeld terrain constants
        f = -alog(ranu(0.0))
        d(i) = 300.*f**1.2
        f = -alog(ranu(0.0))
c      d(i+1) = 750.*f**2.0
        d(i+1) = 100.*f
        if (keyd(1).ge.2) print 1, d(i), d(i+1)
20   CONTINUE
c    Initialize data for each tank
      DO 30 i=ifirst,last
        call path (i,0.,motion(i),0.0,x,y,vx,vy)
        xold(i) = x
        yold(i) = y
        dist(i) = d(1)
        iseg(i) = 1
        call skedul (0.,i,'vanish',NULL)
30   CONTINUE
      if (trace) print *, '<terain'
c NOTES:
c 1. If meeting engagement skip this routine entirely
c 2. If side not moving skip at least part
      END
c V7.1

```

```
c 9  FUNCTION VABS (a)
      Vabs: find absolute value of a vector (magnitude).
      dimension a(3)
      vabs = sqrt(a(1)**2 + a(2)**2 + a(3)**2)
      END
c V7.3
```

```

SUBROUTINE VANISH(t,tgt,firer)
c 0  Vanish: if tgt vanishes treat, otherwise reschedule vanish
      include 'common.h'
      integer tgt, firer
      common /terane/ d(40), xold(20), yold(20), dist(20), iseg(20)
      rss(x,y)=sqrt(x*x+y*y)

c
      if (trace) print *, '>vanish'
      narmy = army(tgt)
      IF (invisb.eq.1) THEN
1        if(speed(narmy).le.0.)print *, 'VANISH: narmy,speed=',narmy,
          speed(narmy)
          IF (speed(narmy).le.0.) STOP
          call path(tgt,t,motion(tgt),0.0,x,y,vx,vy)
c      Terrain causes intervisibility
          travel = rss(x-xold(tgt), y-yold(tgt))
          IF (travel.gt.dist(tgt)) THEN
c          Tgt is now masked by terrain
              xold(tgt) = x
              yold(tgt) = y
              iseg(tgt) = iseg(tgt)-1
              if (iseg(tgt).gt.40) iseg(tgt)=iseg(tgt)-40
              dist(tgt) = d(iseg(tgt))
              call vanter(t,tgt,firer)
              dt = dist(tgt)/speed(narmy) + 0.01
              call skedul (t-dt,tgt,'appear',NULL)
          ELSE IF (life(tgt).eq.ALIVE) THEN
c          Not yet masked by terrain, so reschedule
              dt = (dist(tgt) - travel) / speed(narmy) + 0.01
              call skedul (t-dt,tgt,'vanish',NULL)
          ENDIF
      ELSE
c      Tgt is now masked by smoke
          call vansmk(t,tgt,firer)
      ENDIF
      if (trace) print *, '<vanish'
      END
c V7.1

```

```

SUBROUTINE VANSWK(t,tgt,firer)
c 0  Vansak: Treat tgt that vanished behind smoke.
    include 'common.h'
    integer tgt, firer, armyf, armyt
    format(f8.2,1x,a4,i3,' LOS to ',a4,i3,' broken by smoke.')
c
    if (trace) print *,>'vansak'
    armyt = army(tgt)
    armyf = 3-armyt
    if (keyd(1).ge.2) print 1, t, color(armyf), firer,
1      color(armyt),tgt
c  Cancel line-of-sight between tgt and firer.
    los(firer,tgt) = .false.
    if (seen(firer,tgt)) ndet(firer) = ndet(firer)-1
    seen(firer,tgt) = .false.
    tfire(firer,tgt) = 0.0
CHANGED 2 Oct 88. Next line is new.
    if (busy(firer).and.nrtgt(firer).eq.tgt) busy(firer)=.false.
c  Abort firer missile on tgt.
    IF (mot(firer,tgt).or.fot(firer,tgt)) THEN
        call diseng(t,firer,tgt,.true.,.true.)
        if (mot(firer,tgt)) call abort(t,firer,tgt)
    ENDIF
c  Accelerate tgt that was halting to fire.
    IF (motion(tgt).eq.SLOWNG .and. life(tgt).eq.1 .and.
1      fot(tgt,firer)) THEN
        call skedul (t,tgt,'accel ',NULL)
        call cancel (tgt,'halt ',NULL)
    ENDIF
    if (trace) print *,<'vansak'
c NOTE: shouldn't halted tgt accelerate too?
    END
c V7.3

```

```

SUBROUTINE VANTER(t,tgt,firer)
c 0  Vantar: Treat tgt that vanished behind terrain.
    include 'common.h'
    integer tgt, firer
1    format(f8.2,1x,a4,i3,' vanishes',9x,'(x=',f8.1,' y=',f8.1,')')
c
    if (trace) print *,>'vanter'
    narmy = army(tgt)
    if (keyd(1).ge.2) print 1, t, color(narmy), tgt,
1    x0(tgt), y0(tgt)
    knceal(tgt) = FD
    nrtgt(tgt) = 0
CHANGED 22 Sep 88. Next line added.
    ndet(tgt) = 0
c    Cancel all lines-of-sight and sightings involving tgt
        DO 20 i=1,nblu*nred
            los(tgt,i) = .false.
            los(i,tgt) = .false.
            if (seen(i,tgt)) ndet(i)=ndet(i)-1
            seen(tgt,i) = .false.
            seen(i,tgt) = .false.
            tfire(tgt,i) = 0.0
            tfire(i,tgt) = 0.0
            fot(tgt,i) = .false.
c        Change by HLRood 1-12-90. Seems to be needed to clear busy flag
c        GROUNDWARS has it also.
            busy(tgt) = .false.
20    CONTINUE
c    Abort outgoing missiles
        call abort(t,tgt,ALL)
        nchan(tgt) = 0
c    Abort incoming rounds & disengage tanks firing at tgt
        ifirst=1
        if (narmy.eq.1) ifirst = nblu+1
c        kind = kindrd(3-narmy)
        call newtgt(t,ifirst,tgt)
        call cancel (tgt,'fire ',NULL)
CHANGED 27 Jun 85. Added next line.
        call cancel (tgt,'select',NULL)
c    Accelerate tgt that was halting to fire.
        IF (motion(tgt).eq.SLOWNG .and. life(tgt).eq.1) THEN
            call skedul (t,tgt,'accel ',NULL)
            call cancel (tgt,'halt ',NULL)
        ENDIF
        if (trace) print *,>'vanter'
    END
c
c V7.1

```

```

SUBROUTINE WAVES(n scene)
c 7  Waves: loop thru waves of red tanks.
    include 'common.h'
    dimension istatc(8)
    format (8i10)
    format(' Total',i4,i6,i5,4f6.1,2i3,17x,i9)
    format(f6.2)
CHANGED 31 Mar 86. Next format added.
    format(' Shots by: Blue Red',/,
1      ' Fired',2i6,/, ' Wasted',2i6,/,
2      ' Aborted',2i6,/, ' False tgts',2i6,/,
3      ' Hidden tgts',2i6,/, ' Impacting',2i6,/,
4      ' Misses',2i6,/, ' Hits',2i6,/,
5      ' Duds',2i6,/, ' No damage',2i6,/,
6      ' M-kill only',2i6,/, ' F-kill only',2i6,/,
7      ' M&F-kill only',2i6,/, ' K-kill',2i6,/)

c
    if (trace) print *, 'Waves'
    IF (nreps*nblu.gt.3000 .and. nwaves.gt.1) THEN
        print *, 'WAVES: Too many reps or blues.', nreps, nblu
    ELSE
c      Initialize scenario statistics
CHANGED 31 Mar 86. Next 4 lines added.
        DO 5 i=1,20
            kshot(1,i) = 0
            kshot(2,i) = 0
5          CONTINUE
            nwave = 0
            nreps3 = 0
            loamo2 = 0
            noamo2 = 0
            scene = nscene
            DO 22 i=1,8
                statc(i) = 0.
22          CONTINUE
CHANGED 1 Apr 86. Next line changed.
c          nrg = rg0/500
c          nrg = rg0/irginc
            DO 25 i=1,3000
                nused(i) = 0
25          CONTINUE
            nsurv = nreps*nblu
c          call headr1
c          Loop thru up to 10 waves of red tanks
30          CONTINUE
            nwave = nwave+1
            call nxwave
            IF (nsurv.ge.nblu .and. nwave.lt.nwaves) GOTO 30
c          Calculate summary statistics
            rpbs = statc(6)/(nreps*nblu)
            IF (nwave.gt.1) THEN
                DO 50 i=1,4
                    istatc(i) = 0.5 + 100*statc(i)/nreps3
                    statc(i+4) = statc(i+4)/nreps3
50          CONTINUE
                print 6, nreps3,
1              (istatc(i),i=1,2),(statc(i),i=5,8),
2              loamo2, noamo2, irandm
            ENDIF
CHANGED 31 Mar 86. Next line added
            kshot(1,2) = kshot(1,3)+kshot(1,4)+kshot(1,5)
            kshot(2,2) = kshot(2,3)+kshot(2,4)+kshot(2,5)
        ENDIF
        if (trace) print *, 'waves'
    END

```

```

SUBROUTINE XFER(t,i1,j)
c  Change HLRead. Added Xfer for the transfer & detection of target j
c  to all vehicles on side starting with i1
  include 'common.h'
  i2 = nblu
  if (i1 .ne. 1) i2 = nblu + nred
  DO 10 i = i1,i2
    IF (life(i) .lt. FKILL .and.
1     ndet(i) .lt. ndets(array(i)) .and.
2     los(i,j) .and.
3     .not.seen(i,j) ) THEN
      seen(i,j) = .true.
      ndet(i) = ndet(i) + 1
      thuman = 0.0 * exp(rolln(0.5))
      call select(t,i,thuman)
    ENDIF
10  CONTINUE
  END

```

APPENDIX B
BASIC PROGRAM FOR VULNERABILITY TABLE

INTENTIONALLY LEFT BLANK.

Appendix B

BASIC program to produce vulnerability table from BRL vulnerability data and weapon accuracy.

```

100 DIM PKH(8,2,11,4,6), SIGMAX(3,3), SIGMAY(3,3), PK(3,2,4,8), CARD(6)
105 DIM PKILL(3,2,4,8)
108 DIM PH(8,3,2,6) '(range,case,exposure,angle)
110 OPEN "v6808.doc" FOR INPUT AS #2 'typical name of file with BRL vul data
115 OPEN "v4 basea.doc" FOR OUTPUT AS #3
116 NSIG = 0 'nsig = 0 for base, nsig = 1,2,3 for var 1,2,3
120 INPUT #2, RRX, EX, DISP, TYPE, PKH(RRX/500,EX,DISP,TYPE,0)
130 FOR N = 1 TO 6
140 INPUT #2, PKH(RRX/500,EX,DISP,TYPE,N)
150 NEXT
160 INPUT #2, DUMMY
170 IF -(1-EOF(2)) GOTO 120
171 ' the following set of data are horizontal (sigmax) and vertical
172 ' (sigmay) dispersions in mils. The first index is the variation
173 ' as picked by nsig, the second is the case where
175 ' case=1 is stat / stat; case=2 is moving firer; case=3 is moving tgt
180 SIGMAX(0,1) = .52 : SIGMAX(0,2) = 2.59 : SIGMAX(0,3) = 2.54
181 SIGMAX(1,1) = .41 : SIGMAX(1,2) = .63 : SIGMAX(1,3) = 1.07
182 SIGMAX(2,1) = .40 : SIGMAX(2,2) = .45 : SIGMAX(2,3) = .88
183 SIGMAX(3,1) = .21 : SIGMAX(3,2) = .24 : SIGMAX(3,3) = .44
190 SIGMAY(0,1) = .52 : SIGMAY(0,2) = 2.28 : SIGMAY(0,3) = 1.57
191 SIGMAY(1,1) = .41 : SIGMAY(1,2) = .63 : SIGMAY(1,3) = 1.07
192 SIGMAY(2,1) = .40 : SIGMAY(2,2) = .45 : SIGMAY(2,3) = .88
193 SIGMAY(3,1) = .21 : SIGMAY(3,2) = .24 : SIGMAY(3,3) = .44
195 VK = 1! ' a factor that can be used to look at reduced lethality
200 HT = .375 ' half height of turret
210 WT1 = 1.175 ' half width of turret
220 LT1 = 1.475 ' half length of turret
230 HH = 1.5 ' height of hull
240 WH1 = 1.775 ' half width of hull
250 LH1 = 3.375 ' half length of hull
255 ' define the values of the cardioid distribution for 30 deg increments
260 CARD(0) = .1657
270 CARD(6) = .001
280 FOR N = 1 TO 5
290 THETA = .5236 * N
300 CARD(N) = .16667 * .16477 * COS(THETA)
310 NEXT
320 FOR CASE = 1 TO 3
330 FOR EX = 1 TO 2 ' hull defilade or fully exposed
340 FOR RANGE = 1 TO 8
350 SIGMAX = SIGMAX(NSIG,CASE) * RANGE * .5
351 SIGMAY = SIGMAY(NSIG,CASE) * RANGE * .5
360 D = 3.28*SQR(SIGMAX * SIGMAY) ' dispersion in feet for vul table
361 IF D >= 11! THEN D = 10.999: ELSE IF D < 1! THEN D = 1!
365 DX = D * .5
370 IF DX > 10 THEN DX = 10
380 IF DX < 1 THEN DX = 1
385 D = D - DX
386 D1 = 1! - D
387 D1% = DX * 1
390 IF EX = 1 THEN GOSUB 630: ELSE GOSUB 720
400 FOR TYPE = 0 TO 4 ' type of kill where TYPE = 0 is Ph
410 TEMPPK = 0!
420 FOR N = 0 TO 6
430 IF TYPE = 0 THEN FACTOR = 1!:
    ELSE FACTOR = ( D1*PKH(RANGE,EX,DX,TYPE,N)
      + D * PKH(RANGE,EX,D1%,TYPE,N)) * VK
440 TEMPPK = TEMPPK + CARD(N) * PH(RANGE,CASE,EX,N) * FACTOR
450 NEXT ' loop on N
460 PK(CASE, EX, TYPE, RANGE) = TEMPPK
470 NEXT ' loop on TYPE
480 NEXT ' loop on Range
490 NEXT ' loop on EX
500 NEXT ' loop on case
505 ' convert pk's to the intervals called p() in section 2.5.
510 FOR CX = 1 TO 3

```

```

520 FOR EX = 1 TO 2
530 FOR RX = 1 TO 8
535 PKILL(CX,EX,0,RX) = PK(CX,EX,0,RX)
540 PKILL(CX,EX,1,RX) = PK(CX,EX,0,RX) - PK(CX,EX,4,RX)
545 PKILL(CX,EX,2,RX) = PK(CX,EX,0,RX) - PK(CX,EX,1,RX) - PK(CX,EX,2,RX) + PK(CX,EX,3,RX)
550 PKILL(CX,EX,3,RX) = PK(CX,EX,0,RX) - PK(CX,EX,2,RX)
555 PKILL(CX,EX,4,RX) = PK(CX,EX,0,RX) - PK(CX,EX,3,RX)
570 NEXT RX ' loop on RX
590 NEXT EX ' loop on EX
595 NEXT CX ' loop on CX
596 GOSUB 1510
600 END
610 '
620 ' Hull defilade hit probability given sigma x, sigma y, and n = theta/30
630 FOR N = 0 TO 6
640 THETA = .5236 * N
650 WT = WT1 * ABS(COS(THETA)) + LT1 * ABS(SIN(THETA))
660 GAUSSARG = HT/SIGMAY: GOSUB 860: PHTEMP = 2 * GAUSS - 1
670 GAUSSARG = WT/SIGMAX: GOSUB 860: PH(RANGE,CASE,EX,N) = (2 * GAUSS - 1) * PHTEMP
680 NEXT N
690 RETURN
700 '
710 ' Exposed target hit probability given sigma x, sigma y, and n = theta/30
720 FOR N = 0 TO 6
730 THETA = .5236 * N
740 WT = WT1 * ABS(COS(THETA)) + LT1 * ABS(SIN(THETA))
750 GAUSSARG = (.3 + 2! * HT)/SIGMAY: GOSUB 860: PHTEMP = GAUSS
760 GAUSSARG = .3/SIGMAY: GOSUB 860: PHTEMP = PHTEMP - GAUSS
770 GAUSSARG = WT/SIGMAX: GOSUB 860: PH(RANGE,CASE,EX,N) = (2 * GAUSS - 1) * PHTEMP ' ph turret
780 GAUSSARG = .3/SIGMAY: GOSUB 860: PHTEMP = GAUSS
790 GAUSSARG = (.3 - HH)/SIGMAY: GOSUB 860: PHTEMP = PHTEMP - GAUSS
800 WH = WH1 * ABS(COS(THETA)) + LH1 * ABS(SIN(THETA))
810 GAUSSARG = WH/SIGMAX: GOSUB 860: PH(RANGE,CASE,EX,N) = PHTEMP * (2 * GAUSS - 1) + PH(RANGE,CASE,EX,N)
820 NEXT N
830 RETURN
840 '
850 ' Normal Distribution Subroutine
860 TEMP = ABS(GAUSSARG)
870 GAUSS = .398942 * EXP(-.5 * GAUSSARG * GAUSSARG)
880 IF TEMP > 4.6844 THEN GOTO 940
890 TEMP = 1!/(1! + .2316419 * TEMP)
900 GAUSS = 1! - GAUSS * TEMP * (((1.33027 * TEMP - 1.821256) * TEMP
+ 1.781478) * TEMP - .3565638) * TEMP + .3193815)
910 IF GAUSSARG < 0 THEN GAUSS = 1! - GAUSS
920 RETURN
930 ' Approximation for large values of the argument
940 GAUSS = 1! - GAUSS * (1!/TEMP - 1!/TEMP^3 + 3!/TEMP^5)
950 IF GAUSSARG < 0 THEN GAUSS = 1! - GAUSS
960 RETURN
1510 FOR CX = 1 TO 3
1520 FOR EX = 1 TO 2
1530 FOR TX = 0 TO 4
1540 PRINT #3, USING "###.###"; CX, EX, TX, PKILL(CX, EX, TX, 1); ' range 0 is range 1
1550 FOR RX = 1 TO 8
1560 PRINT #3, USING "###.###"; PKILL(CX, EX, TX, RX);
1570 NEXT RX ' loop on RX
1575 PRINT #3, " "
1580 NEXT TX ' loop on TX
1590 NEXT EX ' loop on EX
1595 NEXT CX ' loop on CX
1600 RETURN

```

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