USER AND ANALYST MANUAL FOR A FORTRAN COMPUTER PROGRAM
SIMULATING THE ENGAGEMENT OF A STATIONARY POINT TARGET
BY A STATIONARY DIRECT FIRE WEAPON

DECEMBER 1980

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U. S. ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY
ABERDEEN PROVING GROUND, MARYLAND
This report documents a FORTRAN computer program usable to make effectiveness calculations for weapons that fire aimed rounds one at a time against point targets. The program is applicable to tank main guns and infantry antitank weapons engaging tanks, armored personnel carriers, and other such targets. Monte Carlo techniques are used to simulate the engagement, which does not involve any firing by the target. The required inputs include rate of fire, delivery accuracy, and reliability data for the firing weapon, as well as detailed vulnerability data for the target. Other parameters that must be...
20. Abstract - Continued

specified are the range, the target orientation and degree of exposure, and the aimpoint. The outputs are hit and kill probabilities for up to 15 rounds, average number of rounds needed for a target hit or kill, as well as hit and kill probabilities for engagement times up to 2 minutes.
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1. INTRODUCTION

This report describes a computer program developed under the sponsorship of the Joint Munitions Effectiveness Manual Surface-to-Surface (JMEM-SS) Methodology and Evaluations Working Group, with a substantial contribution by the Army Materiel Systems Analysis Activity (AMSAA). The program has been used by JMEM-SS and AMSAA to make effectiveness calculations for armor and infantry weapons engaging tanks, armored personnel carriers, and other targets. It utilizes Monte Carlo techniques to simulate the engagement and has been based, to a large extent, on a similar deterministic program previously developed by AMSAA. An earlier version of the JMEM-SS direct fire program has been documented in 1976 by the then US Army Armament Command (Reference 1).

The JMEM-SS direct fire program provides a method for calculating the effectiveness of weapons that fire aimed rounds one at a time against point targets. Such weapons include tank main guns and infantry antitank weapons. The required input includes performance parameters related to the rate of fire, delivery accuracy, and reliability of the firing weapon. A detailed target description and data indicating vulnerability of the target to the type of round fired are also part of the input. Other influencing factors specified for a particular calculation are the range, the orientation of the target, whether the target is fully exposed or only partly exposed, and the aimpoint. To simulate a single engagement, the computer determines the effects of the first round, taking into account several kill criteria of interest. Then, as necessary, second and succeeding rounds up to a limit of 15 rounds are evaluated. Although this limit is a practical one for the calculations, it clearly exceeds the number of rounds normally fired in real combat engagements. The calculations for the first engagement result in an actual possible outcome being established. For example, the target might be determined to be hit on the third round 38 seconds after the start of the engagement. Similar specific numerical values are also assigned to the round number and time corresponding to the target being killed for each kill criterion of concern. The process is repeated until 10,000 engagements have been considered, and data for all engagements are combined to give plausible outputs not unduly influenced by particular engagements. Outputs are:

a. Hit probabilities and kill probabilities corresponding to various numbers of rounds fired.

b. Average numbers of rounds needed to hit or to kill the target.

c. Hit probabilities and kill probabilities for various engagement times up to a practical limit, established as 2 minutes for the calculations.

The engagement simulated by the direct fire program is restricted to being one-sided. This means that the firing weapon is not subjected to return fire from the target or some other opposing element.

This report has been prepared primarily for users and analysts with an interest in documentation far exceeding in scope the very general explanations in this introduction. The material included is as follows:

a. Basic definitions (section 2).
b. General flow of program logic (section 3).
c. Input data (section 4).
d. Output data (section 5).
e. Computer aspects (section 6).
f. Program listing and detailed explanations of program statements (Appendixes A and B).

Input data used to exercise the JMEM-SS direct fire program as well as outputs of the calculations frequently require a CONFIDENTIAL classification. To make this user and analyst manual UNCLASSIFIED, input and output data not bearing any identifiable relation to classified information have been fabricated to illustrate inputs and outputs associated with the program.

The direct fire program contains some options that are of little or no concern to most users or analysts. These options are identified in this report but not necessarily discussed thoroughly. If a need for detailed explanations concerning any program option arises, these can be provided by AMSAA upon request.
2. BASIC DEFINITIONS

2.1 Introduction.

This section contains definitions, as well as related assumptions and explanations, intended to clarify the meaning of terms used in this report. The following terms are covered:

- Firing Engagement (2.2)
- Engagement Time (2.3)
- Orientation (2.4)
- Exposure (2.5)
- Reliability (2.6)
- Delivery Accuracy (2.7)
- Hit Probability (2.8)
- Firing Occasion (2.9)
- Fixed Bias (2.10)
- Variable Bias (2.11)
- Random Error (2.12)
- Lay Error (2.13)
- Round-to-Round Error (2.14)
- Sensing (2.15)
- Sensing Probability (2.16)
- Sensing Error (2.17)
- Target Vulnerability (2.18)
- Kill Probability (2.19)
- Kill Criterion (2.20)
- K, M, F, M or F (2.21)
- K Kill (2.22)
- M Kill (2.23)
- F Kill (2.24)
- M or F Kill (2.25)
- Kill Probability for Specified Number of Rounds Fired (2.26)
- Average Number of Rounds Needed to Kill Target (2.27)
- Expected Personnel Casualties (2.28)
- Rate of Fire (2.29)
- First Round Firing Time (2.30)
- Flight Time (2.31)
- Subsequent Round Firing Time (2.32)
- Fixed Time (2.33)
- Variable Time (2.34)
- Median Time (2.35)
- Variability Factor (2.36)
- Minimum Time (2.37)
- Kill Probability for Specified Engagement Time (2.38)

2.2 Firing Engagement.

The firing of one or more rounds at a target. Although combat is generally two-sided, engagements simulated in the direct fire program are only one-sided in that the firing weapon is not itself subjected to any fire. It is assumed that neither the target nor the firing weapon changes its position during the engagement. An engagement begins when the decision is made to fire at the target with a particular type of round. The engagement ends when either the target is killed or 15 rounds have been fired. This limit has been established for the calculations to ensure obtaining all data of possible interest. It is realized this limit exceeds the number of rounds available in the ready rack of tanks. Firing engagements in combat could sometimes be deliberately ended for reasons not represented in the computer simulation program. For example, an armored force might have a policy whereby each tank fires no more than some specified number of rounds, like three, at any particular target in certain situations.
2.3 Engagement Time.

Time elapsing from the beginning of the firing engagement. Engagement time increases as the program calculations account for more and more specific events, for example, the firing of the first round and the arrival of this round at the target range. Engagement time can, but does not always, mean the time needed for the entire engagement to be completed.

2.4 Orientation.

The view that the target presents to the firing weapon. Orientation is specified as an angle with 0 degrees representing the front view, 180 degrees the rear view, and 90 and 270 degrees the side view from two opposite directions. Other orientations are represented by angles from 0 to 180 degrees or from 180 to 360 (same as 0) degrees. An observer facing the target and located on the circumference of a circle with the target at its center should move to the right to see the target at orientations of 0 to 180 degrees, and to the left for orientations exceeding 180 degrees.

2.5 Exposure.

Whether the maximum possible target area or only a portion of the maximum area is presented, for a particular orientation, to the firing weapon. Two exposures are normally considered in applications of the direct fire program:

a. Open Exposure: The target presents its maximum presented area for a particular orientation.

b. Defilade Exposure: This condition has been applied only to tank targets. Defilade, or hull defilade, applies to the condition where a tank target presents only its turret as the target. The orientation specified applies to the turret and not the hull since the hull is shielded.

2.6 Reliability.

A measure of the ability of a round to function properly when it is fired and of the fuze to function properly upon impact. Proper functioning basically refers to the absence of catastrophic malfunctions affecting flight of the projectile or fuze action.

2.7 Delivery Accuracy.

A measure of the ability of rounds to hit a target. Delivery accuracy data applying to first rounds and data for subsequent rounds are both needed for the direct fire program calculations.
2.8 Hit Probability.

The chance that, under specific conditions, a target is hit.

2.9 Firing Occasion.

The firing of a small, continuous sequence of rounds at a particular target.

2.10 Fixed Bias.

Errors of the weapon-ammunition-fire control system which are usually constant and predictable at any given range, and are fixed for all firing occasions by the system design. Although the term fixed bias may refer to an individual error, it is used in this report only for the aggregated fixed bias error, in each of the horizontal and vertical directions, that accounts for all applicable individual error sources.

2.11 Variable Bias.

Errors whose values remain very nearly constant during a particular firing occasion, but which may vary considerably from occasion to occasion. Term is used in this report only for the aggregated horizontal or vertical variable bias accounting for all contributing error components.

2.12 Random Error.

Errors or an error whose magnitude and direction vary randomly from round to round even during a single firing occasion. The direct fire program explicitly involves the lay error and the round-to-round error, in each of the horizontal and vertical directions, rather than aggregated random errors.

2.13 Lay Error.

Random error associated with the fine lay made by the gunner before firing.

2.14 Round-to-Round Error.

Random error resulting from differences between individual rounds.

2.15 Sensing.

Process whereby sufficient information concerning the trajectory of a missing round is obtained by the gunner, or by the commander with transmittal to the gunner, as a basis for adjustment of fire before firing of the next round. Sensing is applicable to unguided rounds only.
2.16 Sensing Probability.

The chance that sensing occurs as a basis for adjustment of fire on the next round.

2.17 Sensing Error.

The difference between the weapon aimpoint associated with a missing round that is sensed and the new aimpoint following adjustment of fire. Such differences account not only for incorrect judgments about where missing rounds went and possibly inaccuracies arising from transmittal of information from the commander to the gunner, but also for any errors made by the gunner in relaying as part of the fire adjustment process. The sensing error in each of the horizontal and vertical directions is of concern for the direct fire program calculations involving unguided rounds.

2.18 Target Vulnerability.

A measure of the target's susceptibility to sustain a given amount of damage when hit by a round.

2.19 Kill Probability.

The chance that a target is killed as a consequence of damage sustained. The word kill acquires a definite meaning when it is associated with a specific kill criterion.

2.20 Kill (Damage) Criterion.

The function or functions that a target must lose to be considered out of action. A target killed in one engagement could be repaired and participate in a subsequent engagement.

2.21 K, M, F, M Or F.

Symbols representing four kill criteria whose specific definitions have been used, by the United States and several other countries, as the basis for vulnerability analyses of armored vehicles.

2.22 K Kill.

A target vehicle is subjected to a K kill (complete destruction) if it sustains both an M kill and an F kill and is damaged to the extent that it is not economically repairable. A K kill is more likely to be apparent to the crew of the firing weapon than any other kill because of resulting fires and/or detonation of ammunition.
2.23 M Kill.

A target is subjected to an M kill (mobility) if it is incapable of executing controlled movement and the damage is not repairable by the crew on the battlefield. The loss of this function may be caused by either incapacitation of the crew or damage to the propulsion or control equipment. A target that is M killed could sustain other types of damage at the same time, i.e., F kill or K kill.

2.24 F Kill.

A target is subjected to an F kill (firepower) if it is incapable of delivering controlled fire from the main armament and the damage is not repairable by the crew on the battlefield. The loss of this function may be caused by either incapacitation of the crew or damage to the main armament and its associated equipment. A target that is F killed could sustain other types of damage at the same time, i.e., M kill or K kill.

2.25 M Or F Kill.

A vehicle is subjected to an M or F kill if it sustains either an M kill or an F kill, or both an M kill and F kill. A target that sustains an M or F kill could also at the same time sustain a K kill.

2.26 Kill Probability for Specified Number of Rounds Fired.

Probability that the target is killed when a specific number of rounds, say N, are fired. This probability is meaningful only in conjunction with a kill criterion. N is considered to equal 1 through 15 for the program calculations. The kill probability associated with N rounds is an aggregated result that accounts for kills caused by any round up to and including the Nth round. When N equals 2, the second round is fired only when the first does not kill the target. More generally, any round after the first is fired only when the target has not already been killed.

2.27 Average Number of Rounds Needed to Kill Target.

The average number of rounds needed to kill a target is the arithmetic average of the number of rounds needed to achieve a specified type of kill given an unlimited number of individual firing engagements. Although engagements are not continued beyond 15 rounds, the program calculations account for additional rounds needed in exceptional instances where the target may survive 15 rounds. It is not implied by this that such large numbers of rounds would be involved in an actual combat engagement.
2.28 Expected Personnel Casualties.

Refer to the average, or expected, number of personnel casualties sustained by the troops carried in an armored personnel carrier target. Crew members are excluded. Calculations of personnel casualties have been based on the assault --- 5-minute criterion, which means a man must be rendered incapable of performing an assault role within 5 minutes after being wounded in order to be considered a casualty.

2.29 Rate of Fire.

A measure of the ability of a weapon to fire aimed rounds at a target. The direct fire program requires input data permitting the computer to generate the distribution of times, not only average times, that crews would need to fire the weapon in a firing engagement. Furthermore, care is necessary to ensure that the inputs correspond to rate of fire under combat conditions rather than test conditions generally tending to favor rapid fire.

2.30 First Round Firing Time.

Time elapsing between the beginning of the engagement and firing of the first round. Operations involved in firing of the first round include, as applicable, the following:

a. Slewing of the weapon.

b. Target recognition by the gunner.

c. Ranging, which may be done with equipment, such as a rangefinder, or by visual estimation of the range to the target.

d. Laying of the weapon.

Note that some of these operations can be carried out at the same time that others are. Loading of the first round may be included or excluded. In the latter case, the appropriate type of round is considered already loaded before recognition of the target.

2.31 Flight Time.

Time interval between the time a round begins to be propelled forward in the gun or launcher and the time it reaches the range of the target.

2.32 Subsequent Round Firing Time.

Time that elapses between firing of any round and firing of the next round against the same target. Subsequent round firing time involves,
as applicable, the following:

a. Flight time of the previous round.

b. Round loading.

c. Relaying of the weapon, which may or may not reflect efforts to improve the aimpoint with reference to the aimpoint used for the previous round.

2.33 Fixed Time.

Portion of total firing time, for a first or a subsequent round, that is independent of environmental conditions, crew skill and level of training, or other causes of variation in firing time performance. This time is frequently associated with mechanical operations, such as automatic loading, for unguided rounds or with flight time of the previous round for missiles.

2.34 Variable Time.

Component of total first round or subsequent round firing time that needs to be represented by a distribution of times, rather than by a fixed time component. On any particular firing occasion, total firing time equals the sum of the applicable fixed time component and a particular time from the distribution describing the variable time component. Variable time is tied to human operations and generally tends not to equal zero, because there exist so many causes of variation that are not controllable, at least completely.

2.35 Median Time.

Median time can be defined as the particular time which is greater than half the times represented by the corresponding distribution and smaller than the remaining half. For the special case where a logarithmic normal distribution is fitted to data consisting of N particular times, the median time is the Nth root of the product of all times in the set of data considered. Alternatively, for this special case, the median time is the antilogarithm of the arithmetic mean of the N logarithms corresponding to the times constituting the basic data. Detailed studies made many years ago established that logarithmic normal distributions seemed to correspond more closely than other known distributions to test data obtained for tank weapons of interest at the time. Distributions of this type are still considered useful to represent variable components of firing times for weapons of current concern.
2.36 Variability Factor.

Factor indicating to what extent the times represented by logarithmic normal distributions vary with reference to the applicable median times. A factor of about 0.5 (based on calculations with natural logarithms) has been found to apply consistently and is normally used, except when a specific reason for doing otherwise is identified. This factor is the standard deviation of the natural logarithms of time data for a particular set of conditions with reference to the natural logarithm of the median time.

2.37 Minimum Time.

Least time considered possible. Such a least time, if one other than zero is specified, can be made to override any unrealistically shorter times that may be implied by a particular time distribution used.

2.38 Kill Probability for Specified Engagement Time.

Probability that the target is killed when a specific engagement time, say T seconds, has elapsed since the beginning of the firing engagement. Specification of a kill criterion is also necessary. T is considered to equal 0 to 120 seconds for the program calculations. The kill probability associated with any specific time T is an aggregated result that accounts for kills that occur at any time up to T.
3. GENERAL FLOW OF PROGRAM LOGIC

3.1 Introduction.

This section provides a general indication of the principal steps involved in the simulation of firing engagements. Such an indication, which may suffice for many readers, is supplemented by the detailed explanations of the program logic that are contained in the appendixes.

3.2 Principal Program Steps.

The program instructions cause the computer to perform a sequence of steps. The flow can be complicated, principally when special purpose options are exercised. The principal steps for the basic program (exclusive of special purpose options) are as follows:

a. Read input cards for the weapon/round/fire control type, target type, target exposure conditions, and range involved.

b. Make all necessary adjustments to the card input data just read; for example, some data may require conversion from meters to inches.

c. Skip any files on the vulnerability data tape that precede the kill probability and personnel casualty data needed.

d. Read kill probability data from the vulnerability data tape for target orientation angles of 0 and 180, 30 and 210, 60 and 240, and 90 and 270 degrees. The two angles in each pair correspond to reverse directions. It is convenient to refer to the first angle as basic and to the second as the corresponding reverse angle. Steps e through j apply, in turn, to each pair of basic and reverse directions.

e. Simulate the first firing engagement for the basic orientation angle. See 3.3 for details.

f. Simulate the second firing engagement for the basic orientation angle, as for e.

g. Likewise, simulate additional engagements until a total of 10,000 engagements for the basic orientation angle has been reached.

h. Repeat steps e through g for the reverse orientation angle.

i. Combine data from all 10,000 firing engagements for each angle of the matched pair of concern to determine the hit probability and kill probabilities corresponding to 1, 2, 3, etc., 14, 15 rounds, the average, or expected, numbers of rounds needed to hit or to kill the target, and the hit and kill probabilities corresponding to engagement times of 0, 2, 4, etc., 118, 120 seconds.

j. Print as output the results obtained in step i.
3.3 Program Steps for Single Engagement at Particular Angle.

Simulation of a single firing engagement for a particular orientation angle begins with consideration of the first main round fired. Steps involved are as follows:

a. Determine the number of seconds between the beginning of the engagement and the arrival of the first round at the target range.

b. Determine if the first round flies reliably. If not, the target cannot be hit or killed and calculations for the next round begin immediately without any credit for sensing of the first round as a basis for adjustment of fire.

c. If the first round has a reliable flight trajectory, determine the impact point in the plane of the target and whether or not the target is hit.

d. If the first round misses the target, determine whether the round is sensed and begin calculations for the next round. The calculations for the next round eventually reflect whether or not adjustment of fire, to take advantage of information obtained by sensing, has been possible.

e. If the round hits, determine whether reliable functioning of the fuze occurs. If not, the target cannot be killed and calculations for the next round begin without any further consideration of possible damaging effects on the target.

f. If damaging effects are to be assessed, determine whether each of the various types of kill, i.e., M kill, F kill, M or F kill, and K kill, is inflicted on the target. Continue with the calculations for the second round whenever there is at least one kill criterion according to which the target has not been killed by the first round. If the target has been killed according to all criteria, proceed to simulation of the second firing engagement.

Unless the engagement is over, simulate firing of the second main round as follows:

g. Determine the number of seconds between firing of the first round and firing of the second round. Add this number to the time of arrival of the first round at the target range to obtain the time between the start of the engagement and the arrival of the second round at the target range.

h. Determine if the second round flies reliably. If not, proceed as for b above, i.e., begin calculations for the next round.
i. If the second round has a reliable flight trajectory, determine the impact point in the plane of the target and whether or not the target is hit, as for c. The second round is assumed fired with the same aimpoint as for the first round if the latter is not sensed, or with a new aimpoint based on sensing information.

j. If the second round misses the target, determine whether the round is sensed and begin calculations for the next round, as for d.

k. If the round hits, determine whether damaging effects are not to be assessed because of unreliable functioning of the fuze. If the fuze does not function reliably, begin calculations for the next round, as for e.

l. If damaging effects on the target are to be assessed, determine whether each of the various types of kill still being considered is inflicted on the target. Continue with the calculations for the third round whenever there is at least one kill criterion according to which the target has not yet been killed, or proceed to simulation of the second firing engagement.

If the engagement is not yet over after two rounds, simulate firing of the third round and succeeding rounds, as necessary, but not beyond the fifteenth round. Steps g through l also apply to each round following the second round. Times at which rounds arrive at the target range are ignored whenever these times are beyond 2 minutes from the start of the engagement.

3.4 Special Options.

Listing of the various special options available is not attempted here. Two examples, selected somewhat arbitrarily, are as follows:

a. A vulnerability data tape or disc is not absolutely required. It may be possible to substitute a set of input cards containing detailed target shape information identical to that on the tape or disc. Target shape data are sufficient if hit probabilities, but not kill probabilities, need to be computed. Although it would be possible to use input cards, rather than a tape or disc, for detailed vulnerability data also, this is impractical.

b. Calculations can be made for simplified engagements each involving the firing of only one round. In particular, single round hit probabilities and kill probabilities can be obtained for a moving target or a moving firing tank. However, this does not imply that the program can actually simulate in detail the movement of the target or firing tank.
4. INPUT DATA

4.1 Introduction.

The direct fire program can make calculations for several combinations of conditions considered in sequence. However, it is sufficient for this report to emphasize a single basic cycle definable as all the calculations for:

a. A specified firing weapon, round type, and fire control system.

b. A particular target.

c. One target exposure condition, i.e., the target is fully exposed or in defilade.

d. One range.

e. One of the orientation angles 0, 30, 60, or 90 degrees and the corresponding angle for the reverse direction. Matched pairs of angles are 0 and 180, 30 and 210, 60 and 240, and 90 and 270 degrees.

The input data required for a single basic cycle consist of both a set of cards, and normally, a tape or disc file. The cards contain control quantities as well as information related to aimpoint, reliability, delivery accuracy, and rate of fire. The tape or disc provides target vulnerability data.

This report documents the input data used for a sample computer run and the corresponding output results. For this sample run, it was more important to illustrate input and output quantities in detail than to consider weapon, target, and other combat engagement conditions of real concern. The inputs developed for the purpose just stated are listed in this section. They are suitable for illustrating input requirements and formats in detail and, while possibly similar to classified data of actual interest, are not applicable to a specific set of engagement conditions.

4.2 Card Inputs.

Contents of the input cards required to run the direct fire program are listed and briefly described in Table 4.1. The role of some input quantities should be evident from the table. Several other quantities, however, can be fully understood only in connection with detailed explanations subsequently provided. Cards numbered 1 through 5 contain controls needed for each computer run and applicable to each range regardless of how many ranges are grouped for the run. Integer controls are on the first three of these cards, and real quantities on the last two cards. Cards numbered R1 through R8 are needed for each range. Except for the integer controls,
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<td>CODE CONSISTING OF RUN IDENTIFIER (R15 IN EXAMPLE), ROUND IDENTIFIER (985), AND TARGET IDENTIFIER (1340)</td>
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<td>2</td>
<td>1-5</td>
<td>NRS KP</td>
<td>I5</td>
<td>3</td>
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<td>NUMBER OF VULNERABILITY DATA FILES TO BE SKIPPED ON TAPE OR DISC TO REACH FIRST FILE FOR ROUND/TARGET COMBINATION INVOLVED IN RUN</td>
</tr>
<tr>
<td>6-10</td>
<td></td>
<td>NCA SE S</td>
<td>I5</td>
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<td>NUMBER OF RANGES GROUPED TOGETHER FOR COMPUTER RUN</td>
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<td>11-15</td>
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<td>NFRST</td>
<td>I5</td>
<td>250</td>
<td>METERS</td>
<td>FIRST RANGE INVOLVED IN CALCULATIONS</td>
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<td>16-20</td>
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<td>NTGT</td>
<td>I5</td>
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<td>TARGET TYPE CODE ASSOCIATED WITH FORMAT USED TO ENTER VULNERABILITY DATA ON TAPE OR DISC</td>
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<td>21-25</td>
<td></td>
<td>NRDYP</td>
<td>I5</td>
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<td></td>
<td>ROUND TYPE CODE SET TO 0 IF VULNERABILITY DATA DO NOT VARY WITH RANGE, OR 1 OTHERWISE</td>
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<td>26-30</td>
<td></td>
<td>NRD1</td>
<td>I5</td>
<td>0</td>
<td></td>
<td>CONTROL SET TO 1 IF ONLY ONE ROUND IS OF INTEREST FOR EACH ENGAGEMENT, OR ANY NUMBER NOT 1 (O PREFERRED) OTHERWISE</td>
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<td>31-35</td>
<td></td>
<td>NRDS</td>
<td>I5</td>
<td>15</td>
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<td>MAXIMUM NUMBER OF ROUNDS TO BE FIRED PER ENGAGEMENT</td>
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<tr>
<td>36-40</td>
<td></td>
<td>NADJST</td>
<td>I5</td>
<td>0</td>
<td></td>
<td>CONTROL SET TO 1, 2, 3, 4, OR 5 IF ASSOCIATED ADJUSTMENT PROCEDURE IS TO BE USED AFTER MISSING ROUND, OR 0 FOR BASIC PROCEDURE INVOLVING ADJUSTMENT BASED ON SENSING WHEN POSSIBLE AND RELAYING ON PREVIOUS AIMPOINT OTHERWISE</td>
</tr>
<tr>
<td>41-45</td>
<td></td>
<td>NRFBS</td>
<td>I5</td>
<td>1</td>
<td></td>
<td>CONTROL SET TO 1 IF AIMPOINT IS APPROXIMATE CENTER OF MASS OF TARGET (AS WHEN RANGING IS DONE WITH RANGEFINDER), OR 2 IF VERTICAL COORDINATE OF AIMPOINT CORRESPONDS TO BASE OF TARGET (AS WHEN BATTLE SIGHT IS USED)</td>
</tr>
<tr>
<td>46-50</td>
<td></td>
<td>NDROP</td>
<td>I5</td>
<td>0</td>
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<td>CONTROL SET TO 1, 2, 3, 4, 5, OR 6 WHEN VERTICAL CHANGE IS INVOLVED IN ADJUSTMENT PROCEDURE AFTER MISSING ROUND THAT IS NOT SENSED, OR 0 OTHERWISE</td>
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</tr>
<tr>
<td>51-55</td>
<td>NHIT</td>
<td>15</td>
<td>0</td>
<td>CONTROL SET TO ANY NUMBER NOT 0 (1 PREFERRED) IF AIMPOINT IS TO BE ADJUSTED TOWARD TARGET CENTER AFTER TARGET IS HIT, OR 0 OTHERWISE</td>
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</tr>
<tr>
<td>56-60</td>
<td>NPRHIT</td>
<td>15</td>
<td>0</td>
<td>CONTROL SET TO 1 IF HIT PROBABILITIES ARE ONLY DESIRED OUTPUT, OR 0 OTHERWISE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>61-65</td>
<td>NDTRM1</td>
<td>15</td>
<td>0</td>
<td>CONTROL SET TO 1 IF REHIT PROBABILITY OF SECOND ROUND AFTER FIRST ROUND HIT IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>66-70</td>
<td>NDTRM2</td>
<td>15</td>
<td>0</td>
<td>CONTROL SET TO 1 IF REHIT PROBABILITY OF SECOND ROUND AFTER FIRST ROUND HIT THAT DOES NOT CAUSE KILL IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE</td>
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<td>3</td>
<td>NDTRM3</td>
<td>15</td>
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<td>CONTROL SET TO 1 IF HIT PROBABILITY OF SECOND ROUND AFTER FIRST ROUND MISS IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE</td>
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</tr>
<tr>
<td>6-10</td>
<td>NDTRM4</td>
<td>15</td>
<td>0</td>
<td>CONTROL SET TO 1 IF HIT PROBABILITY OF SECOND ROUND AFTER SENSED MISS ON FIRST ROUND IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE</td>
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<td></td>
</tr>
<tr>
<td>11-15</td>
<td>NDTRM5</td>
<td>15</td>
<td>0</td>
<td>CONTROL SET TO 1 IF HIT PROBABILITY OF SECOND ROUND AFTER UNSENSED MISS ON FIRST ROUND IS TO BE CALCULATED DETERMINISTICALLY WITH DATA FROM MONTE CARLO ENGAGEMENTS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE</td>
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<td></td>
</tr>
<tr>
<td>16-20</td>
<td>NHTKLL</td>
<td>15</td>
<td>0</td>
<td>CONTROL SET TO 0 IF DETERMINISTIC CALCULATIONS OF CERTAIN HIT AND KILL PROBABILITIES ARE NOT TO BE MADE WITH DATA FROM INPUT CARDS, 9 IF SUCH CALCULATIONS ARE TO BE MADE AND RESULTS TO CONSTITUTE ONLY OUTPUT, OR ANY NUMBER NOT 0 OR 9 (1 PREFERRED) IF SUCH CALCULATIONS ARE TO BE MADE IN ADDITION TO SIMULATION OF MONTE CARLO ENGAGEMENTS</td>
<td></td>
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<tr>
<td>Table 4.1</td>
<td>CONTENTS OF PROGRAM INPUT CARDS (CONTINUED)</td>
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| 21-25      | NTCD1 | I5  | 0  | CONTROL SET TO 1 IF INPUT CARD DATA ARE NEEDED TO DESCRIBE SHAPE OF 0 DEGREE TARGET, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE |
| 26-30      | NTCD2 | I5  | 0  | CONTROL SET TO 1 IF INPUT CARD DATA ARE NEEDED TO DESCRIBE SHAPE OF 30 DEGREE TARGET, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE |
| 31-35      | NTCD3 | I5  | 0  | CONTROL SET TO 1 IF INPUT CARD DATA ARE NEEDED TO DESCRIBE SHAPE OF 60 DEGREE TARGET, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE |
| 36-40      | NTCD4 | I5  | 0  | CONTROL SET TO 1 IF INPUT CARD DATA ARE NEEDED TO DESCRIBE SHAPE OF 90 DEGREE TARGET, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE |

| 4          | 1-10 | PASSN | F10.4 | 6.0000 | MEN |
| 11-20      | WCELL | F10.4 | 4.0000 | INCHES OR MILLIMETERS |
| 21-30      | XC    | F10.4 | 0.0000 | LIKE WCELL |
| 31-40      | YC    | F10.4 | -28.000 | LIKE WCELL |
| 41-50      | YBASE | F10.4 | -70.000 | LIKE WCELL |
| 51-60      | YTOP  | F10.4 | 9999.9999 | LIKE WCELL |
| 61-70      | RELT  | F10.4 | 0.9900 |
| 5          | 1-10 | RELF  | F10.4 | 0.9280 | PROBABILITY OF RELIABLE FUZE FUNCTIONING FOR EACH ROUND FIRED |

NUMBER OF TARGET PASSENGER PERSONNEL, EXCLUDING CREW
DIMENSION OF EACH TARGET CELL, WHICH CAN BE ONLY 4.0000 FOR 4 INCHES OR 100.0000 FOR 100 MILLIMETERS
HORIZONTAL COORDINATE OF POINT CHOSEN AS APPROXIMATE CENTER OF MASS OF TARGET
VERTICAL COORDINATE OF POINT CHOSEN AS APPROXIMATE CENTER OF MASS OF TARGET
MINIMUM VERTICAL COORDINATE OF UNSHIELDED PORTION OF TARGET
VERTICAL COORDINATE OF POINT CHOSEN AS APPROXIMATE TOP OF TARGET, USUALLY UNNEEDED AND SET TO 9999.9999. ANY OTHER SETTING INDICATES ADJUSTMENT PROCEDURE ASSOCIATED WITH NDROP EQUALLING 1 APPLIES AFTER MISSING ROUND.
PROBABILITY OF RELIABLE PROJECTILE FLIGHT FOR EACH ROUND FIRED
PROBABILITY OF RELIABLE FUZE FUNCTIONING FOR EACH ROUND FIRED
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<td>I5</td>
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<td>INTPL</td>
<td>I5</td>
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<td>11-15</td>
<td>IMILS</td>
<td>I5</td>
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**TARGET RANGE**

- RANGE INTERPOLATION CONTROL SET TO 1 IF NRDTYP EQUALS 1 AND IRANGE IS NOT MULTIPLE OF 500 METERS, OR ANY NUMBER NOT 1 (0 PREFERRED) OTHERWISE
- CONTROL SET TO 0 FOR METERS OR 1 FOR MILS TO INDICATE UNITS CHOSEN FOR VARIOUS DATA ON CARDS R3 THROUGH R8

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**PROJECTILE TIME OF FLIGHT**

- FIXED FIRING TIME FOR FIRST ROUND
- FIXED FIRING TIME FOR EACH SUBSEQUENT ROUND
- MEDIAN VARIABLE FIRING TIME FOR FIRST ROUND
- MEDIAN VARIABLE FIRING TIME FOR EACH SUBSEQUENT ROUND
- MINIMUM FIRING TIME FOR FIRST ROUND
- MINIMUM FIRING TIME FOR EACH SUBSEQUENT ROUND

<p>| | | | | | | | | |</p>
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<tr>
<td>11-20</td>
<td>STD2</td>
<td>F10.4</td>
<td>0.0000</td>
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<tr>
<td>21-30</td>
<td>XB</td>
<td>F10.4</td>
<td>0.0357</td>
<td>METERS OR MILS</td>
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<td>31-40</td>
<td>YB</td>
<td>F10.4</td>
<td>1.0161</td>
<td>METERS OR MILS</td>
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<td>F10.4</td>
<td>0.2277</td>
<td>METERS OR MILS</td>
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**TIME VARIABILITY FACTOR FOR FIRST ROUND**

- TIME VARIABILITY FACTOR FOR EACH SUBSEQUENT ROUND
- HORIZONTAL FIXED BIAS FOR FIRST ROUND
- VERTICAL FIXED BIAS FOR FIRST ROUND
- HORIZONTAL VARIABLE BIAS STANDARD DEVIATION FOR FIRST ROUND
- VERTICAL VARIABLE BIAS STANDARD DEVIATION FOR FIRST ROUND
- HORIZONTAL LAY ERROR STANDARD DEVIATION FOR FIRST ROUND
- VERTICAL LAY ERROR STANDARD DEVIATION FOR FIRST ROUND
- HORIZONTAL ROUND-TO-ROUND ERROR STANDARD DEVIATION
- VERTICAL ROUND-TO-ROUND ERROR STANDARD DEVIATION
- PROBABILITY OF GUNNER AND/OR COMMANDER SENSING MISSING ROUND
- HORIZONTAL SENSING ERROR STANDARD DEVIATION
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<td>SIGYS</td>
<td>F10.4</td>
<td>1.4635</td>
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<td>Vertical Sensing Error Standard Deviation</td>
</tr>
<tr>
<td>61-70</td>
<td>PGH</td>
<td>F10.4</td>
<td></td>
<td>Probability of Gunner Sensing Round That Misses High</td>
</tr>
<tr>
<td>R5</td>
<td>1-10</td>
<td>PGS</td>
<td>F10.4</td>
<td>Probability of Gunner Sensing Round That Misses Short</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Probability of Gunner and/or Commander Sensing Round That Misses High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Probability of Gunner and/or Commander Sensing Round That Misses Short</td>
</tr>
<tr>
<td>31-40</td>
<td>SGHX</td>
<td>F10.4</td>
<td></td>
<td>Horizontal Sensing Error Standard Deviation for Gunner Sensing of Round That Misses High</td>
</tr>
<tr>
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<td>SGHY</td>
<td>F10.4</td>
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<td>Vertical Sensing Error Standard Deviation for Gunner Sensing of Round That Misses High</td>
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<td>Vertical Sensing Error Standard Deviation for Gunner Sensing of Round That Misses Short</td>
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<td>R6</td>
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<td>CDRX</td>
<td>F10.4</td>
<td>Horizontal Add-On Sensing Error Standard Deviation to Be Combined with SGHX or SGSX for Commander Sensing of Missing Round</td>
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<td>Vertical Add-On Sensing Error Standard Deviation to Be Combined with SGHY or SGSY for Commander Sensing of Missing Round</td>
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<td>Horizontal Error Standard Deviation for Gunner Adjustment of Hitting Round Toward Target Center</td>
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<td>Vertical Error Standard Deviation for Gunner Adjustment of Hitting Round Toward Target Center</td>
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<td>Horizontal Variable Bias Standard Deviation for Round Following Hitting Round</td>
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<td>METERS OR MILS</td>
<td>HORIZONTAL FIXED BIAS FOR ROUND FOLLOWING MISSING ROUND THAT IS NOT SENSED</td>
</tr>
<tr>
<td>21-30</td>
<td>YBL</td>
<td>F10.4</td>
<td>METERS OR MILS</td>
<td>VERTICAL FIXED BIAS FOR ROUND FOLLOWING MISSING ROUND THAT IS NOT SENSED</td>
</tr>
<tr>
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<td>METERS OR MILS</td>
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<td>F10.4</td>
<td>METERS OR MILS</td>
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<tr>
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<td>SIGYBS</td>
<td>F10.4</td>
<td>METERS OR MILS</td>
<td>VERTICAL VARIABLE BIAS STANDARD DEVIATION FOR ROUND FOLLOWING MISSING ROUND THAT IS SENSED</td>
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on the R1 card, all input data on these cards are real. The EXAMPLE column of Table 4.1 contains the data used for the run that yielded the sample outputs presented in section 5. Since IMILS is set to 0, meters are the unit associated with cards R3 through R6. Blanks on cards R4 through R8 correspond to input quantities associated with special options that were not exercised in the sample run.

The manner in which input data are actually arranged on cards is illustrated in Table 4.2. This table contains the same inputs as the previous one. The first portion of the table shows how the basic control cards (identifiable by R15 A, B, C, D, E entered in the last 8 columns) are followed by the 8 cards corresponding to 250 meters (identifiable by R15 2501, 2, 3, 4, 5, 6, 7, 8 in these same columns). The 250-meter cards would be followed if necessary by similar groups of 8 cards for other ranges. The remainder of the table repeats the card images, with headings added to facilitate relating each quantity to the explanatory information in Table 4.1.

4.3 Tape or Disc Inputs.

Vulnerability data constituting needed tape or disc input information are generated by the Vulnerability Division of the Ballistic Research Laboratory (BRL). These data are extensive in scope and consist of kill probabilities for a large number of specific impact points on the target. These impact points are selected from the grid squares obtained by dividing the target as shown in Figure 4.1. These squares, usually called cells, are either 4 inches (101.6mm) or 100mm on each side. One impact point is chosen from each cell and data developed for that point are then considered representative of the effects of a hit anywhere on the cell. Table 4.3 illustrates a portion of the data. The associated conditions are not identifiable, since fictitious projectile, target, and range headings appear in the table. The coordinates X and Y are those of the center of each cell and refer to a suitably selected origin, e.g., at the turret center line for some tank targets or at the base of the target. Each line of data includes probabilities of M kill, F kill, M or F kill (M/F in the table), and K kill, as well as expected casualties when applicable, given a hit on the cell of interest for both a basic orientation angle and the corresponding reverse angle. Note that the reverse angle corresponding here to 30 degrees is 150 degrees. This reflects the assumption, established by BRL, that a single set of vulnerability data can reasonably be used for symmetrically related directions, like 150 and 210 degrees, that represent attack of a target from the right in one instance and from the left in the other.

The vulnerability data used for the sample computer run differ from those partly shown in Table 4.3, but need not be identified further.

The points labelled A, B, C, and D in Figure 4.1 are the corners of a rectangle just large enough to enclose the target representation. Such a rectangle is referred to in some of the explanations in Appendix A.
### Table 4.2  Sample Input Card Data

<table>
<thead>
<tr>
<th>Card</th>
<th>Columns 1</th>
<th>Columns 2</th>
<th>Columns 3</th>
<th>Columns 4</th>
<th>Columns 5</th>
<th>Columns 6</th>
<th>Columns 7</th>
<th>Columns 8</th>
</tr>
</thead>
</table>
| R159851340 | 3 | 10 | 250 | 2 | 0 | 0 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | R15 A  
|   | 6.0000 | 4.0000 | 0.0000 | -28.0000 | -70.0000 | 9999.5999 | 0.9900 |
| 0.9280 | 250 | 0 | 0 | 1.7100 | 0.0000 | 0.0000 | 19.8000 | 15.6000 | 0.0000 | 0.0000 | 0.0000 | R15 B  
| 0.0000 | 0.0357 | 1.0161 | 2.7038 | 5.5923 | 0.2277 |
| 0.2277 | 0.6136 | 0.6872 | 0.7800 | 1.4635 | 1.4635 |
| 1234567890 | 1234567890 | 1234567890 | 1234567890 | 1234567890 | 1234567890 | 1234567890 | 1234567890 | 1234567890 |
| CARD R15 A | IDCDE |
| R159851340 |
| CARD R15 B | NRSKP, NCASES, NRFIRST, NTGT, NRTYP, NRD1, NRD3, NADJUST, NRSBS, NDRPS, NDTRM, NDTRM2 |
|   | 3 | 10 | 250 | 2 | 0 | 0 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | R15 B  
| CARD R15 C | NDTRM, NDTRM3, NDTRM4, NDTRM5, NHTKLL, NTCD1, NTCD2, NTCD3, NTCD4 |
|   | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | R15 C  
| CARD R15 D | PASSN, WCAM, XC, YC, YBASE, YTOD, RELT |
|   | 6.0000 | 4.0000 | 0.0000 | -28.0000 | -70.0000 | 9999.5999 | 0.9900 | R15 D  
<p>|   | 0.9900 |</p>
<table>
<thead>
<tr>
<th>CARD R15 2501</th>
<th>IRANGE, INTPL, IMILS</th>
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</thead>
<tbody>
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<td>R15 2501</td>
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</tr>
</tbody>
</table>

<table>
<thead>
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<th>CARD R15 2502</th>
<th>FLT, TF1, TFS, XM1, XM2, AMT1, AMT2</th>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>CARD R15 2503</th>
<th>STD1, STD2, XB, YB, SIGXB, SIGYB, SIGXL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CARD R15 2504</th>
<th>SIGYL, SIGXR, SIGYR, PROBS, SIGXS, SIGYS, PGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2277</td>
<td>0.6136</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CARD R15 2505</th>
<th>PGS, PGCH, PGCS, SGHX, SGHY, SGSX, SGSY</th>
</tr>
</thead>
<tbody>
<tr>
<td>R15 2505</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CARD R15 2506</th>
<th>CDRX, CDRY, HSX, HSY, XBH, YBH, SIGXBH</th>
</tr>
</thead>
<tbody>
<tr>
<td>R15 2506</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>CARD R15 2507</th>
<th>SIGYBH, XBL, YBL, SIGXBL, SIGYBL, XBS, YBS</th>
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</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CARD R15 2508</th>
<th>SIGXBS, SIGYBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>R15 2508</td>
<td></td>
</tr>
</tbody>
</table>
Note: A, B, C, and D are corners of rectangle enclosing target.

Figure 4.1 Medium Tank Target at Orientation of 60 Degrees

X (INCHES)

Y (INCHES)

40 20 0 -20 -40

30
### TABLE 4.3 SAMPLE DATA FROM VULNERABILITY TAPE

**PROJECTILE 985 AT 1500 METERS RANGE VS. VEHICLE 1340  5/77**

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
<th>0 DEG ELEV, M</th>
<th>30 DEG AZIM M/F</th>
<th>K</th>
<th>EC</th>
<th>0 DEG ELEV, 150 DEG AZIM M/F</th>
<th>K</th>
<th>EC</th>
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</tbody>
</table>

999.9

**ETC**
4.4 Requirements for Special Options.

A special option, already mentioned in 3.4, permits using input cards with target shape information instead of the vulnerability data tape or disc normally required for a run. Card requirements associated with this option are illustrated in Table 4.4. Numbers are grouped by threes. For example, 76, -28, -8 mean that the target includes an unbroken string of cells whose centers have coordinates (-28,76), (-24,76), (-20,76), (-16,76), (-12,76), and (-8,76), while 88, -24, -24 simply identify an isolated cell the coordinates of whose center are (-24,88). The total target can thus be specified as a combination of horizontal strips of cells and, normally, some isolated cells toward the edges. The target shape card option has been restricted to only four orientations, namely, 0, 30, 60, and 90 degrees, identified in columns 77 and 78 on the cards. The sample run documented in this report did not involve target shape data cards.

The direct fire program has been designed to permit certain calculations for a moving target or a moving firing tank. Single round hit probabilities and kill probabilities are obtainable for sets of up to 18 conditions. Input card requirements are then as explained in connection with Table 4.1, except for two differences. First, on the R1 card for only the first range involved in the run, INTPL does not have the previously explained meaning but should be set to 987. The second difference is that each R3 card is replaced by a set of 18 such cards. It is assumed that, from other sources, biases and overall standard deviations including contributions of lay and round-to-round errors are known. Thus, these overall standard deviations can be entered in SIGXB and SIGYB, redefined accordingly; redefinition of the biases XB, YB is not necessary. Tape or disc input requirements are not affected. Sections of the computer program that specifically apply to moving target or moving firing tank calculations were not exercised in the sample run made for this report.
### TABLE 4.4  SAMPLE CARDS WITH TARGET SHAPE DATA

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<thead>
<tr>
<th>CARDS</th>
<th>TARGET SHAPE DATA</th>
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<tbody>
<tr>
<td>88- 24- 24 88 8 8 8 84- 24- 24 84- 8- 8</td>
<td>1340 0 1</td>
</tr>
<tr>
<td>84 8 8 84 24 24 80- 24- 20 80- 8- 8</td>
<td>1340 0 2</td>
</tr>
<tr>
<td>80 8 8 80 24 24 76- 28- 8 76 8 12</td>
<td>1340 0 3</td>
</tr>
<tr>
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</tr>
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<td>20- 36- 28- 20 28 36 9999 9999 9999</td>
<td>1340 015</td>
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<tr>
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</tr>
<tr>
<td>84 24 36 80 0 20 80 28 44 80 52 52</td>
<td>134030 2</td>
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</tbody>
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### COLUMNS

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<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
<th>7</th>
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<tbody>
<tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **CARD 1340 0 1**
  NCTRY(1,1), NCTRXL(1,1), NCTRXR(1,1),
  NCTRY(2,1), NCTRXL(2,1), NCTRXR(2,1),
  NCTRY(3,1), NCTRXL(3,1), NCTRXR(3,1),
  NCTRY(4,1), NCTRXL(4,1), NCTRXR(4,1),
  88- 24- 24 88 8 8 8 84- 24- 24 84- 8- 8 | 1340 0 1 |

- **CARD 1340 0 2**
  NCTRY(5,1), NCTRXL(5,1), NCTRXR(5,1),
  NCTRY(6,1), NCTRXL(6,1), NCTRXR(6,1),
  NCTRY(7,1), NCTRXL(7,1), NCTRXR(7,1),
  NCTRY(8,1), NCTRXL(8,1), NCTRXR(8,1),
  84 8 8 84 24 24 80- 24- 20 80- 8- 8 | 1340 0 2 |

- **CARD 1340 0 3**
  NCTRY(9,1), NCTRXL(9,1), NCTRXR(9,1),
  NCTRY(10,1), NCTRXL(10,1), NCTRXR(10,1),
TABLE 4.4 SAMPLE CARDS WITH TARGET SHAPE DATA (CONTINUED)

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<tr>
<th>CARD</th>
<th>NCTRY1(11,1),</th>
<th>NCTRX(11,1),</th>
<th>NCTRXR(11,1),</th>
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<td>NCTRY(57,1),</td>
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<td>NCTRXR(57,1),</td>
</tr>
<tr>
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<td>NCTRX(58,1),</td>
<td>NCTRXR(58,1),</td>
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<td>NCTRX(59,1),</td>
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<table>
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<th>NCTRXR(1,2),</th>
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<table>
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<th>NCTRX(5,2),</th>
<th>NCTRXR(5,2),</th>
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</thead>
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<th>NCTRXL(53,2)</th>
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92 24 24 88 17 16 88 28 28 84 20 36 1340601

E T C . . . . . .
5. OUTPUT DATA

5.1 Introduction.

Output results provided by the direct fire program consist primarily of cumulative hit probabilities and kill probabilities for up to 15 rounds, average numbers of rounds expected to be needed to hit or kill targets, and cumulative hit probabilities and kill probabilities versus engagement time for up to 2 minutes. In addition, cumulative passenger casualties expected for up to 15 rounds are included for personnel carrier targets. Information useful for verifying the input data used also constitutes a part of the printed output.

5.2 Outputs of Sample Computer Run.

The input quantities identified in Table 4.1 (and Table 4.2) and data from a vulnerability data tape were used to make a sample run. Table 5.1 presents selected results of this run.

All data from the input cards used for a run are rewritten exactly as they appear on the cards. The same data are generally repeated with corresponding program symbols and a brief indication of what the symbols mean. Exceptionally, quantities associated with the program symbols may not be strictly identical to the related card quantities. For example, the dimension of target cells may be in millimeters originally and converted to inches.

Identifying conditions associated with input information provided by the vulnerability data tape or disc are printed, but the actual vulnerability data are not.

The number of samples is not calculated but has been fixed in the program itself at 10,000.

Angles 1 and 2 designate target orientation directions of 0 and 180 degrees respectively. Data already identified as the primary output results of a run are printed for each such related pair of target orientations (angles 1 and 2, 3 and 4, etc.).

Cumulative hit probabilities and kill probabilities, as well as personnel casualties when applicable, for up to 15 rounds are arranged in twelve columns of 15 quantities each. Reading horizontally, one sees two sets of five columns followed by two columns. The first five columns correspond to the first angle (0 degrees for the first pair of angles) and are, from left to right, cumulative probabilities of achieving an M kill, an F kill, an M or F kill, a K kill, or a hit on the target. The next five columns contain this same information, similarly arranged, for the second angle (180 degrees for the first pair). The last two columns, printed only when they apply, are cumulative passenger casualties for the two angles (0 and 180 degrees) respectively.
### TABLE 5.1  SAMPLE OUTPUT DATA

| R159851340 |
|-------------------|-----------|
| 3 10 250 2 0 0 0 15 0 1 0 0 0 0 0 |

| NRSKP | VULN. TAPE FILES TO SKIP | 3 |
| NCASES | NO. OF CASES | 10 |
| NRFRST | FIRST RANGE FOR VULN. DATA | 250 |
| NTGT | VULN. TAPE FORMAT | 2 |
| NRDTYP | VULN. DATA DEP. ON RANGE | 0 |
| NRTD1 | SINGLE ROUND ENGAGEMENT | 0 |
| NRDS | MAX. NO. OF RDS. | 15 |
| NADJST | SP. PROC. FOR MISS. RD. | 0 |
| NRFBM | RANGEFINDER OR BATTLEFIELD | 1 |
| NDROP | STANDARD DROP ADJUSTMENT | 0 |
| NHIT | ADJ. HIT | 0 |
| NPRHIT | HIT PROB. OUTPUT ONLY | 0 |
| NDTRM1 | DETERMINISTIC HIT1 | 0 |
| NDTRM2 | DET2 NO KILL HIT1 | 0 |
| NDTRM3 | DET2 MISS1 | 0 |
| NDTRM4 | DET2 OBSERVED MISS1 | 0 |
| NDTRM5 | DET2 UNOBSERVED MISS1 | 0 |
| NHTKLL | HIT AND KILL PROB. INPUT | 0 |
| NTCD1 | CARDS FOR TARGET1 | 0 |
| NTCD2 | CARDS FOR TARGET2 | 0 |
| NTCD3 | CARDS FOR TARGET3 | 0 |
| NTCD4 | CARDS FOR TARGET4 | 0 |

| 6.0000 | 4.0000 | 0.0000 | -28.0000 | -70.0000 | 9999.9999 | .9900 |

HOR.  VERT.

| PASSN | TGT. PERS. EXCL. CREW | 6.0000 |
| W/W | CELL DIM. IN INCHES | 4.0000 | 4.0000 |
| XC, YC | TGT. CTR. COORD. INS. | 0.0000 | -28.0000 |
| YBASE | TGT. BOT. COORD. INS. | -70.0000 | 9999.9999 |
| YTOP | TOP APPR. COORD. INS. | | |
| RELT | PROB. OF REL. FLIGHT | .9900 |
| RELF | PROB. OF REL. FUZE | .9280 |
### Table 5.1 Sample Output Data (Continued)

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<tr>
<th>1.7100</th>
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<th>0.0000</th>
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<th>15.6000</th>
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**Time Data (Seconds)**

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<tr>
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<tr>
<td>XM1, XM2</td>
</tr>
<tr>
<td>AMT1, AMT2</td>
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<tr>
<td>STD1, STD2</td>
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**Accuracy Data (Meters)**

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<th>Vert.</th>
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<td>SIGXB, SIGYB</td>
</tr>
<tr>
<td>SIGXL, SIGYL</td>
<td>SIGXR, SIGYR</td>
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<tr>
<td>PROBS</td>
<td>SIGXS, SIGYS</td>
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**Fixed Bias**

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<td>.2277</td>
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**Median Variable Time**

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**Minimum Time**

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**Fixed Time**

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**Minimum Time Std. Dev.**

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**Median Time Standard Deviation**

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**Median Time Standard Deviation**

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**Time of Flight**

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**Time of Flight Standard Deviation**

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### Projectile 985 vs. Vehicle 1340

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<tr>
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<tr>
<td>Target Code</td>
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<tr>
<td>Range in Meters</td>
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**0 Deg Elevation, 0 Deg Azimuth**

<table>
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<table>
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### Table 5.1 Sample Output Data (Continued)

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TABLE 5.1  SAMPLE OUTPUT DATA (CONTINUED)

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| 0.01730 0.02320 0.02820 0.03500 0.04290 0.05290 0.06290 0.07420 0.08430 0.09650 |
| 0.10700 0.11730 0.12940 0.14250 0.15470 0.16940 0.18300 0.19420 0.20820 0.22026 |
| 0.23260 0.24510 0.25840 0.27030 0.28290 0.29720 0.31110 0.32260 0.33390 0.34540 |
| 0.35540 0.36590 0.37790 0.39030 0.40200 0.41080 0.42180 0.43100 0.44080 0.45110 |
| 0.46000 0.47050 0.47990 0.48920 0.49940 0.50900 0.51790 0.52550 0.53400 0.54260 |
| 0.55140 | |
| 0.00000 0.00000 0.00000 0.00000 0.00050 0.00150 0.00250 0.00630 0.00880 0.01280 |
| 0.01700 0.02270 0.02760 0.03440 0.04190 0.05180 0.06160 0.07240 0.08220 0.09410 |
| 0.10430 0.11390 0.12540 0.13810 0.15010 0.16460 0.17750 0.18860 0.20230 0.21360 |
| 0.22600 0.23820 0.25090 0.26310 0.27550 0.28960 0.30320 0.31410 0.32540 0.33570 |
| 0.34600 0.35670 0.36820 0.38050 0.39000 0.40030 0.41070 0.41980 0.42950 0.43930 |
| 0.44800 0.45830 0.46750 0.47680 0.48690 0.49660 0.50520 0.51390 0.52290 0.53160 |
| 0.54050 | |
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| 0.10750 0.11770 0.12990 0.14300 0.15530 0.17010 0.18370 0.19480 0.20880 0.22070 |
| 0.23310 0.24560 0.25890 0.27080 0.28340 0.29770 0.31150 0.32290 0.33420 0.34470 |
| 0.35560 0.36610 0.37810 0.39050 0.40040 0.41100 0.42200 0.43140 0.44120 0.45150 |
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| 0.55220 | |
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| 0.35710 0.36700 0.37560 0.38270 0.39210 0.40130 0.40900 0.41760 0.42660 0.43340 |
| 0.44050 | |
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| 0.25710 0.27050 0.28400 0.29790 0.31110 0.32680 0.34120 0.35340 0.36570 0.37680 |
| 0.38800 0.39990 0.41220 0.42480 0.43500 0.44570 0.45780 0.46810 0.47780 0.48840 |
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**TABLE 5.1  SAMPLE OUTPUT DATA (CONTINUED)**

ETC. . . FOR OTHER ANGLES
Average numbers of rounds expected to be needed to hit or kill targets consist of two sets of five numbers each. The two sets correspond to the two target orientations respectively. The ordering within each set, according to the type of kill or whether only a target hit is considered, is the same as for the ten groups of hit probabilities and kill probabilities discussed in the preceding paragraph.

Ten groups of cumulative hit probabilities and kill probabilities versus engagement time follow. Five groups apply, as before, to each target orientation. The correspondence with kill type or whether only a target hit is of concern also remains as before. Each group contains 61 numbers. These are cumulative probabilities for engagement times of 0, 2, 4, etc., 118, 120 seconds.

It is recognized that the formats used to print output probabilities and expected personnel casualties contain several unnecessary decimal places. However, all results have been consistently rounded to two decimal places for the tank effectiveness pamphlets published by the JMEM-SS Methodology and Evaluations Working Group.

The choice of 10,000 samples that was made results in the computed output quantities, mostly probabilities, being practically always accurate to within 0.005. This degree of accuracy is basically equivalent to that achievable by deterministic programs.
The direct fire program is coded in FORTRAN IV.

Production runs have been made, with the program, on the CDC 7600 computer at Aberdeen Proving Ground, Maryland and the CDC 6600 computer at Oklahoma State University Field Office, Eglin Air Force Base, Florida. Also, it has recently been learned that the Oklahoma State University Field Office will use a newer CYBER 176 computer for future production runs.

Running times can vary according to various factors, e.g., the computer used and the program options exercised. A basic run, i.e., one primarily intended to simulate 10,000 engagements for several target ranges and four pairs of target orientation angles at each range, would typically require about 1 minute of computer time for each range on either the CDC 7600 or CYBER 176.
APPENDIX A

PROGRAM LISTING AND DETAILED EXPLANATIONS
The principal objective of this appendix is to provide a listing of FORTRAN statements and detailed explanations for the main program. For completeness, however, subroutine NRAN and function CNORM are also listed and briefly described.

Both the listing of program statements and the corresponding detailed explanations cover several pages. Listing and explanation pages have been intermixed so that program statements and accompanying explanations are reasonably near together.

Some input quantities have already been sufficiently explained in Section 4. Additional explanations related to inputs are included only as necessary to supplement that section.

Main program lines are numbered from 1 through 1385. These lines were grouped as seemed most convenient to facilitate the explanations.

Certain program statements require no explanation. Other statements, used more than once, are covered only when they first occur.

The listing and explanations for the main program, subroutine NRAN, and function CNORM follow.
PROGRAM LISTING

1

PROGRAM MEWGD (INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT, TAPE2)

COMMON A(80), AFAIL(15), AKIL(61,10), AX(201)
A, (AS(51), C(10), IDCOD(10), IK(50,200)
B, (IP(10), ITAPE(80), MPK(3000,8), NTEMP(4)
C, (NTEMP(4), PK(10), PKRLFT(10), XTEMP(4)
D, (XTEMPL(4), XIOMXY(3000,4), YTEMPL(4), Z(19,12)
E, (XLEFTH(4), XRGHTF(4), XLEFTD(4), XRGHTD(4)

COMMON KDHSTC(5), BX(5), BY(5), SIGX(3,5)
A, SIGY(3,5), (NMNUS(50,2,5), NPLUS(50,2,5), COORD(12)
B, TOTAL(2), NPOS(50), NNEG(50), NCMPOS(50)
C, NCMNEG(50), NRFLCT(50), BIASXY(2,5), SIGMX(3,2,5)
D, PH(3,5), (PKILL(4,3,5)

COMMON BBX(4), BABY(4), SSIGX(4), SSIGY(4)
A, PPH(5), (PKSHOT(4,5), PPKHIT(4,5)

COMMON KTRGTC(4), NCTR(120,2), NCTRXL(120,4), NCRXR(120,4)
COMMON XXB(3,6), YYB(3,6), SSIGXB(3,6), SSIGYB(3,6)

DATA MASK11 / 3777 B /
DATA MASK16 / 17777 B /

20 WRITE (6,1010)
1010 FORMAT ( / )

READ (5,1110) IDCODE
1110 FORMAT (10A1)

WRITE (6,1112) IDCODE
1112 FORMAT (1HL, 10X, 10A1)

WRITE (6,1010)

READ (5,1120) NRSKP, NCASES, NFRST, NTGT, NDTYP, NRD1, NRDS
A, (NADJST, NRDFS, NDRP, NHIT, NPRHIT, NDM2, NDTRM2
B, NDTRM3, NDTRM4, NDTRM5, NHTKL, NTCRD1, NTCRD2, NTCRD3
C, NTCRD4

1120 FORMAT (1415)

WRITE (6,1122) NRSKP, NCASES, NFRST, NTGT, NDTYP, NRDI, NRDS
A, (NADJST, NRDFS, NDRP, NHIT, NPRHIT, NDM2, NDTRM2
B, NDTRM3, NDTRM4, NDTRM5, NHTKL, NTCRD1, NTCRD2, NTCRD3
C, NTCRD4

1122 FORMAT (10X,1415)

WRITE (6,1020)

1020 FORMAT ( )

IF (NRSKP .EQ. 9999) NRSKP = 0

WRITE (6,1130) NRSKP, NCASES, NFRST, NTGT, NDTYP, NRDI, NRDS
A, (NADJST, NRDFS, NDRP, NHIT, NPRHIT, NDM2, NDTRM2

WRITE (6,1131) NDTRM3, NDTRM4, NDTRM5, NHTKL, NTCRD1, NTCRD2, NTCRD3
A, NTCRD4

1130 FORMAT (10X,39H NRSKP)

A, (VULN. TAPE FILES TO SKIP, 9X, I5)
B, (NO. OF CASES, 21X, I5)
C, (FIRST RANGE FOR VULN. DATA, 7X, I5)
D, (VULN. TAPE FORMAT, 16X, I5)
E, (VULN. DATA DEP. ON RANGE, 9X, I5)
F, (SINGLE ROUND ENGAGEMENT, 10X, I5)
G, (MAX. NO. OF RDS, 17X, I5)
H, (SP. PROC. FOR MISS. RD., 10X, I5)
I, (RANGEFINDER OR BATTLESIGHT, 7X, I5)
J, (STANDARD DROP ADJUSTMENT, 9X, I5)
K, (ADJ. HIT, 25X, I5)
L, (HIT PROB. OUTPUT ONLY, 12X, I5)
M, (DETERMINISTIC HIT, 14X, I5)
N, (DET2 NO KILL HIT, 14X, I5)

1130 FORMAT (10X,39H NRSKP)

A, (VULN. TAPE FILES TO SKIP, 9X, I5)
B, (NO. OF CASES, 21X, I5)
C, (FIRST RANGE FOR VULN. DATA, 7X, I5)
D, (VULN. TAPE FORMAT, 16X, I5)
E, (VULN. DATA DEP. ON RANGE, 9X, I5)
F, (SINGLE ROUND ENGAGEMENT, 10X, I5)
G, (MAX. NO. OF RDS, 17X, I5)
H, (SP. PROC. FOR MISS. RD., 10X, I5)
I, (RANGEFINDER OR BATTLESIGHT, 7X, I5)
J, (STANDARD DROP ADJUSTMENT, 9X, I5)
K, (ADJ. HIT, 25X, I5)
L, (HIT PROB. OUTPUT ONLY, 12X, I5)
M, (DETERMINISTIC HIT, 14X, I5)
N, (DET2 NO KILL HIT, 14X, I5)
1. Tape 5 is associated with input cards and tape 2 with tape or disc containing target vulnerability input data.

3-17. These are really dimension statements. Oklahoma State University Field Office at Eglin Air Force Base has found that systematic use of common statements enhances computer efficiency.

18-19. These data statements are related to retrieval of kill probability and personnel casualty information from files containing such information in packed form.

20-165. Portion of program preceding processing for any particular range.

20-21. Skip 3 lines.

22-25. Read and write input card 1.

27-36. Read and write input cards 2 and 3.

37-38. Skip 1 line.

39. NRSKP = 9999 has been temporarily punched on input cards as conspicuous alert that proper entry needs to be determined later. This is simply matter of convenience. Temporary value 9999 can be retained as input if 0 proves to be correct entry, because of resetting done here.

40-65. Rewrite inputs on cards 2 and 3 with abbreviated indication of what each number represents.

66-69. If NRD1 = 1, NRDS is ignored and not used. Otherwise, maximum number of rounds to be fired per engagement, read as input, may be overridden either by lower or upper bound. Reason for lower bound of 10 rounds is indicated in connection with program lines 1333 through 1340. Upper bound of 19 rounds has been arbitrarily selected simply to limit scope of program calculations. RDS is real form.

71-77. If at least one of controls NDTRM1 through NDTRM5 is not 0, their sum NSMDTR is also not 0 and all five quantities are entered in array KDMSTC.

78-85. If at least one of controls NTCRD1 through NTCRD4 is not 0, their sum NSTCRD is also not 0, all four quantities are entered in array KTRGTC, and program lines 86 through 95 are skipped because tape or disc with vulnerability data is not involved.

87-95. Skip files as necessary on vulnerability data tape or disc. Nskp files skipped are NRSKp files not applying to round/target combination of concern and possibly additional files associated with ranges less than first one to be considered. Statement involving going to 311 if EOF(IU)=1.0 prevents minor inconsistencies in file mark location that are occasionally encountered from...
1131 FORMAT ( 10X,25H NDTRM3
A 10X,34H NDTRM4
B 10X,36H NDTRM5
C 10X,39H NHTKLL
D 10X,32H NTCRD1
E 10X,32H NTCRD2
F 10X,32H NTCRD3
G 10X,32H NTCRD4 )

IF ( NRDS .LT. 10 ) NRDS = 10
IF ( NRDS .GT. 19 ) NRDS = NRDS - 19

1132 CONTINUE
NSMDTR = NDTRM1 + NDTRM2 + NDTPM3 + NDTRM4 + NDTRM5
IF ( NSMDTR .EQ. 0 ) GO TO 1135
KDMSTC(1) = NDTRM1
KDMSTC(2) = NDTRM2
KDMSTC(3) = NDTRM3
KDMSTC(4) = NDTRM4
KDMSTC(5) = NDTRM5
KDMSTC(A) = NDTRM5

1135 CONTINUE
NSTCRD = NTCRD1 + NTCRD2 + NTCRD3 + NTCRD4
IF ( NSTCRD .EQ. 0 ) GO TO 1145
KTRGTC(1) = NTCRD1
KTRGTC(2) = NTCRD2
KTRGTC(3) = NTCRD3
KTRGTC(4) = NTCRD4
GO TO 1200

1145 CONTINUE
REWIND 2
IU = 2
NSKP = NRSKP
IF ( NRDTYP .EQ. 1 ) NSKP = NSKP + NRFRST/500
IF ( NSKP .EQ. 0 ) GO TO 1200
CALL SKIPFE (IU,NSKP,0)
READ ( IU,3110 ) A
IF ( EOF(IU) .EQ. 1.0 ) GO TO 311
311 CONTINUE

1200 CONTINUE
WRITE ( 6,1010 )
READ ( 5,1210 ) PASSN ,WCELL ,XC ,YC ,YBASE ,YTOP ,RELT
A ,RELF
1210 FORMAT ( 7F10.4 )
WRITE ( 6,1212 ) PASSN ,WCELL ,XC ,YC ,YBASE ,YTOP ,RELT
A ,RELF
1212 FORMAT ( 10X,7F10.4 )
WRITE ( 6,1020 )
W = WCELL
IF ( WCELL .EQ. 4.0 ) GO TO 1215
W = W / 25.4
XC = XC / 25.4
YC = YC / 25.4
YBASE = YBASE / 25.4
YTOP = YTOP / 25.4
1215 CONTINUE
WRITE ( 6,1220 )
1220 FORMAT ( 65X,16H HOR. VERT. )
EXPLANATIONS (CONTINUED)

STOPPING RUN.

98-103 READ AND WRITE INPUT CARDS 4 AND 5.

105-111 W IS NEEDED BECAUSE WCELL NEEDS TO BE PRESERVED AS READ FROM INPUT CARD. IF WCELL = 100.0, W, XC, YC, YBASE, AND POSSIBLY YTOP ARE ALL CONVERTED FROM MILLIMETERS TO INCHES. YTOP = 9999.0 OR ANY LARGER NUMBER INDICATES YTOP IS UNNEEDED AND TO BE IGNORED.

113-124 REWRITE INPUTS ON CARDS 4 AND 5 WITH ABBREVIATED INDICATION OF WHAT EACH NUMBER REPRESENTS.

125 H IS HALF OF W AND CONSEQUENTLY REPRESENTS PERPENDICULAR DISTANCE FROM CENTER OF ANY TARGET CELL TO SIDES.

126-127 VERTICAL COORDINATE YAIM OF INTENDED AIMPOINT CAN CORRESPOND EITHER TO APPROXIMATE CENTER OF MASS OR TO BASE OF TARGET.

128-134 VALUES 2, 3, 4, AND 5 FOR NADJST HAVE BEEN USED TO DATE ONLY IN CONNECTION WITH SPECIAL STUDY MADE FOR US ARMY ARMOR SCHOOL, FORT KNOX IN 1978. REQUIREMENTS OF THAT EFFORT ARE NOT OF GENERAL INTEREST AND NEED NOT BE DISCUSSED IN DETAIL IN THIS REPORT. SINCE 5 IS LARGEST VALUE USED TO DATE FOR NADJST, CONSIDERATION IS RESTRICTED TO NADJST EQUALLING 0 OR 1 IN REMAINDER OF THESE EXPLANATIONS.

136-158 NSTCRD IS NORMALLY 0 BECAUSE MOST RUNS INVOLVE TAPE OR DISC CONTAINING TARGET VULNERABILITY DATA. EXCEPTIONALLY, INPUT CARDS CONTAINING TARGET SHAPE DATA NEED TO BE READ. IF NSTCRD IS NOT 0, AT LEAST ONE OF CONTROL QUANTITIES IN KTRGT ARRAY MUST ALSO DIFFER FROM 0. ITGT VALUES 1, 2, 3, AND 4 CORRESPOND TO TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES RESPECTIVELY. ALL COORDINATES ARE IN SAME UNIT AS WCELL. VERTICAL COORDINATE OF CELL CENTERS FOR EACH HORIZONTAL STRIP OF TARGET CELLS IS ENTERED IN NCTRY ARRAY. HORIZONTAL COORDINATES OF CENTERS OF CELLS AT LEFT AND RIGHT ENDS OF STRIP ARE STORED IN HCTRX AND NCTRXR ARRAYS. LAST COORDINATE IN EACH SET IS IDENTIFIED BY USE OF 9999 AS NEXT ENTRY.

160-165 INITIAL SETTINGS.

166-175 CYCLE FOR EACH RANGE CONSIDERED.

166-182 EXCEPT WHEN SET TO INITIAL INTPL SETTING, CONTROL QUANTITY JNTPL PRESERVES VALUE IF INTPL USED IN CALCULATION CYCLE FOR PREVIOUS RANGE WHEN RANGE INTERPOLATION OF TARGET VULNERABILITY DATA MAY HAVE BEEN INVOLVED. INPUT VALUE 987 FOR INTPL IS SPECIAL SETTING ENTERED ONLY ON INPUT CARD R1 FOR FIRST RANGE CONSIDERED IN RUN WHEN MOVING TARGET OR MOVING FIRING WEAPON IS INVOLVED.

167-168 BEGIN PRINTING FOR EACH RANGE ON NEW PAGE.

169-170 READ AND WRITE INPUT CARD R1.

171-172 CONTROL QUANTITY ISTMOV IS SET TO 1 AND COUNTER MSET IS GIVEN INITIAL SETTING IF RUN INVOLVES MOVING TARGET OR MOVING FIRING WEAPON.

174 PROGRAM LINES 175 THROUGH 255 ARE NORMALLY APPLICABLE BUT ARE SKIPPED FOR MOVING TARGET OR MOVING FIRING WEAPON RUN.

175-245 READ AND WRITE INPUT CARDS R2 THROUGH R8. REWRITE INPUTS ON THESE CARDS WITH INDICATION OF WHAT EACH NUMBER REPRESENTS. OPTW AND MHTKL CONTROL REWRITING OR SKIPPING OF SEVERAL QUANTITIES THAT ARE OFTEN UNNEEDED FOR RUN AND SET TO 0 (OR LEFT BLANK) ON INPUT CARDS.
115    WRITE ( 6,1020 )
120    WRITE ( 6,1230 )  PASSN, W, WC, XC, YC, YBASE, YTOP
125    FORMAT ( 10X, 36H PASSN, W, WC, XC, YC, YBASE, YTOP
130    A, RETL, RELF
135    )
140    FORMAT ( 10X, 36H PASSN, TGT, PERS, EXCL, CREW, 7X, F10.4 /
145    A, 10X, 36H CELL DIM. IN INCHES, 19X, F10.4 /
150    B, 10X, 36H XG, YC
155    C, 10X, 36H TGT, BOTT, COORD, INS, 27X, F10.4 /
160    D, 10X, 36H YBASE, TOP APPR, COORD, INS, 27X, F10.4 /
165    E, 10X, 35H RELT, PROB. OF REL. FLIGHT, 8X, F10.4 /
170    F, 10X, 33H RELF, PROB. OF REL. FUZE, 10X, F10.4 )
175    CONTINUE
180    H = W / 2.0
185    YAIM = YC
190    IF ( NRFB ,EQ. 2 ) YAIM = YBASE
195    IF ( NADJST ,LT. 2 OR. NADJST ,GT. 5 ) GO TO 1300
200    XLEFTF(1) = -1650.0 / 25.4
205    XLEFTF(4) = -3050.0 / 25.4
210    XLEFTD(1) = -1350.0 / 25.4
215    XRIGHF(1) = 1650.0 / 25.4
220    XRIGHF(4) = 3550.0 / 25.4
225    XRIGHD(1) = 1450.0 / 25.4
230    CONTINUE
235    IF ( NSTCRD .EQ. 0 ) GO TO 2000
240    WRITE ( 6,1010 )
245    DO 1310 ITGT = 1,4
250    IF ( KTRGTC(ITGT) .EQ. 0 ) GO TO 2000
255    WRITE ( 6,1020 )
260    DO 1320 J = 1,30
265    K = 4 * (J-1)
270    READ ( 5,1330 ) NCTRY(K+1,ITGT),NCTRXL(K+1,ITGT),NCTRXR(K+1,ITGT)
275    A, NCTRY(K+2,ITGT),NCTRXL(K+2,ITGT),NCTRXR(K+2,ITGT)
280    B, NCTRY(K+3,ITGT),NCTRXL(K+3,ITGT),NCTRXR(K+3,ITGT)
285    C, NCTRY(K+4,ITGT),NCTRXL(K+4,ITGT),NCTRXR(K+4,ITGT)
290    CONTINUE
295    IF ( NCTRY(K+1,ITGT) ,EQ. 9999 ) OR.
300    A
305    IF ( NCTRY(K+2,ITGT) ,EQ. 9999 ) OR.
310    A
315    IF ( NCTRY(K+3,ITGT) ,EQ. 9999 ) OR.
320    A
325    IF ( NCTRY(K+4,ITGT) ,EQ. 9999 ) GO TO 1310
330    CONTINUE
335    CONTINUE
340    CONTINUE
345    NRANGE = 1
350    NEJECT = 0
355    JNTPL = 0
360    INTPL = 0
365    ISPLIT = 0
370    ISTMOV = 0
375    IF ( NRDTYP ,EQ. 1 AND. INTPL NE. 987 ) JNTPL = INTPL
380    WRITE ( 6,2020 )
385    IF ( NRANGE ,EQ. 1 AND. INTPL ,EQ. 987 ) ISTMOV = 1
IF ( ISTMV .EQ. 1 ) MSET = 1
WRITE ( 6,1010 )
IF ( ISTMV .EQ. 1 ) GO TO 2200

READ ( 5,1210 ) FLT , TF1 , TFS , XM1 , XM2 , AMT1 , AMT2
   A   STD1 , STD2 , XB , YB , SIGXB , SIGYB , SIGXL
   B   SIGYL , SIGXR , SIGYR , PROBS , SIGXS , SIGYS , PGL
   C   , PGS , PGCH , PGCS , SGHX , SGHY , SGSX , SGSY
   D   , CDRX , CDRY , HSX , HSY , XBH , YBH , SIGXBL
WRITE ( 6,1212 ) FLT , TF1 , TFS , XM1 , XM2 , AMT1 , AMT2
   A   STD1 , STD2 , XB , YB , SIGXB , SIGYB , SIGXL
   B   SIGYL , SIGXR , SIGYR , PROBS , SIGXS , SIGYS , PGL
   C   , PGS , PGCH , PGCS , SGHX , SGHY , SGSX , SGSY
   D   , CDRX , CDRY , HSX , HSY , XBH , YBH , SIGXBL
WRITE ( 6,1010 )
WRITE ( 6,2110 )
2110 FORMAT ( 63X,19H TIME DATA (SECONDS),
   A / 64X,19H 1ST RD. SUBS. RDS. )
WRITE ( 6,1020 )
WRITE ( 6,2120 ) FLT , TF1 , TFS , XM1 , XM2 , AMT1 , AMT2
   A   STD1 , STD2
2120 FORMAT ( 10X,14H TIME OF FLIGHT, 14X,F10.4 /
   A 10X,25H TF1,TFS FIXED TIME, 28X,2F10.4 /
   B 10X,25H XM1,XM2 MEDIAN VARIABLE TIME, 18X,2F10.4 /
   C 10X,25H AMT1,AMT2 MINIMUM TIME, 26X,2F10.4 /
   D 10X,25H STD1,STD2 VARIABILITY FACTOR, 20X,2F10.4 )
WRITE ( 6,1020 )
WRITE ( 6,2130 )
2130 FORMAT ( 62X,23H ACCURACY DATA (METERS),
   A / 66X,16H HOR. VERT. )
GO TO 2135
WRITE ( 6,2140 )
2140 FORMAT ( 63X,21H ACCURACY DATA (MILS),
   A / 66X,16H HOR. VERT. )
WRITE ( 6,1020 )
WRITE ( 6,2150 ) XB , YB , SIGXB , SIGYB , SIGXL , SIGYL , SIGXR
   A , SIGYR , PROBS , SIGXS , SIGYS
2150 FORMAT ( 10X,25H XB,YB FIXED BIAS, 28X,2F10.4 /
   A 10X,34H SIGXB,SIGYB VAR. BIAS STD. DEV., 19X,2F10.4 /
   B 10X,34H SIGXL,SIGYL LAY ERROR STD. DEV., 19X,2F10.4 /
   C 10X,34H SIGXR,SIGYR RD. TO RD. STD. DEV., 19X,2F10.4 /
   D 10X,36H PROBS PROB. SENS. MISS. RD., 6X,F10.4 /
   E 10X,36H SIGXS,SIGYS SENS. ERROR STD. DEV., 17X,2F10.4 )
OPTW = PGH + PGS + PGCH + PGCS + SGHX + SGHY + SGSX + SGSY + CDRX
   A + CDRY + HSX + HSY
IF ( OPTW .EQ. 0.0 ) GO TO 2155
WRITE ( 6,1010 )
WRITE ( 6,2160 ) PGH , PGS , PGCH , PGCS , SGHX , SGHY , SGSX
   A , SGYS , CDRX , CDRY , HSX , HSY
2160 FORMAT ( 10X,38H PGH GUNNER SENS. PROB. HIGH, 5X,F10.4 /
   A 10X,37H PGS GNR. SENS. PROB. SHORT, 6X,F10.4 /
   B 10X,35H PGCH G/C SENS. PROB. HIGH, 8X,F10.4 /
   C 10X,36H PGCS G/C SENS. PROB. SHORT, 7X,F10.4 /
PROGRAM LISTING (CONTINUED)

D  10X,35H SGHX,SGHY
E  10X,36H SGSX,SGSY
F  10X,33H CDRX,CDRY
G  10X,33H HSX,HSY

2155 CONTINUE
  IF ( NHTKLL .EQ. 0 ) GOTO 2165

2170 FORMAT ( 10X,23H SIGXBH,SIGYBH,XBL,YBL,SIGXB,SIGYB )

2220 FORMAT ( 20X,4F10.4 )

2230 FORMAT ( 70X,F10.4 )

2300 CONVRT = 1.0
  PI = 3.14159
  R = IRANGE
  IF ( IMILS .EQ. 0 ) GO TO 2305
  CONVRT = R*PI / 3200.0
  CONVRT = CONVRT * 39.37
  IF ( ISTMOV .EQ. 1 ) GO TO 3000

280  XB = X * CONVRT
    YB = Y * CONVRT
    SIGXB = SIGXB * CONVRT
    SIGYB = SIGYB * CONVRT
    SIGXL = SIGXL * CONVRT

52
EXPLANATIONS (CONTINUED)

247-251 IF NEEDED, RANGE INTERPOLATION FACTOR RATIO IS DETERMINED. FOR EXAMPLE, RANGES OF 600 AND 2350 METERS WOULD CORRESPOND TO 0.8 AND 0.3 RESPECTIVELY. PRODUCT OF RATIO AND 500 IS DIFFERENCE IN METERS BETWEEN RANGE IPANGE AND NEXT HIGHER MULTIPLE OF 500 METERS.

253-254 FOR CONVENIENCE, ZEROS CAN BE USED FOR STD1 AND STD2 ON INPUT CARD R3 INSTEAD OF 0.4983 WHICH IS GENERALLY APPLICABLE. IF THIS HAS BEEN DONE, RESET STD1 AND STD2.

255 SKIP PROGRAM LINES 256 THROUGH 273.

256-273 READ AND WRITE INPUT CARDS CONTAINING FIRST ROUND BIAS AND STANDARD DEVIATION DATA NEEDED FOR MOVING TARGET OR MOVING FIRING WEAPON RUN. SINCE TIMES ARE NOT INVOLVED, FIRST CARD CAN CONTAIN ONLY ZEROS AND STD1 AND STD2 ARE SET TO 0. DO 2210 LOOP PROCESSES SET OF 18 INPUT CARDS AND STORES DATA IN XXB, YYB, SSIGXB, AND SSIGYB ARRAYS. SINCE STANDARD DEVIATIONS ENTERED IN LATTER TWO ARRAYS ALREADY ACCOUNT FOR RANDOM ERRORS AS WELL AS OTHER ERROR CONTRIBUTORS, SIGXL IS SET TO 0. LAST CARD CAN CONTAIN ONLY ZEROS BECAUSE QUANTITIES RELATED TO SUBSEQUENT ROUND SENSING AND ADJUSTMENT AS WELL AS TO RANDOM ERRORS ARE UNNEEDED. THE 18 SETS OF INPUT BIASES AND STANDARD DEVIATIONS MAY INCLUDE DUMMY SETS FOR WHICH CALCULATIONS ARE NOT TO BE MADE. SUCH DUMMY SETS ARE IDENTIFIED BY HORIZONTAL BIAS SETTING OF 999,9999.

274-279 CONVERSION FACTOR CONVRT IS SET TO APPROPRIATE VALUE FOR CHANGING METERS OR MILS TO INCHES.

280 SKIP PROGRAM LINES 281 THROUGH 328 FOR MOVING TARGET OR MOVING FIRING WEAPON RUN.

281-298 CONVERT FROM METERS OR MILS TO INCHES.

299 SKIP PROGRAM LINES 300 THROUGH 328 IF ASSOCIATED QUANTITIES ARE UNNEEDED.

300-312 CONVERT FROM MILS TO INCHES. IF IMILS EQUALS 0, PREVIOUS SETTING OF CONVRT HAS NOT PROVIDED FOR CONVERSION FROM MILS TO METERS.

313-328 ENTER BIASES AND STANDARD DEVIATIONS IN BBX, BBY, SSIGX, AND SSIGY ARRAYS.

330 SKIP PROGRAM LINES 331 THROUGH 462 IF TARGET SHAPE DATA FROM CARDS ARE NEEDED.

331-462 CYCLE FOR READING AND PROCESSING TARGET VULNERABILITY DATA FROM TAPE OR DISC.

331-334 DO NOT READ AND PROCESS VULNERABILITY DATA FROM TAPE OR DISC WHEN NEEDED INFORMATION HAS NOT YET BEEN READ AND PROCESSED. CONDITION INVOLVING NRANGE, INTPL, AND ISPLIT COVERS INSTANCES WHERE FIRST RANGE OF CONCERN FOR RANGE INTERPOLATION OF VULNERABILITY DATA HAS NOT YET BEEN READ AND PROCESSED. CONDITION INVOLVING NRANGE, INTPL, AND ISPLIT COVERS INSTANCES WHERE FIRST RANGE OF CONCERN FOR RANGE INTERPOLATION OF VULNERABILITY DATA HAS BEEN INVOLVED IN PREVIOUS RANGE CYCLE. JNTPL EQALLING 1 INDICATES THAT SECOND RANGE USED IN INTERPOLATION OF IMMEDIATELY PRECEDING RANGE CYCLE IS RANGE OF CONCERN FOR CURRENT CYCLE. VULNERABILITY DATA THAT DO NOT VARY WITH RANGE ARE READ AND PROCESSED IN FIRST RANGE CYCLE ONLY AND CAN THEN BE REUSED.

335 CONDITION IS ASSOCIATED WITH RANGE INTERPOLATION OF TARGET VULNERABILITY DATA. ISPLIT EQALLING 2 INDICATES THAT CALCULATIONS HAVE ALREADY BEEN COMPLETED FOR LESSER OF TWO RANGES BRACKETING ACTUAL RANGE AND PARTICULAR PAIR OF FORWARD AND REVERSE ORIENTATION ANGLES. IF FORWARD ANGLE OF 0 DEGREES IS INVOLVED, CONTINUE WITH PROGRAM LINES 336 THROUGH 374 BEFORE OBTAINING VULNERABILITY DATA FOR RANGE BRACKETING THAT OF TARGET ON HIGH SIDE AND FOR ANGLES OF 0 AND 180 DEGREES. IF FORWARD ANGLE IS 30, 60, OR 90 DEGREES, SKIP TO PROGRAM STATEMENT 320C.
<table>
<thead>
<tr>
<th>Line</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>290</td>
<td>SIGYL = SIGYL * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGXR = SIGXR * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGYR = SIGYR * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGXS = SIGXS * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGYS = SIGYS * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SGHX = SGHX * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SGHY = SGHY * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SGSX = SGSX * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SGSY = SGSY * CONVRT</td>
</tr>
<tr>
<td></td>
<td>CDRX = CDRX * CONVRT</td>
</tr>
<tr>
<td></td>
<td>CDRY = CDRY * CONVRT</td>
</tr>
<tr>
<td></td>
<td>HSX = HSX * CONVRT</td>
</tr>
<tr>
<td></td>
<td>HSY = HSY * CONVRT</td>
</tr>
<tr>
<td></td>
<td>IF ( NHTKL .EQ. 0 ) GOTO 3000</td>
</tr>
<tr>
<td>300</td>
<td>IF ( IMILS .EQ. 0 ) CONVRT = CONVRT * R*PI/3200.0</td>
</tr>
<tr>
<td></td>
<td>XBH = XBH * CONVRT</td>
</tr>
<tr>
<td></td>
<td>YBH = YBH * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGXH = SIGXH * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGYBH = SIGYBH * CONVRT</td>
</tr>
<tr>
<td></td>
<td>XBL = XBL * CONVRT</td>
</tr>
<tr>
<td></td>
<td>YBL = YBL * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGXBL = SIGXBL * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGYBL = SIGYBL * CONVRT</td>
</tr>
<tr>
<td></td>
<td>XBS = XBS * CONVRT</td>
</tr>
<tr>
<td></td>
<td>YBS = YBS * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGXBS = SIGXBS * CONVRT</td>
</tr>
<tr>
<td></td>
<td>SIGYBS = SIGYBS * CONVRT</td>
</tr>
<tr>
<td>310</td>
<td>BBX(1) = XB</td>
</tr>
<tr>
<td></td>
<td>BBY(1) = YB</td>
</tr>
<tr>
<td></td>
<td>BBX(2) = XBH</td>
</tr>
<tr>
<td></td>
<td>BBY(2) = YBH</td>
</tr>
<tr>
<td></td>
<td>BBX(3) = XBL</td>
</tr>
<tr>
<td></td>
<td>BBY(3) = YBL</td>
</tr>
<tr>
<td></td>
<td>BBX(4) = XBS</td>
</tr>
<tr>
<td></td>
<td>BBY(4) = YBS</td>
</tr>
<tr>
<td></td>
<td>SSIGX(1) = SQRT(SIGXH<strong>2+SIGX</strong>2)</td>
</tr>
<tr>
<td></td>
<td>SSIGY(1) = SQRT(SIGYBH<strong>2+SIGY</strong>2)</td>
</tr>
<tr>
<td>320</td>
<td>SSIGX(2) = SIGXH</td>
</tr>
<tr>
<td></td>
<td>SSIGY(2) = SIGYBH</td>
</tr>
<tr>
<td></td>
<td>SSIGX(3) = SIGXBL</td>
</tr>
<tr>
<td></td>
<td>SSIGY(3) = SIGYBL</td>
</tr>
<tr>
<td></td>
<td>SSIGX(4) = SIGXBS</td>
</tr>
<tr>
<td></td>
<td>SSIGY(4) = SIGYBS</td>
</tr>
<tr>
<td></td>
<td>CONTINUE</td>
</tr>
<tr>
<td>330</td>
<td>IF ( NSCTRD .GT. 0 ) GO TO 3800</td>
</tr>
<tr>
<td></td>
<td>IF ( NNRANGE .GT. 1 .AND. INTPL .EQ. 1 .AND. ISPLIT .EQ. 0 ) GO TO 4010</td>
</tr>
<tr>
<td></td>
<td>IF ( JNTPL .EQ. 1 ) GO TO 4010</td>
</tr>
<tr>
<td></td>
<td>IF ( NRDTYP .EQ. 0 .AND. NNRANGE .GT. 1 ) GO TO 4000</td>
</tr>
<tr>
<td>335</td>
<td>IF ( ISPLIT .EQ. 2 .AND. NANGLE .NE. 1 ) GO TO 3200</td>
</tr>
<tr>
<td></td>
<td>WRITE ( 6,1010 )</td>
</tr>
<tr>
<td></td>
<td>IF ( NEJECT .EQ. 1 ) READ ( IU,3110 ) A</td>
</tr>
<tr>
<td>3110</td>
<td>FORMAT ( 80A1 )</td>
</tr>
<tr>
<td></td>
<td>IF ( EOF(IU) .EQ. 1.0 ) GO TO 301</td>
</tr>
<tr>
<td>340</td>
<td>CONTINUE</td>
</tr>
<tr>
<td></td>
<td>IF ( ISTMOV .EQ. 1 .AND. NNRANGE .NE. 1 ) READ ( IU,3110 ) A</td>
</tr>
<tr>
<td></td>
<td>IF ( EOF(IU) .EQ. 1.0 ) GO TO 312</td>
</tr>
</tbody>
</table>
CONTINUE
READ ( IU,3110 ) ITAPE
IF ( EOF(IU) .EQ. 1.0 ) GO TO 302
CONTINUE
WRITE ( 6,3112 ) ITAPE
IF ( ITAPE(K) .NE. IDCODE(I) ) GO TO 3120
IF ( ITAPE(K+1) .NE. IDCODE(1) ) GO TO 3120
IF ( ITAPE(K+2) .NE. IDCODE(2) ) GO TO 3120
M = K+3
GO TO 3130
CONTINUE
GO TO 3140
DO 3150 L = M,77
IF ( ITAPE(L) .NE. IDCODE(7) ) GO TO 3150
IF ( ITAPE(L+1) .NE. IDCODE(8) ) GO TO 3150
IF ( ITAPE(L+2) .NE. IDCODE(9) ) GO TO 3150
IF ( ITAPE(L+3) .NE. IDCODE(10) ) GO TO 3150
GO TO 3160
CONTINUE
WRITE ( 6,3170 )
FORMAT ( 1H0* 10X*32H PROJECTILE/TARGET CODE MISMATCH )
GO TO 9900
CONTINUE
WRITE ( 6,3180 )
A ( IDCODE(I),I=1,3 ), ( IDCODE(I),I=4,6 )
A ( IDC0DE(I),I=7,10 ), IRANGE
FORMAT ( 24X,26H TASK SHEET IDENTIFICATION,10X,3A1 /
B 24X,16H PROJECTILE CODE,20X,3A1 /
C 24X,16H RANGE IN METERS,18X,15 )
IANGLE = 1
CONTINUE
READ ( IU,3110 ) A
IF ( EO(IU) .EQ. 1.0 ) GO TO 303
CONTINUE
NSKIP = 3
WRITE ( 6,1020 )
DO 3210 L = 1,NSKIP
READ ( IU,3110 ) A
IF ( EOF(IU) .EQ. 1.0 ) GO TO 304
CONTINUE
WRITE ( 6,3112 )
CONTINUE
YTEMPL(IC) = 9999.0
YTEMPL = -9999.0
XTMPL(IC) = 9999.0
XTMPL(IC) = -9999.0
M = 1
CONTINUE
IF ( NTGT .GT. 1 ) GO TO 3405
READ ( IU,3410 ) X,Y,( PKRLFT(J), J=1,4 ), ( PKRLFT(J), J=6,9 )
FORMAT ( 1X,F6.1,F7.1,F5X,F7.3,F6X,F7.3 )
GO TO 305
IF ( NTGT .GT. 2 ) GO TO 3415
337–343 SPECIAL STATEMENTS NEEDED TO READ AND IGNORE BLANK LINE OR EJECT PAGE LINE PERIODICALLY USED ON TAPE OR DISC.

344–373 READ NEXT LINE OF INFORMATION FROM TAPE OR DISC. THIS LINE SHOULD CONTAIN PROJECTILE CODE, RANGE, AND TARGET CODE. VERIFY AGREEMENT OF PROJECTILE AND TARGET CODES WITH THOSE IN IDCODE. IF DISCREPANCY IS FOUND, PRINT ERROR INDICATION AND GO TO PROGRAM STATEMENT 9900 TO STOP RUN. OTHERWISE WRITE SPECIFIED REFERENCE INFORMATION.

374 INITIAL SETTING.

375–440 CYCLE FOR ANGLE EQUALING 1, 2, 3, OR 4. THESE VALUES CORRESPOND TO TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES RESPECTIVELY TOGETHER WITH ASSOCIATED REVERSE ANGLES.

375–377 INITIAL SETTINGS.

379–386 READ BLANK LINE FROM TAPE OR DISC. ALSO READ AND WRITE THREE LINES OF HEADER INFORMATION SUCH AS 0 DEG ELEV, 30 DEG AZIM ETC...

390–394 INITIAL SETTING.

395–447 CYCLE FOR EACH TARGET CELL.

395–405 READ CELL CENTER COORDINATES AND RELATED VULNERABILITY DATA. FORMAT PREVIOUSLY USED TO STORE NUMBERS ON TAPE OR DISC IS IDENTIFIED BY NTGT. LABEL CELL COORDINATES AS X AND Y. UCELL INDICATES WHETHER X AND Y ARE IN INCHES OR MILLIMETERS. STORE VULNERABILITY DATA IN PKRLFT ARRAY, USING PKRLFT(1) AND PKRLFT(6) FOR M (MOBILITY) KILL PROBABILITIES, PKRLFT(2) AND (7) FOR F (FIREPOWER) KILL PROBABILITIES; (3) AND (8) FOR M OR F (MOBILITY AND/OR FIREPOWER) KILL PROBABILITIES, (4) AND (9) FOR K (COMPLETE DESTRUCTION) KILL PROBABILITIES AND IF NECESSARY (5) AND (10) FOR PASSENGER PERSONNEL CASUALTIES. PKRLFT(1) THROUGH (5) ARE ASSOCIATED WITH TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES, AND PKRLFT(6) THROUGH (10) WITH CORRESPONDING REVERSE ANGLES.

406–411 NUMBER READ AS X COORDINATE OF CELL CENTER MAY EXCEPTIONALLY BE 999.9 USED ON TAPE OR DISC TO INDICATE ALL DATA FOR PARTICULAR SET OF FORWARD AND REVERSE ANGLES HAVE BEEN READ. IN THAT CASE, MULTIPLICATION OF X BY 10.0 SETS TEND TO 9999. ADDITION OF 10000.001 TO X AND Y ELIMINATES ALL MINUS SIGNS. INTEGER QUANTITIES IMODX AND IMODY ARE READILY COMBINED INTO SINGLE ENTRY STORABLE IN IMODXY ARRAY. WHEN X EQUALS 999.9, IMODX IS SET TO 999999 AND COMBINED WITH Y COORDINATE 0 BEFORE STORAGE OF RESULT IN IMODXY ARRAY. AFTER END INDICATOR IS THUS SCORED, RUN CONTINUES AT PROGRAM STATEMENT 3700.

412–427 IGNORE THESE SPECIAL STATEMENTS FOR ADJUST EQUALLING 2 THROUGH 5.

428–430 IF CELL COORDINATES ARE IN MILLIMETERS, CONVERT TO INCHES.

431–434 UPDATE, AS NECESSARY, MINIMUM AND MAXIMUM COORDINATES RELATED TO RECTANGLE ENCLOSING TARGET. IF PREVIOUSLY ESTABLISHED VALUE OF YTEMPL(IC) IS GREATER THAN Y, RESET YTEMPH(IC) TO Y. SIMILARLY, RESET XEMPL(IC) TO X IF GREATER THAN X, AND XTEMPH(IC) IF LESS THAN X.

435 IF NPRHIT EQUALS 1, SKIP PROGRAM LINES 436 THROUGH 447 SINCE THEY INVOLVE UNNEEDED TARGET VULNERABILITY DATA.

436–447 QUANTITIES IN PKRLFT ARRAY CONTAIN THREE DECIMAL PLACES. CONVERT TO CONVENIENT INTEGER FORM AND ENTER IN IP ARRAY. PACK FIRST FIVE IP VALUES INTO SINGLE NUMBER AND STORE RESULT IN MPK ARRAY. TARGET CELL INVOLVED IS IDENTIFIED BY M. IA EQUALS 1, 3, 5, OR 7 FOR TARGET ORIENTATION ANGLE OF 0, 30, 60, OR
400  READ ( IU,3420 ) X,Y,PKRLFT  
3420  FORMAT ( 1X,2F6.0,2(3X,4F6.2,F7.2) )  
     GO TO 305  
3415  READ ( IU,3430 ) X,Y,PKRLFT  
3430  FORMAT ( 1X,F6.1,F7.1*5X,2(4F7,3,F5.1)  
405  IF ( EOF(IU) .EQ. 1.0 ) GO TO 3500  
3500  IEND = X * 10.0  
     IMODX = X + 10000.001  
     IMODY = Y + 10000.001  
     IMODXY(H,IC) = IMODX*10000 + IMODY  
     IF ( IEND .EQ. 9999 ) IMODX = IMODXY  
810  IF ( NADJST .EQ. 2 .AND. IANGLE .EQ. 2 ) GO TO 3600  
815  IF ( NADJST .EQ. 3 .AND. IANGLE .EQ. 2 ) GO TO 3600  
820  IF ( NADJST .EQ. 4 .AND. IANGLE .EQ. 2 ) GO TO 3600  
825  IF ( NADJST .EQ. 5 .AND. IANGLE .EQ. 2 ) GO TO 3600  
830  IF ( NADJST .EQ. 2 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO TO 3600  
835  IF ( NADJST .EQ. 3 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO TO 3600  
840  IF ( NADJST .EQ. 4 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO TO 3600  
845  IF ( NADJST .EQ. 5 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO TO 3600  
3600  A 0 3600  
     IF ( NADJST .EQ. 2 .AND. IANGLE .EQ. 4 .AND. YBASE .GT. 0.0 ) GO TO 3600  
3605  YTEMPL(IC) = AMIN1(YTEMPL(IC),Y)  
     YTEMHP = AMAX1(YTEMHP,Y)  
     XTEMPL(IC) = AMIN1(XTEMPL(IC),X)  
     XTEMHP(IC) = AMAX1(XTEMHP(IC),X)  
3610  DO 3510 K = 1,10  
3510  IP(K) = 1000.0*PKRLFT(K) + 0.1  
     MPK(M,IA) = SHIFT(IP(1),49) .OR.  
     A  
     MPK(M,IB) = SHIFT(IP(2),38) .OR.  
     B  
     MPK(M,IC) = SHIFT(IP(3),27) .OR.  
     C  
     MPK(M,ID) = SHIFT(IP(4),16) .OR.  
     D  
     IF ( NPRHIT .EQ. 1 ) GO TO 3600  
3615  CONTINUE  
3620  M = M + 1  
     IF ( M .GT. 3000 ) GO TO 3605  
3625  CONTINUE  
3630  WRITE ( 6,3610 )  
3635  3610  FORMAT ( 1H0, 10X,22H TARGET MATRIX TOO BIG )  
     GO TO 9900  
3640  CONTINUE  
3645  NXTEMP(IC) = (XTEMHP(IC)-XTEMPL(IC))/W + 1.001
90 DEGREES RESPECTIVELY. SIMILARLY PACK LAST FIVE IP VALUES FOR STORAGE IN
MPK ARRAY. IB IS ASSOCIATED WITH REVERSE ANGLES AND EQUALS 1 MORE THAN
CORRESPONDING IA VALUE.

448-454  RESET CELL COUNTER M. IF M THEN EQUALS 3001, 3000 CELLS HAVE ALREADY BEEN
PROCESSED AND MAXIMUM ALLOWED 2999 CELLS HAS BEEN EXCEEDED. IF TARGET
CONTAINS EXACTLY 2999 CELLS, CELL 3000 IS ASSOCIATED WITH 999.9 ENTRY. IF
LIMIT HAS BEEN VIOLATED, PRINT ERROR INDICATION AND GO TO PROGRAM STATEMENT
9900 TO STOP RUN. OTHERWISE RECYCLE FOR NEXT CELL.

456-457  CALCULATE NUMBER OF CELLS ALONG EACH SIDE OF RECTANGLE THAT IS JUST LARGE
ENOUGH TO ENCLOSE TARGET FOR FORWARD AND REVERSE ORIENTATIONS CORRESPONDING
TO IC. RECTANGLE HAS NTEMP(IC) CELLS IN HORIZONTAL DIRECTION AND NTMPF(IC)
CELLS IN VERTICAL DIRECTION. NUMBERS OF CELLS BASED ON DIFFERENCES BETWEEN
MINIMUM AND MAXIMUM COORDINATES OF CELL CENTERS ARE INCREASED BY 1.000 TO
ACCOUNT FOR HALF CELLS AT EACH EDGE. ADDITION OF .001 COVERS ROUNDING
INACCURACIES.

458  WHEN RANGE INTERPOLATION OF VULNERABILITY DATA IS INVOLVED AND TARGET RANGE IS
NOT FIRST ONE CONSIDERED IN RUN, CONTINUE AT PROGRAM STATEMENT 4100 FOR EACH
IANGLE VALUE.

459  CONTINUE AT PROGRAM STATEMENT 4000 IF IANGLE VALUES 1 THROUGH 4 HAVE ALL BEEN
COVERED.

460  IF THIRD OF FOUR INTERPOLATION STEPS CORRESPONDING TO ISPLIT IS OF CURRENT
CONCERN, CONTINUE AT PROGRAM STATEMENT 4020 FOR PARTICULAR IANGLE VALUE
UNDER CONSIDERATION.

461-462  SINCE IANGLE VALUES 1 THROUGH 4 HAVE NOT ALL BEEN PROCESSED, REPEAT FOR NEXT
VALUE.

463-505  CYCLE FOR PROCESSING TARGET SHAPE DATA READ FROM CARDS.

464  INITIAL SETTINGS.

465-471  INITIAL SETTINGS. JCELL IS INTEGER FORM OF WCELL.

472-473  IT VALUES 1, 2, 3, AND 4 CORRESPOND TO TARGET ORIENTATION ANGLES OF 0, 30, 60,
AND 90 DEGREES RESPECTIVELY. COUNTER K INDICATES WHICH STRIP OF TARGET CELLS
IS OF CURRENT CONCERN. STRIP CAN EXCEPTIONALLY CONSIST OF ONLY ONE CELL. SET
JY TO EQUAL Y COORDINATE COMMON TO CENTERS OF ALL CELLS IN STRIP. SET JX TO
EQUAL X COORDINATE OF CENTER OF CELL AT LEFT EDGE OF STRIP.

474-477  ADDITION OF 10000 TO JX AND JY ELIMINATES ALL MINUS SIGNS. COMBINE MODXY AND
IMODXY AND STORE RESULTING QUANTITY IN IMODXY ARRAY. WHEN JX EQUALLING 9999
INDICATES THAT ALL TARGET CELLS FOR ANGLE CORRESPONDING TO IT HAVE BEEN
PROCESSED, RUN CONTINUES AT PROGRAM STATEMENT 3900.

478-482  IF CELL COORDINATES ARE IN MILLIMETERS, CONVERT TO INCHES.

483-486  UPDATE, AS NECESSARY, MINIMUM AND MAXIMUM COORDINATES RELATED TO RECTANGLE
ENCLOSING TARGET. IF PREVIOUSLY ESTABLISHED VALUE OF YTEMP(I) IS GREATER
THAN Y, RESET YTEMP(I) TO Y. SIMILARLY, RESET XTEMP(I) IF LESS THAN X,
XTEMP(I) IF GREATER THAN X, AND XTEMP(I) IF LESS THAN X.

487  RESET CELL COUNTER.

488  CELL COUNTER SHOULDN'T EVER EXCEED 3000. IF LIMIT HAS BEEN VIOLATED, GO TO
PROGRAM STATEMENT 3845.
NYTEMP(IC) = (YTEMPH-YTEMPL(IC))/W + 1.001
IF ( INTPL .EQ. 1 .AND. NRANGE .GT. 1 ) GO TO 4100
IF ( IANGLE .EQ. 4 ) GO TO 4000
IF ( ISPLIT .EQ. 2 ) GO TO 4020
IANGLE = IANGLE + 1
GO TO 3200
3800 CONTINUE
IT = 1
3805 YTEMPL(IT) = 9999.0
YTEMPH = -9999.0
XTEMPL(IT) = 9999.0
XTEMPH(IT) = -9999.0
M = 1
K = 1
JCELL = WCELL
3810 JY = NCTRY(K, IT)
JX = NCTRXL(K, IT)
3820 IMODX = JX + 10000
IMODY = JY + 10000
IMODXY(M, IT) = IMODX * 100000 + IMODY
IF ( JX .EQ. 9999 ) GO TO 3900
X = JX
Y = JY
480 IF ( WCELL .EQ. 4.0 ) GO TO 3825
X = X / 25.4
Y = Y / 25.4
3825 YTEMPL(IT) = AMAX1(YTEMPL(IT), Y)
YTEMPH = AMAX1(YTEMPH, Y)
XTEMPL(IT) = AMAX1(XTEMPL(IT), X)
XTEMPH(IT) = AMAX1(XTEMPH(IT), X)
M = M + 1
IF ( H .GT. 3000 ) GO TO 3845
IF ( JX .EQ. NCTRXL(K, IT) ) GO TO 3835
490 JX = JX + JCELL
GO TO 3820
3835 K = K + 1
GO TO 3810
3845 WRITE (6, 3610)
GO TO 9900
495 CONTINUE
3900 CONTINUE
MCELLS = M - 1
WRITE (6, 1020)
WRITE (6, 1122) MCELLS
NXTEMP(IT) = (XTEMPH(IT) - XTEMPL(IT))/W + 1.001
NYTEMP(IT) = (YTEMPH - YTEMPL(IT))/W + 1.001
IF ( IT .EQ. 4 ) GO TO 4000
IT = IT + 1
IF ( KTRGTC(IT) .EQ. 0 ) GO TO 4000
GO TO 3805
4000 CONTINUE
IF ( NSTCRD .GT. 0 ) GO TO 4200
4010 NANGLE = 1
4020 NALPHA = NANGLE / 2
NBETA = NALPHA * 2
IF ( NBETA .EQ. NANGLE ) GO TO 4105
IC = NALPHA + 1
IF ( ISTDV .NE. 1 ) GO TO 4025
NCTRXR(K,IT) IS X COORDINATE OF CENTER OF CELL AT RIGHT EDGE OF STRIP. WHEN
JX EQUALS THIS COORDINATE, STRIP HAS BEEN COMPLETELY PROCESSED. IN THAT
CASE, RESET K TO CORRESPOND TO NEXT STRIP OF TARGET CELLS AND CONTINUE AT
PROGRAM STATEMENT 3810. IN OTHER INSTANCES, RESET JX TO EQUAL X COORDINATE
OF NEXT CELL IN STRIP AND BEGIN PROCESSING FOR THIS CELL AT PROGRAM
STATEMENT 3820.

PRINT ERROR INDICATION AND GO TO PROGRAM STATEMENT 9900 TO STOP RUN.

MCELLS IS TOTAL NUMBER OF TARGET CELLS FOR ANGLE ASSOCIATED WITH IT. CELL
COUNTER M IS REDUCED BY 1 BECAUSE END INDICATOR HAS BEEN INCLUDED. WRITE
MCELLS FOR POSSIBLE USE IN CHECKING RUN OUTPUT.

CALCULATE NUMBER OF CELLS ALONG EACH SIDE OF RECTANGLE THAT IS JUST LARGE
ENOUGH TO ENCLOSE TARGET FOR ORIENTATION CORRESPONDING TO IT. EXPLANATIONS
FOR PROGRAM LINES 456 AND 457 APPLY HERE ALSO IF IC IS REPLACED BY IT.

CONTINUE AT PROGRAM STATEMENT 4000 IF IT VALUES 1 THROUGH 4 HAVE ALL BEEN
COVERED.

RESET IT FOR NEXT ORIENTATION ANGLE. KTRGTC(IT) CAN EQUAL 0 ONLY IF RUN
INVOLVES FEWER THAN FOUR ANGLES. IN THAT CASE, CONTINUE AT PROGRAM STATEMENT
4000. OTHERWISE BEGIN PROCESSING FOR NEW ORIENTATION AT
PROGRAM STATEMENT 3805.

SKIP PROGRAM LINES 508 THROUGH 532 IF RUN DOES NOT INVOLVE VULNERABILITY DATA
FROM TAPE OR DISC.

INITIAL SETTING.

NANGLE EQUALS 1, 3, 5, OR 7 FOR TARGET ORIENTATION ANGLE OF 0, 30, 60, OR 90
DEGREES RESPECTIVELY AND 2, 4, 6, OR 8 FOR CORRESPONDING REVERSE ANGLE.
INALPHA EQUALS 0 WHEN NANGLE IS 1 OR 1 WHEN NANGLE IS 2. CORRESPONDING VALUES
OF NBETA ARE 0 OR 2 RESPECTIVELY FOR NANGLE EQUALLING 1 OR 2. NBETA ALWAYS
DIFFERS FROM NANGLE FOR FORWARD ORIENTATION ANGLES AND EQUALS NANGLE FOR
REVERSE ANGLES.

SKIP PROGRAM LINES 512 THROUGH 542 WHEN NANGLE CORRESPONDS TO REVERSE ANGLE.

IC IS SET TO 1, 2, 3, OR 4 RESPECTIVELY FOR NANGLE EQUALLING 1, 3, 5, OR 7.

PROGRAM LINES 514 THROUGH 523 APPLY ONLY FOR MOVING TARGET OR MOVING FIRING
WEAPON RUN AND ARE SKIPPED OTHERWISE.

IF Dummy SET FOR WHICH NO CALCULATIONS ARE NEEDED IS INVOLVED, SKIP PROGRAM
LINES 515 THROUGH 1374.

INITIAL SETTINGS.

IGNORE STATEMENTS APPLICABLE ONLY FOR NADJST EQUALLING 2 THROUGH 5.

INITIAL SETTINGS.

SKIP PROGRAM LINES 533 THROUGH 537 APPLICABLE ONLY WHEN RUN INVOLVES TARGET
SHAPE DATA FROM CARDS.

SPECIAL SETTINGS ARE NEEDED WHEN TARGET SHAPE DATA FROM CARDS ARE USED.

INITIAL SETTING.

SET IC, NANGLE, AND NBETA SO THAT PROGRAM STATEMENT 4100 AND SUBSEQUENT

60
IF (XXB(IC, MSET) .EQ. 9999999) GO TO 9305

BBX(I) = XXB(IC, MSET) * CONVRT
BBY(I) = YYB(IC, MSET) * CONVRT
SSIGX(I) = SSIGXB(IC, MSET) * CONVRT
SSIGY(I) = SSIGYB(IC, MSET) * CONVRT

DO 4040 N = 2, 4

4025

IF (NADJST .LT. 2 .OR. NADJST .GT. 5) GO TO 4045

4200 CONTINUE

IC = NTRGTC
NANGLE = 0
NBETA = 9
NX = NXTEMP(IC)
NY = NYTEMP(IC)
CNX = NX
CNY = NY
XCORNR = XTEMPL(IC)

4105 IF (NBETA .EQ. NANGLE) XCORNR = -XTEMPL(IC)

DO 4110 I = 1, NX

4110 AX(I) = XCORNR + U*W

DO 4120 J = 1, NY

AY(J) = YTEMPL(IC) + V*W

4130 IK(J, I) = 0

DO 4140 M = 1, 3000

IMODX = IMODXY(M, IC) / 100000
IMODY = IMODXY(M, IC) - IMODX * 100000
X = IMODX - 10000
IEND = X
IF (IEND .EQ. 9999) GO TO 4145

IF (NBETA .EQ. NANGLE) X = -X

4155 I = (X - XCORNR) / W + 1.001

4140 IK(J, I) = M

4145 CONTINUE

4155 J = (Y - YTEMPL(IC)) / W + 1.001

IF (NADJST .EQ. 9) GO TO 7400

IF (NADJST .GT. 0) GO TO 4300

IF (INTPL .EQ. 0 .OR. ISPLIT .EQ. 0) GO TO 4300
EXPLANATIONS (CONTINUED)

INSTRUCTIONS APPLY FOR TARGET SHAPE CARD INPUT AS WELL AS FOR VULNERABILITY
DATA INPUT FROM TAPE OR DISC. SELECTION OF ARBITRARY BUT DIFFERENT VALUES
FOR NANGLE AND NBETA ENSURES CALCULATIONS NORMALLY ASSOCIATED WITH REVERSE
ANGLES ARE NOT ATTEMPTED.

538-541 MX AND NY ARE SET TO EQUAL NUMBERS OF CELLS ON EDGES OF SMALLEST RECTANGLE
ENCLOSING TARGET FOR IC VALUE OF CURRENT CONCERN. CNX AND CNY ARE REAL
FORMS.

542 XCORNR IS SMALLEST X COORDINATE CORRESPONDING TO CENTER OF AT LEAST ONE TARGET
CELL. FOR EXAMPLE, IF PREVIOUS CALCULATIONS HAVE RESULTED IN XTEMPL(IC)
BEING -204 AND XTEMPH(IC) 128 FOR IC VALUE OF INTEREST, XCORNR EQUALS -204.

543 XCORNR NEEDS TO BE RESET FOR REVERSE ANGLE. FOR EXAMPLE, IF XTEMPL(IC) EQUALS
-204 AND XTEMPH(IC) 128, CORRECT SETTING FOR XCORNR IS NOW -128.

544-549 AX AND AY ARRAYS NEED TO CONTAIN X AND Y COORDINATES RESPECTIVELY OF CENTERS
OF CELLS IN SMALLEST RECTANGLE ENCLOSING TARGET. ARRAYS MAY POSSIBLY INCLUDE
SOME VALUES FOR WHICH THERE IS NO CORRESPONDING TARGET CELL.

550-552 INITIAL SETTINGS.

553-566 COORDINATES OF CENTER OF EACH TARGET CELL ARE RETRIEVED AND CONVERTED TO PAIR
OF INDICES J AND I THAT IDENTIFY CELL LOCATION IN RECTANGLE ENCLOSING
TARGET. ONCE PROCESSING IS DONE FOR ALL CELLS, IK ARRAY CONTAINS 1) ZEROS
FOR VALUES OF J AND I ASSOCIATED WITH CELLS OUTSIDE TARGET, AND 2) CELL
COUNTER INDEX M FOR J AND I PAIRS CORRESPONDING TO TARGET CELLS. USE OF
INDICES J AND I IN IK ARRAY PARALLELS EARLIER USE OF THESE SAME INDICES IN
AY AND AX ARRAYS RESPECTIVELY.

568 SKIP PROGRAM LINES 569 THROUGH 1132 IF NHTKLL INDICATES RUN DOES NOT INVOLVE
SIMULATED FIRING ENGAGEMENTS.

569-570 SKIP PROGRAM LINES 571 THROUGH 574 UNLESS ISPLIT EQUALLING 1, 2, OR 3
INDICATES FIRST, SECOND, OR THIRD OF FOUR SETS OF SIMULATED ENGAGEMENTS
INVOLVED IN RANGE INTERPOLATION HAVE BEEN COMPLETED.

571-574 ISPLIT EQUALLING 1 INDICATES FIRST SET OF SIMULATED ENGAGEMENTS INVOLVED IN
RANGE INTERPOLATION HAS BEEN COMPLETED. FIRST SET IS FOR FORWARD ORIENTATION
ANGLE OF CONCERN. Resetting of ISAMP TO 0 BY PROGRAM STATEMENT 5000 IS
NECESSARY BEFORE SIMULATION OF ENGAGEMENTS FOR REVERSE ANGLE CAN BEGIN. IF
ISPLIT EQUALS 2 OR 3, NEND1 ENGAGEMENTS HAVE ALREADY BEEN SIMULATED FOR BOTH
FORWARD AND REVERSE ANGLES. IF NECESSARY, RESET ISAMP TO NEND1 BEFORE NEXT
SET OF ENGAGEMENTS IS INITIATED.

576 BASIC ADJUSTMENT PROCEDURE DOES NOT INVOLVE PROGRAM LINES 577 AND 578.

577-578 INITIAL SETTINGS.

580 NSMDTR EQUALLING 0 INDICATES PROGRAM LINES 581 THROUGH 585 ARE TO BE SKIPPED.

581-585 INITIAL SETTINGS.

587 PROGRAM LINES 588 THROUGH 643 ARE OF POSSIBLE CONCERN FOR FORWARD ORIENTATION
ANGLE OF TARGET BUT NOT FOR REVERSE ANGLE.

588 PROGRAM LINES 589 THROUGH 597 ARE NEVER INVOLVED AFTER PROCESSING FOR FIRST
PAIR OF TARGET ORIENTATION ANGLES HAS BEEN COMPLETED.

590-597 ENGAGEMENT IS TO BE REPEATEDLY SIMULATED TOTAL OF NSAMP TIMES FOR EACH SET OF
CONDITIONS. EACH SIMULATED ENGAGEMENT IS CALLED SAMPLE ENGAGEMENT OR SIMPLY
IF ( ISPLIT .EQ. 1 ) GO TO 5000
IF ( ISPLIT .EQ. 2 ) GO TO 5100
ISAMP = NEND1
GO TO 5100
CONTINUE
575  4300
IF ( NADJST .EQ. 0 ) GO TO 4305
DO 4310 I = 1, NRDS
    AFAIL(I) = 0.0
CONTINUE
4305
IF ( NSMDTR .EQ. 0 ) GO TO 4400
DO 4320 N = 1, 5
    DO 4320 I = 1, 2
        DO 4320 J = 1, 50
            NHINUS(J, I, N) = 0
        CONTINUE
4320
CONTINUE
4400
IF ( NBETA .EQ. NANGLE ) GO TO 5000
IF ( NANGLE .GT. 1 ) GO TO 4500
NSAHP = 10000
SAMP = NSAMP
WRITE ( 6, 4410 ) NSAMP
4410 FORMAT ( 10X, 21H NUMBER OF SAMPLES = I6 )
IF ( NSTCRD .GT. 0 ) GO TO 4415
CONTINUE
4415
NEND1 = NSAMP
GO TO 4500
4425
IF ( NANGLE .EQ. 1 ) NEND1 = RATIO * SAMP
CONTINUE
4500
IF ( NSTCRD .EQ. 0 ) GO TO 4600
IF ( NRANGE .GT. 0 ) GO TO 4600
IF ( NANGLE .GT. 1 ) GO TO 4600
DROP = 0.0
CONTINUE
4600
IF ( NDRDROP .EQ. 0 ) GO TO 4600
IF ( NDRDROP .GT. 1 ) GO TO 4510
DROP = (YTOP-YBASE) * 0.5
CONTINUE
4510
IF ( NADJST .NE. 2 .AND. NADJST .NE. 4 ) GO TO 4510
PI = 3.14159
R = IRANGE
CNMTER = R*PI / 3200.0
CNINCH = CNMTER * 39.37
CONTINUE
4520
IF ( NDRDROP .GT. 2 ) GO TO 4520
DROP = 0.5 * CNINCH
CONTINUE
4530
IF ( NDRDROP .GT. 3 ) GO TO 4530
DROP = 1.0 * CNINCH
CONTINUE
4540
IF ( NDRDROP .GT. 4 ) GO TO 4540
DROP = 2.0 * CNINCH
CONTINUE
4550
IF ( NDRDROP .GT. 5 ) GO TO 4550
DFLCTN = 1.0 * CNINCH
CONTINUE
4560
IF ( NDRDROP .GT. 6 ) GO TO 4560
DFLCTN = 2.5 * CNINCH
CONTINUE
4570
DFLCTN = 5.0 * CNINCH
EXPLANATIONS (CONTINUED)

SAMPLE IN THESE EXPLANATIONS. SAMP IS REAL FORM, NEND1 REPRESENTS NUMBER OF ENGAGEMENTS THAT REQUIRE CONSIDERATION AS PART OF FIRST, AND POSSIBLY ONLY, GROUP PROCESSED. NEND1 IS SET EITHER TO NSAMP OR, IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA IS INVOLVED, TO APPROPRIATE FRACTION OF NSAMP. IN LATTER CASE PROGRAM STATEMENT 6015 SUBSEQUENTLY CAUSES REMAINING PORTION OF NSAMP ENGAGEMENTS TO BE ACCOUNTED FOR.

509-601 PROGRAM LINES 602 THROUGH 627 CAN BE OF CONCERN ONLY WHEN FIRST RANGE AND FIRST PAIR OF TARGET ORIENTATION ANGLES ARE BEING PROCESSED. CONDITION INVOLVING NSTCRD IS INCLUDED BECAUSE SPECIAL SETTINGS OF NANGLE AND N3ETA ESTABLISHED BY PROGRAM LINES 536 AND 537 WHEN RUN INVOLVES TARGET SHAPE DATA FROM CARDS WOULD OTHERWISE CAUSE PROBLEM.

602 INITIAL SETTING.

603 SKIP PROGRAM LINES 604 THROUGH 627 IF NDROP IS 0.

604-627 RESET STANDARD VERTICAL ADJUSTMENT DROP TO HALF OF TARGET HEIGHT FOR NDROP EQUALLING 1. NDROP VALUES 2 THROUGH 6 ARE ASSOCIATED WITH NADJST EQUALLING 2 THROUGH 5. IGNORE CORRESPONDING PROGRAM STATEMENTS.

629-634 INITIAL SETTINGS.

635-643 CONDITIONS OF INTEREST INCLUDE PAIR OF TARGET ORIENTATION ANGLES REPRESENTED BY NANGLE AND N3ETA OR PARTICULAR TARGET ASSOCIATED WITH NTRGTC.

644 INITIAL SETTING BEFORE ANY SAMPLE ENGAGEMENTS FOR PARTICULAR CONDITIONS.

645-892 CYCLE FOR EACH SAMPLE ENGAGEMENT SIMULATED.

645-653 INITIAL SETTINGS FOR PARTICULAR SAMPLE ENGAGEMENT BEING SIMULATED.

654-656 R1 AND R2 ARE RANDOM NORMAL DEVIATES DRAWN FROM NORMAL DISTRIBUTION WITH MEAN OF 0 AND STANDARD DEVIATION OF 1. CALCULATED VALUES OF XC1 AND YC1 ARE COORDINATES OF POINT IN TARGET COORDINATE SYSTEM WHERE FIRST ROUND WOULD IMPACT IF THERE WERE NO RANDOM ERRORS. XC1 IS SUM OF 1) HORIZONTAL COORDINATE XC OF INTENDED AIMPOINT, 2) HORIZONTAL FIXED BIAS XB, AND 3) HORIZONTAL VARIABLE BIAS DETERMINED FOR PARTICULAR FIRING ENGAGEMENT OF CONCERN BY APPLYING R1 AS ADJUSTMENT FACTOR TO VARIABLE BIAS STANDARD DEVIATION SIGXB. SIMILARLY FOR YC1.

657-658 INITIAL SETTINGS.

659-891 CYCLE FOR EACH ROUND FIRED.

659-660 INITIAL SETTINGS.

661-669 COORDINATES X1 AND Y1 OF ROUND IMPACT POINT IN PLANE OF TARGET ARE DETERMINED. FAC IS CONTROL THAT CAN EQUAL ONLY 0 OR 1. FAC IS INITIALLY SET TO 1 TO INDICATE THAT NO ADJUSTMENT BASED ON SENSING HAS YET OCCURRED, AND RESET TO 0 AFTER FIRST SUCH ADJUSTMENT. LAY ERRORS ARE EXCLUDED FROM FURTHER CONSIDERATION WHEN ADJUSTMENT BASED ON SENSING HAS BEEN MADE, BECAUSE ASSOCIATED SENSING ERRORS ARE DEFINED TO INCLUDE LAY ERRORS AS WELL AS ROUND OBSERVATION ERRORS. HORIZONTAL LAY ERROR X2, IF APPLICABLE, IS GOTTEN BY APPLYING R1 TO HORIZONTAL LAY ERROR STANDARD DEVIATION SIGXL. SIMILARLY FOR VERTICAL LAY ERROR Y2. HORIZONTAL RANDOM ERROR XRE ACCOUNTS FOR LAY ERROR, IF NECESSARY, AND ALWAYS INCLUDES HORIZONTAL ROUND-TO-ROUND ERROR DETERMINED, FOR SPECIFIC ROUND BEING CONSIDERED, BY APPLYING R1 TO HORIZONTAL ROUND-TO-ROUND STANDARD DEVIATION SIGXR. SIMILARLY FOR VERTICAL RANDOM ERROR YRE. COORDINATES X1 AND Y1 OF ACTUAL IMPACT POINT ARE OBTAINED BY ADJUSTING XC1 AND YC1 TO REFLECT CONTRIBUTION OF RANDOM ERRORS.
CONTINUE

4600 DD 4610 J = 1,10
      DD 4610 I = 1,61

4610 AKIL(I,J) = 0.0
      DD 4620 J = 1,12
      DD 4620 I = 1,NRDS
      Z(I,J) = 0.0

4630 IF ( NSTCRD .GT. 0 ) GO TO 4640
      NVRSE = NANGLE + 1
      WRITE ( 6,4630 ) NANGLE,NVRSE
      FORMAT ( /,10X,10H ANGLES = ,2I7 )
      WRITE ( 6,1020 )
      GO TO 5000

4640 WRITE ( 6,4650 ) NTRGTC
      FORMAT ( /,10X,10H TARGET = ,I7 )
      WRITE ( 6,1020 )

5000 ISAMP = 0
5100 ISAMP = ISAMP + 1
      T = FLT
      SUMCASE = 0.0
      XC1 = 0.0
      YC1 = 0.0
      IHW = 0
      NFAIL = 0
      DD 5110 J = 1,10
      C(J) = 0.0
      CALL NRAN(R1,R2)
      XC1 = XC1 + XC + XB + R1*SIGXB
      YC1 = YC1 + YAIM + YB + R2*SIGYB
      FAC = 1.0
      J = 0
5200 J = J + 1
      NSHORT = 0
      IF ( FAC .EQ. 0.0 ) GO TO 5205
      CALL NRAN(R1,R2)
      X2 = R1 * SIGXL
      Y2 = R2 * SIGYL
      CALL NRAN(R1,R2)
      XRE = FAC*X2 + R1*SIGXR
      YRE = FAC*Y2 + R2*SIGYR
      XI = XC1 + XRE
      Y1 = YC1 + YRE

5215 CALL NRAN(T1,T2DUM)
      IF ( J .GT. 1 ) GO TO 5215
      HWM = XM1 * EXP(T1*STD1)
      IF ( HWM .LT. AMT1 ) HWM = AMT1
      T = T + TF1 + HWM
      GO TO 5220

5220 CONTINUE

660 IF ( NADJST .LT. 2 .OR. NADJST .GT. 5 ) GO TO 5225

5235 GO TO 5245
EXPLANATIONS (CONTINUED)

670-678 ENGAGEMENT TIME T IS RESET TO EQUAL TIME AT WHICH ROUND UNDER CONSIDERATION REACHES TARGET RANGE. SECOND RANDOM NORMAL deviate t2dummy IS UNNEEDED AND IGNORED. DISTINCTION IS MADE BETWEEN FIRST ROUND AND SUBSEQUENT ROUNDS.

FIRST ROUND FIRING TIME, MEASURED FROM BEGINNING OF ENGAGEMENT, INCLUDES FIXED TIME COMPONENT TFI THAT MAY EQUAL 0. VARIABLE COMPONENT, WHICH IS TOTAL FIRING TIME IF FIXED TIME EQUALS 0, IS OBTAINED FROM LOGARITHMIC NORMAL DISTRIBUTION WITH MEDIAN TIME XM1 AND VARIABILITY FACTOR ST1. HWM REPRESENTS SPECIFIC VARIABLE TIME GENERATED FROM DISTRIBUTION OF TIMES BY APPLICATION OF T1. IF INITIAL VALUE OF HWM IS EVER LESS THAN MINIMUM TIME AMT1, LATTER VALUE OVERIDES. UPDATED VALUE OF T IS TIME AT WHICH FIRST ROUND HITS OR MISSES TARGET, BECAUSE FLIGHT TIME FLT HAS ALREADY BEEN ACCOUNTED FOR BY INITIAL SETTING. NOTE THAT PROGRAM DOES NOT PROCESS FLIGHT TIME AND FIRING TIME OF FIRST ROUND IN ORDER MATCHING CHRONOLOGICAL SEQUENCE OF BATTLE EVENTS, SINCE FIRING OF ROUND OBVIOUSLY PRECEDES ITS FLIGHT TOWARD TARGET. FIRING TIME FOR EACH SUBSEQUENT ROUND IS ESTABLISHED BASICALLY LIKE FIRST ROUND FIRING TIME. EACH SUBSEQUENT ROUND FIRING TIME IS CONSIDERED MEASURED FROM TIME AT WHICH PREVIOUS ROUND IS FIRED. SUBSEQUENT ROUND FIRING TIME ACCOUNTS FOR FIXED TIME COMPONENT THAT MAY AGAIN BE 0. VARIABLE TIME COMPONENT, WHICH MAY BE TOTAL FIRING TIME, IS OBTAINED FROM LOGARITHMIC NORMAL DISTRIBUTION WITH MEDIAN TIME XM2 AND VARIABILITY FACTOR ST2. HWM REPRESENTS SPECIFIC VARIABLE TIME BASED ON T1. IF NECESSARY, INITIAL VALUE OF HWM IS OVERWRITTEN BY MINIMUM TIME AMT2. UPDATED VALUE OF T IS TIME AT WHICH SUBSEQUENT ROUND OF INTEREST HITS OR MISSES TARGET. ANOTHER OBSERVATION IS STRIGHTLY SPEAKING, ONE NEEDS TO SUBTRACT PROJECTILE FLIGHT TIME TO GET TIME AT WHICH THIRD ROUND IS FIRED, ADD FOURTH ROUND FIRING TIME, AND THEN ADD TIME OF FLIGHT FOR FOURTH ROUND. FIRST AND THIRD OF THESE STEPS CLEARLY CANCEL EACH OTHER OUT AND ARE CONSEQUENTLY NOT EXPLICITLY REQUIRED.

680 TIME T IS CONVERTED TO INDEX J10 ASSOCIATED WITH AKN ARRAY. J10 EQUALLING 1 IS RESERVED FOR 0 SECONDS, RATHER THAN FOR ANY INTERVAL. SUBSEQUENT INTEGER VALUES OF J10 CORRESPOND TO TIME INTERVALS OF 0 TO 2 SECONDS (EXCLUDING BOTH 0 AND 2 SECONDS), 2 TO 4 SECONDS (EXCLUDING 4 SECONDS), ETC., RESPECTIVELY. ASSUME, FOR EXAMPLE, THAT T EQUALS 47.8 SECONDS. THEN, T/2 EQUALS 23.9, AND 23.9 + 2 EQUALS 25.9. SINCE J10 IS INTEGER QUANTITY, IT IS SET TO 25.

681-694 IGNORE THESE SPECIAL STATEMENTS FOR NADJST EQUALLING 2 THROUGH 5.

696-710 DETERMINE WHETHER ROUND HITS TARGET.

696-701 ANY ROUND FOR WHICH VERTICAL COORDINATE OF IMPACT POINT IS LESS THAN VERTICAL COORDINATE YBASE DEFINING TARGET BASE MISSES TARGET. WHEN NADJST EQUALS 1, NSHORT IS SET TO 1 TO INDICATE THAT PARTICULAR MISSING ROUND UNDER CONSIDERATION HAS BEEN SHORT OF TARGET. FIRE ADJUSTMENT PROCEDURE ASSOCIATED WITH NADJST EQUALLING 0 DOES NOT INVOLVE DISTINGUISHING WHETHER MISSING ROUND IS SHORT OR NOT.

703 IGNORE.

704 HORIZONTAL COORDINATE OF IMPACT POINT IS SMALLER THAN SMALLEST X COORDINATE ASSOCIATED WITH VERTICAL RECTANGLE ENCLOSING TARGET. ROUND MISSES TO LEFT.

705 ROUND MISSES TO RIGHT.

706 ROUND IS TOO LOW TO HIT TARGET. ALTHOUGH COMPARISON INVOLVING YBASE HAS BEEN MADE EARLIER, IT IS POSSIBLE YBASE AND AY(1)-H DIFFER SLIGHTLY DUE TO ROUNDING.
685  IF ( NADJST .EQ. 5 ) GO TO 5625
690  IF ( X1 .LT. XLEFTD(IC) ) XC1 = XC1 + DFLCTN
695  IF ( NADJST .EQ. 2 .OR. NADJST .EQ. 3 ) GO TO 5665
700  IF ( X1 .GT. XRGHTD(IC) ) GO TO 5800
705  IF ( X1 .LT. XLEFTD(IC) ) XC1 = XC1 + DFLCTN
710  IF ( X1 .GT. XRGHTD(IC) ) GO TO 5800
715  CONTINUE
720  CONTINUE
725  CONTINUE
730  CONTINUE
735  CONTINUE
740  CONTINUE
707  ROUND MISSES HIGH.

708-710  ROUND HITS WITHIN RECTANGLE ENCLOSING TARGET. IMPACT POINT IS WITHIN CELL WHOSE CENTER HAS Y AND X COORDINATES EQUAL TO JV AND IH RESPECTIVELY. FORMULAS FOR JV AND IH SYSTEMATICALLY RESOLVE AMBIGUITIES THAT ARISE, EXCEPTIONALLY, IF IMPACT POINT IS COMMON TO TWO OR FOUR CELLS. FOLLOWING ILLUSTRATION SHOULD CLARIFY FORMULA FOR JV. 1) Y1-(AY(1)+H), WHICH EQUALS Y1-AY(1)+H, IS DISTANCE IN INCHES FROM IMPACT POINT TO BOTTOM EDGE OF RECTANGLE. LET THIS DISTANCE EQUAL 22.415 INCHES. 2) DIVISION BY CELL DIMENSION W CONVERTS FROM INCHES TO CORRESPONDING NUMBER OF CELLS. LET W EQUAL 3.937 INCHES. THEN 22.415 INCHES EQUAL 5.693 CELLS. 3) FOR EXAMPLE CHOSEN, IMPACT POINT OBVIOUSLY LIES IN SIXTH ROW OF CELLS. SINCE JV IS INTEGER QUANTITY, ANY DECIMAL FRACTION SUCH AS .693 IS EVENTUALLY DROPPED FROM CALCULATION AND ADDITION OF 1 TO GET 6.693 IS NECESSARY. INTEGER VALUE 6 FOR JV IS OBTAINED BY DROPPING .693. COMPARISON OF 6.693 TO CNY ENSURES THAT MAXIMUM POSSIBLE VALUE NY IS NEVER EXCEEDED DUE TO ROUNING. SIMILAR EXPLANATIONS APPLY TO IH. PREVIOUS PROCESSING OF TARGET DESCRIPTION AND VULNERABILITY DATA HAS SET IK ARRAY VALUES TO BE POSITIVE IF AND ONLY IF CORRESPONDING CELLS ARE INCLUDED IN TARGET. ROUND MISSES IF IT IMPACTS ON CELL WHICH, ALTHOUGH IN RECTANGLE ENCLOSING TARGET, IS NOT PART OF TARGET.

711-713  PROGRAM LINES 714 THROUGH 731 INVOLVE SPECIAL CALCULATIONS ASSOCIATED WITH AT LEAST ONE OF CONTROLS NDTRM1 AND NDTRM2 EQUALLING 1. THESE CALCULATIONS CANNOT BE ATTEMPTED IF ROUND INDEX J INDICATES THAT SOME SUBSEQUENT ROUND RATHER THAN FIRST ROUND IS BEING PROCESSED OR IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA IS NEEDED.

714-715  COORD(1) AND COORD(2) RESPECTIVELY ARE ESSENTIALLY HORIZONTAL AND VERTICAL MISS DISTANCES IN TARGET PLANE WITH REFERENCE TO APPROXIMATE CENTER OF MASS OF TARGET. TO VERIFY THIS, SEE HOW XC1 AND YC1 ARE CALLED BY PROGRAM LINES 655 AND 656 AND HOW X1 AND Y1 ARE SET BY LINES 668 AND 669. COORD(1) IS DIFFERENCE BETWEEN X COORDINATE OF APPROXIMATE CENTER OF MASS AND X COORDINATE OF POINT THAT WOULD BE HIT REPEATEDLY IF THERE WERE NO RANDOM ERRORS AND WEAPON FIRED SEVERAL ROUNDS WITHOUT ANY ADJUSTMENT BETWEEN ROUNDS. SIMILARLY, COORD(2) IS DIFFERENCE OF CORRESPONDING Y COORDINATES.

716-731  INDEX I VALUES 1 AND 2 ARE ASSOCIATED WITH PROCESSING OF HORIZONTAL AND VERTICAL MISS DISTANCES RESPECTIVELY. PROGRAM LINES 718 THROUGH 723 APPLY TO NEGATIVE COORD(I) VALUES, WHILE LINES 725 THROUGH 730 COVER POSITIVE VALUES OR 0. QUANTITIES IN NMINUS AND NPLUS ARRAYS ARE COUNTERS INDICATING NUMBERS OF ENGAGEMENTS FOR WHICH MISS DISTANCE FALLS WITHIN ANY 20-INCH INTERVAL. TOTAL SPREAD COVERED IS BASICALLY FROM -1000.0 TO 1000.0 (EXCLUDING -1000.0 AND 1000.0) INCHES. ANY MISS DISTANCE OUTSIDE THIS SPREAD WOULD BE COUNTED AS BEING WITHIN INTERVAL NUMBER 50 ASSOCIATED WITH NMINUS OR NPLUS ARPA. N EQUALLING 1 CORRESPONDS TO ALL FIRST ROUNDS THAT HIT TARGET. CALCULATIONS FOR N EQUAL TO 2 ARE IDENTICAL AT THIS STAGE TO THOSE FOR N EQUAL TO 1 BUT EVENTUALLY APPLY TO FIRST ROUND HITS THAT DO NOT RESULT IN K (COMPLETE DESTRUCTION) KILL OF TARGET.

733  RANDOM NUMBER RANF(DUM) IS COMPARED TO PROBABILITY BELT THAT ROUND HAS FLOWN RELIABLY TO TARGET RANGE. DEFECTS CAUSING ERRATIC FLIGHT OF ROUND ARE CONSIDERED TO MAKE IT IMPOSSIBLE FOR ROUND TO HIT AND FIRE ADJUSTMENT TO BE ATTEMPTED. PROCESSING CONTINES AT PROGRAM STATEMENT 5700 AFTER DETERMINATION OF DEFECTIVE TRAJECTORY.

734  SKIP PROGRAM LINES 735 THROUGH 738 IF NHIT CONTROL INDICATES AIMPOINT IS NOT TO BE ADJUSTED AFTER TARGET HIT.

735-738  ADJUSTMENT OF AIMPOINT AFTER TARGET HIT IS CONSIDERED BASED ON GUNNER SENSING OF IMPACT. UPDATED VALUES OF XC1 AND YC1 ARE COORDINATES OF POINT IN TARGET COORDINATE SYSTEM WHERE NEXT ROUND WOULD IMPACT IF THERE WERE NO RANDOM
EXPLANATIONS (CONTINUED)

ERRORS. XC1 IS OBTAINED BY COMBINING 1) HORIZONTAL COORDINATE Xc OF INTENDED AIMPOINT, 2) DIFFERENCE Xc-X1 WHICH INVOLVES Xc AND X1 VALUES FROM EARLIER CALCULATIONS AND WHICH, AS CAN BE SEEN FROM PROGRAM LINE 668, CAUSES SPECIFIC HORIZONTAL RANDOM ERRORS THAT AFFECTED IMPACT POINT OF HITTING ROUND TO BE REMOVED, AND 3) ADJUSTMENT ERROR OBTAINED BY APPLYING R1 TO HORIZONTAL STANDARD DEVIATION HSX. TERM ACCOUNTING FOR ADJUSTMENT ERROR INVOLVES 'PLUS' SIGN BECAUSE, IF HITTING ROUND IS JUDGED TO BE OFF TARGET CENTER IN ONE DIRECTION, WEAPON IS MOVED IN OPPOSITE DIRECTION. FORMULA FOR YC1 OBVIOUSLY PARALLELS THAT FOR XC1. FAC IS RESET SO THAT LAY ERRORS, CONSIDERED INCLUDED AS PART OF ADJUSTMENT ERRORS, WILL NO LONGER BE TREATED EXPLICITLY.

740-741 IF IHW EQUALS 0, RESET TO 1. IHW CAN BE ONLY 0 OR 1, LATTER INDICATING THAT TARGET HAS BEEN HIT AT LEAST ONCE IN PARTICULAR SAMPLE ENGAGEMENT UNDER CONSIDERATION. ONCE IHW IS SET TO 1, IT REMAINS UNCHANGED FOR REMAINDER OF ENGAGEMENT.

742-748 UPDATE Z AND AKIL ARRAYS TO ACCOUNT FOR TARGET HIT BEING PROCESSED. SET INDEX KH TO 5 FOR 0, 30, 60, OR 90 DEGREES OR TO 10 FOR REVERSE ANGLE MATCHED WITH EACH FIRST ANGLE. EACH Z(K,5) OR Z(K,10) VALUE REPRESENTS HOW MANY TIMES FIRST TARGET HIT OCCURRED EITHER ON ROUND K OR ON EARLIER ROUND IN SAMPLE ENGAGEMENTS PROCESSED SO FAR. INDEX J10 ASSOCIATED WITH AKIL ARRAY IS RESTRICTED AT THIS POINT TO MAXIMUM VALUE OF 61 TO PRECLUDE FURTHER CONSIDERATION OF HITS THAT OCCUR AT TIMES EQUALLING OR EXCEEDING LIMIT OF 120 SECONDS (2 MINUTES). AKIL ARRAY IS UPDATED TO ACCOUNT FOR TIME AT WHICH HIT UNDER CONSIDERATION OCCURS. EACH AKIL(K,5) OR AKIL(K,10) VALUE REPRESENTS HOW MANY TIMES TARGET HAS BEEN HIT AT LEAST ONCE PRIOR TO TIME EQUALLING 2(K-1) SECONDS IN SAMPLE ENGAGEMENTS PROCESSED SO FAR. ANY PARTICULAR ENGAGEMENT DOES NOT CONTRIBUTE TO AKIL(K,5) OR AKIL(K,10) VALUE IF TARGET IS NOT HIT AT ALL OR IF IT IS FIRST HIT AT TIME EQUALLING OR EXCEEDING 2(K-1) SECONDS.

749 SKIP PROGRAM LINES 750 THROUGH 891 IF NPRHIT INDICATES TARGET HIT ONLY IS OF CONCERN BUT KILLS ARE NOT. ENGAGEMENT IS OVER SINCE FIRST HIT ON TARGET HAS BEEN ACHIEVED.

750 IT IS CONSIDERED THAT TARGET CANNOT BE KILLED IF, FOR ROUNDS WITH FUZE, LATTER DOES NOT PERFORM RELIABLY WHEN TARGET IS HIT. INPUT PROBABILITY RELF IS SIMPLY SET EQUAL TO 1.0000 FOR ANY ROUND TYPE THAT DOES NOT INVOLVE FUZING. PROCESSING CONTINUES AT PROGRAM STATEMENT 5700 AFTER DETERMINATION OF DEFECTIVE FUZE FUNCTIONING.

751-753 KILLING EFFECTS THAT RESULT FROM TARGET BEING HIT BY PARTICULAR ROUND OF CONCERN, EXCEPT FOR PASSENGER PERSONNEL CASUALTIES CONSIDERED LATER, ARE DETERMINED.

751-753 INITIAL SETTINGS. HW2 IS USED FOR TEMPORARY STORAGE OF RANDOM NUMBER NEEDED SUBSEQUENTLY TO DETERMINE WHETHER OR NOT TARGET IS KILLED AS RESULT OF BEING HIT. K22 IS USED FOR TEMPORARY STORAGE OF IK(JV,IH) VALUE ASSOCIATED WITH TARGET CELL HIT. N IS INVOLVED IN UNPACKING OF ARRAY MPK QUANTITIES.

754-772 UNPACK NPK ARRAY QUANTITY THAT CORRESPONDS TO TARGET CELL HIT AND ASSOCIATED TARGET ORIENTATION TO RETRIEVE PROBABILITIES OF M KILL, F KILL, M OR F KILL, AND K KILL PER HIT AND, IF NECESSARY, EXPECTED CASUALTIES PER HIT. STORE THESE IN PK ARRAY, USING PK(1) OR PK(6) FOR M KILL PROBABILITY, PK(2) OR PK(7) FOR F KILL PROBABILITY, PK(3) OR PK(8) FOR M OR F KILL PROBABILITY, PK(4) OR PK(9) FOR K KILL PROBABILITY, AND PK(5) OR PK(10) FOR CASUALTIES. PK(1) THROUGH PK(5) ARE USED FOR TARGET ORIENTATION ANGLE OF 0, 30, 60, OR 90 DEGREES, AND PK(6) THROUGH PK(10) FOR CORRESPONDING REVERSE ANGLE.

773-784 CONSIDER KILL CRITERIA IN TURN. INDEX K21 EQUALS 1 OR 6 FOR M KILL, 2 OR 7 FOR
PROGRAM LISTING (CONTINUED)

KH = 5
IF ( NBETA .EQ. NANGLE ) KH = 10
DO 5410 K = JNRDS

5410 Z(K,KH) = Z(K,KH) + 1.0
IF ( J10 .GT. 61 ) GO TO 5405
DO 5420 K = J10,61

5420 AKIL(K,KH) = AKIL(K,KH) + 1.0
IF ( NPRHIT .EQ. 1 ) GO TO 6000

5405 IF ( RANF(DUM) .GT. RELF ) GO TO 5700
HW2 = RANF(DUM)
K22 = I(KV,IV)
N = 49
DO 5430 K = 1,4
IF ( NBETA .EQ. NANGLE ) GO TO 5435
IST = SHIFT(MPK(K22,IA),N) .AND. MASK11
ST = IST
PK(K) = 0.001 * ST
GO TO 5430

5435 IST1 = SHIFT(MPK(K22,IB),N) .AND. MASK11
ST1 = IST1
PK(K+5) = 0.001 * ST1

5430 N = N + 11
IF ( NBETA .EQ. NANGLE ) GO TO 5445
IST = MPK(K22,IA) .AND. MASK16
ST = IST
PK(5) = 0.001 * ST
GO TO 5450

5445 IST1 = MPK(K22,IB) .AND. MASK16
ST1 = IST1
PK(10) = 0.001 * ST1
CONTINUE
DO 5460 KILL = 1,4
K21 = KILL

775 IF ( C(K21) .GT. 0.0 ) GO TO 5460
IF ( PK(K21) .LT. HW2 ) GO TO 5460
C(K21) = 1.0
DO 5490 K = J,NRDS

780 Z(K,K21) = Z(K,K21) + 1.0
IF ( J10 .GT. 61 ) GO TO 5460
DO 5480 K = J10,61

5480 AKIL(K,K21) = AKIL(K,K21) + 1.0
CONTINUE

785 IF ( J .GT. 1 ) GO TO 5505
IF ( INTPL .EQ. 1 ) GO TO 5505
IF ( NDTRM2 .EQ. 0 ) GO TO 5505

KILL = 4
IF ( NBETA .EQ. NANGLE ) KILL = KILL + 5
IF ( C(KKILL) .EQ. 0.0 ) GO TO 5505

790 N = 2
COORD(1) = X1 - XRE - XC
COORD(2) = Y1 - YRE - YC
DO 5510 I = 1,2

795 IF ( COORD(I) .GE. 0.0 ) GO TO 5515
NCOORD = -COORD(I)/20.0 + 1.0
IF ( NCOORD .GT. 50 ) NCOORD = 50
NMINUS(NCOORD,I,N) = NMINUS(NCOORD,I,N) - 1
F KILL, 3 OR 8 FOR M OR F KILL, AND 4 OR 9 FOR K KILL. VALUES 1 THROUGH 4 APPLY TO TARGET ORIENTATION ANGLES OF 0, 30, 60, AND 90 DEGREES, WHILE 6 THROUGH 9 APPLY FOR ASSOCIATED REVERSE ANGLES. EACH QUANTITY IN C ARRAY CAN BE ONLY 0 OR 1, LATTER VALUE INDICATING TARGET HAS BEEN KILLED FOR ANGLE UNDER CONSIDERATION AND KILL CRITERION CORRESPONDING TO K21. NO FURTHER PROCESSING IS TO BE DONE FOR PARTICULAR ANGLE AND CRITERION WHEN RELATED C VALUE ALREADY EQUALS 1. IF TARGET KILL HAS NOT ALREADY BEEN ACHIEVED BY EARLIER ROUND, FOR SPECIFIC COMBINATION OF ANGLE AND CRITERION, RANDOM NUMBER HW2 AND APPLICABLE KILL PROBABILITY P(K(K21)) ARE COMPARED TO DETERMINE WHETHER TARGET IS KILLED. IF TARGET KILL IS ACHIEVED, RESET C(K21) AND UPDATE Z AND AKIL ARRAYS ACCORDINGLY. Z AND AKIL ARRAY UPDATING IS VERY SIMILAR TO THAT ALREADY EXPLAINED FOR PROGRAM LINES 742 THROUGH 748. EACH Z(K,K21) VALUE REPRESENTS HOW MANY TIMES TARGET ORIENTED AS INDICATED BY K21 HAS BEEN KILLED ACCORDING TO CRITERION ASSOCIATED WITH K21 EITHER ON ROUND K OR ON EARLIER ROUND IN SAMPLE ENGAGEMENTS PROCESSED SO FAR. EACH AKIL(K,K21) VALUE REPRESENTS HOW MANY TIMES TARGET HAS BEEN KILLED PRIOR TO TIME EQUALLING 2(K-1) SECONDS.

765- 787 PROGRAM LINES 788 THROUGH 803 INVOLVE SPECIAL CALCULATIONS ASSOCIATED WITH NDTRM2 EQUALLING 1. THESE CALCULATIONS CANNOT BE ATTEMPTED IF ROUND INDEX J INDICATES THAT SOME SUBSEQUENT ROUND RATHER THAN FIRST ROUND IS BEING PROCESSED OR IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA IS NEEDED.

768- 790 SET KKILL TO EQUAL 4 FOR FORWARD ANGLE OR 9 FOR REVERSE ANGLE. IF C(KKILL) INDICATES K KILL OF TARGET HAS NOT BEEN ACHIEVED, SKIP PROGRAM LINES 791 THROUGH 803 BECAUSE HORIZONTAL AND VERTICAL MISS DISTANCES HAVE ALREADY BEEN ACCOUNTED FOR BY LINES 714 THROUGH 731.

791- 803 CALCULATIONS APPLY ONLY IF K KILL HAS BEEN INFLICTED ON TARGET. SINCE MISS DISTANCES ALREADY Processed BY LINES 714 THROUGH 731 ARE NOT TO BE COUNTED, CORRESPONDING COUNTERS IN MMINUS ARRAY AND/OR NPLUS ARRAY ARE REDUCED ACCORDINGLY.

805- 828 PROCESSING FOR HITTING ROUND CONTINUES WITH ACCOUNTING FOR PASSENGER PERSONNEL CASUALTIES, AS NECESSARY, AND DETERMINATION OF WHETHER ENGAGEMENT HAS BEEN COMPLETED.

805- 806 INITIAL SETTINGS.

807- 828 NONZERO VALUE OF PASSN INDICATES PASSENGER PERSONNEL CASUALTIES NEED TO BE CONSIDERED. EXPECTED CASUALTIES PER HIT HAVE ALREADY BEEN STORED IN PK(5) FOR TARGET ORIENTATION ANGLE OF 0, 30, 60, OR 90 DEGREES, OR IN PK(10) FOR ASSOCIATED REVERSE ANGLE. RATIO CASLT/PASSN INDICATES WHAT FRACTION OF PASSENGER PERSONNEL CARRIED IN TARGET VEHICLE WOULD BECOME CASUALTIES FROM EFFECTS OF ROUND BEING PROCESSED IF NO CASUALTY HAD BEEN CREDITED TO ANY PREVIOUS ROUND. DIFFERENCE PASSN-SUMCASE, WHICH EQUALS ORIGINAL NUMBER OF PASSENGER PERSONNEL PASSN IF TOTAL CASUALTIES SUMCASE INFLECTED BY PREVIOUS ROUNDs EQUAL ZERO, REPRESENTS HOW MANY PASSENGER PERSONNEL HAVE NOT ALREADY BECOME CASUALTIES. UPDATE SUMCASE TO ACCOUNT FOR ADDITIONAL CASUALTIES, REASONABLY ESTIMATED AS PRODUCT OF RATIO CASLT/PASSN AND DIFFERENCE PASSN-SUMCASE, THAT RESULT FROM ROUND OF CURRENT CONCERN. UPDATE Z ARRAY SO THAT Z(J,11) OR Z(J,12) FOR REVERSE ANGLE, REPRESENTS TOTAL NUMBER OF PASSENGER PERSONNEL CASUALTIES INFLECTED IN ALL SAMPLE ENGAGEMENTS PROCESSED SO FAR, BY FIRST J ROUNDS. FIRST THREE CONDITIONAL STATEMENTS IN DO 5550 LOOP ENSURE CONSIDERATION OF PROPER K VALUES, BE THEY 1 THROUGH 4 OR 6 THROUGH 9. IF C(K) EVER EQUALS 0, ENGAGEMENT IS STILL INCOMPLETE UNLESS CURRENT PROCESSING INVOlVES LAST OF NRDS ROUNDS ALLOWED AS MAXIMUM. IF ALL FOUR C(K) VALUES OF CONCERN EQUAL 1, PROCEED TO NEXT ENGAGEMENT BUT ONLY AFTER UPDATING, AS NECESSARY, CUMULATIVE PERSONNEL CASUALTIES IN Z ARRAY FOR ROUNDS WHICH NEED NOT BE FIRED IN CURRENT ENGAGEMENT.
GO TO 5510

800 5515 NCOORD = COORD(I)/20.0 + 1.0
     IF ( NCOORD .GT. 50 ) NCOORD = 50
     NPLUS(NCOORD,I,N) = NPLUS(NCOORD,I,N) + 1
     CONTINUE

805 CONTINUE

810 IF ( NBETA .EQ. NANGLE ) KCAS = 5
     IF ( PASSN .LE. 0.0 ) GO TO 5545
     CASLT = PK(KCAS)
     SUMCASE = SUMCASE + (CASLT/PASSN)*(PASSN-SUMCASE)

815 IF ( NBETA .EQ. NANGLE ) GO TO 5535
     Z(J,11) = Z(J,11) + SUMCASE
     GO TO 5545

5535 Z(J,12) = Z(J,12) + SUMCASE

5540 DO 5550 K = 1,10
     IF ( K .EQ. 5 .OR. K .EQ. 10 ) GO TO 5550
     IF { K .GT. KCAS ) GO TO 5550
     IF ( KCAS .EQ. 10 .AND. K .LT. 5 ) GO TO 5550
     IF ( CIK) .EQ. 0.0 ) GO TO 5800
     CONTINUE

5550 CONTINUE

820 IF ( J .EQ. NRDS ) GO TO 6000
     JNXT = J + 1
     DO 5560 K = JNXT,NRDS
     IF ( NBETA .EQ. NANGLE ) GO TO 5565
     Z(K,11) = Z(K,11) + SUMCASE
     GO TO 5560

5565 Z(K,12) = Z(K,12) + SUMCASE

5560 CONTINUE

GO TO 6000

5600 CONTINUE

830 IF ( J .GT. 1 ) GO TO 5605
     IF ( INTPL .EQ. 1 ) GO TO 5605
     IF ( NDTRM3 .EQ. 0 ) GO TO 5605
     N = 3
     COORD(1) = X1 - XRE - XC
     COORD(2) = Y1 - YRE - YC
     DO 5610 I = 1,2
     IF ( COORD(I) .GE. 0.0 ) GO TO 5615
     NCOORD = -COORD(I)/20.0 + 1.0
     IF ( NCOORD .GT. 50 ) NCOORD = 50

840 NMINUS(NCOORD,I,N) = NMINUS(NCOORD,I,N) + 1
     GO TO 5610

5615 NCOORD = COORD(I)/20.0 + 1.0
     IF ( NCOORD .GT. 50 ) NCOORD = 50
     NPLUS(NCOORD,I,N) = NPLUS(NCOORD,I,N) + 1

5640 CONTINUE

5650 CONTINUE

850 CONTINUE

5635 YC1 = YC1 + DROP
     GO TO 5800

5625 YC1 = YC1 + DROP
     GO TO 5800

855 CALL NRAN(R1,R2)
EXPLANATIONS (CONTINUED)

830-884  CYCLE FOR EACH ROUND THAT IS FIRED FLIES RELIABLY AND MISSES TARGET.

830-832  PROGRAM LINES 833 THROUGH 845 INVOLVE SPECIAL CALCULATIONS ASSOCIATED WITH NDTRM3 EQUALLING 1. THESE CALCULATIONS CANNOT BE ATTEMPTED IF ROUND INDEX J INDICATES THAT SOME SUBSEQUENT ROUND RATHER THAN FIRST ROUND IS BEING PROCESSED OR IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA IS NEEDED.

833-845  N EQUALLING 3 CORRESPONDS TO ALL FIRST ROUNDS THAT MISS TARGET. MISS Distances FOR SUCH ROUNDS ARE USED FOR SETTING COUNTERS IN NMINUS AND NPLUS ARRAYS IN SAME MANNER THAT MISS DistANCES FOR FIRST ROUNDS HITTING TARGET ARE PROCESSED BY PROGRAM LINES 714 THROUGH 731.

847-853  IGNORE STATEMENTS APPLICABLE ONLY FOR NADJST EQUALLING 2.

855  RANDOM NORMAL DEVIATES ARE OBTAINED FOR POSSIBLE LATER USE IN PROGRAM LINES 858 AND 859 OR LINES 875 AND 876.

856  PROGRAM LINES 857 THROUGH 860 APPLY FOR BASIC ADJUSTMENT PROCEDURE AND ARE SKIPPED IF NADJST IS 1.

857-860  IF NADJST EQUALS 0, RANDOM NUMBER IS COMPARED TO PROBABILITY PROBS OF ROUND BEING SENSED. IF ROUND IS NOT SENSED, BURST-ON-TARGET ADJUSTMENT IS NOT MADE AND PROCESSING CONTINUES AT PROGRAM STATEMENT 5700. OTHERWISE DETERMINE ADJX AND ADJY. THESE TWO QUANTITIES, RELATED TO BURST-ON-TARGET ADJUSTMENT, ARE EXPLAINED IN CONNECTION WITH PROGRAM LINES 882 THROUGH 884 WHERE PROCESSING CONTINUES.

861-864  ADJX AND ADJY ARE DETERMINED FOR NADJST EQUALLING 1. TWO QUANTITIES RELATED TO BURST-ON-TARGET ADJUSTMENT ARE EXPLAINED IN CONNECTION WITH PROGRAM LINES 882 THROUGH 884.

865-872  MHIGH EQUALS 0 IF MISSING ROUND IS SHORT OF TARGET, 1 OTHERWISE. HIGH AND SHORT ARE REAL FORMS. PRSCG IS SET TO APPLICABLE PROBABILITY OF ROUND BEING SENSED COMMANDER.

865-872  RANDOM NUMBER RANF(DUM) IS STORED IN RANDOM FOR REUSE IN PROGRAM LINE 878. COMPARE RANDOM TO PROBABILITY OF ROUND BEING SENSED BY GUNNER AND/OR COMMANDER. PROCESSING CONTINUES AT PROGRAM STATEMENT 5655 IF ROUND IS SENSED. OTHERWISE NUMBER NFAIL OF UNSENSED ROUNDS IS UPDATED. IF NFAIL THEN EQUALS 1, DROP AIMPOINT BY HALF TARGET HEIGHT BEFORE CONSIDERATION OF NEXT ROUND. TWO FAILURES TO SENSE CAUSE THIS OUTCOME TO BE RECORDED IN AFAIL ARRAY AND ENGAGEMENT TO BE ENDED.

873-884  THESE STATEMENTS COMPLETE ACCOUNTING FOR BURST-ON-TARGET ADJUSTMENT BASED ON SENSING. UPDATED VALUES OF XC1 AND YC1 ARE COORDINATES OF POINT IN TARGET COORDINATE SYSTEM WHERE NEXT ROUND WOULD IMPACT IF THERE WERE NO RANDOM ERRORS. XC1 IS OBTAINED BY COMBINING 1) HORIZONTAL COORDINATE XC OF INTENDED AIMPOINT, 2) DIFFERENCE XC1-X1 WHICH INVOLVES XC1 AND X1 VALUES FROM EARLIER CALCULATIONS AND WHICH, AS CAN BE SEEN FROM PROGRAM LINE 668, CAUSES SPECIFIC HORIZONTAL RANDOM ERRORS THAT AFFECTED IMPACT POINT OF SENSED MISSING ROUND TO BE REMOVED, AND 3) ADJX VALUE RELATED TO BURST-ON-TARGET ADJUSTMENT. WHEN NADJST EQUALS 0, ADJX HAS BEEN OBTAINED BY APPLYING R1 TO
IF (NADJST .EQ. 1) GO TO 5645
IF (RANF(DUM) .GT. PROBS) GO TO 5700
ADJX = R1 * SIGXS
ADJY = R2 * SIGYS
GO TO 5650

5645
NHIGH = 1 - NSHORT
HIGH = NHIGH
SHORT = NSHORT
PRSCG = HIGH*PGCH + SHORT*PGCS
RANDOM = RANF(DUM)
IF (RANDOM .LE. PRSCG) GO TO 5655
NFAIL = NFAIL + 1
IF (NFAIL .EQ. 2) GO TO 5665
YCI = YCI - DROP
GO TO 5800

5665
AFAIL(J) = AFAIL(J) + 1.0
GO TO 6000

5655
SGX = HIGH*SGHX + SHORT*SGSX
SGY = HIGH*SGHY + SHORT*SGSY
ADJX = R1 * SGX
ADJY = R2 * SGY
PRSG = HIGH*PGH + SHORT*PGS
IF (RANDOM .LE. PRSG) GO TO 5650
CALL NRAN(R3,R4)
ADJX = ADJX + R3*CDRX
ADJY = ADJY + R4*CDRY

5650
XC1 = XC1 - XI + XC - ADJX
YCI = YCI - Y1 + YC - ADJY
FAC = 0.0

5700
IF (PASSN .LE. 0.0) GO TO 5800
IF (NADJST .NE. 0) GO TO 5800
IF (NBETA .EQ. MANGLE) GO TO 5735
Z(J,11) = Z(J,11) + SUMCASE
GO TO 5800

5735
Z(J,12) = Z(J,12) + SUMCASE

5800
IF (J .LT. NRDS) GO TO 5200
CONTINUE

6000
IF (ISAMP .LT. NEND1) GO TO 5100
IF (INTPL .EQ. 0) GO TO 6005
IF (ISAMP .GT. NEND1) GO TO 6015
ISPLIT = ISPLIT + 1
GO TO 9010

6015
IF (ISAMP .LT. NSAMP) GO TO 5100
ISPLIT = ISPLIT + 1
IF (ISPLIT .EQ. 3) GO TO 9010
CONTINUE

6005
IF (NADJST .EQ. 0) GO TO 7000
IFAIL = AFAIL(I)
WRITE (6,1020)
WRITE (6,6020) I,IFAIL

6020
FORMAT (10X,2I10)
SUM = 0.0
DO 6030 I2 = 2,NRDS
SUM = SUM + AFAIL(I2-1)
6030
IFAIL = AFAIL(I2) + SUM
WRITE (6,6020) I2,IFAIL
CONTINUE
HORIZONTAL SENSING ERROR STANDARD DEVIATION SIGXS. WHEN NADJST EQUALS 1, ADJX HAS BEEN DETERMINED IN SIMILAR FASHION WITH CONSIDERATION OF POSSIBLY DIFFERENT ERRORS FOR GUNNER AND COMMANDER. MINUS SIGN IS USED WITH ADJX BECAUSE, IF ROUND IS SENSED AS BEING OFF IN ONE DIRECTION (FOR EXAMPLE, RIGHT AND DOWN), FIRING WEAPON IS MOVED IN OPPOSITE DIRECTION (IN THIS EXAMPLE, LEFT AND UP). TERMS IN FORMULA FOR YC1 PARALLEL THOSE IN XC1 FORMULA. FACT NEEDS TO BE RESET SO THAT LAY ERRORS WILL NO LONGER BE TREATED EXPONENTIALLY SINCE THEY ARE INCLUDED IN SENSING ERRORS.

WHEN PASSN HAS NONZERO VALUE AND ENGAGEMENT INVOLVES BASIC ADJUSTMENT METHOD, UPDATE Z ARRAY TO ACCOUNT FOR CUMULATIVE PASSENGER PERSONNEL CASUALTIES CAUSED BY ROUNDS FIRED BEFORE MISSING round OF CURRENT CONCERN.

PROCEED WITH NEXT round UNLESS MAXIMUM NUMBER OF rounds ALLOWED HAVE ALREADY BEEN ACCOUNTED FOR.

PROCEED WITH NEXT SAMPLE ENGAGEMENT UNLESS ALL ENGAGEMENTS NEEDED AT THIS STAGE OF CALCULATIONS HAVE BEEN COMPLETED.

SKIP PROGRAM LINES 895 THROUGH 900 IF ISAMP EQUALS NEND1 AND RUN DOES NOT INVOLVE RANGE INTERPOLATION OF VULNERABILITY DATA.

WHEN ISAMP EQUALS NEND1, RESET ISPLIT TO INDICATE FIRST PART OF ENGAGEMENT SIMULATIONS FOR IC VALUE OF INTEREST AND ASSOCIATED FORWARD OR REVERSE ANGLE HAS BEEN COMPLETED. AFTER BEING RESET, ISPLIT EQUALS 1 FOR FORWARD ANGLE OR 2 FOR REVERSE ANGLE. CONTINUE PROCESSING AT PROGRAM STATEMENT 9010. PROGRAM LINE 895 CAUSES NEXT TWO LINES TO BE SKIPPED WHEN ISAMP EXCEEDS NEND1.

PROCEED WITH NEXT ENGAGEMENT UNLESS ALL HSAMP ENGAGEMENTS HAVE BEEN COMPLETED. RESET ISPLIT TO 3 FOR FORWARD ANGLE OR 4 FOR REVERSE ANGLE TO INDICATE SECOND PART OF ENGAGEMENT SIMULATIONS FOR IC AND RELATED FORWARD OR REVERSE ANGLE HAS BEEN DONE. CONTINUE AT PROGRAM STATEMENT 9010 IF CALCULATIONS FOR REVERSE ANGLE ARE STILL INCOMPLETE.

IFAIL ARRAY CONTAINS CUMULATED VALUES CORRESPONDING TO AFAIL ARRAY. IFAIL(I2) IS NUMBER OF ENGAGEMENTS IN WHICH SECOND FAILURE TO SENSE THAT CAUSED END OF ENGAGEMENT OCCURRED ON ROUND LESS THAN OR EQUAL TO I2. WRITE IFAIL ARRAY QUANTITIES.

PROGRAM LINES 915 THROUGH 1132 INVOLVE SPECIAL CALCULATIONS ASSOCIATED WITH AT LEAST ONE OF NDTRM1, NDTRM2, NDTRM3, NDTRM4, AND NDTRM5 EQUALLING 1. THESE CALCULATIONS CANNOT BE ATTEMPTED IF RANGE INTERPOLATION OF TARGET VULNERABILITY DATA HAS BEEN INVOLVED.

THERE STATEMENTS ESSENTIALLY CONSTITUTE COMPUTER ROUTINE (ALTHOUGH STATEMENTS HAVE NOT BEEN STRUCTURED AS SEPARATE ROUTINE IN THIS PROGRAM) FOR PROCESsing HORIZONTAL OR VERTICAL OFFSET DISTANCES BASED ON IMPACT POINTS OF HITTING OR MISSING rounds IN TARGET PLANE. OBJECTIVE OF PROCESSING IS TO ESTIMATE MEAN AND OBTAIN THREE ESTIMATES OF STANDARD DEVIATION FOR NORMAL DISTRIBUTIONS TENTATIVELY ASSUMED TO FIT SUCH OFFSET DATA. AFTER COMPLETION OF COMPUTER RUN, ANALYST CAN STUDY THREE SETS OF PARAMETERS TO JUDGE HOW CLOSELY NORMAL DISTRIBUTION APPLIES AND TO MAKE BEST ESTIMATE FOR PARAMETERS OF INTEREST. PAPER EXPLAINING PROCESSING OF OFFSET DISTANCES WAS PRESENTED AT 1979 ARMY NUMERICAL ANALYSIS AND COMPUTERS CONFERENCE. THIS PAPER (WITH MINOR CHANGES) IS INCLUDED AS APPENDIX B OF THIS REPORT. N EQUALLING 1, 2, OR 3 IS RELATED TO HITTING OR MISSING FIRST rounds AS ALREADY EXPLAINED. PROVISION HAS ALSO BEEN MADE FOR N VALUES OF 4 AND 5 TO BE AVAILABLE FOR POSSIBLE FUTURE USE. CALCULATIONS INVOLVING ANY PARTICULAR N VALUE ARE DONE ONLY IF CONTROL QUANTITY KDMSTCU1) IS NOT 0.

PROGRAM LINES 1136 THROUGH 1295 INVOLVE DETERMINISTIC CALCULATIONS OF HIT
7000 CONTINUE
  IF ( ISPLIT .EQ. 4 ) GO TO 7400
  N = 0
  7005 IF ( N .EQ. 5 ) GO TO 7400
  N = N + 1
  IF ( KDHSTC(N) .EQ. 0 ) GO TO 7005
  DO 7010 I = 1, 2
  920 AVRG = 0.0
  TMINUS = 0.0
  TPLUS = 0.0
  K TIMES = 0
  DO 7020 J = 1, 50
  925 TERM1 = NMINUS(J, I, N)
  TERM2 = NPLUS(J, I, N)
  TMINUS = TMINUS + TERM1
  TPLUS = TPLUS + TERM2
  TOTAL(I) = TMINUS + TPLUS
  930 NTOTAL = TOTAL(I)
  T5000 = TOTAL(I) + 0.5
  N5000 = T5000
  IF ( T5000 .NE. TMINUS ) GO TO 7024
  DO 7022 K = 1, 50
  935 NPOS(K) = NPLUS(K, I, N)
  NNEG(K) = NMINUS(K, I, N)
  GO TO 7200
  7024 IF ( T5000 .LT. TMINUS ) GO TO 7025
  DO 7030 J = 1, 50
  940 PLUS = NPLUS(J, I, N)
  IF ( PLUS .LT. DIFF ) GO TO 7035
  IFRACTN = 1000.0 * DIFF / PLUS
  FRCTN = FLOAT(IFRACTN) / 1000.0
  AVRG = AVRG + FRCTN*20.0
  JEND = 100 - K TIMES
  LTIMES = 50 - K TIMES
  LEND = 1 + K TIMES
  DO 7040 K = 1, 50
  950 NNEG(K) = 0
  NPOS(K) = 0
  NCMLTN = 0
  NCMLTP = 0
  L = 0
  7050 IF ( L .EQ. 100 ) GO TO 7200
  L = L + 1
  LL = L
  IF ( LL .LE. 50 ) LL = 51 - L
  M = L
  IF ( M .GT. 50 ) M = L - 50
  IF ( LL .LE. JEND ) GO TO 7055
  NPOS(M) = 0
  GO TO 7060
  7055 IF ( LL .GT. JEND ) GO TO 7065
  NTERM = (IFRACTN*NPLUS(50, I, N)+500) / 1000
  NPOS(M) = NPLUS(50, I, N) - NTERM
  NCMLTP = NCMLTP + NPOS(M)
  GO TO 7060
  7065 IF ( LL .LE. LTIMES ) GO TO 7075
IF ( LL .LE. 50 ) GOTO 7070
NTERM1 = (IFRCTN*NPLUS(L-LTIMES,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(L-LTIMES+1,I,N)+500) / 1000
NPOS(H) = NPLUS(L-LTIMES,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NPOS(H)
GO TO 7060

7070 NTERM1 = (IFRCTN*NPLUS(LEND-M,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(LEND-M+1,I,N)+500) / 1000
NNEG(M) = NPLUS(LEND-M,I,N) - NTERM1 + NTERM2
NCMLTN = NCMLTN + NNEG(M)
GO TO 7060

7075 IF ( LL .LT. LTIMES ) GOTO 7085
NTERM1 = (IFRCTN*NMINUS(I,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(I+1,I,N)+500) / 1000
NNEG(H) = NMINUS(I,I,N) - NTERM1 + NTERM2
NCMLTN = NCMLTN + NNEG(H)
GO TO 7060

7085 IF ( LL .EQ. 1 ) GO TO 7095
NTERM1 = (IFRCTN*NMINUS(LTIMES-LL+1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(LTIMES-LL,I,N)+500) / 1000
NNEG(L-KTIMES+1) = NMINUS(LTIMES-LL+1,I,N) - NTERM1 + NTERM2
NCMLTN = NCMLTN + NNEG(L-KTIMES+1)
GO TO 7060

7095 NNEG(50) = (IFRCTN*NMINUS(49-KTIMES,I,N)+500) / 1000
MXTRA = KTIMES + 1
DO 7100 JXTRA = 1, MXTRA
    NNEG(50) = NNEG(50) + NMINUS(49-KTIMES+JXTRA,I,N)
NTERM = (IFRCTN*NMINUS(50,I,N)+500) / 1000
NNEG(50) = NNEG(50) + NTERM
NCMLTN = NCMLTN + NNEG(50)
1000 IF ( NCMLTN .EQ. NTOTAL ) L = 100
   IF ( L .GT. 50 ) GO TO 7050
   IF ( NCMLTN .LT. N5000 ) GO TO 7050
   NCMLTP = NCMLTN
   L = 50
GO TO 7050

7035 DIFF = DIFF - PLUS
   KTIMES = KTIMES + 1
   AVRG = AVRG + 20.0
7030 CONTINUE

7025 DIFF = TMINUS - T5000
   DO 7110 J = 1, 50
      AMINUS = NMINUS(J,I,N)
      IF ( AMINUS .LT. DIFF ) GOTO 7115
      IFRCTN = 1000.0 * DIFF / AMINUS
   1015 FRACT = FLOAT(IFRCTN) / 1000.0
      AVRG = AVRG - FRACT * 20.0
      JEND = 100 - KTIMES
      LTIMES = 50 - KTIMES
      LEND = 1 + KTIMES
      DO 7120 K = 1, 50
         NPOS(K) = 0
      7120 NNEG(K) = 0
      NCMLTP = 0
      NCMLTN = 0
      L = 0
7130 IF ( L .EQ. 100 ) GO TO 7200
L = L + 1
LL = L
IF ( L .LE. 50 ) LL = 51 - L
1030
M = L
IF ( L .GT. 50 ) M = L - 50
IF ( LL .LE. JEND ) GOTO 7135
NNNEG(M) = 0
GO TO 7140.

1035 IF ( LL .LT. JEND ) GOTO 7145
NTERM = (IFRCTN*NMINUS(50,I,N)+500) / 1000
NNNEG(M) = NMINUS(50,I,N) - NTERM
NCMLTN = NCMLTN + NNEG(M)
GO TO 7140.

1040 IF ( LL .LE. LTIMES ) GOTO 7155
IF ( LL .LE. 50 ) GOTO 7150
NTERM1 = (IFRCTN*NMINUS(L-LTIMES,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(L-LTIMES+1,I,N)+500) / 1000
NNNEG(M) = NMINUS(L-LTIMES,I,N) - NTERM1 + NTERM2
NCMLTN = NCMLTN + NNEG(M)
GO TO 7140.

1045 IF ( LL .LT. LTIMES ) GOTO 7145
NTERM1 = (IFRCTN*NMINUS(LEND-M,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(LEND-M+1,I,N)+500) / 1000
NP0S(M) = NMINUS(LENO-H,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NP0S(M)
GO TO 7140.

1050 IF ( LL .EQ. 1 ) GO TO 7175
NTERM1 = (IFRCTN*NPLUS(1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(L-LTIMES,I,N)+500) / 1000
NP0S(M) = NPLUS(I,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NP0S(M)
GO TO 7140.

1055 IF ( LL .LT. LTIMES ) GOTO 7165
NTERM1 = (IFRCTN*NMINUS(LENO-I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(LENO-I,N)+500) / 1000
NP0S(M) = NMINUS(L-LTIMES,1,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NP0S(M)
GO TO 7140.

1060 IF ( LL .EQ. 1 ) GO TO 7175
NTERM1 = (IFRCTN*NPLUS(LTIMES-LL+1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(LTIMES-LL+1,I,N)+500) / 1000
NP0S(L-KTIMES+1) = NPLUS(LTIMES-LL+1,I,N) - NTERM1 + NTERM2
NCMLTP = NCMLTP + NP0S(L-KTIMES+1)
GO TO 7140.

1065 IF ( LL .LE. 50 ) GOTO 7170
DIFF = DIFF - AHINUS
KTIMES = KTIMES + 1
AVRG = AVRG - 20.0
1070 CONTINUE
DO 7200 K = 1,50
1075 CONTINUE
DO 7310 K = 1,50
IF ( K .GT. 1 ) GO TO 7315
NSUM1 = NPDS(K)
NSUM2 = NNEG(K)
GO TO 7320
7315 NSUM1 = NSUM1 + NPDS(K)
NSUM2 = NSUM2 + NNEG(K)
7320 NCMPDS(K) = NSUM1
NCNEG(K) = NSUM2
NRFLCT(K) = NSUM1 + NSUM2
7310 CONTINUE
DO 7330 J = 1,50
SIGMAX = J * 20
IF ( J .GT. 1 ) GO TO 7335
SMFRQ1 = 0.0
SMFRQ2 = NRFLCT(J) * 10000 / NTOTAL
K5 = 5
K10 = 10
GO TO 7350
7335 SMFRQ1 = SMFRQ2
IF ( J .EQ. 50 ) GO TO 7345
SMFRQ2 = NRFLCT(J) * 10000 / NTOTAL
GO TO 7350
7345 SMFRQ2 = 10000.0
7350 FRQNCY = SMFRQ2 - SMFRQ1
IF ( K5 .NE. 5 ) GO TO 7355
IF ( SMFRQ2 .LT. 3829.2 ) GO TO 7330
D05 = (SMFRQ2-3829.2) / FRQNCY
SIG05 = (SIGMAX-D05*20.0) / 0.5
K5 = 0
7355 IF ( K10 .NE. 10 ) GO TO 7365
IF ( SMFRQ2 .LT. 6826.8 ) GO TO 7330
D10 = (SMFRQ2-6826.8) / FRQNCY
SIG10 = SIGMAX - D10*20.0
K10 = 0
7365 IF ( SMFRQ2 .LT. 8663.8 ) GO TO 7330
D15 = (SMFRQ2-8663.8) / FRQNCY
SIG15 = SIGMAX - D15*20.0 / 1.5
GO TO 7370
7330 CONTINUE
7370 WRITE ( 6,1020 )
WRITE ( 6,7380 ) N,I,SIG05,SIG10,SIG15
7380 FORMAT ( 10X,26H N*I*SIG05*SIG10*SIG15 ,21I0,3F10.4 )
1125 BIASXY(I,N) = AVRG
IF ( I .EQ. 1 ) SSQRRE = SIGXL**2 + SIGXR**2
IF ( I .EQ. 2 ) SSQRRE = SIGYL**2 + SIGYR**2
SIGMXY(1,I,N) = SQRT(SIG05**2+SSQRRE)
SIGMXY(2,I,N) = SQRT(SIG10**2+SSQRRE)
SIGMXY(3,I,N) = SQRT(SIG15**2+SSQRRE)
1130 CONTINUE
7010 CONTINUE
GO TO 7005
7400 CONTINUE
IF ( NSMDTR .EQ. 0 ) GO TO 8000
IF ( ISPLIT .EQ. 4 ) GO TO 8000
NCLLS1 = 99999
NCLLS2 = 99999
7405 CONTINUE
IF ( NSMDTR .EQ. 0 ) GO TO 7405
IF ( ISPLIT .EQ. 4 ) GO TO 7405
NCLLS1 = 0
DO 7410 N = 1, 5
BX(N) = BIASXY(1, N)
BY(N) = BIASXY(2, N)
DO 7410 K = 1, 3
PH(K*5) = 0.0
SIGX(K*5) = SIGMXY(K, 1, N)
SIGY(K*5) = SIGMXY(K, 2, N)
DO 7410 L = 1, 4
PKILL(L, K*5) = 0.0
7410 CONTINUE

7415 IF ( NHTKLL .EQ. 0 ) GO TO 7415
NCLLS2 = 0
DO 7420 N = 1, 5
PPH(N) = 0.0
7420 CONTINUE

7430 IF ( N .EQ. 5 ) PPH(N) = 1.0
DO 7440 L = 1, 4
PKSHOT(L, N) = 0.0
PPKHIT(L, N) = 0.0
CONTINUE

7435 IF ( NHTKLL .EQ. 0 ) GO TO 7445
N = -49
DO 7450 L = 1, 4
IF ( NBETA .EQ. NANGLE ) GO TO 7452
IST = SHIFT(MPK(K22, IA)*N) .AND. MASK11
ST = IST
PK(L) = 0.001 * ST
GO TO 7450
7452 IST1 = SHIFT(MPK(K22, IB)*N) .AND. MASK11
ST1 = IST1
PK(L+5) = 0.001 * ST1
7455 N = N + 11

7470 IF ( NSMDTR .EQ. 0 ) GO TO 7475
IF ( ISPLIT .EQ. 4 ) GO TO 7475
N = 0
7475 N = N + 1
IF ( KDMSTC(N) .EQ. 0 ) GO TO 7455
DO 7460 K = 1, 3
QDFZ1 = CNORM((X2-BX(N))/SIGX(K, N))
QDFZ2 = CNORM((X1-BX(N))/SIGX(K, N))
QDFZ3 = CNORM((Y2-BY(N))/SIGY(K, N))
QDFZ4 = CNORM((Y1-BY(N))/SIGY(K, N))
POFX = (QDFZ1-QDFZ2) * (QDFZ3-QDFZ4)
PH(K, N) = PH(K, N) + POFX
7475 CONTINUE

7490 IF ( NFRHIT .EQ. 1 ) GO TO 7490
DO 7470 L = 1, 4
PKCELL = PK(L)
7490 CONTINUE
PROBABILITIES AND KILL PROBABILITIES. LINES NEED TO BE SKIPPED WHEN NSMDTR AND NHTKLL CONTROLS ARE BOTH 0. CONDITION INVOLVING ISPLIT EQUALLING 4 CAUSES LINES TO BE SKIPPED ONLY FOR RANGES REQUIRING INTERPOLATION OF VULNERABILITY DATA IF NSMDTR IS NOT 0.

1136-1137 INITIAL SETTINGS.

1138-1139 PROGRAM LINES 1140 THROUGH 1150 CAN BE INVOLVED ONLY IF NSMDTR EXCEEDS 0 AND RANGE OF CONCERN DOES NOT REQUIRE INTERPOLATION OF VULNERABILITY DATA.

1140 NEW INITIAL SETTING OVERRIDING 99999.

1141-1150 INITIAL SETTINGS.

1151 PROGRAM LINES 1152 THROUGH 1159 CAN BE INVOLVED ONLY IF NHTKLL EXCEEDS 0.

1152 NEW INITIAL SETTING OVERRIDING 99999.

1153-1159 INITIAL SETTINGS.

1160-1227 CONSIDER IN TURN EACH HORIZONTAL STRIP OF CELLS IN SMALLEST RECTANGLE ENCLOSING TARGET.

1161-1164 DETERMINE Y COORDINATES Y1 AND Y2 CORRESPONDING TO LOWER AND UPPER EDGES RESPECTIVELY OF PARTICULAR STRIP. AY(J) REPRESENTS Y COORDINATE OF HORIZONTAL CENTERLINE OF STRIP. IGNORE STRIP IF ITS CENTERLINE IS BELOW BASE OF TARGET. IF NECESSARY, RESET Y1 TO MAKE IT CORRESPOND TO TARGET BASE.

1165-1226 CONSIDER IN TURN EACH CELL IN PARTICULAR HORIZONTAL STRIP.

1166-1167 K22 IS USED FOR TEMPORARY STORAGE OF IK(J,I) VALUE ASSOCIATED WITH PARTICULAR CELL. IGNORE CELL WHEN K22 EQUALLING 0 INDICATES CELL IS NOT PART OF TARGET.

1168-1169 DETERMINE X COORDINATES X1 AND X2 CORRESPONDING RESPECTIVELY TO LEFT AND RIGHT EDGES OF TARGET CELL.

1170 SKIP PROGRAM LINES 1171 THROUGH 1181 IF ONLY HIT PROBABILITIES ARE INVOLVED.

1171-1181 UNPACK MPK ARRAY QUANTITY THAT CORRESPONDS TO TARGET CELL HIT AND ASSOCIATED TARGET ORIENTATION TO RETRIEVE PROBABILITIES OF M KILL, F KILL, M OR F KILL, AND K KILL PER HIT. STORE THESE IN PK ARRAY. THESE PROGRAM LINES ARE ESSENTIALLY LIKE LINES 753 THROUGH 763. EXCEPT FOR EXPECTED CASUALTIES NOT BEING OF CONCERN HERE, EXPLANATIONS FOR LINES 753 THROUGH 772 APPLY.

1182-1183 SKIP PROGRAM LINES 1184 THROUGH 1203 IF NSMDTR IS 0 OR IF RANGE OF CONCERN INvolves INTERPOLATION OF VULNERABILITY DATA.

1184-1187 PROCESSING INDICATED BY PROGRAM LINES 1188 THROUGH 1203 IS DONE OR SKIPPED FOR N EQUALLING 1, 2, 3, 4, OR 5 ACCORDING TO WHETHER KDMSTC(N) EXCEEDS OR EQUALS 0.

1188-1201 K CORRESPONDS TO THREE ALTERNATIVE SETS OF STANDARD DEVIATIONS ESTIMATED FOR HORIZONTAL AND VERTICAL OFFSET DISTANCE DATA FROM SIMULATED ENGAGEMENTS.

1189-1194 QOFZ1 IS PROBABILITY THAT PARTICULAR PAIR OF BIAS AND STANDARD DEVIATION VALUES RESULTS IN X COORDINATE OF PROJECTILE IMPACT POINT NOT EXCEEDING X COORDINATE OF RIGHT EDGE OF CELL BEING CONSIDERED. QOFZ2 IS PROBABILITY X COORDINATE OF IMPACT POINT DOES NOT EXCEED THAT OF LEFT EDGE OF CELL. DIFFERENCE QOFZ1-QOFZ2 EQUALS PROBABILITY THAT IMPACT POINT LIES ON VERTICAL LINE THROUGH SOME CELL POINT. SIMILARLY, DIFFERENCE QOFZ3-QOFZ4 EQUALS PROBABILITY THAT IMPACT POINT LIES ON HORIZONTAL LINE THROUGH SOME CELL POINT.
IF ( NBETA .EQ. NANGLE ) PKCELL = PK(L*5)
PKILL(L*K,N) = PKILL(L,K,N) + PPDFXY*PKCELL
CONTINUE

NCLLS1 = NCLLS1 + 1
GO TO 7455

7475 IF ( NHTKLL .EQ. 0 ) GO TO 7440
DO 7480 N = 1,5
IF ( N .EQ. 5 ) GO TO 7485
IF ( SSIGX(N) .EQ. 0.0 ) OR SSIGY(N) .EQ. 0.0 ) GO TO 7480
QQDFZ1 = CNORM((X2-BBX(N))/SSIGX(N))
QQDFZ2 = CNORM((X1-BBX(N))/SSIGX(N))
QQDFZ3 = CNORM((Y2-BBY(N))/SSIGY(N))
QQDFZ4 = CNORM((Y1-BBY(N))/SSIGY(N))
PPDFXY = (QQDFZ1-QQDFZ2) * (QQDFZ3-QQDFZ4)
PPH(N) = PPH(N) + PPDFXY
GO TO 7490

CONTINUE

7485 IF ( NHTKLL .EQ. 0) AND NRANGE .GT. 1) GO TO 7480
PPDFXY = 1.0
PPH(5) = PPH(5) + PPDFXY
NCLLS2 = NCLLS2 + 1
IF ( NPRHIT .EQ. 1) GO TO 7480
DO 7510 L = 1,4
PPCELL = PK(L)
IF ( NBETA .EQ. NANGLE ) PPCELL = PK(L+5)
PKSHOT(L,N) = PKSHOT(L,N) + PPDFXY*PPCELL
CONTINUE

7510 CONTINUE

7525 CONTINUE
7540 CONTINUE
7530 CONTINUE

IF ( NHTKLL .EQ. 0) GO TO 7600
IF ( NPRHIT .EQ. 1) GO TO 7600
DO 7530 L = 1,4
DO 7540 N = 1,5
IF ( PPH(N) .GT. 0.000001 ) PPKHIT(L,N) = PKSHOT(L,N) / PPH(N)
CONTINUE

7540 CONTINUE
7530 CONTINUE

1235 7600 CONTINUE
IF ( NSHTR .EQ. 0) GOTO 7700
IF ( ISPLIT .EQ. 4) GOTO 7700
WRITE ( 6,1020 )
WRITE ( 6,1020 ) ( BX(I),I=1,5 )
WRITE ( 10X,11H BX(5) ,10X,5F10.4 )
WRITE ( 6,1020 ) ( BY(I),I=1,5 )
WRITE ( 10X,11H BX(5) ,10X,5F10.4 )
7620 FORMAT ( 10X,11H BY(5) ,10X,5F10.4 )
DO 7630 I = 1,3
WRITE ( 6,1020 )
WRITE ( 6,1020 ) ( SIGX(I,J),J=1,5 )
WRITE ( 10X,11H SIGX(3,5) ,10X,5F10.4 )
WRITE ( 6,1020 ) ( SIGY(I,J),J=1,5 )
WRITE ( 10X,11H SIGY(3,5) ,10X,5F10.4 )
WRITE ( 6,1020 ) ( PH(I,J),J=1,5 )
WRITE ( 10X,11H PH(3,5) ,5F10.4 )
7660 FORMAT ( 10X,21H PH(3,5) ,5F10.4 )
7630 CONTINUE

IF ( NPRHIT .EQ. 1) GOTO 7700
DO 7670 J = 1,3
WRITE ( 6,1020 )
EXPLANATIONS (CONTINUED)

POINT. PRODUCT POFXY OF TWO DIFFERENCES IS PROBABILITY OF Hitting CELL. EACH
PK(K,N) VALUE IS CUMULATIVE HIT PROBABILITY FOR ALL CELLS ALREADY PROCESSED
AND EVENTUALLY APPLIES TO ENTIRE TARGET.

1195 SKIP PROGRAM LINES 1196 THROUGH 1200 IF ONLY HIT PROBABILITIES ARE INVOLVED.

1196-1200 L CORRESPONDS TO FOUR KILL CRITERIA CONSIDERED IN TURN. PKCELL IS USED FOR
TEMPORARY STORAGE OF PK(L) OR PK(L+5). THESE TWO VALUES APPLY TO FORWARD OR
REVERSE ANGLE RESPECTIVELY. PRODUCT OF POFXY AND PKCELL IS PROBABILITY OF
HITTING PARTICULAR CELL AND THEREBY KILLING TARGET. EACH PKILL(L,K,N) VALUE
IS CUMULATIVE PROBABILITY ACCOUNTING FOR ALL CELLS ALREADY PROCESSED AND
EVENTUALLY EQUALS PROBABILITY OF HIT AND KILL FOR ENTIRE TARGET.

1202 NCLLS1 IS UPDATED AND EVENTUALLY EQUALS PRODUCT OF 1) TOTAL NUMBER OF TARGET
CELLS AND 2) NUMBER OF NONZERO QUANTITIES IN SET KDMSTC(1), KDMSTC(2),
KDMSTC(3), AND KDMSTC(4).

1203 PROCESSING HAS BEEN COMPLETED FOR PARTICULAR VALUE OF N AND MAY NEED TO BE
REPEATED FOR SOME OTHER VALUE.

1204 PROGRAM LINES 1205 THROUGH 1225 CAN BE INVOLVED ONLY IF NHTKLL EXCEEDS 0.

1205-1225 N EQUALS 1 FOR FIRST ROUNDS, 2 FOR ROUNDS IMMEDIATELY FOLLOWING ROUND THAT
HITS TARGET; 3 FOR ROUNDS IMMEDIATELY FOLLOWING SENSED MISS; 4 FOR ROUNDS
IMMEDIATELY AFTER MISS THAT IS NOT SENSED, AND 5 FOR HITTING ROUNDS WHOSE
IMPACT POINTS ARE CONSIDERED SPREAD UNIFORMLY AT RANDOM OVER VERTICAL TARGET
AREA. CALCULATE HIT PROBABILITIES AND PROBABILITIES OF HITTING AND KILLING
TARGET FOR N EQUALLING 1 THROUGH 4 AND KILL PROBABILITY OF RANDOM HIT FOR N
EQUALLING 5.

1206-1207 CALCULATIONS CORRESPONDING TO PROGRAM LINES 1208 THROUGH 1214 ARE NOT
APPLICABLE FOR N EQUALLING 5. FOR N EQUAL TO 1 THROUGH 4, PROCESSING
INDICATED BY LINES 1208 THROUGH 1224 IS DONE WHEN NONZERO STANDARD DEVIATION
INPUTS HAVE BEEN PREVIOUSLY ESTABLISHED OR IS OTHERWISE SKIPPED.

1208-1214 SIMILAR TO PROGRAM LINES 1189 THROUGH 1194. EACH PPH(N) VALUE IS CUMULATIVE
HIT PROBABILITY FOR ALL CELLS ALREADY PROCESSED AND EVENTUALLY APPLIES TO
ENTIRE TARGET. CONTINUE AT PROGRAM STATEMENT 2490.

1215 FOR NRDTYP EQUALLING 0, SKIP PROGRAM LINES 1216 THROUGH 1224 WHEN ASSOCIATED
CALCULATIONS HAVE ALREADY BEEN DONE FOR FIRST RANGE. PROCESSING INVOLVED IS
REPEATED FOR ALL OTHER RANGES WHEN TARGET VULNERABILITY DATA CAN VARY WITH
RANGE.

1216-1217 FOR N EQUALLING 5, PROBABILITY OF HITTING EACH CELL IS NOT INVOLVED IN SAME
WAY AS FOR OTHER N VALUES AND IS SET TO 1. THIS SPECIAL SETTING CAUSES
PPH(5) TO BECOME CELL COUNTER.

1218 NCLLS2 IS UPDATED AND EVENTUALLY EQUALS PRODUCT OF 1) TOTAL NUMBER OF TARGET
CELLS AND 2) NUMBER OF SETS OF NONZERO HORIZONTAL AND VERTICAL STANDARD
DEVIATIONS USED FOR HIT PROBABILITY CALCULATIONS PLUS 1 IF SETTING OF PPOFXY
TO 1.0 AND PROGRAM LINES 1220 THROUGH 1224 ARE NOT SKIPPED FOR N EQUAL TO 5.

1219 SKIP PROGRAM LINES 1220 THROUGH 1224 IF ONLY HIT PROBABILITIES ARE INVOLVED.

1220-1224 SIMILAR TO PROGRAM LINES 1196 THROUGH 1200. FOR N EQUALLING 1 THROUGH 4, EACH
PKSHOT(L,N) VALUE IS CUMULATIVE PROBABILITY ACCOUNTING FOR ALL CELLS ALREADY
PROCESSED AND EVENTUALLY EQUALS PROBABILITY OF HIT AND KILL FOR ENTIRE
TARGET. PKSHOT(L,5) VALUES ARE SIMILAR BUT DO NOT REPRESENT PROBABILITIES.

1228 PROGRAM LINES 1230 THROUGH 1234 CAN BE INVOLVED ONLY IF NHTKLL EXCEEDS 0.
EXPLANATIONS (CONTINUED)

1229  SKIP PROGRAM LINES 1230 THROUGH 1234 IF ONLY HIT PROBABILITIES ARE INVOLVED.

1230-1234  DIVIDE PKSHOT(L,N) VALUES BY PPH(N) TO OBTAIN KILL PROBABILITIES PER HIT ON TARGET. FOR N EQUALLING 5, DIVISOR IS TOTAL NUMBER OF TARGET CELLS BECAUSE UNITY CHANCE OF HIT HAS BEEN PREVIOUSLY USED FOR EACH CELL.

1236-1237  PROGRAM LINES 1238 THROUGH 1258 CAN BE INVOLVED ONLY IF NSMDTR EXCEEDS 0 AND RANGE OF CONCERN DOES NOT REQUIRE INTERPOLATION OF VULNERABILITY DATA.

1238-1258  WRITE OUTPUT.

1260  PROGRAM LINES 1261 THROUGH 1292 CAN BE INVOLVED ONLY IF NHTKLL EXCEEDS 0.

1261-1292  WRITE OUTPUT.

1261-1263  SPECIAL TITLING INVOLVING IC AND MSET APPLIES ONLY FOR MOVING TARGET OR MOVING FIRING WEAPON RUN.

1275-1278  FOR MOVING TARGET OR MOVING FIRING WEAPON RUN, WRITE FIRST ROUND HIT PROBABILITY ONLY AFTER ADJUSTING TO ACCOUNT FOR RELIABILITY FACTOR RELT.

1280  SKIP PROGRAM LINES 1281 THROUGH 1292 IF ONLY HIT PROBABILITIES ARE INVOLVED.

1285-1288  FOR MOVING TARGET OR MOVING FIRING WEAPON RUN, WRITE KILL PROBABILITIES PER SHOT ONLY AFTER ADJUSTING TO ACCOUNT FOR RELIABILITY FACTORS RELT AND RELF.

1294-1295  WRITE NCLLS1 AND NCLLS2 FOR POSSIBLE USE IN CHECKING OUTPUT. EITHER QUANTITY STILL EQUALLING 99999 INDICATES ASSOCIATED CALCULATIONS WERE SKIPPED.

1297-1358  IF SIMULATED ENGAGEMENTS ARE INVOLVED IN RUN AND HAVE BEEN COMPLETED FOR BOTH TARGET ORIENTATION ANGLES OF CONCERN, PROCESS DATA IN Z AND AKIL ARRAYS AND PRINT OUTPUT.

1299-1315  CALCULATE AVERAGE VALUES PER SAMPLE ENGAGEMENT FOR EACH QUANTITY IN Z ARRAY. AVERAGE Z(I2,I) VALUES PER ENGAGEMENT FOR I EQUALLING 1 THROUGH 10 CAN BE INTERPRETED AS CORRESPONDING PROBABILITIES OF HITTING OR KILLING TARGET. PERSONNEL CASUALTIES ASSOCIATED WITH I EQUALLING 11 AND 12 REPRESENT AVERAGE EXPECTED CASUALTIES APPLICABLE TO TARGET VEHICLE PASSENGERS.

1317-1344  IF RUN INVOLVES SUBSEQUENT ROUNDS AS WELL AS FIRST ROUNDS AND BASIC FIRE ADJUSTMENT PROCEDURE FOR MISSING ROUNDS, CALCULATE AND PRINT AVERAGE NUMBERS OF ROUNDS NEEDED TO HIT TARGET AND TO ACHIEVE TARGET KILL ACCORDING TO VARIOUS CRITERIA CONSIDERED.

1322-1344  ACHIEVEMENT OF FIRST HIT AND KILLING OF TARGET ACCORDING TO VARIOUS CRITERIA ARE CONSIDERED FOR RELATED FORWARD AND REVERSE ORIENTATION ANGLES.

1323-1325  CONSIDER ONLY FIRST HIT ON TARGET WHEN NPRHIT EQUALS 1.

1327-1328  INITIAL SETTINGS.

1329-1340  AVERAGE (OR EXPECTED) NUMBER OF ROUNDS NEEDED FOR TARGET HIT OR TARGET KILL CAN BE OBTAINED BY ADDING ALL PRODUCTS OF 1) SPECIFIC NUMBER OF ROUNDS AND 2) CORRESPONDING FRACTION OF ALL ENGAGEMENTS FOR WHICH EXACTLY THAT NUMBER OF ROUNDS ARE REQUIRED TO HIT OR KILL TARGET. ONLY FIRST NPRS ROUNDS ARE PROCESSED EXPLICITLY IN THIS FASHION. APPROXIMATE EXTRAPOLATION FORMULA IS APPLIED AS NECESSARY TO ACCOUNT FOR ALL OTHER ROUNDS.

1329-1332  FOR I EQUAL TO 2, SMIK = SMIK + 2(Z(2,K)-Z(1,K)). TERM SMIK APPEARING TO RIGHT OF EQUAL SIGN IN THIS EQUATION IS EQUIVALENT TO 1(Z(1,K)). SINCE Z(2,K) IS
1255  DO 7670  I = 1,4
      WRITE ( 6,7680 ) ( PKILL(I,J,K), K=1,5 )
7680  FORMAT ( 10X,21H PKILL(4,3,5) )
5F10.4 )
7670  CONTINUE
7700  CONTINUE
1260  IF ( NHTKLL .EQ. 0 ) GO TO 7800
      IF ( ISTMOV .NE. 1 ) GO TO 7705
      WRITE ( 6,7702 ) IC, MSET
7702  FORMAT ( /*, 20X, 6H IC = , I3, 10X, 8H MSET = , I3 )
1265  WRITE ( 6,1020 )
      WRITE ( 6,7710 ) ( BBX(I), I=1,4 )
7710  FORMAT ( 10X, 11H BBX(4) )
7610  WRITE ( 6,7720 ) ( BBY(I), I=1,4 )
7720  FORMAT ( 10X, 11H BBY(4) )
7620  WRITE ( 6,7730 ) ( SSIGX(I), I=1,4 )
7730  FORMAT ( 10X, 11H SSIGX(4) )
7630  WRITE ( 6,7740 ) ( SSIGY(I), I=1,4 )
7740  FORMAT ( 10X, 11H SSIGY(4) )
7640  WRITE ( 6,7750 ) ( PPH(I), I=1,5 )
7750  FORMAT ( 10X, 21H PPH(5) )
5F10.4 )
1275  IF ( ISTMOV .NE. 1 ) GO TO 7755
      PPH(1) = PPH(1) * RELT
5F10.4 )
      WRITE ( 6,7753 ) ( PPH(I), I=1,5 )
7753  FORMAT ( 10X, 21H PPH(5) )
20X, 5F10.4 )
7755  CONTINUE
1280  IF ( NPRHIT .EQ. 1 ) GO TO 7800
      DO 7760  I = 1,4
5F10.4 )
      PKSHOT(I,5) = 0.0
7760  FORMAT ( 10X, 21H PKSHOT(4,5) )
5F10.4 )
1285  IF ( ISTMOV .NE. 1 ) GO TO 7775
5F10.4 )
      PKSHOT(I,1) = PKSHOT(I,1) * RELT * RELF
5F10.4 )
      WRITE ( 6,7773 ) ( PKSHOT(I,J), J=1,5 )
7773  FORMAT ( 10X, 21H PKSHOT(4,5) )
20X, 5F10.4 )
1290  CONTINUE
7775  WRITE ( 6,7780 ) ( PPKHIT(I,J), J=1,5 )
7780  FORMAT ( 10X, 21H PPKHIT(4,5) )
5F10.4 )
7760  CONTINUE
7800  WRITE ( 6,1020 )
      WRITE ( 6,7810 ) NCLLS1, NCLLS2
7810  FORMAT ( 10X, 18H NCLLS1, NCLLS2 = , 2I10 )
7800  CONTINUE
1295  IF ( NHTKLL .EQ. 9 ) GO TO 9000
      IF ( NBETA .LT. NANGLE ) GO TO 9000
5F10.4 )
      WRITE ( 6,8110 )
8110  FORMAT ( /*, 11X, 28H NRDS, PROB. (EXP. CAS.) ) /
5F10.4 )
      DO 8120  I = 1,12
1200  IF ( I .EQ. 10 .AND. PASSN .EQ. 0.0 ) GO TO 8125
8120  FORMAT ( I2, I )
Z(I2,I) = Z(I2,I) / SAMP
8125  CONTINUE
8120  IF ( N .EQ. 3 .AND. PASSN .EQ. 0.0 ) GO TO 8200
8125  CONTINUE
      WRITE ( 6,1020 )
8200  CONTINUE
1300  IL = 5*N - 4
      IF ( N .EQ. 3 ) IR = 12
DO 8130 I2 = 1,NRDS
WRITE ( 6,8140 ) I2,(Z(I2,I),I=IL,IR)
8140 FORMAT ( 11X,I4,9F13.7 )
8130 CONTINUE
8200 CONTINUE
IF ( NRD1 .EQ. 1 ) GO TO 9000
IF ( NAJST .GT. 0 ) GO TO 8400
WRITE ( 6,8310 )
8310 FORMAT ( / /, 31X,17H AVG. NO. OF RDS. / )
WRITE ( 6,1020 )
DO 8320 K = 1,10
8320 CONTINUE
IF ( NPHIT .EQ. 0 ) GO TO 8325
IF ( K .EQ. 5 .OR. K .EQ. 10 ) GO TO 8325
GO TO 8320
8325 CONTINUE
SMIK = Z(I,K)
AUL = 2.0
DO 8330 I = 2,NRDS
8330 SMIK = SMIK + AUL*(Z(I,K)-Z(I-1,K))
AUL = AUL + 1.0
IF ( Z(NRDS,K) .LE. 0.9999 ) GO TO 8335
AV = SMIK
GO TO 8340
8335 AR = 5.0 - (Z(NRDS-5,K)+Z(NRDS-4,K)+Z(NRDS-3,K)+Z(NRDS-2,K)
AV = SMIK
GO TO 8340
8340 IF ( AV .GT. 999.0 ) AV = 999.0
WRITE ( 6,8350 ) K,AV
8350 FORMAT ( 20X,I5,10X,F7.2 )
8320 CONTINUE
8400 CONTINUE
WRITE ( 6,8402 )
8402 FORMAT ( / /, 22X,24H PROBABILITY VERSUS TIME, / )
DO 8410 J = 1,10
8410 IF ( NPHIT .EQ. 0 ) GO TO 8415
IF ( J .EQ. 5 .OR. J .EQ. 10 ) GO TO 8415
GO TO 8410
8415 WRITE ( 6,1020 )
DO 8420 K = 1,61
8420 AKIL(K,J) = AKIL(K,J) / SAMP
WRITE ( 6,8430 ) ( AKIL(K,J),K=1,61 )
8430 FORMAT ( 11X,10F8.5 )
8410 CONTINUE
WRITE ( 6,1010 )
9000 CONTINUE
IF ( ISTMOV .EQ. 1 ) GO TO 9305
9010 IF ( ISPLIT .EQ. 4 ) ISPLIT = 0
IF ( ISPLIT .NE. 2 ) GO TO 9100
NANGLE = NANGLE - 1
IF ( NRANGE .EQ. 1 ) NEJECT = 1
GO TO 3000
9100 CONTINUE
IF ( NSTCRD .GT. 0 ) GO TO 9302
NANGLE = NANGLE + 1
FRACTION OF ALL ENGAGEMENTS IN WHICH TARGET WAS HIT OR KILLED BY FIRST OR SECOND ROUND, DIFFERENCE $Z(2, K) - Z(1, K)$ REPRESENTS FRACTION OF ALL ENGAGEMENTS IN WHICH ACHIEVING HIT OR KILL REQUIRED EXACTLY TWO ROUNDS. FOR $I$ EQUAL TO 3, SHIK EQUALS ITS PREVIOUS VALUE PLUS TERM $3(Z(3, K) - Z(2, K))$. EVENTUALLY SHIK ACCOUNTS FOR ALL OF FIRST NRDS ROUNDS. FURTHER CALCULATING IS UNNEEDED IF $Z(NRDS, K)$ IS EQUAL TO 1 OR VERY NEARLY SO, INDICATING THAT NRDS OR FEWER ROUNDS SUFFICED IN ALL OR PRACTICALLY ALL SAMPLE ENGAGEMENTS. IN THAT CASE AVERAGE NUMBER OF ROUNDS AV EQUALS SMIK.

1333-1340 APPLY APPROXIMATE AND RATHER INTRICATE EXTRAPOLATION FORMULA TO ACCOUNT FOR ENGAGEMENTS WHERE NRDS OR FEWER ROUNDS DID NOT SUFFICE TO HIT OR KILL TARGET. FORMULA IS BASED ON CONDITIONAL PROBABILITIES OF HIT OR CONDITIONAL PROBABILITIES OF KILL. SUCH CONDITIONAL PROBABILITIES HAVE NOT BEEN INVOLVED SO FAR IN PROGRAM CALCULATIONS BUT ARE INFERRABLE FROM PROBABILITIES IN Z ARRAY. IF NRDS IS NOT TOO SMALL, CONDITIONAL PROBABILITIES FOR EACH ROUND FOLLOWING FIRST NRDS ROUNDS CAN BE CONSIDERED APPROXIMATELY EQUAL TO AVERAGE OF FIVE CONDITIONAL PROBABILITIES APPLYING TO LAST FIVE OF FIRST NRDS ROUNDS. LOWER BOUND OF 10 FOR NRDS HAS BEEN CHOSEN AS ACCEPTABLE IN THIS CONTEXT. AZ REPRESENTS AVERAGE NUMBER OF ROUNDS NEEDED IN ADDITION TO FIRST NRDS ROUNDS WHEN NRDS ROUNDS ARE INSUFFICIENT. CORRESPONDING FRACTION OF ENGAGEMENTS IS INDICATED BY DIFFERENCE 1.0 - $Z(NRDS, K)$. AVERAGE NUMBER OF ROUNDS AV IS OBTAINED BY ADDING SMIK VALUE ASSOCIATED WITH ENGAGEMENTS WHERE NRDS ROUNDS SUFFICE AND PRODUCT ACCOUNTING FOR ALL OTHER ENGAGEMENTS.

1341 PRIMARILY TO AVOID HAVING TO PRINT VERY LARGE NUMBERS, REPLACE ANY NUMBER LARGER THAN 999 BY THIS LIMIT. THERE IS OF COURSE NO PRACTICAL INTEREST IN MANY AVERAGE NUMBERS OF ROUNDS THAT ARE MUCH SMALLER THAN 999 BUT STILL TOO LARGE TO CORRESPOND TO REALISTIC COMBAT ENGAGEMENT SITUATIONS.

1346-1357 CALCULATE AVERAGE VALUES PER SAMPLE ENGAGEMENT FOR EACH QUANTITY IN AKIL ARRAY. CONSIDER ONLY FIRST HIT ON TARGET WHEN NPRHIT EQUALS 1. RESULTING AVERAGE AKIL(K*J) VALUES CAN BE INTERPRETED AS CORRESPONDING PROBABILITIES OF HITTING OR KILLING TARGET BEFORE 2(K-1) SECONDS.

1360 SKIP PROGRAM LINES 1361 THROUGH 1369 FOR MOVING TARGET OR MOVING FIRING WEAPON RUN.

1361 SINCE CALCULATIONS INVOLVING RANGE INTERPOLATION OF TARGET VULNERABILITY DATA HAVE BEEN COMPLETED, RESET ISPLIT TO INITIAL SETTING.

1362-1365 PROGRAM LINES 1363 THROUGH 1365 APPLY ONLY IF ISPLIT IS 2. CALCULATIONS FOR FIRST PART OF SIMULATIONS HAVE JUST BEEN COMPLETED FOR REVERSE ANGLE OF CONCERN AND NANGLE NEEDS TO BE RESET BEFORE SECOND PART OF SIMULATIONS FOR CORRESPONDING FORWARD ANGLE. MEJECT IS ASSOCIATED WITH LINE SKIPPING OCCASIONALLY NEEDED WHEN TARGET VULNERABILITY DATA ARE READ FROM TAPE OR DISC. CONTINUE AT PROGRAM STATEMENT 3000.

1367 SKIP PROGRAM LINES 1368 THROUGH 1370 IF RUN INVOLVES TARGET SHAPE DATA FROM CARDS.

1368-1370 CONTINUE EITHER AT PROGRAM STATEMENT 4020 FOR NEXT VALUE OF NANGLE IF ANY OR AT STATEMENT 9310.

1371-1374 IF RUN INVOLVES TARGET SHAPE DATA FROM CARDS, CONTINUE AT PROGRAM STATEMENT 4210 FOR NEXT HTRGLC VALUE OF CONCERN OR AT STATEMENT 9310.

1375-1379 APPLICABLE FOR MOVING TARGET OR MOVING FIRING WEAPON RUN ONLY. MSET EQUALS 1 THROUGH 6 FOR VARIOUS TARGET SPEED AND EVASIVE MANEUVERING CONDITIONS. NANGLE VALUES FOR MOVING TARGET OR MOVING FIRING WEAPON RUN ARE RESTRICTED TO 1 FOR 0 DEGREES, 3 FOR 30 DEGREES, AND 5 FOR 60 DEGREES. CONTINUE AT PROGRAM STATEMENT 4035 IF ALL SIX MSET VALUES HAVE BEEN CONSIDERED.
PROGRAM LISTING (CONTINUED)

1370 IF ( NANGLE .LE. 8 ) GO TO 4020
    GO TO 9310
9302 NTRGTC = NTRGTC + 1
    IF ( NTRGTC .GT. 4 ) GO TO 9310
    IF ( KTRGTCC .LT. KTRGT ) GO TO 4210
    GO TO 9310
1375 NTRGTC = NTRGTC + 1
    IF ( MSET .LE. 6 ) GO TO 4035
    MSET = 1
    NANGLE = NANGLE + 2
    IF ( NANGLE .LE. 5 ) GO TO 4020
1380 NRANGE = NRANGE + 1
    IF ( NRANGE .LE. NRANGE ) GO TO 2010
9900 CONTINUE
CALL EXIT
END

1 SUBROUTINE NRAN(R1,R2)
    A = SQRT(-2.0*ALOG(RANF(X)))
    B = 6.28318530718 * RANF(X)
    R1 = A * SIN(B)
    R2 = A * COS(B)
    RETURN
END

1 FUNCTION CNORM(X)
    F = 0.0
    AX = ABS(X)
    IF ( AX .GE. 5.0 ) GO TO 10
    F = (((((0.5383E-5*AX+0.488906E-4)*AX+0.380036E-4)*AX*0.0032776263
          *AX+0.0211410061)*AX+0.0498673469)*AX+1.0
          *F) + .5 / ((F**8)**2)
10 IF ( X .GE. 0.0 ) F = 1.0 - F
    CNORM = F
    RETURN
END

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OTHERWISE RESET MSET TO INITIAL SETTING BEFORE CONTINUING AT STATEMENT 4020 OR 9310 ACCORDING TO WHETHER CALCULATIONS HAVE OR HAVE NOT YET BEEN DONE FOR ALL THREE NANGLE VALUES OF CONCERN.

1380-1382 CONTINUE AT PROGRAM STATEMENT 2010 UNLESS CALCULATIONS FOR LAST RANGE HAVE JUST BEEN COMPLETED. NEJECT MAY NEED TO BE RESET WHEN TARGET VULNERABILITY DATA FROM TAPE OR DISC ARE INVOLVED.

1383-1385 RUN STOPS, POSSIBLY PREMATURELY IF PROBLEM HAS OCCURRED.

SUBROUTINE MRAN(R1,R2) PRODUCES PAIR OF RANDOM NORMAL DEVIATES R1 AND R2 FROM NORMAL DISTRIBUTION WITH MEAN OF 0 AND STANDARD DEVIATION OF 1.

WHEN X EQUALS (X2-BX(N))/SIGX(K,N), FOR EXAMPLE, FUNCTION CNORM(X) CALCULATES PROBABILITY OF RANDOM VARIABLE LYING BETWEEN MINUS INFINITY AND X2 FOR NORMAL DISTRIBUTION WITH BIAS OF BX(N) AND STANDARD DEVIATION OF SIGX(K,N).
APPENDIX B

EXPLANATIONS OF PROGRAM STATEMENTS 919 THROUGH 1131
This appendix contains a paper presented, in early 1979, at the Army Numerical Analysis and Computers Conference. This paper, entitled "A FORTRAN ROUTINE FOR ESTIMATING NORMAL DISTRIBUTION PARAMETERS", provides detailed explanations of program lines 919 through 1131 of the direct fire program.

The paper was subdivided into three parts, namely, the introduction, the description of the basic mathematical procedure, and the conclusion. The contents of these three parts follow.

1. INTRODUCTION. A Monte Carlo computer program simulating the engagement of a single target by a tank main armament system has been developed by the Joint Munitions Effectiveness Manual (JMEM) Methodology and Evaluations Working Group, a tri-service group responsible for establishing certain standardized estimates of weapon effectiveness. The program is often referred to as the JMEM Direct Fire program. Exercise of this program yields large amounts of data concerning the location of round impacts in the target plane. First rounds fired against a particular target are of chief concern, and these can be subdivided into rounds that hit and rounds that miss the target. Chart 1 illustrates a possible target and a few conceivable first round impact points.

   This paper describes a computer routine for processing the horizontal coordinates or the vertical coordinates of hitting rounds or of missing rounds. The routine provides, for each set of data considered, an estimate of the mean and three estimates of the standard deviation for a normal distribution tentatively assumed to fit the data. After the computer run, an analyst can judge by comparing the three standard deviation values whether the tentative assumption of normality is sufficiently substantiated and, if so, make a best estimate for the parameters of interest. The word "routine" is used for the logical processing documented in this paper. However, the associated program statements have not actually been structured as a separate routine, but are a portion of the complete engagement simulation program previously mentioned. A separate routine could readily be developed for other applications.

2. DESCRIPTION OF ROUTINE. The program instructions of interest are listed in Chart 2. Note that the entire chart consists of the loop DO 7010 I = 1,2. The index I equals 1 for horizontal coordinates and 2 for vertical coordinates. For any other application, one could allow for more values of I or establish a single dummy setting for this index.
CHART 1  IMPACT POINTS FOR HITTING AND MISSING FIRST ROUNDS
DO 7010 I = 1,2  
AVRG = 0.0  
TMINUS = 0.0  
TPLUS = 0.0  
KTIMES = 0  
DO 7020 J = 1,50  
TERM1 = NMINUS(J,I,N)  
TERM2 = NPLUS(J,I,N)  
TMINUS = TMINUS + TERM1  
TPLUS = TPLUS + TERM2  
TOTAL(I) = TMINUS + TPLUS  
N5000 = TOTAL(I) * 0.5  
N5000 = T5000  
IF ( T5000 .NE. TMINUS ) GO TO 7024  
DO 7022 K = 1,50  
NPOS(K) = NPLUS(K,I,N)  
NNEG(K) = NMINUS(K,I,N)  
GO TO 7200  
7024 IF ( T5000 .LT. TMINUS ) GO TO 7025  
DIFF = T5000 - TMINUS  
DO 7030 J = 1,50  
PLUS = NPLUS(J,I,N)  
IF ( PLUS .LT. DIFF ) GO TO 7035  
IFRCTN = 1000.0 * DIFF / PLUS  
IFRCTN = FLOAT(IFRCTN) / 1000.0  
AVRG = AVRG + IFRCTN*20.0  
JEND = 100 - KTIMES  
LTIMES = 50 - KTIMES  
LEND = 1 + KTIMES  
DO 7040 K = 1,50  
NNEG(K) = 0  
NPOS(K) = 0  
NCMLTN = 0  
NCMLTP = 0  
L = 0  
7040 IF ( L .LE. 100 ) GO TO 7200  
L = L + 1  
LL = L  
IF ( L .LE. 50 ) LL = 51 - L  
M = L  
IF ( L .GT. 50 ) M = L - 50  
IF ( LL .LE. JEND ) GOTO 7055  
NPoS(M) = 0  
GO TO 7060  
7055 IF ( LL .LT. JEND ) GOTO 7065  
NTERM = (IFRCTN*NPLUS(50,I,N)+500) / 1000  
NPoS(M) = NPLUS(50,I,N) - NTERM  
NCMLTP = NCMLTP + NPoS(M)  
GO TO 7060  
7065 IF ( LL .LE. LTIMES ) GOTO 7075  
IF ( LL .LE. 50 ) GOTO 7070
CHART 2  PROGRAM STATEMENTS (CONTINUED)

NTERM1 = (IFRCTN*NPLUS(L-LTIMES,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(L-LTIMES+1,I,N)+500) / 1000
NPDS(M) = NPLUS(L-LTIMES,I,N) - NTERM1 + NTERM2
NCMLTP = MCMLTP + NPDS(M)
GO TO 7060

7070 NTERM1 = (IFRCTN*NPLUS(LEND-M,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(LEND-M+1,I,N)+500) / 1000
NPDS(M) = NPLUS(LEND-M,I,N) - NTERM1 + NTERM2
NCMLTN = MCMLTN + NPDS(M)
GO TO 7060

7075 IF ( LL .LT. LTIMES ) GO TO 7085
NTERM1 = (IFRCTN*NMINUS(1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NPLUS(1,I,N)+500) / 1000
NPDS(M) = NMINUS(1,I,N) - NTERM1 + NTERM2
NCMLTN = MCMLTN + NPDS(M)
GO TO 7060

7085 IF ( LL .EQ. 1 ) GO TO 7095
NTERM1 = (IFRCTN*NMINUS(LTIMES-LL+1,I,N)+500) / 1000
NTERM2 = (IFRCTN*NMINUS(LTIMES-LL,I,N)+500) / 1000
NPDS(L-KTIMES+1) = NMINUS(LTIMES-LL+1,I,N) - NTERM1 + NTERM2
NCMLTN = MCMLTN + NPDS(L-KTIMES+1)
GO TO 7060

7095 NPDS(50) = (IFRCTN*NMINUS(49-KTIMES,I,N)+500) / 1000
NXTRA = KTIMES + 1
DO 7100 JXTRA = 1,NXTRA
7100 NPDS(50) = NPDS(50) + NMINUS(49-KTIMES+JXTRA,I,N)
NTERM = (IFRCTN*NMINUS(50,I,N)+500) / 1000
NPDS(50) = NPDS(50) + NTERM
NCMLTN = MCMLTN + NPDS(50)
GO TO 7060

7060 IF ( NCMLTP .EQ. NTOTAL ) L = 100
IF ( L .GT. 50 ) GO TO 7050
IF ( NCMLTN .LT. N5000 ) GO TO 7050
NCMLTP = NCMLTN
L = 50
GO TO 7050

7035 DIFF = DIFF - PLUS
KTIMES = KTIMES + 1
AVRG = AVPG + 20.0
7030 CONTINUE

7025 DIFF = TMINUS - T5000
DO 7110 J = 1,50
AMINUS = NMINUS(J,I,N)
IF ( AMINUS .LT. DIFF ) GO TO 7115
IFRCTN = 1000.0 * DIFF / AMINUS
FRCTN = FLOG(IFRCTN) / 1000.0
AVRG = AVRG - FRCTN*20.0
JEND = 100 - KTIMES
LTIMES = 50 - KTIMES
LEND = 1 + KTIMES
DO 7120 K = 1,50
NPDS(K) = 0
7120 NPDS(K) = 0
NCMLTP = 0
NCMLTN = 0
L = 0
7130 IF ( L .EQ. 100 ) GO TO 7200
L = L + 1
CHART 2    PROGRAM STATEMENTS (CONTINUED)

 LL = L
 IF ( L .LE. 50 ) LL = 51 - L
 M = L
 IF ( L .GT. 50 ) M = L - 50
 IF ( LL .LE. JEND ) GOTO 7135
 NNEG(M) = 0
 GO TO 7140

7135 IF ( LL .LT. JEND ) GOTO 7145
 NTERM = (IFRCTN*NMINUS(50,I,N)+500) / 1000
 NNEG(M) = NMINUS(50,I,N) - NTERM
 NCMLTN = NCMLTN + NNEG(M)
 GO TO 7140

7145 IF ( LL .LE. LTIMES ) GOTO 7155
 IF ( LL .LE. 50 ) GOTO 7150
 NTERM1 = (IFRCTN*NMINUS(L-LTIMES,I,N)+500) / 1000
 NTERM2 = (IFRCTN*NMINUS(L-LTIMES+1,I,N)+500) / 1000
 NNEG(M) = NMINUS(L-LTIMES,I,N) - NTERM1 + NTERM2
 NCMLTN = NCMLTN + NNEG(M)
 GO TO 7140

7150 NTERM1 = (IFRCTN*NMINUS(LEND-M,I,N)+500) / 1000
 NTERM2 = (IFRCTN*NMINUS(L-NTIMES+1,I,N)+500) / 1000
 NPOS(M) = NMINUS(L-NTIMES,I,N) - NTERM1 + NTERM2
 NCMLTP = NCMLTN + NPOS(M)
 GO TO 7140

7155 IF ( LL .LT. LTIMES ) GOTO 7165
 NTERM1 = (IFRCTN*NPLUS(1,I,N)+500) / 1000
 NTERM2 = (IFRCTN*NMINUS(L-NTIMES,I,N)+500) / 1000
 NPOS(M) = NMINUS(L-NTIMES,I,N) - NTERM1 + NTERM2
 NCMLTP = NCMLTN + NPOS(M)
 GO TO 7140

7165 IF ( LL .EQ. 1 ) GO TO 7175
 NTERM1 = (IFRCTN*NPLUS(LTIMES-LL+1,I,N)+500) / 1000
 NTERM2 = (IFRCTN*NPLUS(LTIMES+1,I,N)+500) / 1000
 NPOS(L-KTIMES+1) = NPLUS(LTIMES-LL+1,I,N) - NTERM1 + NTERM2
 NCMLTP = NCMLTN + NPOS(L-KTIMES+1)
 GO TO 7140

7175 NPOS(50) = (IFRCTN*NPLUS(49-KTIMES,I,N)+500) / 1000
 NXTRA = KTIMES + 1
 DO 7180 JXTRA = 1,NXTRA

7180 NPOS(50) = NPOS(50) + NPLUS(49-KTIMES+JXTRA,I,N)
 NTERM = (IFRCTN*NPLUS(50,I,N)+500) / 1000
 NPOS(50) = NPOS(50) + NTERM
 NCMLTP = NCMLTP + NPOS(50)

7140 IF ( NCMLTN .EQ. NTOTAL ) L = 100
 IF ( L .GT. 50 ) GO TO 7130
 IF ( NCMLTP .LT. N5000 ) GO TO 7130
 NCMLTN = NCMLTP
 L = 50
 GO TO 7130

7115 DIFF = DIFF - AMINUS
 KTIMES = KTIMES + 1
 AVRGC = AVRGC - 20.0

7110 CONTINUE
7200 CONTINUE
 DO 7310 K = 1,50
 IF ( K .GT. 1 ) GO TO 7315
 NSUM1 = NPOS(K)
NSUM2 = NNEG(K)
GO TO 7320

7315 NSUM1 = NSUM1 + NPOS(K)
NSUM2 = NSUM2 + NNEG(K)

7320 NCMPDS(K) = NSUM1
NCMNEG(K) = NSUM2
NRFLCT(K) = NSUM1 + NSUM2

7310 CONTINUE
DC 7330 J = 1,50
SIGMAX = J * 20
IF ( J .GT. 1 ) GO TO 7335
SMFRQ1 = 0.0
SMFRQ2 = NRFLCT(1) * 10000 / NTOTAL
K5 = 5
K10 = 10
GO TO 7350

7335 SMFRQ1 = SMFRQ2
IF ( J .EQ. 50 ) GO TO 7355
SMFRQ2 = NRFLCT(J) * 10000 / NTOTAL
GO TO 7350

7345 SMFRQ2 = 10000.0

7350 FRQNCY = SMFRQ2 - SMFRQ1
IF ( K5 .NE. 5 ) GO TO 7355
IF ( SMFRQ2 .LT. 3829.2 ) GOTO 7330
D05 = (SMFRQ2-3829.2)/FRQNCY
SIG05 = (SIGMAX-D05*20.0)/0.5
K5 = 0

7355 IF ( K10 .NE. 10 ) GO TO 7365
IF ( SMFRQ2 .LT. 6826.8 ) GOTO 7330
D10 = (SMFRQ2-6826.8)/FRQNCY
SIG10 = SIGMAX - D10*20.0
K10 = 0

7365 IF ( SMFRQ2 .LT. 8663.8 ) GOTO 7330
D15 = (SMFRQ2-8663.8)/FRQNCY
SIG15 = (SIGMAX-D15*20.0)/1.5
GO TO 7370

7330 CONTINUE

7370 WRITE ( 6,1020 )
WRITE ( 6,7380 ) N,I,SIG05,SIG10,SIG15

7380 FORMAT ( 10X,26H N,I,SIG05,SIG10,SIG15 ,2I10,3F10.4 )
BIASXY(I,N) = AVRG
IF ( I .EQ. 1 ) SSQRRE = SIGXL**2 + SIGXR**2
IF ( I .EQ. 2 ) SSQRRE = SIGYL**2 + SIGYR**2
SIGMXY(1,I,N) = SQRT(SIG05**2+SSQRRE)
SIGMXY(2,I,N) = SQRT(SIG10**2+SSQRRE)
SIGMXY(3,I,N) = SQRT(SIG15**2+SSQRRE)

7010 CONTINUE
The index N is set before the DO 7010 loop and presently has possible values of 1 through 5. N equals 1 when hitting first rounds are of concern and 3 for missing first rounds. Meanings of the values 2, 4, and 5 need not be explained here. The range of values of N can, for other applications, be increased or decreased; in particular, a single dummy setting can be used.

The horizontal and vertical coordinate axes are each subdivided into 100 intervals of 20 inches each; positive and negative coordinates are each covered by 50 intervals. Intervals are related to the index J in a way that should soon be clear. Assume that one has run many simulated engagements and determined, for hitting rounds and missing rounds separately, how many times a particular interval contained the horizontal coordinate of the first round and, again separately, the vertical coordinate. Input data of this sort are shown in Chart 3. Numbers in the array NPLUS(J,I,N) indicate how many coordinates are within the interval 0 to 20 inches for J = 1, within the interval 20 to 40 inches for J = 2, and so forth. Similarly, the NMINUS(J,I,N) array contains the number of coordinates within the interval -20 to 0 inches for J = 1, and so forth.

The arrays involved in Chart 2 and their dimensions in the JMEM Direct Fire program are as follows:

NMINUS(50,2,5)
NPLUS(50,2,5)
TOTAL(2)
NEG(50)
POS(50)
NCPOS(50)
NCNEG(50)
NRFLCT(50)

The NMINUS and NPLUS arrays contain the data to be processed.

The complete calculations for particular values of N and I yield an estimate of the mean, denoted by AVRG, and three estimates of the standard deviation, represented by SIG05, SIG10, and SIG15.

A total of 1000 engagements were simulated to obtain the data in Chart 3. A first round hit was obtained in 529 instances, and the first round missed the target in the other 471 instances. The impact points for the 529 hits were (for an observer at the firing weapon) to the right of the Y-axis illustrated in Chart 1 on 324 occasions, and to the left on the other 205 occasions. These same impact points were above the X-axis 198 times and below 331 times. Impact points of the 471 misses had positive horizontal coordinates in 278 engagements, and positive vertical coordinates in 369 engagements. To illustrate the remainder of these explanations, an arbitrary choice has been made of the values N = 3 (missing first rounds) and I = 2 (vertical coordinates).

It is useful to digress and consider how the mean and standard deviation of a normal distribution corresponding to the input data selected can be estimated graphically. Chart 4 shows the associated quantitative basis and Chart 5 the plotted points to which one would attempt, using judgement rather than calculation, to fit a straight line. The computer routine being described performs computations that basically parallel the graphical approach.
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### CHART 4  BASIS FOR CHART 5

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99
CHART 5  DISTRIBUTION OF COORDINATE DATA
The steps involved in estimating the mean are illustrated in Chart 6. Note that, for this example, the nonzero input data of concern are NPLUS(1,I,N) = 71, NPLUS(2,I,N) = 104, ..., NPLUS(7,I,N) = 2, NMINUS(1,I,N) = 20, ..., NMINUS(6,I,N) = 3. The totals 102 and 369 are the values of TMINUS and TPLUS after completion of the DO 7020 loop. Since TPLUS exceeds TMINUS, the program attempts to identify a positive value on the Y-axis as the estimate of the mean. Consequently, DIFF is calculated by the statement right before the DO 7030 loop, rather than by the statement preceding the DO 7110 loop. The DO 7030 loop establishes first that the point of central tendency is at least as great as 20 inches, the right end of the first interval considered. This is so because 133 impact point coordinates need to be dropped from the NPLUS group before the coordinates equal half of NTOTAL. Since the 71 coordinates in NPLUS(1,I,N) are less than 133, KTIMES is reset to 1 and the difference is reduced to 62. Next, the DO 7030 loop determines that .6 of the 104 coordinates in the interval 20 to 40 inches need to be dropped. Since .6 times 20 equals 12, the points to be dropped are simply assumed to be located in the interval 20 to 32 inches, while all other points in the interval 20 to 40 inches are considered to exceed 32. One can observe in Chart 7 that the calculated value of AVRG corresponds to the point where one of the line segments joining adjacent points crosses the .5 probability level.

Once the mean is known, the next step is to relate the original input data to a new set of 20-inch intervals centered about the mean. Chart 8 illustrates how this is done. Each NMINUS(J,I,N) and NPLUS(J,I,N) value is first subdivided into two subelements according to the value of FRCTN. For example, NMINUS(6,I,N) is broken up into 2, associated with the 12 inches to the left, and 1, considered in the right 8 inches of the interval -100 to -120 inches. Subelements from adjacent intervals are then paired appropriately and added to get NNEG(M) and NPOS(M) values, where the index M is associated with the adjusted set of intervals. Note how NPLUS(2,I,N), which involves the original interval containing the estimated mean 32, contributes 62 to NNEG(1) and 42 to NPOS(1). The cumulative totals MCMLTN and NCMLTP, where NCMLTP always includes the maximum value of NCMLTN, enable the computer to determine when all the original nonzero input information has been processed. The interval adjustment just described is done by the statements beginning with JEND = 100 - KTIMES that follow the final determination of AVRG in the DO 7030 loop, or in the DO 7110 loop.

After the interval adjustment calculations have been completed, the DO 7310 loop of the program computes the values in the NRFLCT array as shown in Chart 9. The NRFLCT array represents an equal weight combination of the NPOS and NNEG data. Any NRFLCT(K) value indicates how often the absolute values of the differences between the vertical coordinates of missing first rounds and the estimated mean are equal to or less than 20 K inches. The fractions obtained when one divides the NRFLCT values by NTOTAL are not calculated by the program, but are included in Chart 9. Chart 10 illustrates how these fractions are related to the distribution of concern.

The DO 7330 loop determines the three alternative estimates for the standard deviation. These estimates are based on the probabilities associated in a normal distribution with the mean plus or minus 0.5 standard deviation, plus or minus 1.0 standard deviation, and plus or minus 1.5 standard deviation. Linear interpolation is applied, as necessary, to the distribution implied by the NRFLCT values to infer estimates of 0.5, 1.0, and 1.5 times the standard deviation.
CHART 6  CALCULATION OF MEAN

TMINUS = 102.

TPLUS = 369.

NTOTAL = 471
N5000 = 235
DIFF = 133.
71. < 133.

KTIMES = 1
FRCTN = .6

DIFF = 62.
104. > 62.
AVRG = 32.0

102
CHART 7  ESTIMATED MEAN (AVRG)
### Chart 8: Adjustment of Intervals

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| 201 |
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### Chart 9: Calculation of NRFLCT and Corresponding Fractions

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Note: NRFLCT(K)/471 is the ratio of NRFLCT(K) to 471.
CHART 10  FRACTIONS BASED ON NRFLCT VALUES
• POINTS AS IN CHART 5
• POINTS BASED ON NRFLECT ARRAY

CHART 11  ESTIMATE OF 0.5 STANDARD DEVIATION
CHART 12  ILLUSTRATION OF DISTRIBUTION FOR MEAN OF 32 INCHES AND STANDARD DEVIATION OF 40 INCHES
deviation. For example, as is shown in Chart 11, a frequency of .383 is associated with the mean plus or minus 0.5 standard deviation. Vertical lines through $.5 - (.383/2)$, which equals about $.31$, and through $.5 + (.383/2)$, approximately $.69$, cross line segments joining points based on the NRFLCT array at intersections that correspond to adjusted horizontal scale values of $-18.6$ and $18.6$ inches. The related standard deviation estimate is $37.2$ inches. Similarly, standard deviation estimates based on $1.0$ and $1.5$ times the standard deviation turn out to be $39.9$ and $53.4$ inches respectively.

3. CONCLUSION. Consider again the context within which arose the need for the procedure explained in this paper. Chart 12 illustrates the information concerning the vertical coordinates of missing first rounds that is conveyed by the calculated mean and a standard deviation estimate of $40$ inches, selected as a best estimate for the particular situation used as an illustrative example in this paper.
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